Guidance for Road Safety Assessments & Reviews

September 2016

Alabama Department of Transportation

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GUIDANCE FOR ROAD SAFETY ASSESSMENTS & REVIEWS

September 2016

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ADMONITION

This document is exempt from open records, discovery or admission under Alabama Law and 23 U.S.C. §§ 148(h)(4) and 409). The collection of safety data is encouraged to actively address safety issues on regional, local, and site specific levels. Congress has laws, 23 U.S.C. § 148(h)(4) and 23 U.S.C. § 409 which prohibit the production under open records and the discovery or admission of crash and safety data from being admitted into evidence in a Federal or state court proceeding. This document contains text, charts, tables, graphs, lists, and diagrams for the purpose of identifying and evaluating safety enhancements in this region. These materials are protected under 23 U.S.C. §409 and 23 U.S.C. § 148(h)(4). In addition, the Supreme Court in *Ex parte Alabama Dept. of Trans., 757 So. 2d 371* (Ala. 1999) found that these are sensitive materials exempt from the Alabama Open Records Act.

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Introduction

1.1 Overview of a Road Safety Assessment Program Effort

Road Safety Assessment Programs (RSAPs) are a proactive approach to improving transportation safety for road users. Adaptable to local needs and conditions, RSAPs have been implemented by agencies across the United States to help reduce crash frequency and severity on transportation facilities. For the purposes of this manual “Road Safety Assessment” (RSA) will be used to describe a formal safety performance examination of an existing (post-construction) or future (pre-construction) road or intersection by an independent, multidisciplinary team. The term ”Road Safety Review” (RSR) will be used to describe a brief and less formal safety review of an existing road or intersection conducted by a team with primarily design and/or safety expertise.

An RSAP serves three major purposes: 1) to identify potential safety problems for road users, 2) to make sure that options for eliminating or reducing deficiencies are fully explored and evaluated, and 3) risk assessment. Road Safety Assessment Programs have been implemented with different approaches. Some RSAPs take a “spot improvement” approach and focus only on locations with high crash frequency or severity. Other programs take a system-wide approach, focusing instead on safety issues that affect all roadways in a jurisdiction. An example of a system-wide RSAP project is to evaluate clear zone encroachments on all high-speed facilities. Jurisdictions that use a balance of these two approaches, “spot” and system-wide, tend to experience the greatest benefits.

An RSA can be conducted at any stage (planning, design, construction, or post-construction) in the project development process. Generally speaking, the earlier an RSA is conducted, the more potential it has to proactively alleviate safety issues.

A pre-construction RSA, conducted during the planning and/or design stages, examines a road before it is built. For example, during the planning stage, an RSA considers policies, alignment and typical section elements, and engagement of stakeholders and affected jurisdictions to positively impact safety. During the design stage, an RSA could be conducted on a preliminary design to examine design criteria, cross-sectional elements, transitions, design exceptions, and human factors for safety implications. For a detailed design, other items of consideration include traffic operational elements for traffic signing and markings, traffic signals, overhead lighting, and drainage.

During the construction stage of project development, an RSA examines work zone traffic control, construction phasing, and temporary access for non-vehicular modes during construction, safety of contractor personnel and construction vehicles, and/or assessment of public information plans. If there are changes made to plans during construction, those changes would benefit from an RSA.

A post-construction RSA examines a road that is operational and is typically conducted to address a documented crash problem. A system-wide RSA approach could be used as a diagnostic tool to determine maintenance priorities or policies.

1.2 Differences between an RSAP and Other Safety Programs

The Road Safety Assessment Program is intended to be a simpler and more cost-effective safety program than others that have preceded it. A similar program, the Highway Safety Improvement Program (HSIP), was developed in 1979 by the Federal Highway Administration (FHWA). The HSIP is more data intensive than the RSAP with many more process steps that require financing, personnel, and expertise far beyond the resources of typical local transportation agencies.

Another federal program, Safety Management Systems (SMS), was developed in response to requirements in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). The four processes of the SMS are:

1. Identifying hazards, setting priorities, and developing a program to correct hazardous highway locations and features.
2. Maintaining and upgrading the safety of highway features and highway hardware.
3. Ensuring routine and timely inclusion of safety concerns in the development of all highway projects.
4. Identifying special safety needs of commercial motor vehicles in the planning, design, construction, and operation of the highway system.

Unlike the HSIP and SMS, the RSAP has a rather simple and straightforward process:

1. Collect and review background data.
    a. Aerial photos
    b. Crash reports
    c. Traffic counts
    d. Citizen complaints, if any
2. Conduct an on-site field review with an assessment team.
3. Develop recommendations.
4. Prepare RSA/RSR reports.
5. Conduct an owner review of the report and prepare a response.
6. Implement the recommendations.

Typical traffic safety issues that might be examined in an RSA/RSR include:

- Use and location of signs.
- Fixed objects or steep slopes in recovery area.
- Uncontrolled access near intersections.
- Guardrail and guardrail end treatments.
- Sight distance.
- Edge drop-offs or shoulder deterioration.
- Sign retroreflectivity.
- Intersection geometry.
- Turn lanes.
- Speeding and speed variations.
- Pavement markings.
- Street lighting.
- Pedestrian/bicyclist accommodations.

1.3 Purpose of this Guide

This Guidance for Road Safety Assessments & Road Safety Reviews was developed by the Alabama Department of Transportation for the purpose of documenting a standard procedure for conducting RSAs and RSRs in Alabama. Alabama's Strategic Highway Safety Plan (SHSP), 2nd Ed., identified RSAs as a strategy to reduce fatal and severe injury crashes in support of Alabama's vision of zero fatalities from highway crashes. RSAs and RSRs shall accomplish this by identifying, assessing, and prioritizing highway safety concerns and providing an appropriate range of countermeasure strategies for action by responsible highway jurisdictions, enforcement agencies, and other stakeholders.

This Guide seeks to define best practices for conducting RSAs/RSRs, describe their use within various project stages, provide resources for practitioners who perform safety assessments, and outline a process for incorporating RSAs into ALDOT's routine activities. While the Guide is primarily targeted for ALDOT processes, it contains guidance and information that is also applicable to county and local transportation agencies, law enforcement, and others concerned with improving transportation safety in Alabama.

1.4 Liability Issues

When considering whether or not to implement an RSAP, several liability-related questions are typically asked:

1. Does a public entity have a duty to assess its roadways for potential defects?
2. Is being ignorant or unaware of roadway defects a more defensible position than knowing but being unable to correct those defects due to time or finances?
3. What is the appropriate standard of care for safety?
4. Is an RSA or RSR report discoverable in a lawsuit?
5. Is a governing entity's use of the RSAP legally defensible?

These are all important questions that should be carefully considered by the governing entity's legal counsel. Some insight into these questions can be found in a research report entitled, *Safety Analysis Without the Legal Paralysis: The Road Safety Audit Program*. (Wilson & Owens, 2001). The results of this study show that the RSAP "adds value to a transportation entity, and those legal doctrines such as sovereign immunity and the rules of discovery and evidence can operate to protect the transportation entity from liability. Furthermore, the public interest of improving road safety outweighs the plaintiff's interests in a potential lawsuit." (Wilson & Owens, 2001)

Prior to the 1960's and 1970's, governments were protected from lawsuits by sovereign immunity. Since that time, governing entities have become increasingly vulnerable and sensitive to the threat of liability. While the State of Alabama still maintains absolute sovereign immunity, the same cannot be said for local governments. The expectation is that agencies will monitor and maintain their roadway facilities to mitigate any potential harm to the public. Ignorance of a defect is not considered an acceptable defense.

The duty to know the condition of roads requires that public agencies focus on risk management with a logical and systematic method for identifying the locations with the highest potential for harm and prioritizing them for mitigation. An RSAP is a logical and systematic means for identifying, assessing, and prioritizing improvements to roadway facilities with the clear goal of improving safety. RSAs and RSRs have several benefits in this regard:

1. The basic principle of RSAs and RSRs is to identify problems where safety could be an issue and to mitigate them. By implementing an RSAP, a governing entity demonstrates its intent to provide safe roadway conditions for its users.
2. The documentation steps of an RSA or RSR help to establish whether engineering judgment was exercised in resolving any perceived safety issues thus minimizing grounds for claims of negligence. Exercised engineering judgment refutes an allegation of negligence by showing the project owner has acknowledged a safety concern and selected the best response available given a known set of circumstances.
3. An RSA/RSR Final Report should document the perceived safety concern, associated crash types, perceived level of risk, and a range of mitigation strategies. Mitigation strategies should include low-cost, short-term options as well as longer-term solutions. By presenting a full range of options, the project owner is better equipped to choose an appropriate plan of action.
4. A response report, as required by the RSA process, provides written documentation that the project owner received the RSA findings and establishes in writing agreement or disagreement with the findings and what course of action will follow, if any. If the project owner disagrees with the findings, the response report provides an opportunity for the owner to document reasons for disagreement. If no subsequent action will be taken, the response report documents the factors considered in making that decision.

RSA documents produced for a Federal-Aid Highway Program project are protected from discovery in a lawsuit. Section 409 of Title 23 of the United States Code (initially passed by Congress in 1987) provides that an internal safety evaluation generated by a transportation entity may be privileged and not discoverable nor admissible when the evaluation is to be implemented in a Federal-Aid Highway Program (FAHP) project (Wilson & Owens, 2001).

> "Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying[,] evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130 [Railway-highway crossings], 144 [Highway bridge replacement and rehabilitation program], and 152 [Hazard elimination program] of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data." 23 U.S.C. § 409 (2000).

In order to fully document and acknowledge the protections provided by 23 U.S.C. § 409, any RSA or RSR produced for ALDOT must include the following admonition. This statement must also be included in any local- or county-produced RSA or RSR that utilizes safety-related data provided by ALDOT.

> *This document is exempt from open records, discovery or admission under Alabama Law and 23 U.S.C. §§ 148(h)(4) and 409). The collection of safety data is encouraged to actively address safety issues on regional, local, and site specific levels. Congress has laws, 23 U.S.C. § 148(h)(4) and 23 U.S.C. § 409 which prohibit the production under open records and the discovery or admission of crash and safety data from being admitted into evidence in a Federal or state court proceeding. This document contains text, charts, tables, graphs, lists, and diagrams for the purpose of identifying and evaluating safety enhancements in this region. These materials are protected under 23 U.S.C. §409 and 23 U.S.C. § 148(h)(4). In addition, the Supreme Court in Ex parte Alabama Dept. of Trans., 757 So. 2d 371 (Ala. 1999) found that these are sensitive materials exempt from the Alabama Open Records Act.*

In addition to the admonition statement, every page of an RSA or RSR must also include this statement, which would typically be included as a footer:

> *This report is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.*

1.5 Selecting / Prioritizing Locations for Assessment

Several methods have been used by agencies in the U.S. to select and prioritize RSA/RSR locations. Smaller agencies often use input from citizens, law enforcement, city officials/employees, and/or routine inspections for identifying locations for safety improvements. Larger agencies tend to favor more analytical methods, such as crash data analysis, for selecting and prioritizing assessment locations.

An agency with access to a comprehensive database of crash records, such as ALDOT has with the Critical Analysis Reporting Environment (CARE) database, can conduct a crash analysis to identify locations with high crash frequency or severity. Those “hot-spot” locations can then be prioritized and reviewed for potential spot safety improvements. Crash analyses can also focus on areas with an elevated number of one or more types of crashes that could potentially be mitigated by a system-wide safety initiative. For example, an analysis of locations with multiple run-off-road crashes could be used to identify routes for assessments focused on roadside safety features and/or horizontal curves.

Although helpful and/or desirable, crash analysis is not a requirement of an RSA. Another approach for selecting locations might begin with a survey of local law enforcement and transportation agency officials to create a “top ten” list of locations with potential safety concerns. These locations could be cross-checked with locations that have been the subject of citizen complaints.

Whether the selection method is scientific or anecdotal, the identified locations should be ranked into groups by priority with consideration given to the number of assessments that the maintaining agency could potentially complete in a given year.

Although an RSA/RSR is most often conducted on existing facilities with a history of crash occurrence, it can also be conducted on projects in the early planning stages, within the design stage, or when under construction. Characteristics of an RSA/RSR in these various stages of project development and guidance for conducting these assessments are further described in later chapters of this document.

1.6 Definitions and Characteristics

The following paragraphs provide explanations for common RSAP terminology. These definitions and characteristics are provided to clarify the use of these common RSAP terms.

<u>Road Safety Assessment</u>: A Road Safety Assessment (RSA) is the formal examination of a road’s safety performance by an independent and multidisciplinary team.

<u>Road Safety Review</u>: A Road Safety Review (RSR) is the examination of a road’s safety performance by a small team with design and/or safety experience. An RSR is a less formal process than an RSA and can be conducted by the roadway’s maintaining agency.

<u>Nominal Safety</u>: Nominal safety is compliance with design criteria such as AASHTO’s *A Policy on Geometric Design of Highways and Streets* or the *Manual on Uniform Traffic Control Devices*

(MUTCD). Compliance with authoritative standards is important to support safety, but ranges of values for criteria and combinations of various criteria can result in varying levels of safety performance.

Safety Performance: Safety performance is the frequency and severity of crashes on a road segment or at an intersection. For a segment, crashes are measured per mile per year. For intersections, crashes are measured per year. Depending on available data, safety performance may be the observed performance, the predicted performance, or the expected performance. The *Highway Safety Manual* (HSM) should be referenced for instructions on methods for predicting safety performance.

Substantive Safety: Substantive safety is the actual long-term or expected safety performance of a roadway which is the safety approach of the HSM. Quantitative measures of substantive safety include crash frequency, crash type, and crash severity. These are measured over a long enough period of time to provide a high level of confidence that the observed crash experience is a true representation of the expected safety characteristics of that location or highway. Expected safety performance will vary based on inherent differences among highway types and contexts.

RSA Characteristics: The RSA is a process of measuring and assessing risk and proposing a range of countermeasures to reduce the contributing factors that degrade safety performance. Within the activity of identifying and addressing potential safety concerns, an RSA attempts to:

- Consider the safety of all roadway users.
- Consider proactive mitigation of safety concerns.
- Examine the interaction of project design elements.
- Consider the interactions at the project limits.

The assessment of safety concerns and selection of countermeasures is accomplished through a multidisciplinary team of professionals with experience in various highway specialties. A team typically includes four to seven people with a team leader. It functions independently from the roadway owner in order to maintain objectivity.

While nominal safety criteria provide a basis for safe design of highways, care has to be taken to evaluate the effect of design decisions on crashes to minimize or avoid the creation of hazards. A location or roadway may meet nominal safety criteria, but each location brings its own unique set of safety concerns that need to be evaluated by the RSA team on a case-by-case basis. Where applicable the RSA employs procedures and methods from the HSM to diagnose and address safety concerns and to quantify safety performance.

RSAs are applicable to every stage of project development. The applicability of an RSA and commentary on the types of projects that most benefit from application of an RSA are summarized in Table 1-1.

RSR Characteristics: If no initial safety analysis, project scoping, or plans has been completed by the project owner, an RSR may be appropriate. An RSR is conducted by a smaller team and will use analysis procedures similar to those of an RSA, but an RSR is an abbreviated, less formal process and does not have to be conducted independently from the project owner. An RSR incorporates the safety diagnosis and countermeasure steps of an RSA and requires a Final Report, but does not require the other meetings used in the RSA process or a formal Response Report from the project owner. If an RSR leads to the initiation of a project to improve the road, that project might be considered for an RSA during its development. Additionally, an RSR may be used for identifying safety improvements that are considered the best practice and low-complexity, regardless of whether an initial safety analysis is conducted.

Table 1-1: RSA Application in Project Development

Project Phase	Examples of Elements Reviewed	Project Types That Benefit Most	Additional Comments
Planning	Project scope, route location, intersection type, access management, cross sections, impacts to existing facilities	New construction, 3R/4R, HSIP, or other safety improvement	RSAs at this phase allow early identification of potential concerns and future design stages to be scoped so that all concerns are adequately addressed. Planning RSAs may also result in re-scoping of project(s).
Preliminary Design	Alignments (horizontal and vertical), cross-sections, intersection/interchange type and layout, sight distances, lane and shoulder widths, pedestrian and bicyclist considerations, special user needs, traffic management	Appropriate for most design projects	At this stage, identified concerns may be incorporated into the design to mitigate problems and determine the associated construction costs. Generally, an RSA need not be conducted at both preliminary and final design.
Final Design	Geometric elements, pedestrian and bicyclist considerations, signing and striping, illumination, acceleration and deceleration lanes, drainage, roadside fixed objects, mobility and safety, traffic management, constructability	Appropriate for most design projects	RSAs at this stage allow the RSA team to review most of the design. However, recommended changes may require time for redesign.
Construction	Traffic management, mobility and safety, interim geometry, effects on vulnerable users, business access, existing infrastructure	Projects constructed under high traffic volumes and locations with vulnerable users	RSAs at this stage provide benefit by isolating problems that can occur during construction or were not easily identified from design plans.
Existing Facility	Crash records, sight distances, speed zones, compliance with current design and operation standards, access management, and driver behavior	Facilities identified in any previous safety study, locations above the critical PSI (potential for safety improvement) for a peer group, overrepresentation of crash types or other attributes (wet pavement, night, etc.) or made at a stakeholder's request	RSAs can improve the safety of open facilities, especially if an RSA was not performed during initial planning or design.

1.7 Differences between an RSA and an RSR

While an RSA and an RSR have the same goal of improving transportation safety for road users, they do have several differences. An RSA is a formal examination of an existing (post-construction) or future (pre-construction) roadway by an interdisciplinary assessment team, whereas an RSR is a brief and less formal safety review of an existing road or intersection conducted by two or three people. Table 1-2 summarizes the differences between an RSA and an RSR.

Table 1-2: Road Safety Assessment and Road Safety Review Comparison

Road Safety Assessment	Road Safety Review
Reactive and Proactive – responds to a high frequency or severity of crashes or attempts to prevent conflicts and crashes before they occur	**Reactive** – responds to a high frequency or severity of crashes
Independent Team – review team not previously involved in the project	**In-House or Independent Team** – performed by engineers that may have been involved in the original design
Comprehensive Field Review – field observations under various conditions play necessary role in successful study	**Limited Field Review** – field review is recommended
Safety Performance – considers issues such as operations and driver behavior, in addition to standards and guidelines	**Standards** – checks compliance with standards and guidelines and considers effects of various design decisions on safety performance
Formal Reporting – specific communication and report development steps leading to a Final Report to the owner and requiring owner's written decision and reasons on each point	**Summary Reporting –** summary report of findings and recommendations generated for the project file
Approval Process – Final Report to be approved by the Region or Area Engineer and State Safety Operations Engineer	**Approval Process** – summary report to be approved by project owner

Chapter 2

RSA/RSR Benefits

The primary benefit of RSAs comes from the reduction in the occurrence of crashes as the safety on a roadway is improved. Traffic crashes produce negative societal impacts that go beyond monetary costs. When people are killed or injured in traffic crashes, families, employers, and communities suffer emotional, productivity, and developmental losses. RSAs use science-based analytical tools to predict safety outcomes and are a demonstrated tool for improving safety performance on transportation facilities.

An RSA requires more time, coordination, and participation by a multidisciplinary team of many members. An RSR may be performed by an abbreviated team of knowledgeable professionals in a shorter period of time, yet it is still a safety analysis to determine proper countermeasures. Therefore, many of the benefits discussed before apply to both RSAs and RSRs.

2.1 Anecdotal Benefits

FHWA's Safety webpage (http://safety.fhwa.dot.gov/rsa/benefits/) documents a number of anecdotal benefits gathered from RSA programs across the U.S. The benefits described below are suggested by safety leaders in states that have conducted RSAs for a variety of project types and in differing stages of project development.

Benefits to road users:

- RSAs have demonstrated effectiveness in reducing fatalities, injuries, and total crashes.
- Human factors are considered in all facets of design and the needs of all travel modes are addressed.
- An RSAP can lead to greater consistency in roadway features, especially when used as a system-wide tool.

Benefits to maintaining agencies:

- RSAs are a proactive way to address safety issues before construction. They help eliminate reconstruction costs associated with correcting safety deficiencies after a road is in service.
- By incorporating an unbiased technical review, RSAs produce recommendations that are more defensible against political or legal challenge.
- Over time, RSAs improve design processes and standard practices. They also raise awareness of safety measures among designers.
- RSAs encourage consistency & high quality in project delivery.
- They are inexpensive to conduct and generally yield a high rate of return.
- RSAs can reduce lifecycle costs and liability claims.

2.2 Quantitative Benefits

Until recently, the recorded benefits of RSAs have been mostly anecdotal since there has been little measurement of quantitative benefits on a national scale. The publication *Road Safety Audits: An Evaluation of RSA Programs and Projects* (Nabors, Gross, Moriarty, Sawyer, & Lyon, 2012), quantifies the costs and benefits of RSAs from five RSA sites in four different states. The report documents a statistical analysis conducted to predict the level of crash modification produced by the implemented RSA recommendations.

Costs for the studied RSA sites were estimated to include:

- Labor costs for the audit team.
- Labor, startup, and materials costs for design and management of the RSA.
- Implementation costs associated with installing recommended mitigation measures.

Benefits were tabulated using estimated costs of automotive crashes as published by the USDOT, *Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses* (http://www.transportation.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life). Assuming a fatality or injury is prevented by implementation of an RSA, the monetary benefit is estimated as follows:

- $6,000,000 for a traffic fatality
- $4,422,500 for a critical injury
- $1,087,500 for a severe injury
- $333,500 for a serious injury
- $89,900 for a moderate injury
- $11,600 for a minor injury
- $6,500 for property damage only (PDO)

If the benefit derived from an RSA divided by the total cost of the RSA and its implementation is greater than 1, then the project produced a positive net benefit. The five projects resulting from the evaluated RSAs varied in cost from $35,000 to $921,000. Reductions in total crashes ranged from 10 percent to 50 percent and benefit/cost ratios ranged from 1.2:1 to 116:1, depending on whether the measured benefit was for total crashes or injury crashes.

The *Road Safety Audits: An Evaluation of RSA Programs and Projects* report provides an estimate of the reduction in crashes that would be needed to justify the cost of conducting an RSA. Table 2-1 is extracted from the report and shows that the cost of a detailed $50,000 RSA is justified if one moderate injury crash is prevented by the RSA implementation.

Table 2-1: Type of Safety Review Based on Number of Crashes

Type of Safety Review (Existing Roadway)	**Average Cost**	Moderate Injury	Minor Injury	PDO
		Associated Crash Cost		
		$89,900	$11,600	$6,500
Traditional Safety Review	$1,000	1	1	1
RSA – Simple	$10,000	1	1	2
RSA – Intermediate	$15,000	1	2	3
RSA – Complex	$25,000	1	3	4
Detailed Safety Review	$50,000	1	5	8

Source: (Nabors, Gross, Moriarty, Sawyer, & Lyon, 2012)

Another table from the report considers the cost of implementation to assess the justification thresholds for RSA-recommended improvements. It shows that the benefits of preventing severe or critical injuries and death outweigh a $1,000,000 project implementation cost. To yield a benefit-cost ratio greater than 1 for RSA implementation of improvements above $250,000, there must be more significant reductions in crashes when those crashes involve only property damage or minor injuries.

Table 2-2: Type of Project Based on Number of Crashes

Project Type	**Average Project Cost**	Killed	Critical Injury	Severe Injury	Serious Injury	Moderate Injury	Minor Injury	PDO
		Associated Crash Cost						
		$6,000,000	$4,422,500	$1,087,500	$333,500	$89,900	$11,600	$6,500
Maintenance – Low[1]	$1,000	1	1	1	1	1	1	1
Maintenance – Medium[1]	$10,000	1	1	1	1	1	1	2
Low-Cost Safety Improvement[2]	$10,000	1	1	1	1	1	1	2
Maintenance – High[1]	$250,000	1	1	1	1	2	9	16
HSIP – Medium[2]	$250,000	1	1	1	1	3	22	39
HSIP – Med/High[2]	$500,000	1	1	1	2	6	44	77
HSIP – High[2]	$1,000,000	1	1	1	3	12	87	154

[1] Assumes a 3-year service life

[2] Assumes a 10-year service life

Source: (Nabors, Gross, Moriarty, Sawyer, & Lyon, 2012)

Strong Candidate for RSA and Countermeasures
Likely Candidate for RSA and Countermeasures
Questionable Candidate for RSA and Countermeasures
Weak Candidate for RSA and Countermeasures

A crash modification factor (CMF) can also be useful when evaluating the benefits of potential safety measures through an RSA. A CMF is a factor used to compute the expected reduction in crashes after implementing a given countermeasure based on before and after empirical data for comparable improvements for other project locations. For example, if a countermeasure has a CMF of 0.75 for left-turn crashes, and the intersection currently experiences 100 crashes per year, then 75 left-turn crashes per year would be expected after the implementation of the countermeasure (100 x 0.75 = 75). The Crash Modification Factors Clearinghouse is an online compilation of CMFs that helps identify the appropriate countermeasure and related CMFs.

In summary, RSAs have been proven to be a cost-effective tool to reduce crashes and improve the quality of transportation facilities. Some transportation agencies utilize RSAs on a regular basis due to their effectiveness in improving consistency and quality in design, construction, and maintenance activities.

Chapter 3
Project Selection

The process for deciding whether to conduct an RSA or RSR requires significant engineering judgment. In the case of an existing facility, the engineer should consider the location's crash history (either through quantitative data or qualitative knowledge) and the potential to yield a benefit/cost ratio greater than one (as described in Chapter 2) through crash reduction. For proposed facilities in the planning, design, or construction phases, the engineer must consider the purpose and need for the project (Was safety an important factor in purpose and need?), the traffic operational and geographic conditions of the project, and any unusual factors that might yield a negative safety impact if not carefully addressed.

Chapter 3 outlines a process for assessing a project's eligibility for an RSA or RSR, provides information on funding sources and how projects are prioritized for funding, and outlines an application process for requesting an RSA or RSR.

3.1 Project Eligibility

Since it is not economically feasible to conduct an RSA or RSR on all projects, the following guidelines should be used to help determine if a location or project could benefit from a safety assessment. Engineering judgment might suggest a project should be assessed even if it does not fall within the categories in the following lists.

The following locations or projects would be appropriate for a RSA:

Existing facilities where state agency is the lead:
- Locations with elevated crash severity and frequency (e.g., intersections, road segments, ramps).
- Resurfacing, Restoration and Rehabilitation projects where a safety concern has been identified.
- Facility types that generally correlate with safety performance issues (e.g., 4-lane undivided facilities) or that are identified in the SHSP as a focus area.
- "Hot-Spot" locations for which HSIP funding is requested.
- Sites identified through previous safety studies.
- Locations with vulnerable users, such as locations near schools or popular bicycle or motorcycle routes.

Planning/Permitting Phase:
- Projects that include safety as part of the purpose & need.
- Access Management projects.

Design Phase:
- Projects for which value engineering may produce a safety impact.
- Projects for which a design exception has been requested.

- Major capacity projects where safety is a concern.

The following locations or projects would be appropriate for a shorter RSR**:**

Existing facilities where local or county agency is the lead:

- Locations with elevated crash severity and frequency (e.g., intersections, road segments, ramps).
- Resurfacing, Restoration and Rehabilitation projects where a safety concern has been identified.
- Facility types that generally correlate with safety performance issues (e.g., 4-lane undivided facilities with overrepresentation of crashes) or that are identified in the SHSP as a focus area.
- Locations with vulnerable users, such as locations near schools or popular bicycle or motorcycle routes.
- Facilities for which High Risk Rural Roads (HRRR) funding is requested.

Planning/Permitting Phase

- A traffic signal is warranted under the crash experience warrant.
- Driveway permit requests that do not conform to the *ALDOT Access Management Manual*.

Construction Phase

- Work zones.

3.2 Funding

Funding for RSAs could potentially come from a variety of sources. The primary funding source for RSAs on existing facilities is HSIP funds. RSAs for planning or design projects should be added to the project cost. Funding from local sources is typically needed for RSRs at the local or county level. Agencies without a local funding source interested in conducting an RSA or RSR should contact the ALDOT Traffic & Safety Operations Section for guidance on the availability and sources for financial support.

3.3 Project Prioritization

Requests made to ALDOT for RSAs will be prioritized for funding based on the following general criteria. The criteria are intended to allow flexibility and are not strictly data-driven. The State Safety Operations Engineer will determine final funding priorities based on funds available and expected safety impact of the requested projects.

High Priority:

- High number of crashes or high crash severity.
- Potential “Hot-Spot” HSIP project.
- Sites identified through previous safety studies.

Moderate Priority:

- Potential to apply results at similar locations (systematic improvement).
- Complex or high-profile project.
- High potential for safety improvement (PSI) value as determined by the State Safety Operations Engineer. PSI is the difference of the Empirical Bayes adjusted average crash frequency and the predicted average crash frequency from a safety performance function.

Low Priority:

- Requests based on institutional or geographic area knowledge without quantitative or qualitative safety data, or a lack of severe crash history.
- Requests based on a single crash.

3.4 Application for an RSA or RSR

ALDOT's Traffic & Safety Operations Section has the capability to organize and complete a limited number of RSAs/RSRs in a given year. The intent of this Guide is to encourage local/county agencies and ALDOT Districts and Regions to conduct their own RSAs/RSRs, following the procedures outlined in this manual. Personnel from the Office of Safety Operations may, if requested, provide support for RSAs conducted by outside agencies either through participation in the RSA/RSR Team, through provision of support data, and/or as a document reviewer.

RSAs/RSRs conducted for any state route or using funds administered by ALDOT must be reviewed and approved by the Traffic & Safety Operations Section. In order to obtain funding or personnel support for an RSA/RSR, an application must be submitted to and approved by the State Safety Operations Engineer. Application forms for an RSA and an RSR are provided in Appendix C of this Guide. The application requires that the RSA/RSR requestor provide background information about the requested RSA/RSR site as well as contact information for the requestor and project owner(s).

Typically a request for an RSA/RSR will be initiated by the project owner. However, a stakeholder other than the project owner may request an RSA/RSR. This could result from public input to a project under development, or concerns for the safety of an existing facility. Requests could come from law enforcement, local agency engineering departments, elected officials, or private individuals through their political representatives. Requests from special interest groups or individuals should be directed to the facility owner; if state assistance is requested, the RSA/RSR application would be forwarded to the State Safety Operations Engineer.

3.5 Application/Request Process

A typical process for requesting an RSA or RSR is diagrammed in Figure 3-1. The request is usually initiated by a design team or project owner. If participation from ALDOT is requested, the project applicant submits a written application to the State Safety Operations Engineer. The application (provided in Appendix C) should include contact information for the applicant, reason for the request, phase of project, type of facility, location, proposed improvement, supporting data, and estimate of funding needed.

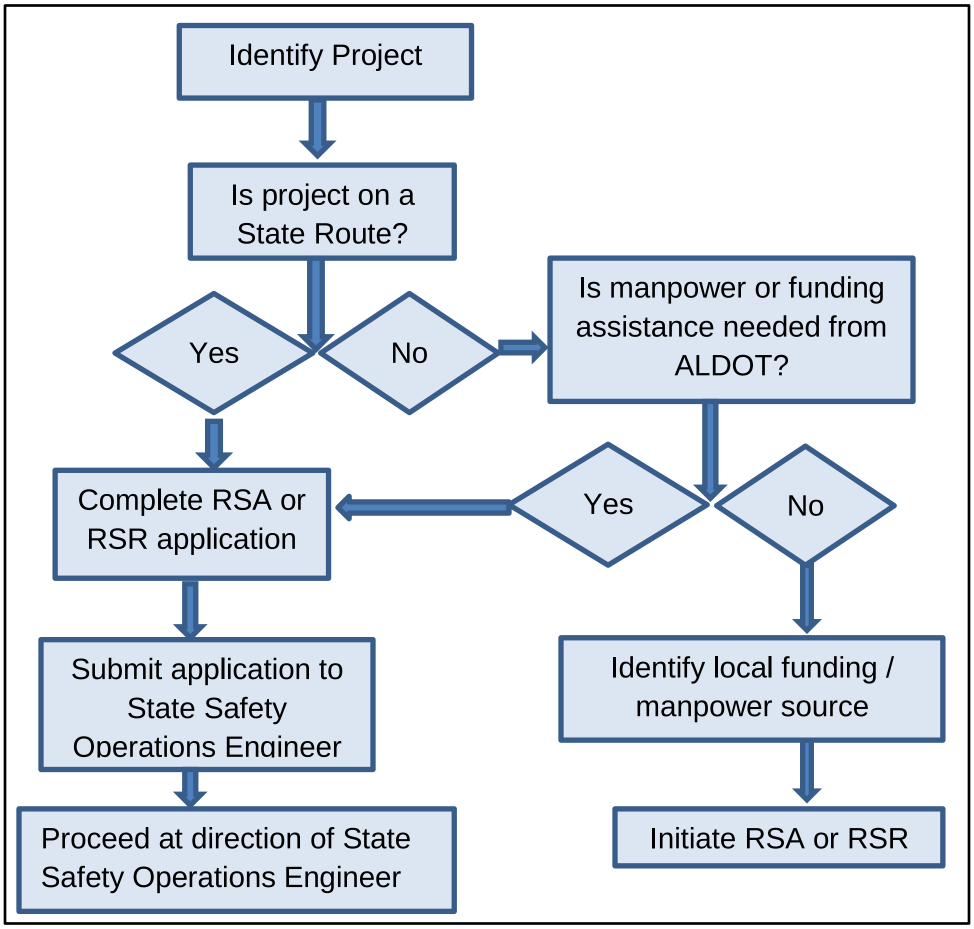

Figure 3-1: RSA/RSR Request Process

Chapter 4

Road Safety Assessment / Road Safety Review Team

When initiating an RSA or RSR, consideration must be given to assembling a team with the experience and training necessary to achieve the desired results from the effort. Team members should be trained in RSA/RSR processes, have related technical skills, and understand their roles and responsibilities prior to performing an RSA or RSR. Additionally, team members should be knowledgeable about the logistics, planning, and preparatory aspects of the RSA/RSR. Specifics of RSA and RSR team member involvement are discussed in this chapter.

4.1 Road Safety Assessment Team

4.1.1 Prerequisite RSA Training

ALDOT will offer training on the RSA/RSR for prospective team members that outlines the process to include project background and details of typical RSA/RSR efforts. The training will be in a workshop format explaining applicable policy and case studies with office and field components. The training will be required for participating ALDOT staff and the RSA/RSR team leader. Although not required of non-ALDOT staff (e.g., City, County, emergency response, law enforcement), attending the training would be highly encouraged.

4.1.2 Team Members

In proceeding with an RSA, various pre-planning and logistics efforts are needed along with determining the work plan, schedule, preliminary assessment of available information and selecting the various participants. The RSA leader will be responsible for initiating and facilitating the meeting, documenting the process, recommending countermeasures, and subsequent review. When a project location falls within multiple jurisdictions, additional coordination will be required for joint leadership or an agreement for one leader for the joint effort.

<u>Team Leader</u>

The leader will be responsible for assembling the required field resources and support team to assess operational viability, geometry, and constructability. The leader is ultimately responsible for gaining consensus on proposed recommendations, including gathering team input through votes and general discussion. Key roles of an RSA team leader are as follows:

- Organize gathering of background data.
- Schedule all meetings.
- Facilitate meetings and the field review with the assistance of safety review prompt lists.
- Display leadership and management to ensure team productivity.
- Develop and manage a work site safety plan for working on right-of-way and near traffic.

- Appoint a note taker and a photographer for project documentation.
- Prepare a report and coordinate review by team members and project owner.

Team Members

The RSA team members may be composed of professionals in transportation planning, traffic safety, law enforcement, design, academia, and consulting from the public and private sectors including representatives at various levels of government (e.g., federal, state, local). For the early stages of a project, a transportation planner would be appropriate. Similarly, a law enforcement representative would be applicable for efforts regarding an existing facility, as crash data could be supplemented with explanations of crash trends and/or driver behavior on a particular facility. Design professionals are a critical part of the RSA effort. They not only have the understanding of applicable general planning data and design considerations, but they serve as a resource for location-specific design questions and may provide analysis in support of the effort. Individuals with maintenance and operations expertise are also advisable to support an RSA team. Key roles of an RSA team member are as follows:

- Review background data as provided by the team leader.
- Attend pre-assessment and post-assessment meetings and provide comments.
- Participate in a field review.
- Provide comments on the draft report.

The following are preferred prerequisites to serve as a team member:

- Complete ALDOT's RSA/RSR training program.
- Experience as a team member in previous RSAs.
- Possess an applicable skill set and area of expertise to complement a multidisciplinary team.

Observer

In addition to team leaders and members, other individuals may observe, be aware of discussions, or be present to understand the process. Observers are encouraged to participate in discussions, particularly if they have supplemental background information which would be beneficial for the team. The limitation of observers is that they are not relied upon for input on key decisions or recommendations.

Core Skills and Expertise

The disciplines appropriate to an RSA team were previously defined. Inclusion of a specific discipline or skill set may vary from one project to another. However, the following core skill set should always be represented on a multidisciplinary RSA team: roadway design, traffic engineering/operations, and transportation safety. A typical RSA team will have between 4 and 7 members. Certain members may represent more than one area of expertise. The objectivity of the RSA team is critical as team members function independently of entities closely associated with the project including the project owner or design professional involved with the specific project.

4.1.3 Team Leader Training Requirements

An RSA team leader serves as the key contact between the RSA team, project owner, and participants and is responsible for the entire RSA process including team member participation, team consensus, and completion of the final RSA report. The following are prerequisite requirements to serve as a team leader:

- Complete ALDOT's RSA training program.
- Experience as a team member in previous RSAs.
- Current licensure as a Professional Engineer in the State of Alabama.
- Trained in application of Temporary Traffic Control (e.g. IMSA Work Zone Traffic Control or other).

4.1.4 Team Objectivity

An RSA must be conducted independently with team members only having general knowledge of the project without any prior exposure to its history or development at any stage or level. If the RSA is on an existing facility, team members may not be involved with the facility or have prior knowledge of its operational characteristics or human factors issues. RSA teams will often include members from ALDOT; therefore an independent team will include those ALDOT staff with no knowledge of the project and no history of the project design specifics.

4.1.5 Preferred RSA Representation

An RSA team member is required to participate in the assessment and to provide input for countermeasure development and review. The following is a recommended composition for an RSA team:

Required members:

- Representative of ALDOT Traffic & Safety Operations Section.
- Region/Area/District/County/or Local traffic engineer.
- ALDOT Design Bureau engineer.

Supplemental members (as appropriate):

- Law enforcement officer.
- Region/District Maintenance Engineer or Local Public Works Director (if not the owner of the facility).
- ALDOT Bridge Bureau engineer.
- ALDOT Right-of-Way representative.
- ALDOT Construction engineer.
- FHWA representative.
- MPO (Metropolitan Planning Organization) or RPO (Rural Planning Organization) representative.
- Emergency response personnel.
- ALDOT Modal Programs (e.g., railroad, bicycle/pedestrian, Safe Routes to School) representative.
- ADA (Americans with Disabilities Act) specialist.
- Neighborhood or business representative.

4.2 Road Safety Review Team

Composition of an RSR team requires appropriate consideration of team member experience and training to achieve desirable results from the effort. Many of the same elements considered for an RSA apply to an RSR, just on a more abbreviated level. The RSR team will typically have the following composition:

- Directed by an Engineer (also preferred as the team leader with previous knowledge of RSR elements)

- Staffed with at least 2 people with different areas of expertise (e.g., a design engineer, maintenance engineer)

The preferred representation on the RSR team includes the following:

Required members:

- Local or Regional Traffic Engineer

Optional supplemental members (as appropriate):

- Local or Regional Maintenance Engineer
- ALDOT Traffic & Safety Operations Section engineer
- Law enforcement officer
- Emergency response personnel

An RSR Team Leader will be responsible for the following duties:

- Organize gathering of background data.
- Schedule and facilitate meetings and/or field review.
- Determine recommendations with input from supplemental team members.
- Prepare a report.

RSR Team Members will be responsible for the following duties:

- Review background data as provided by the Team Leader.
- Participate in a meeting and/or field review.
- Provide comments on recommended improvements.

Chapter 5

RSA Process Guide

The RSA process applies the techniques in the Highway Safety Manual (HSM) and adds a risk assessment procedure. Beyond the limits of the RSA process, consideration must also be given to logistics and preparation before and during the RSA, as well as follow-through to implement countermeasures. Figure 5-1 shows an overview of the steps required to conduct an RSA. The sections of this report that address each step are referenced in the flowchart. The organization structure of the HSM is presented at the end of this chapter.

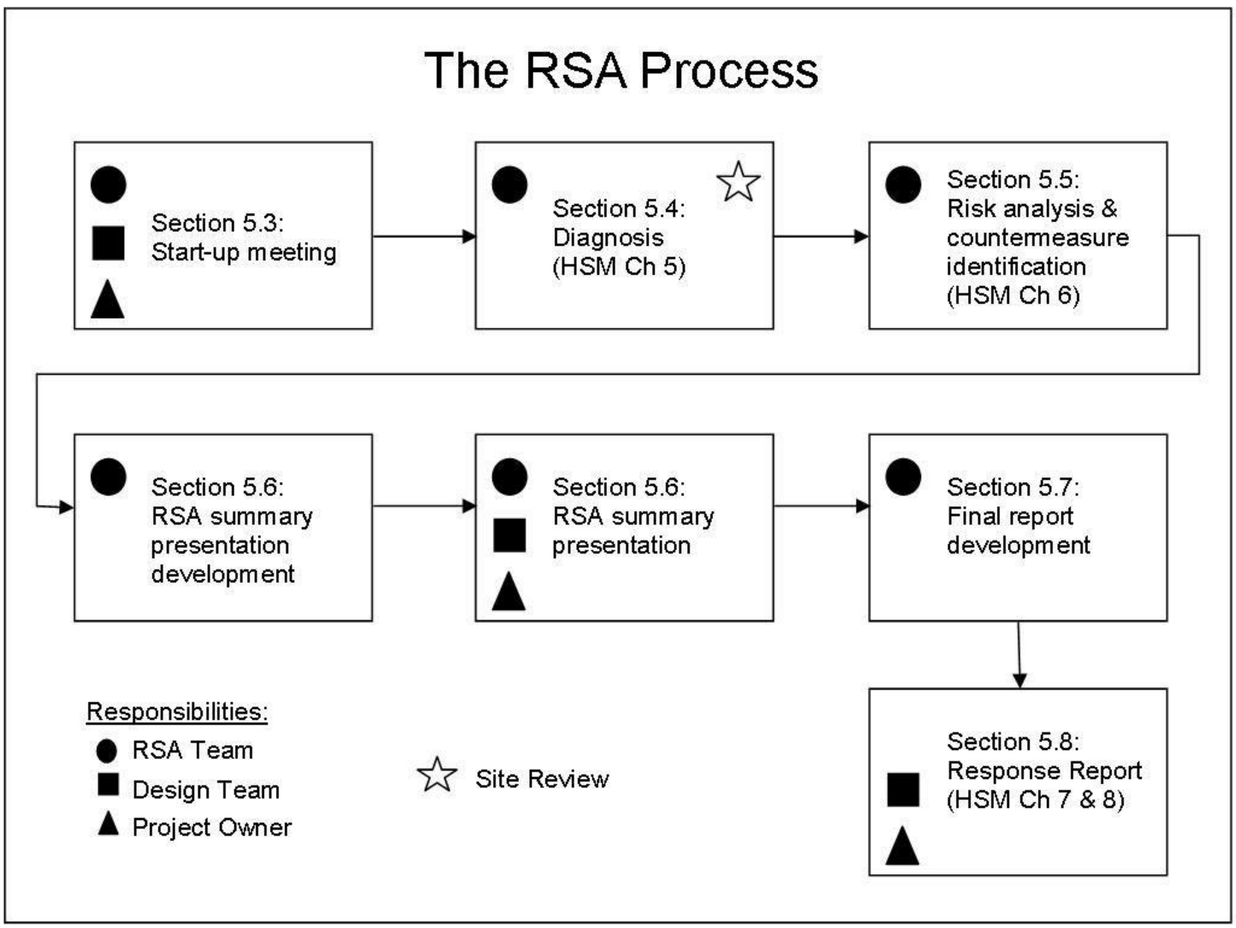

Figure 5-1: RSA Flowchart

5.1 Considerations for Initiating an RSA

Most RSAs are conducted on existing transportation facilities because a safety need has already been identified, but they can also be conducted on projects in the planning, design, or construction phases. The benefit of conducting an RSA during the design period of a project is that it allows the RSA team to proactively identify any safety issues that could be mitigated before construction is started. RSAs can be conducted during multiple phases of a project (e.g. during preliminary engineering and final design) to increase the opportunities for safety issues to be mitigated before construction is completed. If only one RSA is to be conducted on a project, it should be completed during the design phase.

Performing the RSA during the planning and early stages of design, when changes can be made before construction, means that the improvement benefits can be achieved at a relatively low cost. During these RSAs, recommendations should be made on the need for additional RSAs later in project development. While it is ideal to perform an RSA before construction, application of RSAs to existing sites with safety problems should not be overlooked.

5.2 RSA Steps

The following list shows a detailed process for completing an RSA:

1. Identify a project or site to be assessed.
2. Select RSA team members (See Chapter 4).
3. Assemble safety and operational data.
   a. Traffic volumes (annual average daily traffic (AADT) or turning movement counts as applicable)
   b. Crash data, including crash reports
   c. Other items as appropriate to the location (e.g., speed data, signal timing/phasing, roadway plans, growth or development plans in the area)
4. Analyze background data.
   a. Prepare crash analyses
   b. Prepare collision diagrams
5. Invite team members, distribute pertinent background information, and schedule pre-assessment meeting. Background information may include the following:
   a. Design plans and/or cross-sections
   b. Documentation of design exceptions
   c. Location of schools, hospital, or other special traffic generators
   d. Previous operations or safety assessments documentation
6. Issue invitations to pre-assessment (“start-up”) meeting to team members, project owner, and design team (if applicable).
7. Conduct pre-assessment team meeting and data review.
8. Perform field review.
9. Analyze safety issues and identify/prioritize countermeasures.
10. Conduct post-assessment review meeting.
11. Prepare draft RSA report.
12. Distribute draft report for review and comment.
13. Address comments and finalize report.
14. Obtain final approval of report.
15. Owner prepares and issues response report.
16. Implement selected recommendations.

The RSA for a small, single site might only take two to three days from the startup meeting to the summary presentation. For more complex projects, it is recommended that RSAs be completed within thirty (30) days from the startup meeting to the closeout meeting. The response report should be completed within two weeks after the closeout meeting.

5.3 Start-up Meeting

The start-up meeting is required for an RSA, and all RSA participants should attend. The RSA team leader and project owner are responsible for planning and running the meeting. The purpose of the start-up meeting is to ensure that the project owner, design team, and RSA team all have a common understanding of the safety concerns, schedule, and logistics of the RSA. The project owner and/or team leader should present the RSA team all of the applicable background information for the project, including but not limited to:

- Traffic volumes.
- Aerial photographs.
- Background reports.
- Design drawings.
- Design criteria.

5.4 Diagnosis (Reference HSM Ch. 5)

The purpose of the diagnosis is to determine the factors contributing to crashes and crash patterns. This step is the responsibility of the RSA team but may require assistance from the design team or owner if any questions arise. The diagnosis requires both an office review and a site visit(s).

During the office review, the RSA team reviews crash data and identifies possible contributing crash factors. If applicable and available, the following should be provided to the RSA team by the project owner prior to the start of the RSA process:

- Plans/drawings – plan sheet, profile sheet, roadway cross-sections.
- Standards used – design, operational, planning, etc.
- Documentation of design exceptions.
- General information – posted speed limits, measured travel speeds, forecasted traffic and methodology, environmental constraints, etc.
- Volume data – AADT, peak hour traffic counts, multimodal counts, etc.
- Crash records – location, time/date, type, severity, contributing factors, etc.
- Previous RSA/RSR reports – as relevant to the site or project.
- Public comments – comments on existing facilities, stakeholder interviews, etc.
- Video logs.
- Adjacent land use information – locations of nearby schools, hospitals, etc.
- Emergency vehicle routes.
- Multimodal information – bus/streetcar/rail schedules, pedestrian usage, bicycle considerations, etc.
- Maintenance and police contacts.

All of this information may not be available or relevant for every project; it will be at the discretion of the RSA team to determine what information is needed.

5.4.1 Crash Data

Crash reports reveal the location, severity, and contributing factors of a crash. Crash data may be obtained from ALDOT if the site location is on a state-maintained or county route. Crash data for local streets may be obtained from the local municipality. Typically, the most recent 3 to 5 years of crash data is gathered and analyzed. Any operational changes, traffic distribution changes, or construction changes that have occurred at the review site during the crash analysis period should be analyzed for impact on crash patterns.

While reviewing crash data, it is helpful to read the crash narrative/description to gain a better understanding of all circumstances surrounding the crash. It is also important to check the data for crash frequency and calculate a crash rate. Crash frequency is the number of recorded crashes at a given location. Crash rate is a calculation that takes into account the number of crashes over a certain period of time and traffic exposure at the crash site. Calculation of a crash rate can help the analyst determine if there is an overrepresentation of crashes compared with other similar sites where crash rates have been calculated. It should be noted, however, that crash rate can become misleading with lower traffic volumes and should be used with caution. Example calculations of crash frequency and crash rates are provided in Appendix D.

A useful way to visualize crash trends at an intersection or segment is by drawing collision diagrams. Collision diagrams use a plan view of the project location and identify recorded crashes with symbols that illustrate the crash type. The severity, date, weather, vehicle maneuver, and any other relevant crash information can be included on the collision diagram. Two example collision diagrams are provided in Appendix A. After a review of the data and collision diagrams, the RSA team should compile a list of contributing crash factors and crash patterns. Additionally, the RSA team should consider the factors contributing to crash occurrence which may result from the proposed work.

Many states have developed state-specific software tools to compile and analyze crash data. ALDOT uses the Critical Analysis Reporting Environment (CARE) system to access crash data, analyze crash statistics, and locate crashes to improve traffic safety statewide on all public roads. Local agencies can access CARE once a confidentiality agreement is signed. CARE has the ability to analyze data and generate reports as well as crash diagrams.

5.4.2 Site Visit

After the office review of available background information is completed, a site visit(s) must be conducted with all members of the RSA team. The site visit should cover time of day or environmental conditions related to the crash patterns such as peak volume times, varied weather conditions, peak pedestrian times, and sunrise/sunset. It is helpful to conduct a site visit with comparable characteristics to a known, problematic condition so the RSA team can visually verify the suspected contributing crash factors. It is preferred that more than one site visit be included in an RSA.

It is helpful for the RSA team to take a prompt list to the field to help them conduct a thorough review. A basic abbreviated prompt list is included on the following page. In addition, this manual contains more detailed prompt lists for project stages and special conditions in Appendix G and H, respectively. FHWA provides very detailed prompt lists for various project phases to help the RSA team identify potential safety issues. These lists can be found at http://safety.fhwa.dot.gov/rsa/guidelines/chapter8.htm. The lists should be viewed as a prompt only and should be used in conjunction with the list of expected contributing crash factors developed by the RSA team.

The following basic Prompt List can help guide the RSA team on items to note during a site visit (Expanded listings of field prompts are provided in Appendix G and H.):

CONSIDERATIONS FOR ROADWAYS AND INTERSECTIONS

- ☐ Pavement and Lane Characteristics
  - Pavement width dimension
  - Pavement material
  - Grade
  - Lane width and pavement markings
  - Median presence
  - Shoulder width and type
  - Right-of-way and presence of utilities
  - Posted speed limit
- ☐ Intersection Characteristics
  - Signalization or stop controlled
  - Traffic signage and pavement markings
  - Left and right turn lane storage
  - Sight distance
  - Lighting
- ☐ Driveway
  - Locations
  - Widths
- ☐ Sidewalks, ADA Ramps, Parking
  - Location
  - Width
- ☐ Railroad Crossing and Operation
  - Active or passive warning devices
  - Pre-emption of nearby traffic signal
- ☐ Drainage
  - Curb and gutter design
  - Storm drains and manholes
  - Box culverts

CONSIDERATIONS FOR BICYCLE AND PEDESTRIAN ACCOMMODATIONS

- ☐ Bicycle lane or wide shoulder
- ☐ Walkable surface (One or Both Sides)
  - Sidewalk
  - Shoulder
  - Steepness
  - Cross slope
- ☐ Buffer Separation or median refuge
- ☐ Driveway conflicts (bicycle or pedestrian)
  - Driveways or parking too close to pedestrian crossing
- ☐ Turning vehicles at intersections
  - Wide curb radii
  - Channelized right turn lanes
  - Skewed intersection

- ☐ Clear direction for walking activities
  - Crossing pavement flush with roadway surface
  - Connectivity for pedestrian network
  - Presence of pedestrian crossing lighting
- ☐ Traffic Signals and Pedestrians
  - Pedestrian heads provided and MUTCD compliant
  - Pedestrian infrastructure at necessary corners
  - Pedestrian crossing timings adequate
  - ADA accessibility to buttons
  - Pedestrians clearly visible by approaching vehicles

When performing the site visit, the RSA team should drive and walk through the site. If the subject site is an intersection the driver should enter the intersection from all approaches and make as many traffic movements as possible, especially the most common movements and the movements most represented in the collision diagram. Walking through the site can provide the RSA team with the pedestrians' perspective and any safety problems that they might encounter. It is helpful to take photographs or record video during the site visit for future reference and for use in report documentation.

After completing the site visit(s), the RSA team should finalize their list of contributing factors related to crashes and should have some initial ideas for possible countermeasures.

5.4.3 Report Photo Guidelines

On the site visit, photos will be taken of various key elements of the study segment or spot location. These photos will include each approach to the site. Also, include photos of any traffic signs, infrastructure, intersecting roadways, or obstructions of sight distance that are pertinent to the location and/or crash site. These photos need to be clear in resolution and accuracy in order to convey the information necessary to understand the characteristics of a location when viewed within report documentation.

Photos should be clearly organized and documented with directional labeling and a photo key as described below. An example of RSA photo documentation within an RSA report is provided in Appendix F.

- Create an Existing Conditions Photo Key figure (Zoomed images will supplement Photo Key).
  - Show a north arrow.
  - Include an aerial photograph of the roadway segment being evaluated. If the study roadway covers a greater distance than can be shown on one page, break it up to show on multiple pages so that the aerial scale is not too small to label and clearly note study area details. This aerial does not have to be at a certain scale, it is for informational purposes only.
  - Label all roadways on the aerial.
  - Number each photo location on the aerial and use an arrow to indicate the direction that the photo was taken.
- Create a photo log with ground level photography that references back to the photo key. A site visit "Prompt List" can also provide direction in choosing photo perspectives needed in documenting field conditions.
- Insert labels for each photo to describe what is shown.

Figure 5-2: Example Photo Locations Key

5.5 Risk Analysis and Countermeasure Identification (Reference HSM Ch. 6)

The purpose of risk assessment is to quantify risk events that were identified in the preceding RSA stages. The purpose of countermeasure identification is to provide the project owner with options to reduce crashes.

There are two aspects of risk assessment: frequency and severity. Frequency determines the likelihood of a risk occurring, while severity judges the impact of the risk should it occur. Risk assessment is not directly referenced in the HSM; however, HSM methods are used to supply the input measures for the risk assessment matrix. HSM predictive models should be used with care and should be adjusted for the observed crashes. Table 5-1 combines the frequency and severity of crashes to form a prioritization matrix.

Table 5-1: Prioritization Matrix

Frequency of Crashes	Enhanced Crash Severity Level			
	Possible/Minor Injury	Moderate Injury	Serious Injury	Fatal
Frequent	Middle-High	High	Highest	Highest
Occasional	Middle	Middle-High	High	Highest
Infrequent	Low	Middle	Middle-High	High
Rare	Lowest	Low	Middle	Middle-High

After performing the risk analysis, a full list of countermeasures should be developed. The RSA team needs to not only address the specific concerns raised by the project owner, but also fulfill the proactive intent of the RSA process by identifying any additional countermeasures. It is important to provide the project owner with a variety of mitigation options ranging from short-term, low-cost projects to long-term, high-cost projects. All recommended countermeasures should be documented regardless of their immediate constraints as they may become feasible in the future.

From a risk management perspective, it is important to provide the project owner a list of countermeasures as it demonstrates consideration was given to several options before determining which are feasible. The variety of countermeasures enables the owner to consider, select, and enact safety mitigations that fit within the project scope and budget.

5.6 RSA Summary Report Development and Post-Assessment Meeting

The RSA team is responsible for the preparation and delivery of a summary report. The RSA team, design team, and project owner are all expected to attend the post-assessment (closeout) meeting. The purpose of the meeting is to establish a basis for writing the RSA report and to ensure that the report will adequately address issues within the scope of the RSA process, providing another opportunity for discussion and clarification. The project owner and design team may ask questions to seek clarification on the RSA findings or suggest additional/alternative mitigation measures. The team's goal should be to obtain consensus for all recommendations prior to preparation of a final report. Publication of a final report will require coordination with project stakeholders and decision makers to facilitate continuation of the effort through implementation.

5.7 Final Report Development

The purpose of the Final Report is to document the work of the RSA team and to give the project owner the final list of countermeasure recommendations. The Final Report format shall be determined by the RSA team leader. The delivery of the report is the responsibility of the team leader as well. The Final

Report may be included in applications for funding (HSIP, HRRR, etc.), but the project must meet all the requirements for the targeted funding category. The Final Report should contain the sections in Table 5-2. Two example RSA reports are provided in Appendix F.

Table 5-2: Suggested RSA Report Format and Content

Report Section	Report Content
Executive Summary	Include a list of identified concerns, a location map with numbering to show where each deficiency is located, and describe the recommended mitigations.
Disclaimer	The Final Report is not a commitment for implementation or for funding of the recommendations. All projects must meet the criteria of a particular funding source to be eligible for those funds.
Introduction and Project Description	This section defines an RSA, describes the process followed for the specific RSA (time, date, location, etc.), and includes a condensed outline of the general RSA process. It also includes the project phase, why the RSA is warranted, and identification of the project owner.
RSA Team	Identify the RSA team members by position (leader, member, observer), fields or specialties they represent (design, safety, operations, etc.) professional titles or licenses, and offices.
Data Reviewed	Identify all documents and data considered during the RSA process.
Site Visit	Describe the site visit(s) and include photographs, date of the visit(s), weather conditions, time, light conditions, observations made, attendees, etc.
Safety Concerns and Risk Analysis	Outline safety concerns and the results of risk analyses. If appropriate, group findings by identified problem and associated crash type.
Proposed Mitigations	Outline mitigation measures for each safety deficiency identified previously. Provide low, intermediate, and high cost options for the project owner to select. For existing facilities, include cost estimates.
Conclusion	Summarize identified risks and recommend mitigations (for each safety concern select the most appropriate of the proposed mitigations).

The Final Report should be provided to the project owner no more than 60 days after the closeout meeting. The cover letter for the transmittal of the Final Report should be similar to the one provided in Appendix B.

5.8 Response Report (Reference HSM Ch. 7 & 8)

When the owner and/or design team have reviewed the Final Report, it is their responsibility to prepare a written response to the findings in the report. The main purpose of the response report is to document the owner's decision for selecting or declining a countermeasure. Preparation of the response report is the project owner's opportunity to apply the methods presented in the HSM's Chapter 7, Economic Appraisal, and Chapter 8, Project Prioritization. The response report should be completed and distributed no more than 60 days after the project owner's receipt of the Final Report.

The response report is important for several reasons. It reduces the chance of tort liability claims against the project owner, which usually occur if the project owner was aware of a safety concern but did nothing in response, and injury or property damage occurred. Documentation of the project's owner response to each suggested countermeasure should defend against claims of tort liability. It encourages the owner to thoroughly review the Final Report and determine which countermeasure is best for the project. The response report also encourages follow-up to the RSA process through implementation.

A letter or a memo is a valid method of responding to the RSA report; it should include the following information:

- Name and title of author.
- Signature and date of response report completion.
- Completion date of the RSA.
- List of each safety concern identified in the RSA and a point-by-point response and justification of the response. The owner should either agree with the suggestion and action to be taken or give reason why no action will be taken. For recommendations beyond the jurisdiction of the owner (e.g., enforcement, education, emergency response), the response report should note what contacts were made and any decisions or reasons discussed.
- Define how multiple mitigation strategies will be coordinated. For example, “The low-cost mitigation for pavement restriping will be implemented while we pursue funding to add a full-depth asphalt lane on the northbound approach to the intersection.”

If there is no action to be taken on one or more of the RSA findings, a response should still be prepared and a reason should be given as to why no mitigation strategies were employed. A lack of funding should never be the primary reason for declining a recommended mitigation. When funding is scarce, the response should describe how funds will be prioritized to address the identified needs. The owner should keep the original response report and send copies to the appropriate parties. A sample response report can be found in Appendix B.

5.9 Implementation

The implementation of the RSA team’s recommendations is the responsibility and decision of the project owner. The main purpose of implementation, and the RSA itself, is to reduce the frequency and severity of crashes.

The project owner’s selection and documentation of countermeasures signal intent to follow through with implementation. If project timelines and funding make it difficult for all mitigations to be completed, they can be deferred to a future funding cycle.

Chapter 6

RSR Process Guide

The RSR process applies the techniques in the HSM and adds a risk assessment procedure. Beyond the limits of the RSR process, consideration must also be given to logistics and preparation before and during the RSR as well as follow-through to implement countermeasures. Figure 6-1 shows an overview of the steps required to conduct an RSR. The sections of this report that address each step are referenced in the flowchart.

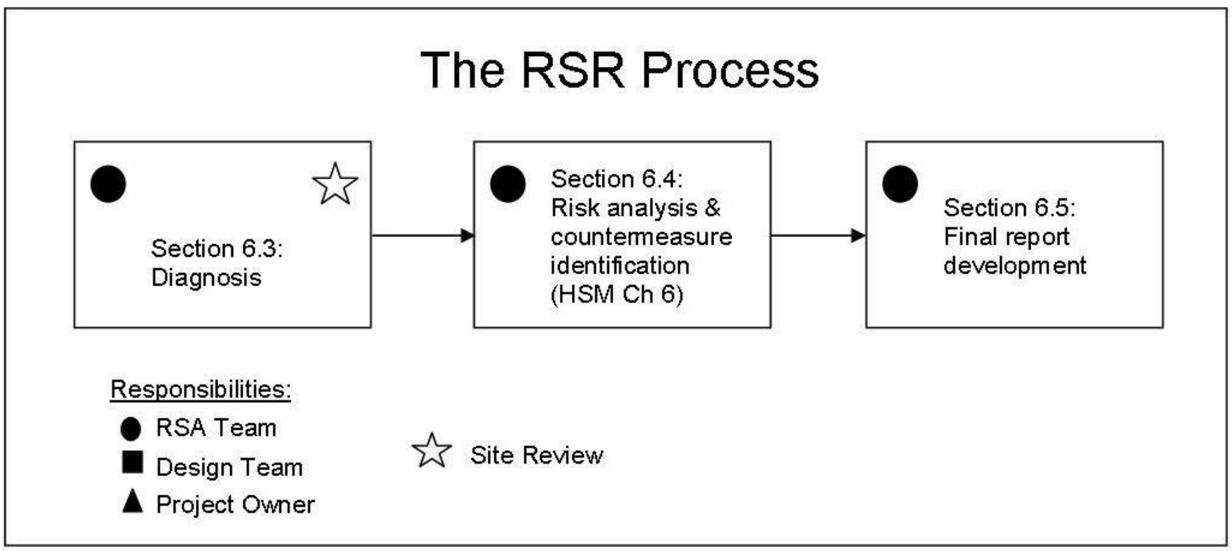

Figure 6-1: RSR Flowchart

6.1 Considerations for Initiating an RSR

Unlike RSAs, RSRs are conducted only on existing transportation networks after a safety need has been identified. They are usually performed at locations with higher levels of severe and/or frequent crashes.

6.2 RSR Steps

The following list outlines the process for completing an RSR:

1. Assemble safety and operational data.
    a. Traffic volumes
    b. Crash data, including crash reports
    c. Other
2. Analyze background data.

3. Conduct a field review (advisable but not required).
4. Analyze safety issues and check compliance with standards/guidelines.
5. Prepare summary report.

The field review for an RSR is usually completed in one day. The safety issues analysis and summary report is expected within 30 days of the field review.

6.3 Diagnosis (Reference HSM Ch. 5)

The purpose of the diagnosis is to determine the factors contributing to crashes and crash patterns. This step is the responsibility of the RSR team but may require assistance from the design team or owner if any questions arise. The diagnosis involves both an office review and a site visit. The site visit is not required for the RSR, but it is recommended.

Refer to section 5.4 for information on the office review. Refer to sections 5.4.1 and 5.4.2 for information regarding crash data and the site visit, respectively.

After completing the site visit(s), the RSR team should finalize their list of contributing factors related to crashes and should have some initial ideas for possible countermeasures.

6.4 Risk Analysis and Countermeasure Identification (Reference HSM Ch. 6)

Refer to Section 5.5 for information on risk analysis and countermeasure identification.

6.5 Final Report Development

The purpose of the final report is to document the work of the RSR team and to give the project owner the final list of countermeasure recommendations. The final report format shall be determined by the RSR team leader and could be a simple memorandum. The delivery of the report is the responsibility of the team leader as well. The final report may be included in applications for funding (HSIP, HRRR, etc.), but the project must meet all the requirements for a funding category. The final report should contain the sections as shown in Table 6-1.

Table 6-1: Suggested RSR Report Format and Content

Report Section	Report Content
Summary	Include a list of identified concerns, a location map, and describe recommended mitigations
Introduction and Project Description	This section defines an RSR, describes the process followed for the specific RSR (time, date, location, etc.), identified the project owner and describes why the RSR is warranted.
RSR Team	Identify the RSR team members. The team will be 2-3 members with experience in the area of design and safety assessment as a minimum.
Data Reviewed	Identify all documents and data considered during the RSR process.
Site Visit	Describe the site visit(s), and include photographs, date of site visit(s), weather conditions, time, light conditions, observations made, participants, etc.
Safety Concerns and Risk Analysis	Outline safety concerns and the results of risk analyses.
Proposed Mitigations	Outline recommended mitigation measures for each safety deficiency identified previously.

The final report should be provided to the project owner no more than two weeks after the closeout meeting. The cover letter for the transmittal of the final report should be similar to the one provided in Appendix B.

6.6 Implementation

Refer to section 5.9 for information on the implementation of the RSR team's recommendations.

Chapter 7

Application of RSAs in Project Development Stages

An RSA can be completed at various stages of project development. RSAs completed in the feasibility and planning stage, detail/final design stage, construction work zone stage, pre-opening stage, or post-opening stage all present the RSA team with different challenges. In general, the RSA process described in Chapter 5 of this manual will apply throughout project development, but in some instances special considerations or an abbreviated process will be necessary. Those deviations and considerations are described herein.

7.1 Feasibility and Planning Stage

7.1.1 Applications for Safety Assessment

The feasibility and planning stage of project development presents an excellent opportunity to address potential safety issues early, before they become significant design or maintenance challenges. RSA procedures can be incorporated easily and inexpensively into planning tasks such as:

- Policy development and application.
- Project selection and definition.
- Project prioritization.
- Feasibility screening for project location and alignments.

The RSA process documented in this section specifically addresses application of safety assessment procedures in project feasibility screening and corridor planning. Planning professionals are encouraged to adapt the procedures to fit the needs of other planning tasks.

7.1.2 Opportunities, Challenges, and Resources

In the planning stage of project development, the widest range of choices remains for a corridor's character (e.g., alignment, geometrics, and other design choices). Decisions affecting existing roads and nearby land uses may be assessed and addressed at this time. Evaluation of safety issues during early project development can include any existing route(s) to be improved or replaced, as well as network or local systemic issues within the area to be affected by the project. The RSA process may recognize safety issues that would involve other stakeholders, such as affected road jurisdictions beyond that of the project owner.

An RSA during early phases of a project will lack detailed information on the proposed work and may need to look at a range of alternatives. Depending on the scope of the project, details of the alignment or corridor might not be decided. Crash data for a new location or significant relocation will not be available, but safety data should be gathered for any existing routes located within the project's area of influence. Existing safety concerns may be reflected in systemic analysis or may be revealed through network screening of existing routes to be replaced or affected by the project.

Detailed alignment, geometric designs, and engineering studies will not be available for RSA review in the planning stage. For safety analysis, some assumptions and/or generic values may need to be incorporated into predictive methods. Key documents likely to be available include street mapping, aerial photography, topographic maps, zoning, highway inventories, and existing statistical maps (e.g., network screening of traffic volumes, population concentrations, crashes).

7.1.3 Process Steps

The tasks to be accomplished in a planning-stage safety assessment are consistent with the process outlined in Chapter 5. The following considerations are particularly applicable to a planning stage RSA.

Prior to the Start-up Meeting: The RSA team leader should work with the project owner to retrieve any applicable existing mapping, aerial photography, traffic information, engineering studies, correspondence, and news articles.

The leader should review and assess all background information and share a summary with the full RSA team prior to the start-up meeting, giving the RSA a head start. The team should review the available safety performance network screening, mapping of crashes, and tabulation of crashes. If crash reports are available, the reports associated with severe crashes or crash patterns should be reviewed.

The team should analyze all route(s) to be affected by the project. Such effects may be along an existing route to be upgraded or replaced, but the analysis should also include nearby roads that are likely to see changes in traffic demand or functional classification. Questions that should be answered include:

- What crash patterns appear?
- What crash patterns might result from the changes in and near the corridor?
- Does it appear that other road jurisdictions would be affected and should these be considered?

The team leader should document these observations in list form to share with the RSA team prior to the start-up.

Start-up Meeting: Before proceeding with a diagnosis, the outcome of the preliminary office review among the RSA team should be presented to the project owner and applicable stakeholders in a start-up meeting. There may be a need to update and revise the office review based on input from the full team and from information provided at the start-up meeting. Questions that should be discussed during the start-up meeting include:

- What safety issues are or should be part of the purpose and need for the project?
- What safety issues, identified in the office review, exist but would not be addressed by the project?
- What safety issues are anticipated to be introduced as a result of the project?

An RSA team should pay particular attention to the owner's statements about the needs for the project and any noted constraints upon the location and design. Also, address the following items for land use implications:

- What changes in development or land use are expected?

- Are there any particular development plans being coordinated with the project?

Diagnosis: Before proceeding with the diagnosis, the team should review information gathered in the office review and start-up meeting.

To facilitate and direct discussions, a prepared list of potential safety issues to review in the field should be developed. Use of Chapter 6 of the HSM will aid in linking crash patterns observed in association with the project to specific contributing factors.

Field Review: During the field review, the RSA team should examine the existing and proposed corridor plus any adjoining roads, development, and communities to see how these would affect or be affected by the project. Additionally, the team should investigate any stated or assumed constraints on the project. Finally, the team should review each item on the list from the office review and confirm or modify each according to field observations and add any newly observed safety issues. All field observations should be documented by photos, videos, and measurements. Items to review in the field for a planning-stage project may include, but are not limited to:

- Roadside characteristics and geometric features.
- Intersection locations and spacing.
- Horizontal and vertical curvature.
- Sight distance restrictions.
- Topography and drainage.
- Vehicle types and modes of travel currently in use.
- Traffic control.

Risk Assessment and Countermeasure Selection: In the planning stage, risk assessment predicts likely outcomes with less precise data inputs than at later project development stages. It is important for the RSA team to understand the limitations inherent to the planning stage and work within those limitations. The goals are to assess likely risks associated with the range of design options that will follow in the next stage and to provide adequate assessment and information to guide sound planning choices.

Risk assessment may need to use different crash frequency scales for different locations. For example, a reconstruction of a two-lane highway to a multilane highway may have a higher expected crash frequency for a given risk, compared to a nearby side road intersection that would have some increased crash risk due to an anticipated development. Identifying increased risk alone is not sufficient; increases should be quantified, contextualized, and evaluated in comparison to a full range of choices. Similarly, estimates of crash risk reduction should be quantified, compared, and considered for cost and benefit.

As the RSA team develops countermeasures for identified safety concerns it will be important for the team to consider potential constraints to implementation. A wide range of ideas will be needed to address issues related to the constraints. For example, a team might identify median separation as a safety countermeasure and will thus need to consider whether sufficient right-of-way can feasibly be obtained to contain a median-separated roadway cross section. How would that median separation affect adjoining roads, adjacent properties, and the overall street network? Consideration of these constraints in the planning stage provides an opportunity to develop workable solutions before other later project decisions narrow the field of choices.

Applying procedures within the HSM is a useful approach to assess anticipated changes in crashes or severity associated with projects. The HSM provides crash modification factors which quantify changes to crash frequency and severity associated with specific infrastructure or traffic operational changes. Additionally, the HSM allows for comparison between differing concepts and improvement elements under consideration for a corridor or an intersection. This is particularly important in the planning phase of a project as two or more alternatives under consideration may be generally equal in other facets typically used for alternative selection. Project elements such as median type, number of travel lanes or number of allowable driveways can be assessed with the aid of the HSM.

7.1.4 Special Considerations

It is very important that an RSA conducted in the planning stage becomes part of the project record so that data, analysis, considerations, and recommendations are passed along through subsequent project development stages. Since project development is a fluid process whereby factors that affect decision making change over time, it is critically important that the RSA team clearly document the data, observations, and assumptions that were used in the evaluation based on what was known at that time.

If an environmental document is required for the proposed project, the RSA documentation may be included as an appendix or referenced. This would be particularly important if safety is an element of the project purpose and need. Coordination with ALDOT's Environmental Technical Section is advisable under these circumstances.

Early in the planning stage, the RSA may raise questions or challenge the anticipated project as it is initially defined. It is important to remind stakeholders that the team's efforts are intended to advance the safety of the project and must address all issues to fully assess and offer ideas to mitigate safety concerns. The owner is the decision maker, and with the RSA report, can consider the safety assessment along with other factors. The RSA process informs and supports proactive decision-making to improve project planning and design.

7.1.5 Documentation and Closeout

An RSA in the planning stage should be documented in a report format similar to that outlined in Chapter 5 of this report. The RSA report should be submitted to the project owner for review and response.

7.2 Preliminary Design Stage

7.2.1 Applications for Safety Assessment

The preliminary design stage also presents an early opportunity to identify and address potential safety issues before major design or construction costs are incurred. At the start of preliminary design, general details of alignment are typically set unless more than one alternative is under consideration, in which case each alternative would need to be evaluated. The preliminary design stage focuses on refining vertical and horizontal alignments, pavement design, typical sections, and intersection conceptual layouts. Preliminary plans should be developed to a sufficient level of detail to determine the needed right-of-way and typically represent a 30-40% stage of final design.

In this stage, an RSA team checks a set of preliminary design plans for elements that are likely to have a negative safety impact and identifies mitigation measures, if appropriate. Items most likely to be checked in a preliminary design-stage RSA include but are not limited to:

- Horizontal and vertical curvature.
- Typical section.

- Intersection layout (i.e. type, laneage, traffic control measure, channelization).
- Intersection spacing, including access driveways.
- Sight distance.
- Clear zone and roadside hazards.
- Bicycle, pedestrian, and/or transit accommodations.
- Heavy vehicle considerations.
- Lighting needs.

The RSA process at this preliminary design stage anticipates the impact to operational safety from each basic design element. The above items should be reviewed with respect to driver expectation and human factors under operational conditions.

7.2.2 Opportunities, Challenges, and Resources

Conducting an RSA in the preliminary design stage presents an opportunity to:

- Avoid the risk of redesign in the detailed design stage.
- Keep substantive safety from being compromised where multiple minimum design standards interact within the design.
- Evaluate from a safety perspective how the basic design will fit within the roadside context.
- Identify how project staging might impact safety.
- Evaluate whether the needs of all road users are being safely accommodated.
- Identify if design exceptions are likely to be needed and what their potential safety impact will be.

Since the plans in this stage are more conceptual than detailed, the RSA team may be faced with considering the implications of a range of design options. Team members will need to be creative in thinking through the various potential safety performance outcomes. As an example of how this stage may be challenging from an RSA perspective, consider a three-lane (2 travel lanes and a center turn lane) typical section with six-foot (6') paved shoulders. While the typical section may, on the surface, seem perfectly acceptable, the RSA team might consider these questions to fully assess potential safety performance:

- Are bicyclists likely to use the shoulders? What design aspects are important to assure a safe bicycle accommodation?
- What is the spacing of driveways along the road? Is access management an issue? Would a raised median be preferable to a center turn lane in order to help control turn movements to and from driveways?
- Is the paved shoulder likely to be used as a de facto right turn lane? Might the 6-foot width present a safety concern?
- Would the wide outside shoulder tend to increase travel speeds of motor vehicles? Would higher travel speeds be appropriate for the roadway's context and users?

The RSA team in preliminary design will benefit from guidance provided by AASHTO, FHWA and ITE design guidelines as well as the Highway Safety Manual. The important task is to look not only at adherence to nominal safety standards but to think about how the designed facility will operate in its unique setting.

7.2.3 Process Steps

The tasks to be accomplished in a design stage safety assessment are consistent with the process outlined in Chapter 5. The following considerations are particularly applicable to a preliminary design-stage RSA.

Prior to the Start-up Meeting: The team leader should work with the project owner to retrieve all background information from the planning stage of the project, any mapping or data that influenced the design (e.g., flood maps for drainage considerations, projected traffic volumes), a complete set of the preliminary design plans, and current crash data. The leader should start the office portion of the HSM-based diagnosis, and it should be shared with the full RSA team prior to the start-up meeting. The diagnosis provides an opportunity to apply an agency's safety screening methods to a site and also to apply the predictive methods of the HSM based on proposed work as indicated in preliminary design plans.

Questions appropriate to this point in a design-stage RSA include, but are not limited to:

- What crash patterns are typically consistent with this type of facility and what contributing factors should the team look to find?
- Does it appear that other road jurisdictions would be affected and have these been considered?
- What traffic operational conditions are anticipated from the traffic projections?
- Are the proposed design criteria consistent with the desired traffic flow characteristics?
- Are all road users accommodated by the preliminary design?

The team leader should document all observations in list form to share with the RSA team prior to the start-up.

Start-up Meeting: During the start-up meeting, the RSA team should carefully review all the gathered data to form a complete understanding of the project goals, the roadway's travel characteristics and anticipated users. The team may find it helpful to use a "what if" approach to exploring potential safety issues.

Diagnosis: To facilitate the preliminary design-stage diagnosis, a prepared list of potential safety issues to review in the field should be developed. Use of Chapter 6 of the HSM will aid in linking crash patterns observed in association with specific contributing factors.

Field Review: For the field review of a preliminary design plan, the RSA team should invite a representative from the pre-construction section of the ALDOT Region office. This individual is a resource for the RSA team, but the team must function in an independent, unbiased capacity. The team should review each item on the list from the office review and confirm or modify each according to field observations and add any newly observed safety issues. All field observations should be documented by photos, videos, and measurements.

Questions to consider in the field for a preliminary design-stage project may include, but are not limited to:

- Are there any sight distance restrictions that need to be corrected as part of the design?
- How are access points distributed through the project and what is their existing or potential impact to traffic operations?
- Will adjacent roadside development affect the proposed project? How should the design manage those impacts?

- Are the design criteria, typical section, and vertical/horizontal alignment appropriate for the anticipated mix, speed, and volume of traffic?
- How are roadside shoulders likely to be used and is their design appropriate for that use?
- Is intersection geometry appropriate for the volume and mix traffic? What traffic control measure is most appropriate for safe and efficient operation?
- Are there any roadside or environmental features that might contribute to driver confusion? Can the design be adjusted to remediate these concerns?
- Are all road users appropriately accommodated by the design?

Additional thought prompts are included in the Prompt Lists for Project Stages in Appendix G.

Risk Assessment and Countermeasure Selection: Risk assessment in preliminary design is somewhat more straightforward than in the planning stage because specific design values have been identified for the basic elements of the project. Some of the more detailed aspects of design will not be developed until the final design stage, but that should not hinder an RSA team from assessing the core design elements of this project stage.

The procedures within the HSM provide a useful tool to assess anticipated changes in crash or severity associated with projects in terms of design elements. The HSM provides crash modification factors which quantify changes to crash frequency and severity associated with a variety of design elements.

Design restrictions based on environmental issues or useable right-of-way may require a designer to consider design exceptions from established design standards. Assessing the design exception using the HSM is a tool to quantify its impact in terms of crash frequency or severity. The project documentation will benefit from a narrative of the HSM-based assessment to explain the implications of the design exception.

7.2.4 Special Considerations

While representatives from the project design team are resources for information, the RSA team is expected to function independently from the design team in order to produce an unbiased safety evaluation.

7.2.5 Documentation and Closeout

An RSA in the preliminary design stage should be documented in a report format similar to that outlined in Chapter 5 of this guide. The report should be submitted to the project owner for review and response and should be kept as part of the project records.

At the preliminary design phase, an RSA may highlight items that need to be modified before proceeding to final design. Making modifications at this stage of project development is one of the most cost effective opportunities to improve safety. The owner is the decision maker, and an RSA provides an unbiased assessment of safety impacts of the proposed design for the owner's consideration.

7.3 Detail/Final Design Stage

7.3.1 Applications for Safety Assessment

In the detailed road design stage, before right-of-way acquisition begins, a final opportunity exists for a thorough pre-construction safety assessment. Many of the elements considered in the feasibility and planning stage are already determined and incorporated before proceeding further in detailed design. In this stage, an RSA team checks a set of design plans for elements that are likely to have a negative safety impact and identifies mitigation measures, if appropriate. Items most likely to be checked in a design-stage RSA include but are not limited to:

- Horizontal and vertical curvature.
- Superelevation and cross-slope.
- Shoulder treatments.
- Intersection alignment and turning conflicts.
- Intersection spacing and radii.
- Drainage and potential for hydroplaning.
- Sight distance.
- Signing, striping, and signalization.
- Lighting.
- Clear zone and roadside hazards.
- Bicycle, pedestrian, and/or transit accommodations.
- Heavy vehicle considerations.
- Traffic control during construction.

The RSA process at this detailed design stage examines the interaction between the geometric design and operational characteristics. All of the above items should be reviewed with respect to driver expectation and human factors under operational conditions. Attention to the details of geometrics and operations can alleviate changes later that may otherwise be discovered in the pre-opening stage or when missed safety details become obvious at the post-opening stage. As with the planning stage, conducting an RSA in the design stage provides a very cost-effective way to improve safety performance prior to construction or opening.

7.3.2 Opportunities, Challenges, and Resources

It is important to complete an RSA at the detailed design stage as safety considerations may not have occurred at previous stages or they may have been missed within a previous stage's safety assessment. Also, design values from previous stages would be well defined at the detailed design phase and may be different from what was previously assumed. These will need to be evaluated more intently to assess their safety impact. This stage offers the final opportunity to change the design before construction begins and can minimize construction change orders and/or changes after project opening. The detailed design stage safety assessment can verify adherence to standards and consider the impact to safety from design exceptions when applied.

Design consistency with the latest version of the MUTCD will be most obvious at the detailed design phase. The need for additional traffic control devices or the removal of traffic control devices should be considered in the detailed design stage. Where there are multiple driveways and/or multiple signalized intersections on a relatively straight corridor, conflicting traffic control devices within a driver's field of view can be problematic and may not be obvious until examining the overall operation of the corridor, rather than just the individual intersections.

7.3.3 Process Steps

The tasks to be accomplished in a design stage safety assessment are consistent with the process outlined in Chapter 5. The following considerations are particularly applicable to a design-stage RSA.

Prior to the Start-up Meeting: The team leader should work with the project owner to retrieve all background information from the planning stage of the project, any mapping or data that influenced the design (e.g., flood maps for drainage considerations, projected traffic volumes), a complete set of the design plans, and current crash data. The leader should start the office portion of the HSM-based diagnosis, and it should be shared with the full RSA team prior to the start-up meeting. The diagnosis provides an opportunity to apply an agency's safety screening methods to a site and also to apply the predictive methods of the HSM based on proposed work as indicated in design plans.

Questions appropriate to this point in a design-stage RSA include, but are not limited to:

- What crash patterns are typically consistent with this type of design, and what contributing factors should the team look to find?
- Does it appear that other road jurisdictions would be affected and have these been considered?
- Is there a potential for drainage issues? Is the proposed highway action consistent with the existing watershed and floodplain management programs?
- Are there bridge structures within the project limits, and have these been coordinated with the Bridge Bureau?
- What traffic operational conditions are anticipated from the traffic projections?

The team leader should document all observations in list form to share with the RSA team prior to the start-up.

Start-up Meeting: During the start-up meeting, the RSA team should gather a complete understanding of any design exceptions that are being requested as part of the project design as well as the reasons why the exceptions were requested.

Diagnosis: To facilitate the design-stage diagnosis, a prepared list of potential safety issues to be reviewed within the plans and in the field should be developed and shared among the RSA team. Use of Chapter 6 of the HSM will aid in linking crash patterns observed in association with specific contributing factors. The HSM predictive method and/or CMFs from the CMF Clearinghouse may be applied to address both observed crash issues, but also crash issues that might be introduced by the proposed design.

Field Review: For the field review of a detailed design plan, the RSA team should invite a representative from the Design Section, the responsible design engineer and representatives from the Region, the Design Bureau Environmental Technical Section, the Location Section, the Bureau of Materials and Tests, and the FHWA, if required. These individuals are resources for the RSA team, but the team must function in an independent, unbiased capacity. The field review should be performed in varying weather conditions. For instance, if a roadway has drainage issues that might cause hydroplaning, the RSA team may not notice the issue on a sunny day.

In addition to the items listed in the RSA prompts for this project phase, a listing of items to assess upon reviewing the plans and in the field review include, but are not limited to:

- Encroachments within the clear zone – Consider the severity of a potential crash with any encroachments as well as the cost of removing natural obstacles. The cost of removing rock outcroppings and rows of trees can escalate quickly if there are large amounts within the clear zone. In cases where the project budget will not bear such

cost, other favorable alternatives should be considered such as include installing roadside barriers, improving positive guidance with rumble strips, or traffic warning signs.
- Non crash-compliant mailboxes – Are these present within the project limits and have the design plans addressed their replacement?
- Median and/or shoulder protection – Is guardrail needed and what design specifications are appropriate?
- Pavement conditions and sub-base – Are there any asphalt failures that should be addressed within the project design? If so, what type? If an existing facility, what is the skid number threshold for the roadway?
- Gores and drainage structures – The Initial Hydraulic Investigation should already be performed and the HYD 100 and HYD 101 forms should be filled out. Review existing drainage structures and verify the accuracy of the topographic maps and/or the existing surface models.

Each item on the list from the office review should be confirmed or modified according to the design plans and field observations. This is also an opportunity to add any newly observed safety issues. Document the field observations by photos, videos, measurements, timing, or as needed. Summary documentation of items noted within the design plans should also be recorded.

<u>Risk Assessment and Countermeasure Selection</u>: Risk assessment is more straightforward in the design stage than in the planning stage because specific design values are known, whereas in the planning stage design values may have to be assumed. The interaction of the project's design elements with driver expectancy and the dynamics of traffic operations under varied environmental conditions must be predicted. For a new roadway, the RSA team members will not have the benefit of observations to inform their assessment, so an understanding of contributing risk factors is necessary.

Countermeasures should be considered in light of implementation constraints, cost benefit, and impact to other aspects of the design. The following is a sequential example of how a potential countermeasure might be vetted:

1. Obstacles in the clear zone are identified as a potential hazard. The RSA team lists potential countermeasures.
2. A retaining wall, cable barrier, or barrier rail is listed as a countermeasure. Is one of those a potential option at the location?
3. If a feasible option, would addition of one of these shielding apparatuses create a greater hazard than the obstacle itself? Is the shoulder or median area sufficient to accommodate installation? Would revisions to cross-sections or right-of-way limits have to be adjusted to accommodate the barrier? What is the impact to the project cost and can it be accommodated? What is the expected safety performance compared to making no change and compared to other countermeasures?
4. The RSA team examines the direct and indirect effects of each potential countermeasure.

Again, the procedures within the HSM provide a useful tool to assess anticipated changes in crash or severity associated with projects in terms of design details and elements. The HSM provides crash modification factors which quantify changes to crash frequency and severity associated with detailed design elements. A specific design parameter, design exception, or other newly available design details, previously unavailable until the detailed design stage, can be thoroughly considered for final inclusion within the design project.

Design restrictions based on environmental issues or useable right-of-way may require a designer to consider design exceptions from established design standards. Assessing the design exception using the HSM is a tool to quantify its impact in terms of crash frequency or severity. The project documentation will benefit from a narrative of the HSM-based assessment to explain the implications of the design exception.

7.3.4 Special Considerations

While representatives from the project design team are resources for information, the RSA team is expected to function independently from the design team in order to produce an unbiased safety evaluation.

7.3.5 Documentation and Closeout

An RSA in the design stage should be documented in a report format similar to that outlined in Chapter 5 of this guide. The report should be submitted to the project owner for review and response and should be kept as part of the project records.

At the detailed design phase, an RSA may slow progression of the project to construction if safety concerns are identified. It is critical that the RSA comprehensively review safety and address all issues to mitigate existing or potential safety issues associated with the project. The owner is the decision maker, and an RSA provides a tool for considering safety enhancements along with other factors.

7.4 Construction Work Zone Stage

7.4.1 Applications for Safety Assessment

In the construction phase of a roadway project, a thorough safety assessment considers the characteristics of active work zones. The RSA team will evaluate the traffic control plan and its implementation in the construction work zone. Particular attention will need to be given to signing, pavement condition, and safety devices for channelizing traffic as these are keys to maintaining safety in the work zone for motorists. Additionally, the safety of contractor personnel within the work zone is critical as is the movement of construction vehicles navigating the work zone. The RSA team should seek to minimize interaction between construction vehicles and traveling motorists where possible.

7.4.2 Opportunities, Challenges, and Resources

An RSA in this project stage is a time-sensitive matter. In order to provide timely recommendations, the RSA team will need to utilize an abbreviated RSA process and be prepared to quickly document any safety recommendations.

A construction work zone is a dynamic environment in which traffic control may be altered to suit the needs of various construction activities. If the traffic control plan is altered significantly, the RSA team may need to review the new configuration. Furthermore, the RSA team needs to focus on evaluating motorists' ability to traverse the work zone through varied weather and lighting conditions as characteristics of the travel path or operation may differ based on environmental conditions.

Additional assistance for RSA teams conducting construction stage evaluations can be found in the American Traffic Safety Services Association (ATSSA) publication Work Zone Road Safety

Audit Guidelines and Prompt Lists. The publication can be found online at www.workzonesafety.org.

7.4.4 Process Steps

The time-sensitive nature of a construction stage RSA demands a more abbreviated process than is described in Chapter 5 of this Guide. The following is a list of steps that are appropriate to delivering a timely but thorough construction stage RSA:

1. Identify a site to be assessed.
2. Select RSA team members with work zone and traffic control experience.
3. Assemble plans and data.
    a. Design plans with traffic control plan
    b. Crash data, including crash reports, for any crashes in or near the work zone
    c. Contractor's incident reports and Daily Traffic Control Reports
4. Schedule and conduct a pre-assessment meeting to review project information and drawings.
5. Schedule and conduct field review and determine recommendations.
6. Prepare documentation.
7. Submit documentation to project owner.
8. Owner determines disposition of recommendations.
9. Owner documents response, incorporates findings into the project, and evaluates results.

Prior to the Start-up Meeting: The RSA Team Leader should work with the project owner to retrieve the latest design plans with the work zone traffic control plan. The team should also collect all prior documentation of safety issues within the work zone, including crash reports if available. These will help the team understand the crash characteristics or crash trends and how they correspond to the work zone traffic control layout. The collected information should be compiled and summarized for the RSA Team prior to the start-up meeting.

Start-up Meeting and Diagnosis: During the start-up meeting, particular attention should be paid to the owner's statements about construction sequencing and schedule as well as constraints upon the location, design, or construction activities. The RSA team leader should share and get feedback on an overview of the preliminary office review of traffic operational issues and crash occurrence within the construction zone.

Risk Assessment and Countermeasure Selection: The following paragraphs contain some suggestions to help an RSA team understand the broad range of items that will need attention. The list is not comprehensive but should be used as a prompt.

Signing and Markings: As part of the RSA, the team should examine the traffic control plan to determine if it is consistent with the latest edition of the MUTCD. Proper signage and markings provide the driver with the information needed to safely travel through the work zone. The intent of the signage and markings should be clear to the driver. The following questions should be addressed regarding traffic control information in the vicinity of the work zone:

- Are all the signs accurate? (e.g., "RIGHT LANE CLOSED").
- Are the signs posted at the proper height?
- Are signs posted at the proper location? Many times it is difficult to place the signs exactly where they need to go due to obstructions in the field, so the signs should be placed as close as possible to the appropriate location. Carefully

review any potential line of sight constraints and recommend appropriate adjustments.

- Is there an excessive amount of signage or is there too little?
- Are signs clearly visible in all lighting and weather conditions? Work zone signs are typically reused and can become dirty and hard to read after several uses. Signs should also be checked during night hours to ensure proper retroreflectivity.
- If there is an adjacent project, does the signage for the two projects overlap? Signage for adjacent projects should not overlap.
- If dynamic message signs are used, are they easy to read for a driver traveling at the posted speed limit?

Flaggers: Flaggers are responsible for public safety and, of all highway workers, make the greatest number of contacts with the public. The flaggers should be highly visible and should be trained in safe traffic control practices. Drivers should be given advance notice of a lane closure before they arrive at the flagger's position. The flagger should be wearing high-visibility safety apparel that meets the requirements of the MUTCD.

Pavement Conditions and Travel Way: Existing or changed pavement conditions, uneven pavement, steel plates, lane shifts, and grooved pavement can all contribute to a work zone crash. Signage should warn drivers, especially motorcyclists, about any problems in advance. Unclear lane shifting can confuse drivers and cause side-swipe crashes. Poor drainage in work zones could lead to work zone crashes (e.g., ponding that might cause hydroplaning).

Barriers: There are several options that can provide protection to the workers and enhance worker and motorist safety. Rigid traffic barriers, such as jersey barriers, and truck-mounted attenuators provide the workers with a high level of protection. Barrels and cones are usually used in a work zone to guide vehicles but provide no rigid protection for the workers. At the site, the RSA team should discuss which protection devices are most appropriate and if rigid protection is needed instead of barrels or cones. The RSA team should also note whether the protective devices would present any adverse impacts to traveling motorists. A common occurrence is barriers that are placed on top of lane striping so they overlap into the adjacent lane of travel and cause drivers to drift into the adjacent lane to create separation between their vehicle and the barriers.

Addressing Pedestrians: At locations with pedestrian facilities, the RSA team needs to examine how pedestrian traffic is being routed through the project. Construction fencing and caution tape are both common options to guide pedestrians through the construction zone. Key questions to address regarding pedestrian provisions in work zones include:

- Is way-finding clear to the pedestrian or is additional signage needed?
- Have ADA accessibility issues been addressed?
- Were any ADA facilities removed during construction?

During the site visit, the RSA team should speak with the contractor, if possible. The contractor may be very knowledgeable about how traffic operates around the work zone and if there are any areas with safety concerns. The team should also examine the daily Traffic Control Reports.

Some low-cost countermeasures for the work zone include rigid protection devices and law enforcement. Rigid protection devices and temporary impact attenuators are effective options to prevent vehicles from entering the work zone or a closed section of the roadway. Law enforcement positioned at the beginning of a work zone may be effective in drawing the driver's attention to the reduced speed limits and may reduce the chances of a distracted driving crash. Flaggers or temporary traffic signals can be used to control alternating two-way traffic on a one-lane road.

Higher cost countermeasures for the work zone include several Intelligent Transportation Systems (ITS) options. ITS can be used to relay information to drivers regarding congestion, delays, and alternate routes. Variable speed limits may also be used to reduce the speed of road users upstream of an active work zone to be consistent with the speed limit at the construction site.

7.4.5 Special Considerations

There is a conceptual difference between a work zone RSA and Work Zone Inspections. Typically, inspections examine compliance with basic standards of the MUTCD and State-specific policies as well as conformance to the design plans. These activities are consistent with a concern for nominal safety. A work zone RSA, however, is concerned with substantive safety and looks at crash frequency, type, and severity with a goal of improving safety performance.

7.4.6 Documentation and Closeout

RSA documentation in the construction work zone stage will be briefer than in other stages in order to facilitate timely completion. A memorandum format is preferred, and the content should include the following items:

- Identification of RSA team members
- List of documentation reviewed for the RSA
- Summary of crash history
- List of participants in the field review and date of review
- Recommendations

The project owner is responsible for determining disposition of the RSA team's recommendations. The owner's response must be documented and included as part of the project records.

7.5 Pre-Opening Stage

7.5.1 Applications for Safety Assessment

An RSA at pre-opening involves a visual observation of a newly constructed design prior to opening. The RSA team provides a fresh perspective to a constructed project in order to identify potential safety issues for mitigation before final construction acceptance by the owner. The RSA team will review all aspects of the new facility which may include a road segment, intersection approaches, and side street or driveway connections. The assessment may include performing a critical review by driving the project at the design speed and/or doing a walkthrough of the improvements to get a road user's perspective for each of the various transportation modes that will use a facility.

A pre-opening assessment should consider how the constructed project conforms to the design and how it will function and be perceived by traveling motorists. Conflicting messages in the design and/or operation of the facility as perceived by the road user may be most obvious when driving or walking the completed corridor. Often, slight modifications to the designed improvement or signage may communicate a clearer message to motorists, preventing safety from being compromised. A nighttime assessment will help the RSA team identify if adjustments are needed to help motorists perceive signing, pavement markings and roadway conditions to choose the proper travel path on a facility.

The following list of items should be carefully considered by the RSA team in the pre-opening stage. The list is not comprehensive but is provided to prompt RSA team members' thought processes.

- Are there conflicts between vehicle turning paths?
- Is adequate sight distance provided at all intersections and along the roadway?
- Will all traffic control devices be clearly understood by drivers and pedestrians?
- Are lane alignments, roadway cross-section, and traffic control consistent throughout the project and do they meet driver expectations?
- Are all bicycle and pedestrian accommodations clearly visible to drivers? Do they provide appropriate separation from vehicles at conflict points?
- Are there any environmental factors that negatively affect drivers such as sun glare?

7.5.2 Opportunities, Challenges, and Resources

In the pre-opening stage, there is a more limited opportunity to address safety issues as compared to assessments conducted at earlier stages. However, details that may have been missed in a detailed design stage assessment may still be caught in this stage and applied just prior to opening. Design items that are presented in two dimensions on design plans can be better assessed in a pre-opening stage drive or walkthrough. Vertical or horizontal curvature and sight distance are examples that can be difficult to fully assess in design, but when constructed may reveal issues that were not anticipated and may need remediation. As with the construction work zone stage RSA, a pre-opening stage RSA is time-sensitive and will work best with an abbreviated process.

7.5.3 Process Steps

The process for evaluating a project at the pre-opening stage should be similar to that conducted at the design and post-opening stages but with attention to timely completion. An abbreviated RSA process for pre-opening stage projects would include the following steps:

1. Identify a site to be assessed.
2. Select RSA team members.
3. Assemble plans and data.
   a. Design plans (primarily signing and striping plans)
   b. Crash data if applicable
   c. Traffic volumes (existing or projected)
4. Schedule and conduct a pre-audit meeting to review project information and drawings.
5. Schedule and conduct field review and determine recommendations.
6. Prepare documentation.
7. Submit documentation to project owner.
8. Owner determines disposition of recommendations.
9. Owner documents response, incorporates findings into the project, and evaluates results.

7.5.4 Special Considerations

An RSA in the pre-opening stage will likely need to be conducted in a short period of time between substantial completion of construction and project close-out. The project may be open to traffic when the audit is conducted. The RSA team will need to adjust its approach to the specific circumstances of the project.

7.5.5 Documentation and Closeout

RSA documentation in the pre-opening stage will be briefer than in other stages in order to facilitate timely completion. A memorandum format is preferred, and the content should include the following items:

- Identification of RSA team members
- List of documentation reviewed for the RSA
- Summary of crash history if applicable
- List of participants in the field review and date of review
- Recommendations

The project owner is responsible for determining disposition of the RSA team's recommendations. The owner's response must be documented and included as part of the project records.

7.6 Post-Opening Stage

Post-opening (or existing conditions) is the stage where RSAs are most frequently applied. The process steps described in Chapters 5 (for RSAs) and 6 (for RSRs) are directly applicable to post-opening conditions. Guidance for applying the HSM procedures in an RSA that is in the post-opening stage is included in Chapter 9.

Chapter 8

RSAs with Special Cases

Occasionally, RSAs will have to be performed outside of the steps outlined in Chapter 5. Example cases include performing an RSA without crash data, performing an RSA in conjunction with value engineering processes, and incorporating an RSA in resurfacing projects.

8.1 RSAs without Crash Data

Crash data can give the RSA team information on the crash locations, severity, and crash contributing factors such as driver behavior, roadway design, or inadequate lighting. Occasionally, an RSA will have to be performed without crash data. Crash data can be found for most project sites. However, at rural locations or locations with new roadways or new intersections, there may be no crash data. Without crash data, the RSA team will have to rely on their expertise and observations to identify any safety issues. This can actually be a benefit, as the RSA team will go into the site visit with no bias on the contributing crash factors. Being able to identify potential contributing crash factors can help prevent future crashes.

8.1.1 Team Members

An important part of performing a road safety assessment without the information from crash data is selecting the appropriate RSA team. In addition to engineers and designers, the RSA team at a location with no crash data should include professionals who travel the road frequently and are aware of any safety issues. Maintenance workers and public works employees will know of locations with repeated maintenance requests, such as broken guardrails and damaged signs. Law enforcement officers and public transportation drivers might know of unreported crashes, near misses, and driver behavior problems at the location.

8.1.2 Site Visit

As with other RSAs, the team should drive through the road or intersection from all approaches several times. This will give the team information on possible danger areas. In addition to the items looked for at a usual site visit, the RSA team should look for any indications of previous crashes. Indications could include damaged guardrail, skid marks, or damaged poles. When crash data is not available, road and roadside data become even more useful. As with standard RSAs, attention should be paid to roadside barriers, speed limits, lane and shoulder widths, clear zone widths, road surface condition, pavement markings, warning signs, median barriers, delineation, lighting, and sight distance.

Even without the crash data, the RSA team can identify potential contributing crash factors. The site visit and discussions with professionals that often travel the road network should give the RSA team a reasonable understanding of the safety conditions and the issues contributing to any safety risks. If the crash data were not available because of a lack of record-keeping, the

RSA team should coordinate data improvement efforts with ALDOT. After the site visit has been performed, the RSA team should proceed with the steps listed in Chapter 5.

8.2 Value Engineering Studies

Value engineering is defined as the systematic application of recognized techniques by a multidisciplinary team to identify the function of a product or service, establish a worth for that function, generate alternatives through the use of creative thinking, and provide the needed functions to accomplish the original purpose of the project at the lowest life-cycle cost without sacrificing safety, necessary quality, and environmental attributes of the project (FHWA).

To ensure that the design is delivering the best value to the customers, an RSA can be effectively integrated with value engineering practices at three different stages: as part of the value engineering process, after the value engineering process, or concurrently with the value engineering process. When an RSA is performed as part of the value engineering process, the road safety members of the RSA team will be able to identify any safety issues with the value engineering recommendations and give their input on the value engineering proposals. When an RSA and the value engineering process are performed concurrently with two different teams, the project owner will have two different reports to review and will be able to make an informed decision on potential recommendations. The advantage of performing the RSA after the value engineering process is that the RSA team will gain a full understanding of the potential safety impacts that the changes recommended through the value engineering process will have on the project location.

8.3 Resurfacing Projects

Incorporating safety improvements as part of resurfacing projects provides a way to continually improve safety with limited funding. Resurfacing projects or roadway restoration projects are ideal opportunities to advance a DOT's safety initiatives, but should not be the only program for implementing needed safety improvements.

There should be a consistent approach for the determination of the types of improvements to be included in resurfacing projects, and a resurfacing program itself should be considered an on-going element in an agency's safety strategy at both the state and local levels. Selection of a specific improvement should be data-driven to address typical crash characteristics observed through a comprehensive study of historical crash data. An evaluation of the improvement's success in decreasing the occurrence or severity of those crash types should be routinely conducted.

Resurfacing projects with an overlay of more than 1.5 inches should be considered for safety improvements where possible. The appropriate safety countermeasures should have been determined prior to the resurfacing project so as not to interfere with timely resurfacing of the roadway. Incorporating safety into resurfacing projects should also consider available funding, project priorities, and results previously observed from other projects. Resurfacing is a prime opportunity for implementing safety measures; often it is the only time within a 10-20 year period that a roadway segment is considered for major maintenance efforts. Therefore, agencies should consider implementing safety improvements as part of every resurfacing project.

A range of geometric improvements that can be implemented as part of a resurfacing project that have notable benefits to roadway safety include:

- Auxiliary lanes (e.g., turn lanes).
- Improved cross-slopes.

- Better drainage with added inlets.
- Widened travel lanes or pavement width.
- Added shoulder or shoulder widening.
- Improved sight distance.

Various traffic operational controls that may be implemented or modified to improve safety in association with a resurfacing project include:

- Edge rumble strips.
- Centerline rumble strips.
- Curve delineation/warning (e.g., pavement markings and chevrons).
- Pavement markings.
- Retroreflective pavement markers.
- Sheet delineation (on median barrier).
- Signs.
- Signal upgrades.

Resurfacing projects may include countermeasures to address roadway departure crashes which are often overrepresented on rural two-lane roads. The countermeasures that may be considered include:

- Safety edge.
- Guardrail installation, replacement, or adjustment.
- Pavement markings.
- Retroreflective pavement markers.
- Signs.
- Utility pole or other obstacle removal or delineation.
- High friction surface treatments.

A comprehensive list of approved safety countermeasures can be found in the ALDOT HSIP Manual. A complete assessment of the proposed countermeasures can be performed using the procedures within the HSM. It is a useful tool to assess anticipated changes in crash or severity associated with resurfacing projects that have changes in geometric design or traffic operational details. The HSM provides crash modification factors which quantify changes to crash frequency and severity associated with proposed change elements as part of the resurfacing project. Additionally, other projects typically considered to be maintenance, such as roadside design (e.g., guardrail, signs, and lighting) or bridge rehabilitation or modification, can be assessed for changes to their various elements.

Chapter 9
Incorporating HSM Methodologies into the RSA

Quantifying safety in the Road Safety Assessment (RSA) process is a critical aspect to understanding the benefits and trade-offs of safety strategies considered for implementation. Tools and methods for quantifying the impact of operations, environmental, and design decisions have been available for quite some time, whereas safety has been assumed to be inherent in design policies.

With the release of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM), agencies have access to a set of tools that allow the explicit consideration of safety in all the stages of the project development process. The HSM contains the most current and accepted knowledge covering safety fundamentals, roadway safety management process, predictive methods, and crash modification factors (CMFs).

HSM methods can be used in all the steps of the Road Safety Assessment process. This chapter provides analysts and practitioners with a brief introduction to the tools and methods included in the HSM, and examples of HSM applications at each of the different stages of the RSA process.

9.1 Highway Safety Manual Overview

The HSM provides a set of analytical tools and techniques that can be used for quantifying the safety performance of decisions made in the various stages of the RSA process.
HSM tools can be used to:

- Identify sites with potential for safety improvement.
- Identify factors contributing to crashes and potential mitigation measures.
- Conduct economic appraisals of safety countermeasures.
- Prioritize and program treatments.
- Evaluate the crash reduction benefits of implemented treatments.

The HSM also provides a predictive method to estimate crash frequency and severity for various facility types and includes a collection of CMFs for various geometric and operational conditions.

The HSM is organized in four parts: Part A – Introduction, Human Factors, and Fundamentals; Part B – Roadway Safety Management Process; Part C – Predictive Method; and Part D – Crash Modification Factors.

9.1.1 HSM Part A: Introduction, Human Factors, and Fundamentals

HSM Part A describes the purpose and scope of the HSM, outlines the basics of highway safety, and explains the relationship of the HSM to planning, design, operations, and maintenance activities.

Chapter 2 of Part A introduces the core elements of human factors and how they affect the interaction of drivers and roadways. The HSM provides an introduction to human factors to support the application of information presented in Parts B, C, and D.

In Chapter 3, the HSM describes the fundamentals of analysis approaches and methodologies as well as the background information needed to apply the predictive method, CMFs, and evaluation methods provided in Parts B, C, and D of the HSM.

9.1.2 HSM Part B: Roadway Safety Management Process

HSM Part B discusses the process of monitoring and reducing crash frequency and severity on existing roadway networks. The roadway safety management process is comprised of six steps:

1) Network screening (HSM Chapter 4).
2) Diagnosis (HSM Chapter 5).
3) Safety countermeasure selection (HSM Chapter 6).
4) Economic appraisal (HSM Chapter 7).
5) Project prioritization (HSM Chapter 8).
6) Safety effectiveness evaluation (HSM Chapter 9).

Methods included in Part B allow users to identify and rank sites based on potential for safety improvement, identify crash patterns and contributing factors at a site, select appropriate safety countermeasures, evaluate the benefits and costs of proposed safety countermeasures, determine countermeasure cost-effectiveness, and evaluate countermeasure effectiveness at reducing crash frequency or severity. The HSM roadway safety management process can be applied in the different stages of the RSA process, as shown in Table 9-1.

Table 9-1: Application of HSM Part B on Different Stages of RSA Process

HSM Chapter	Feasibility and Planning	Detail/Final Design	Pre-Opening	Post-Opening	Existing Conditions
Chapter 4 - Network Screening	✓				✓
Chapter 5 - Diagnosis	✓			✓	✓
Chapter 6 - Select Countermeasures	✓	✓	✓	✓	✓
Chapter 7 - Economic Appraisal	✓	✓	✓	✓	✓
Chapter 8 - Prioritize Projects	✓				
Chapter 9 - Safety Effectiveness Evaluation				✓	

Source: Highway Safety Manual User Guide, NCHRP 17-50, Aug. 2014, p. 2-2

Some of the innovations included in Part B are described in HSM Chapters 4 and 9. Chapter 4 contains new network screening performance measures that offer more reliability than the traditional crash rates. Crash rates incorrectly assume that the relationship between traffic volume and frequency of crashes is linear. In addition, some of the performance measures account for the regression-to-the-mean (RTM) bias, which is the natural fluctuation of crash frequencies over time. Figure 9-1 contains the different performance measures included in HSM Part B in relative order of complexity, from the least to the most complex. Crash rates are the most common method, but the results are not statistically stable. Excess Expected Average Crash Frequency with Empirical Bayes Adjustments is the most reliable performance measure, but it requires more data and analysis than any other method. Detailed information about these methods can be found in the HSM.

Chapter 9 contains methods for evaluating the safety effectiveness of an individual or group of treatments, and for calculating a CMF. The evaluation of the effectiveness of safety investments are an important part of the roadway safety management process. Typically, the network screening will be performed by the Alabama Department of Transportation (ALDOT), and selected locations with the greatest potential for safety improvement will be provided to Regions, Areas and local agencies for a detailed Road Safety Assessment.

Figure 9-1: Stability of Performance Measures

More data; Account for RTM bias

Performance Measure	Accounts for RTM Bias	Method Estimates a Performance Threshold
Average Crash Frequency	No	No
Crash Rate	No	No
Equivalent Property Damage Only (EPDO) Average Crash Frequency	No	No
Relative Severity Index	No	Yes
Critical Rate	Considers data variance; does not account for RTM bias	Yes
Excess Predicted Average Crash Frequency using Method of Moments	Considers data variance; does not account for RTM bias	Yes
Level of Service of Safety	Considers data variance; does not account for RTM bias	Expected average crash frequency plus/minus 1.5 standard deviations
Excess Expected Average Crash Frequency using SPFs	No	Predicted average crash frequency at the site
Probability of Specific Crash Types Exceeding Threshold Proportion	Considers data variance; does not account for RTM bias	Yes
Excess Proportions of Specific Crash Types	Considers data variance; does not account for RTM bias	Yes
Expected Average Crash Frequency with EB Adjustments	Yes	Expected average crash frequency at the site
Equivalent Property Damage Only (EPDO) Average Crash Frequency with EB Adjustments	Yes	Expected average crash frequency at the site
Excess Expected Average Crash Frequency with EB Adjustments	Yes	Expected average crash frequency per year at the site

Greater Reliability

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Source: Highway Safety Manual User Guide, NCHRP 17-50, Aug. 2014, p. 2-4

9.1.3 HSM Part C: Predictive Method

9.1.3.1 Terminology

Base Conditions – Specific set of geometric design and traffic control features, under which the SPFs were developed.

Safety Performance Function (SPF) – Regression equation used to calculate the predicted average crash frequency per year for a specific site. SPFs are a function of annual average daily traffic and, in the case of roadway segments, the segment length.

Crash Modification Factor (CMF) – An index used to calculate the change in crashes following a modification in design or traffic control. HSM Part C CMFs are used to account for the safety effects of differences between the base conditions and the site-conditions of the facility under investigation.

Calibration Factor – A factor used to adjust the predicted crash frequency to local conditions. The calibration factor takes into consideration differences between jurisdictions for which the SPFs were developed including driver population, weather, and reporting thresholds.

Observed Crash Frequency – Refers to the historical crash data observed or reported at the site during the period of analysis.

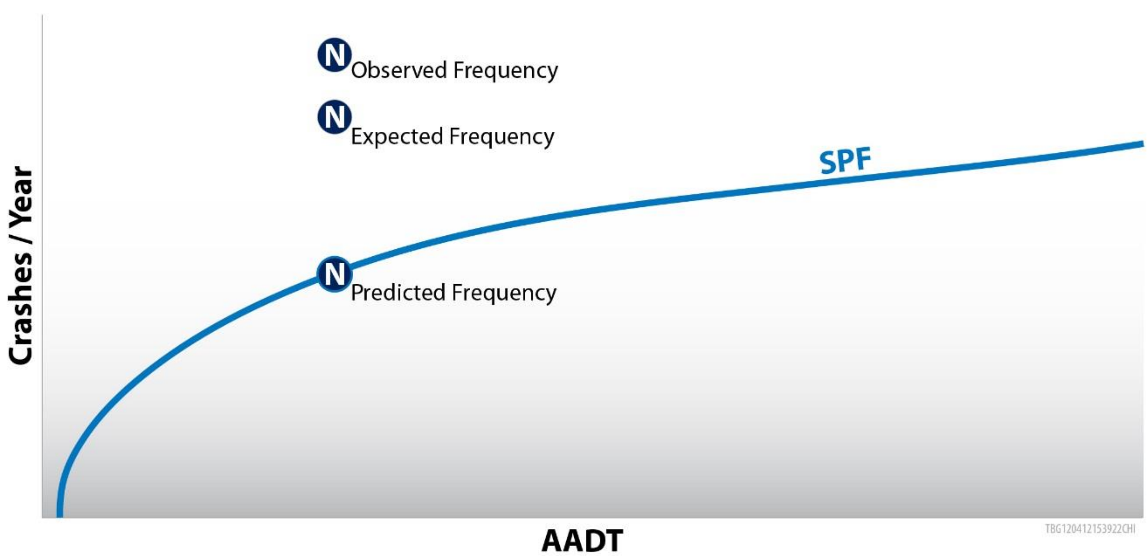
Predicted Crash Frequency – Refers to the crash frequency calculated using the predictive method (using SPFs, CMFs, and if available, calibration factor), which uses traffic volume, geometric design, and traffic control features.

Expected Crash Frequency – Refers to the crash frequency calculated using the EB method and the observed and predicted crash frequencies. The expected crash frequency is more statistically reliable than the predicted crash frequency. Instructions for converting predicted crash frequency to expected crash frequency are documented in HSM Appendix A.2.4.

Empirical Bayes (EB) Method – A method to combine the observed and predicted average crash frequencies into a more reliable estimate known as the expected average crash frequency. This method compensates for the regression-to-the-mean bias. When observed crash data is not available, the EB method does not apply.

Figure 9-2 shows the three different crash frequency estimates related to the HSM predictive method.

Figure 9-2: Observed, Predicted, and Expected Average Crash Frequency Estimates



Source: Highway Safety Manual User Guide, NCHRP 17-50, Aug. 2014, p. 2-11

9.1.3.2 Overview of the Predictive Method

HSM Part C introduces a predictive method for calculating the predicted and/or expected average crash frequency of an individual site, facility, or network. The predictive method uses statistical models that address the inherent randomness in crashes. This method can be applied to a wide variety of projects including design projects, corridor planning studies, and site specific studies such as RSAs. The method is applicable for both safety specific studies and as an element of a more traditional transportation study or environmental analysis.

The application steps of the predictive method are similar for most facility types. The predicted crash frequency is estimated using applicable SPFs, CMFs, and calibration factors, based on geometric design features, traffic control, and traffic volume for the site. To improve the statistical reliability of the crash prediction, the observed and predicted crash frequencies can be combined using the Empirical Bayes (EB) method to calculate an expected crash frequency. The predictive method can be used to estimate the crashes for various alternatives under consideration, or to understand the existing or future safety performance of a particular site.

HSM Part C provides predictive methods for segments and intersections for various facility types including rural two-lane roads, rural multilane highways, and urban and suburban arterials. Table 9-2 illustrates the different SPFs included in the HSM Part C Chapters 10, 11, and 12.

Table 9-2: Safety Performance Functions included in HSM Chapters 10-12

HSM Chapter	Undivided Roadway Segments	Divided Roadway Segments	Intersections			
			Stop Control on Minor Leg(s)		Signalized	
			Three-Leg	Four-Leg	Three-Leg	Four-Leg
10 – Predictive Method for Rural, Two-Lane, Two-Way Roads	✓		✓	✓		✓
11 – Predictive Method for Rural Multilane Highways	✓	✓	✓	✓		✓
12 – Predictive Method for Urban and Suburban Arterials	✓	✓	✓	✓	✓	✓

The first edition of the HSM included predictive methods for two-lane highways, rural multilane highways, and urban and suburban arterials. The HSM predictive methods chapters for freeway and interchanges were released in 2014. The predictive method for freeways and interchanges follows a similar methodology for estimating the predictive/expected average crash frequency for facilities with known characteristics. These chapters will be included in the next edition of the HSM.

Chapter 18 contains predictive methods for freeway segments and freeway speed-change lanes, and CMFs that describe the relationship with various geometric elements and the extent of recurring congestion. Chapter 19 documents predictive methods for ramp segments, C-D road segments, and crossroad ramp terminals. Tables 9-3 and 9-4 illustrate the different SPFs included in HSM Part C Chapters 18 and 19.

Table 9-3: Safety Performance Functions included in HSM Chapter 18

HSM Chapter	Lanes	Cross Section (lanes)	Speed Lane Changes	
			On Ramp	Off Ramp
18 – Predictive Method for Freeways	4	✓	✓	✓
	6	✓	✓	✓
	8	✓	✓	✓
	10 (urban)	✓	✓	✓

Table 9-4: Safety Performance Functions included in HSM Chapter 19

HSM Chapter	Lane Number/ Control Typed	Ramps		C-D Roads	Configuration-Based Terminals Diagonal			Crossroad Ramp Terminal			
		On Ramp	Off Ramp		On	Off	Four-leg	Four quadrant Parclo A	Four quadrant Parclo B	Two quadrant Parclo A	Two quadrant Parclo B
19 – Predictive Method for Ramps and Ramp Terminals	1 lane	✓	✓	✓							
	2 lane (urban)	✓	✓	✓							
	One-way				✓	✓	✓				
	Signal				✓	✓	✓				
	Three-leg									✓	✓
	Four-leg							✓	✓		

9.1.4 HSM Part D: CMF Applications Guidance

HSM Part D provides a compilation of various safety treatments and their effectiveness at reducing crashes. The effectiveness of geometric and operational changes is expressed in terms of CMFs or trends describing whether the treatment increases or decreases the total crashes. CMFs are provided for roadway segments (HSM Chapter 13), intersections (HSM Chapter 14), interchanges (HSM Chapter 15), special facilities and geometric situations (HSM Chapter 16), and roadway networks (HSM Chapter 17).

Some Part D CMFs are included in Part C for use with specific SPFs. The remaining Part D CMFs can be used with the outcomes of the predictive method to estimate the change in crash frequency (refer to HSM Section C.7 for additional details).

CMFs indicate the change in crashes that might be expected after implementing a safety treatment at a specific site. The CMF is calculated using the following formula:

$$CMF = \frac{Expected\ Crashes\ With\ Treatment}{Expected\ Crashes\ Without\ Treatment}$$ HSM Equation 3-5 (p. 3-19)

Some additional concepts related to CMFs are listed below:

Star Rating – The star rating indicates the quality or confidence in the results of the study that produced the CMF. The star rating varies from 1 to 5, with 5 being the most reliable. The CMFs included in the HSM have a star rating of 3 or higher.

Standard Error – The standard error is the standard deviation of a sample mean. It indicates the precision of an estimated CMF, and it is used as a measure of reliability. The smaller the standard error, the more reliable the CMF estimate. It can also be used to calculate the confidence interval for the estimated change in expected crashes. A CMF with a high standard error does not necessarily mean that it should not be used, but rather the user should consider the range of results that could be obtained.

Confidence Interval – This is another measure of the certainty of a CMF. It provides a range of potential values of the CMF based on the standard error. As the width of the confidence interval increases, there is less certainty in the estimate. If the confidence interval value is 1, it can be stated that the CMF is significant at the given confidence interval. If the value of 1 falls within the confidence interval, it can be stated that the CMF is insignificant at the confidence interval. Table 9-5 contains cumulative factors for various confidence intervals. The 95 percent confidence interval is the most commonly used in practice.

Table 9-5: Cumulative Probability Factors for Various Confidence Intervals

Confidence Interval	Cumulative Probability Factors
99%	2.576
95%	1.960
90%	1.645

The confidence interval is calculated using the following formula:

$$Confidence\ Interval\ for\ CMF = \ CMF\ \pm cumulative\ probability \times Standard\ Error$$

HSM Equation 3-8 (p. 3-22)

For instance, a specific safety strategy has a CMF value of 0.90, with a standard error of 0.08. The 95 percent confidence interval would be calculated as follows:

$$95\%\ Confidence\ Interval = 0.90\ \pm 1.96(0.08)$$

The 95 percent confidence interval values are 0.74 and 1.06. Since the value of 1 is within the confidence interval, it can be stated that the CMF may result in a decrease, increase, or no change in the number of crashes.

Trend – If the standard error was greater than 0.10, the CMF value was not sufficiently accurate, precise, and stable to be included in HSM Part D. In such cases, the HSM Part D indicates a trend, if sufficient information is available. The HSM appendix also list treatments with unknown crash effects.

9.1.5 Distinction of Various CMFs

HSM Part C CMFs Chapters 10, 11, 12, 18 and 19 – These CMFs are used to adjust for differences between the base conditions and the site-specific conditions. These CMFs were developed with the research that originated the various SPFs for all HSM chapters, and are also listed in HSM Part D.

HSM Part D CMFs Chapters 13 to 17 – Compilation of CMFs that are used to calculate the change in crashes as a result of the implementation of a safety strategy to any site analysis. These CMFs have been reviewed and approved by the HSM Task Force. HSM Part C CMFs are included as part of the compilation.

Federal Highway Administration (FHWA) CMF Clearinghouse – Extensive compilation of CMFs that are used to calculate the change in crashes as a result of the implementation of safety strategies to any site analysis. These CMFs are reviewed and approved by FHWA. It includes HSM Part C CMFs, Part D CMFs, and non-HSM CMFs.

9.2 Diagnosis and Selection of Countermeasures

The diagnosis step provides the RSA team members with an opportunity to identify the major contributing factors to crash occurrence, including the different collision types, weather, time of day, and geometric conditions or human factors that may be relevant for the site under investigation. Past studies, if available, are also a helpful resource during the identification of potential safety concerns. This information will be helpful to narrow down the list of safety strategies to be proposed for the project location. The diagnosis step involves analyzing the crash data, and reviewing all available information. The data sources needed vary depending on the site under consideration. Examples of data needed for the analysis include plans, posted speeds, operating speeds, traffic volumes, pedestrian and bicycle volumes, signal timing information, bus schedules, and nearby schools and hospitals. Not all data will be available for every project; the RSA team will determine the data needed for the analysis.

9.2.1 Safety Data Review and Descriptive Statistics Evaluation

Typically, using the most recent consecutive 3 to 5 years of crash data is recommended for the crash analysis. The Center for Advanced Public Safety (CAPS), in cooperation with Alabama Department of Transportation (ALDOT), maintains integrated crash, driver-vehicle, driver behavior and pedestrian data. In addition, obtaining georeferenced crash data will provide the RSA team the ability to perform a descriptive statistics analysis, and to map the crashes along the site under consideration. Crash reports are optional; but if available, they will provide specific details about each crash.

The descriptive crash statistics analysis is used to review and summarize the crash data with the goal of finding patterns that are over-represented. Spatial, temporal, driver/pedestrian characteristics, and other contributing factors are evaluated in detail to understand the main safety issues at the site. Common spatial characteristics include area type, jurisdiction, segments versus intersections, direction of travel, curves, and other location related attributes. Some temporal characteristics include time of day, day of the week, and season. Personal characteristics include driver and vehicle related factors such as age group, speeding, impaired driving, use of restraint, and vehicle type. Other contributing factors include the collision type, crash severity, road condition, lighting condition, and weather condition.

Crosstabs, bar charts, or other tabular summaries are useful tools for generating descriptive statistics summaries. It is helpful to look at crashes in various dimensions, and to use crash frequencies to identify overrepresentations. Figure 9-3 is an example of a graphical representation of collision types among different crash severities.

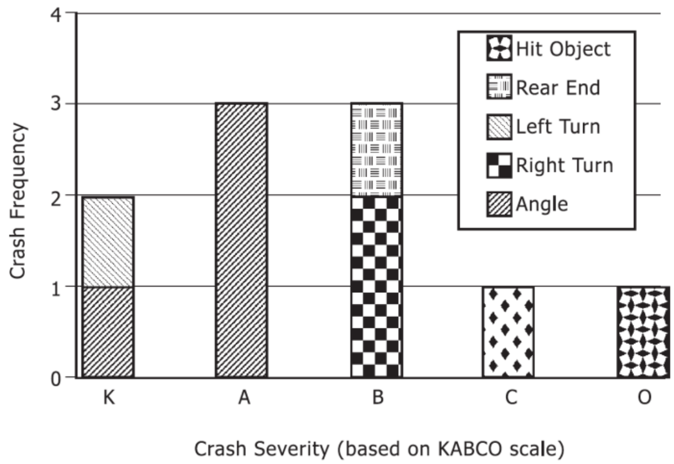


Figure 9-3: Example Graphical Crash Summary - HSM Chapter 5

Table 9-6 illustrates a few crash data crosstabs that can be generated to identify trends at the project site.

Table 9-6: Example Crash Data Crosstabs

Collision Type	Crash Severity					Total
	K	A	B	C	PDO	
Head On	0	0	0	0	0	0
Left Turn	0	0	0	0	5	5
Non-collision	0	1	0	0	5	6
Other	0	1	1	0	6	8
Rear End	0	1	2	1	18	22
Right Turn	0	0	0	0	4	4
Right Angle	0	2	4	10	49	65
Sideswipe Same Direction	0	0	0	0	0	0
Sideswipe Opposite Direction	0	1	0	0	1	2
Grand Total	0	6	7	11	88	112

	Time of Day	Crash Severity					Total
		K	A	B	C	PDO	
Nighttime	12AM-3AM	0	1	0	2	4	7
Nighttime	3AM-6AM	0	0	0	0	2	2
Nighttime	6PM-9PM	0	2	3	4	9	18
Nighttime	9PM-12AM	0	1	1	2	12	16
	Nighttime Subtotal	0	4	4	8	27	43
Daytime	6AM-9AM	0	0	1	1	21	23
Daytime	9AM-12PM	0	1	1	0	19	21
Daytime	12PM-3PM	0	1	0	1	15	17
Daytime	3PM-6PM	0	0	1	1	6	8
	Daytime Subtotal	0	2	3	3	61	69
	Grand Total	0	6	7	11	88	112

Surface Condition	Crash Severity					Total
	K	A	B	C	PDO	
Dry	0	6	6	9	73	94
Unknown	0	0	0	0	1	1
Wet	0	0	1	2	14	17
Grand Total	0	6	7	11	88	112

Year	Crash Severity					Total
	K	A	B	C	PDO	
2010	0	3	2	4	24	33
2011	0	1	2	4	28	35
2012	0	2	3	3	36	44
Grand Total	0	6	7	11	88	112

Alcohol Involvement	Crash Severity					Total
	K	A	B	C	PDO	
No	0	4	5	10	86	105
Yes	0	2	2	1	2	7
Grand Total	0	6	7	11	88	112

Number of Vehicle(s)	Crash Severity					Total
	K	A	B	C	PDO	
Single Vehicle	0	1	1	2	5	9
Multiple Vehicles	0	5	6	9	83	103
Grand Total	0	6	7	11	88	112

Collision diagrams also may be used to identify patterns at segments or intersections. The collision diagrams can be generated using spreadsheet tools or commercially available software tools.

ALDOT has developed a number of tools to perform crash analysis. The Critical Analysis Reporting Environment (CARE) tool provides access to Alabama Department of Public Safety crash data, and has the ability to perform descriptive statistical analysis for all roads in the state.

Some additional features of CARE include pattern identification, collision diagram development, and geographical information system (GIS) visualization. The web portal version can be downloaded from the CAPS website using the following link: http://www.caps.ua.edu/analytics/downloads/care-software/.

Once general trends have been identified, the RSA team will have some insights of what might be the problem, which is beneficial before conducting the field visit.

9.2.2 Selection of Countermeasures

A preliminary selection of countermeasures can be made using the information obtained as part of the crash analysis. This will be complemented with the site visit findings and the discussion with the RSA team and others involved.

The RSA team should have the ability to quantify the effectiveness of the selected strategies. Most CMFs included in the HSM and the FHWA Clearinghouse provide a value or a function expressing the estimation of the CMF effect in crash reduction. All the HSM CMFs can be found in the FHWA CMF Clearinghouse at http://www.cmfclearinghouse.org/. All the CMFs in the FHWA Clearinghouse can be accessed by performing an empty search in the main menu, and downloading the resulting search as an Excel file.

While some strategies may not have a CMF that is an exact fit, there still may be a few CMFs that can provide a reasonable estimation of the strategy effect. For instance, the countermeasure “install a traffic signal” has multiple CMF values. The selected CMF should be reviewed to ensure the value corresponds to the project facility type, crash type, and severity type. The RSA team should select the CMF that most closely matches the project and particular situation. The team should keep in mind that each CMF has been developed using different assumptions and input data including, but not limited to, terrain, climate, and traffic volumes.

An additional consideration when selecting CMFs is selecting strategies that have a star rating of 3 stars or more. If two CMFs have the same value, select the strategy that has the highest star rating. Several CMFs may come from the same research, but each one may address specific crash types, severity types, roadway types, and area types. Figure 9-4 illustrates a screen capture of a few CMF values related to the installation of a traffic signal. Four out of five CMFs come from the same study and address different collision types. The RSA team should use engineering judgment to select the most appropriate CMF for the project.

▼ Countermeasure: Install a traffic signal

CMF	CRF (%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
0.56 [B]	44	★★★★★	All	All	Rural	Harkey et al., 2008	Countermeasure name has been slightly … [read more]
0.23 [B]	77	★★★★★	Angle	All	Rural	Harkey et al., 2008	Countermeasure name changed to match … [read more]
0.33	67	★★★★☆	Angle	Fatal,Serious Injury,Minor Injury	Urban	McGee et al., 2003	Countermeasure name has been slightly … [read more]
0.4 [B]	60	★★★★☆	Left turn	All	Rural	Harkey et al., 2008	Countermeasure name changed to match … [read more]
1.58 [I]	-58	★★★★☆	Rear end	All	Rural	Harkey et al., 2008	Countermeasure name has been slightly … [read more]

Figure 9-4: Example CMFs from the FHWA CMF Clearinghouse - Install a Traffic Signal

9.3 Quantitative Safety Performance in the Different Phases of RSAs

This section provides examples of the application of the HSM predictive methods, as well as the application of CMFs in the different stages of the RSA process.

9.3.1 HSM in the Feasibility and Planning Stage

Five examples are included:

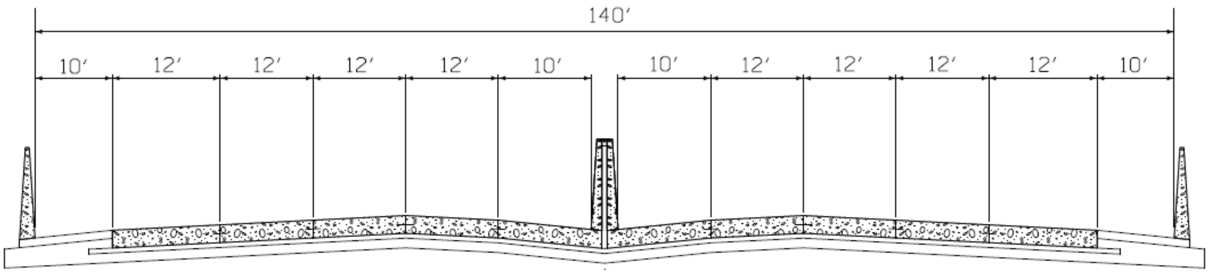
- Example 1: Evaluation of Different Cross Sections – Freeway Reconstruction
- Example 2: Widening Shoulder versus Adding Chevrons
- Example 3: Evaluation of Curve Realignment versus Design Exception
- Example 4: Evaluation of Installation of Cycle Track at Various Distances from the Main Road

9.3.1.1 Example 1: Evaluation of Different Cross Sections – Freeway Reconstruction

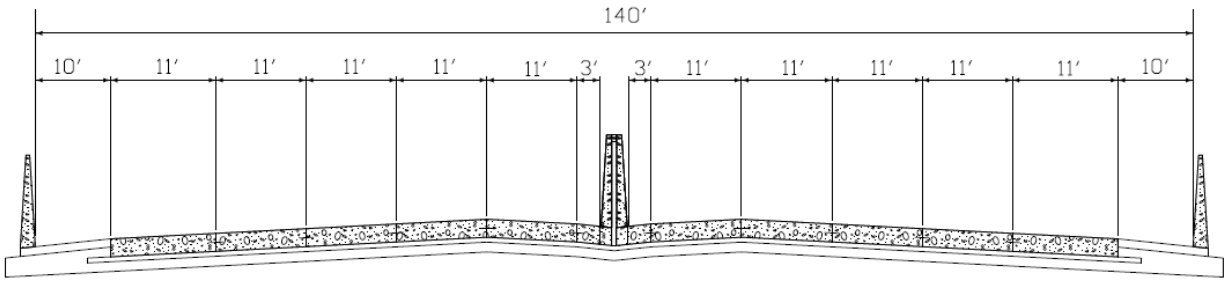
Problem

Two freeway design alternatives that use the same total cross section dimension are being evaluated to determine which one has better safety performance and level of service. Alternative 1 consists of 4 12-ft lanes with 10-ft right and left shoulders. Alternative 2 consists of 5 11-ft lanes with 10-ft right shoulders and 3-ft left shoulders.

Alternative 1: 4 – 12-ft lanes with 10-ft right shoulders and 10-ft left shoulders



Alternative 2: 5 – 11-ft lanes with 10-ft right shoulders and 3-ft left shoulders



Background

This example is focused on determining the safety performance of two freeway design alternatives to help the design team with their decision-making process. The analysis uses the freeway and interchanges predictive method to estimate the predicted average crash frequency for an individual site. The estimate represents a given time period during which the geometric design and traffic control features are unchanged and traffic volumes are known.

Many factors are considered when calculating predicted average crash frequency; the combined CMF calculation alone considers 11 unique CMFs when determining the composite value. For conciseness, this example will present the results of the application of the predictive method using the Interchange Safety Analysis Tool - Enhanced (ISATe), and explain the difference in results.

In addition, a capacity analysis was performed using the HCM 2010 to understand the differences in operations between the two scenarios.

Data Requirements

- Segment Length: 1 mile
- AADT: 150,000 vehicles/day
- Directional Distribution: 60/40
- K factor: 10%
- DHV: 9,000 vehicles/hour
- Truck Percentage: 8%
- Peak Hour Factor: 0.94
- Ramp Density: 0.2 ramps/mile
- Number of through lanes
- Terrain: Rolling

- Presence of Horizontal Curve: N/A
- Widths of lanes, outside shoulders, inside shoulders, and median
- Length of rumble strips on inside and outside shoulders: 1 mile
- Length of (and offset to) the barrier in the median and the barrier on the outside
- Width of continuous median barrier if present: 2.5 ft
- Distance to nearest upstream and downstream entrance/exit ramps in each direction of travel
- Clear zone width: N/A
- Proportion of AADT that occurs during hours where the lane volume exceeds 1,000 vehicles per hour per lane (veh/h/ln): Default

Analysis

Table 1 shows a comparison of the capacity or throughput for these designs, based on HCM methods and assumptions. The traffic-carrying capability of the five-lane segment is substantially greater than that of the four-lane segment, even with narrower lanes and left shoulder.

The substantive safety comparison of the two designs in Table 2 indicates that Alternative 1 produced more crashes, although less severe crashes, than Alternative 2. The results may appear counterintuitive. It reflects the following:

- Safety performance of higher volume freeways reflects multivehicle crashes, typically rear-end, which are little affected by marginal differences in lane width.
- Crash frequency increases with density and volume to capacity; both of which are a function of the throughput capacity, which is defined by the number of lanes. The effects of providing one more lane of traffic, even with lesser width dimensions and reduced left shoulder width, exceed the marginal adverse effects of the narrower lane and left shoulder widths. It is important to note that even when the total number of crashes is lower for alternative 2, the fatal crashes increased slightly. This is mainly due to the effect of narrow lanes and reduced shoulder width.

The analysis, while hypothetical, demonstrates both the value of considering more flexible lane and shoulder width design values, as well as the concept of optimizing a design for a given available total width dimension.

Alternative	Capacity Analysis Results		
	Level of Service	Density (pc/mi/ln)	Speed (mph)
1	F	61.3	43.7
2	E	35.5	60.5

LOS was determined using HCS 2010 Freeways Version 6.60

Alternative	Predicted Crashes per mile per year					
	Total	K	A	B	C	PDO
1	46.8	0.21	0.57	3.19	9.67	33.20
2	40.1	0.28	0.59	3.46	8.07	27.67

Predicted crashes were determined using ISATe (Build 6.10) (uncalibrated model without crash data input)

K = Fatal; A = Incapacitating Injury; B = Non-incapacitating Injury; C = Reported Injury; PDO = Property Damage Only

9.3.1.2 Example 2: Widening Shoulder versus Adding Chevrons

Problem

A sharp horizontal curve on a two-lane, two-way rural roadway with 2-foot paved shoulders has a bi-directional AADT of 1,000 vehicles per day. Sixty percent of crashes along the curve are due to single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes. Determine which countermeasure will be more effective in reducing crashes at this location: widening the paved shoulder to 4 feet or installing chevron signs along the curve.

Background

CMFs can be used comparatively to measure the effectiveness of crash mitigation treatments relative to one another. This example will compare the effectiveness of widening the shoulder on a curve against the placement of chevron signing along the curve.

When comparing two different countermeasures, it is important to establish a base condition CMF value for *each of the countermeasures being tested*. While the existing conditions will be the same for both countermeasures prior to being tested, each CMF is specific to a particular aspect of that configuration; there is no universal "base condition" CMF value that is applied to each countermeasure. This example will demonstrate this condition, as the CMF for the existing shoulder width and CMF for the lack of chevron signing (both "base conditions" for this problem) have distinct numerical values that must be used accordingly.

The CMF for Shoulder Width on Rural Two-Lane Roadway Segments can be calculated using HSM Equation 13-3 (p. 13-18) in conjunction with Table 13-7 (p. 13-11). While the CMF calculated is for total crashes, the percentage of related crashes for pavement width (single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes) must be known in order to make the calculation.

The current edition of the HSM does not provide crash modification factor information for chevron signing along a horizontal curve. Therefore, this example will utilize CMF ID 2436 from the CMF Clearinghouse, Install Chevron Signs on Horizontal Curves.[1]

Data Requirements

- AADT: 1,000 vehicles/day
- Proportion of related crashes: 0.60
- Existing shoulder width: 2 feet
- Existing curve signing: none
- Proposed shoulder width (Alt A): 4 feet
- Proposed curve signing (Alt B): chevrons along horizontal curve

[1] From *Safety Evaluation of Improved Curve Delineation,* Srinivasan et al., 2009 http://www.cmfclearinghouse.org/detail.cfm?facid=2436

Analysis

Table 13-7 in the HSM (p. 13-11) provides the factor calculation for shoulder with:

Shoulder width	AADT (vehicles per day)		
	< 400	400 to 2000	> 2000
0 ft	1.10	1.10 + 2.5 * 10^{-4} * (AADT - 400)	1.50
2 ft	1.07	1.07 + 1.43 * 10^{-4} * (AADT - 400)	1.30
4 ft	1.02	1.02 + 8.125 * 10^{-5} * (AADT - 400)	1.15
6 ft	1.00	1.00	1.00
8 ft or more	0.98	0.98 + 6.875 * 10^{-5} * (AADT - 400)	0.87

For the existing condition with an AADT of 1,000 vehicles per day and a shoulder width of 2 feet, the following equation from the above table will be used:

$$CMF_{wra(ex)} = 1.07 + 1.43 \times 10^{-4} \times (AADT - 400)$$
$$CMF_{wra(ex)} = 1.07 + 1.43 \times 10^{-4} \times (1000 - 400)$$
$$CMF_{wra(ex)} = 1.1558$$

For the proposed condition with an AADT of 1,000 vehicles per day and a shoulder width of 4 feet, the following equation will be used:

$$CMF_{wra} = 1.02 + 8.125 \times 10^{-5} \times (AADT - 400)$$
$$CMF_{wra} = 1.02 + 8.125 \times 10^{-5} \times (1000 - 400)$$
$$CMF_{wra\ (Pr)} = 1.0688$$

Using Equation 10-12 (HSM p. 10-27), the shoulder width CMF for total crashes with each treatment scenario can be calculated as follows:

$$CMF_{shld} = (CMF_{wra} - 1.0) \times p_{ra} + 1.0$$ HSM Equation 10-12 (p. 10-27)

Existing: $CMF_{shld(ex)} = (1.1558 - 1.0) \times 0.6 + 1.0 = 1.0935$

Proposed: $CMF_{shld(pr)} = (1.0688 - 1.0) \times 0.6 + 1.0 = 1.0413$

The CMFs for shoulder width in HSM Table 13-7 apply only to the collision types that are most likely to be affected (single-vehicle run-off-road and multiple vehicle head-on, opposite direction sideswipe and same-direction sideswipe). These CMFs must be adjusted to reflect total crashes. In the equation above *Pra* equals 0.60 since sixty percent of crashes are of the aforementioned related types (see problem statement).

The percent change in total expected crashes due to shoulder widening can now be calculated:

$$\Delta_{shld} = \frac{CMF_{shld(pr)}}{CMF_{shld(ex)}} - 1$$

HSM Equation 3-5 (p. 3-19)

$$\Delta_{shld} = \frac{1.0413}{1.0935} - 1 = -0.0477$$

Based on the analysis for installation of chevron signing along a horizontal curve documented on the CMF Clearinghouse as CMF ID 2436, the CMF for all crashes following installation of chevron signs is 0.96. The value for CMF ID 2436 represents the change from a base condition with no signing, which is consistent with the base condition for the analyzed site (see problem statement); the signing CMF for the existing base condition (no chevron signing installed) is represented as 1.00.

The percent change in expected crashes due to sign installation can now be calculated:

$$\Delta_{sign} = \frac{CMF_{sign(pr)}}{CMF_{sign(ex)}} - 1$$

$$\Delta_{sign} = \frac{0.96}{1.00} - 1 = -0.04$$

Based on the CMF calculations for shoulder width, widening the paved shoulder from 2 feet to 4 feet will reduce the expected average crash frequency by 0.0477 (4.77%). The CMF calculations for chevron signing indicate the installation of the signs will reduce the expected average crash frequency by 0.04 (4%). Therefore, the widening of the shoulder will be *slightly* more effective than chevron sign installation in mitigating crashes under the conditions given. Because the differences in crash reduction are marginal, the countermeasure selection will most likely be driven by a benefit-cost analysis to determine which feature is more cost-effective.

9.3.1.3 Example 3: Evaluation of Curve Realignment versus Design Exception

Problem

A rural two-lane road is being upgraded from a 50-mph facility to a 60-mph facility. A curve is located along the roadway, with crash data and geometric characteristics provided below in the Data Requirements section. With the aforementioned data, use the predictive method outlined in HSM Part C to determine the expected number of crashes per year for three roadway design scenarios:

1. The curve remains unmodified despite the design speed increase (Existing without Modification).
2. The roadway alignment remains unmodified, but the shoulders are widened and paved to mitigate the substandard curve radius (Design Exception).
3. The curve radius is increased to meet agency design standards (Realignment).

Background

This example is focused on determining the safety performance of two design alternatives of a curve location to help design engineers with the decision-making process. The problem illustrates how to calculate the predictive and expected average crash frequency for two curve locations with different radii.

Many factors are considered when calculating predicted average crash frequency; the combined CMF calculation alone considers 12 unique CMFs when determining the composite value. For conciseness, this example will make a number of assumptions for some values, focusing on the values most relevant to this example.

Data Requirements

The following is 5 years of recorded traffic data for the curve. The average of total crashes per year is 20 crashes.

Year	Annual Average Daily Traffic (AADT)	Fatal and Injury (KAB)	Possible Injury (C)	Property Damage Only (PDO)	Total
2009	17,600	3	4	20	27
2010	17,860	2	4	10	16
2011	18,130	1	2	12	15
2012	18,400	2	2	16	20
2013	18,680	2	3	17	22
Total		10	15	75	100
Average/year		2	3	15	20

The following is the roadway geometric data for each of the three scenarios. As indicated in the Analysis section, the rows highlighted in orange will be the areas of focus for calculating the CMFs in this example:

Design Feature	Geometric Scenario		
	Existing	Design Exception	Realignment
Length (mi)	0.31	0.31	0.5
Lane width (ft)	12	12	12
Shoulder width (ft)	2	6	6
Shoulder type	Gravel	Paved	Paved
Horizontal curve length (mi)	0.31	0.31	0.5
Radius of curvature (ft)	1550	1550	2500
Spiral transition	None	None	None
Superelevation variance (ft/ft)	0.01	0.01	0
Grade (%)	1	1	1
Driveway density (per mi)	0	0	0
Centerline rumble strips	None	None	None
Passing lanes	None	None	None
Two-Way Left-Turn Lane	None	None	None
Roadside Hazard Rating	5	5	3

Design Feature	Geometric Scenario		
	Existing	Design Exception	Realignment
Segment Lighting	None	None	None
Automated Speed Enforcement	None	None	None

Analysis
The first requirement of the process is the safety performance function, calculated using HSM Equation 10-6 (p. 10-15). Using the formula, the SPFs for year 2009 can be calculated as:

$$N_{spf} = AADT \times L \times 365 \times 10^{-6} \times e^{-0.312}$$ HSM Equation 10-6 (p. 10-15)

Existing, D.E.: $N_{spf} = 17{,}600 \times 0.31 \times 365 \times 10^{-6} \times e^{-0.312} = 1.458$

Realignment: $N_{spf} = 17{,}600 \times 0.5 \times 365 \times 10^{-6} \times e^{-0.312} = 2.351$

Using the same formula, values for years 2010-2013 are as follows:

Year:	2010	2011	2012	2013
Existing, D.E.:	1.479	1.502	1.524	1.547
Realignment:	2.386	2.422	2.458	2.495

Note that the existing condition and the Design Exception scenario share the same SPF for a given year, as the segment length remains unchanged.

Next, the Combined CMF for each scenario will be calculated. As mentioned, this example is focused primarily on the differences in geometry defined in the problem statement. Therefore, this example will assume baseline CMF values for lane width (CMF_{1r} = 1.00), grade (CMF_{5r} = 1.00), driveway density (CMF_{6r} = 1.00), centerline rumble strips (CMF_{7r} = 1.00), passing lanes (CMF_{8r} = 1.00), two-way left-turn lanes (CMF_{9r} = 1.00), lighting (CMF_{11r} = 1.00), and automated speed enforcement (CMF_{12r} = 1.00).

The calculation of the Shoulder Width and Type CMFs (CMF_{2r}) requires Tables 10-9, 10-10, and Equation 10-12 from the HSM (p. 10-25 – 10-27).

CMF for Shoulder Width on Roadway Segments (CMF_{wra})
HSM Table 10-9 (p. 10-25)

Shoulder width	AADT (vehicles per day)		
	< 400	400 to 2000	> 2000
0 ft	1.10	1.10 + 2.5 * 10-4 * (AADT - 400)	1.50
2 ft	1.07	1.07 + 1.43 * 10-4 * (AADT - 400)	1.30
4 ft	1.02	1.02 + 8.125 * 10-5 * (AADT - 400)	1.15
6 ft	1.00	1	1.00
8 ft or more	0.98	0.98 + 6.875 * 10-5 * (AADT - 400)	0.87

Crash Modification Factors for Shoulder Types and Shoulder Widths on Roadway Segments (CMF_{tra}) HSM Table 10-10 (p. 10-26)

Shoulder type	**Shoulder width (ft)**						
	0	**1**	**2**	**3**	**4**	**6**	**8**
Paved	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Gravel	1.00	1.00	1.01	1.01	1.01	1.02	1.02
Composite	1.00	1.01	1.02	1.02	1.03	1.04	1.06
Turf	1.00	1.01	1.03	1.04	1.05	1.08	1.11

Because the roadway annual average daily traffic (AADT) exceeds 2,000 vehicles per day, the values in the far right column of the CMF for Shoulder Width table 10-9 can be utilized. For the existing condition, the 2-foot shoulders have a CMF_{wra} of 1.30. For the Design Exception and the Curve Realignment scenario, the 6-foot shoulders have a CMF_{wra} of 1.00. Likewise, Table 10-10 shows a CMF_{tra} of 1.01 for 2-foot gravel shoulders, and a CMF_{tra} of 1.00 for 6 -foot paved shoulders.

Using Equation 10-12, the CMF for each scenario can be calculated. This example will assume 60 percent of related crashes (run-off-road, head-on, sideswipe).

$$CMF_{2r} = (CMF_{wra} \times CMF_{tra} - 1.0) \times p_{ra} + 1.0$$ HSM Equation 10-12 (p. 10-27)

Existing: $CMF_{2r} = (1.30 \times 1.01 - 1.0) \times 0.60 + 1.0 = 1.188$

Realignment, D.E.: $CMF_{2r} = (1.00 \times 1.00 - 1.0) \times 0.60 + 1.0 = 1.00$

The calculation of the Horizontal Curve CMFs (CMF_{3r}) requires Equation 10-13 from the HSM (p.10-27).

Verify that all measurements for the equation have the correct units (radius in feet, length in miles). This example will assume no spiral transitions are present on the curve (S = 0).

$$CMF_{3r} = \frac{(1.55 \times L_C) + \left(\frac{80.2}{R}\right) - (0.012 \times S)}{(1.55 \times L_C)}$$ HSM Equation 10-13 (p. 10-27)

Existing, D.E.: $CMF_{3r} = \frac{(1.55 \times 0.31) + \left(\frac{80.2}{1550}\right) - (0.012 \times 0)}{(1.55 \times 0.31)} = 1.108$

Realignment: $CMF_{3r} = \frac{(1.55 \times 0.5) + \left(\frac{80.2}{2500}\right) - (0.012 \times 0)}{(1.55 \times 0.5)} = 1.041$

The calculation of the Superelevation CMFs (CMF_{4r}) requires the use of Equations 10-14, 10-15, and 10-16 from the HSM (p. 10-28). These equations are calculated based on superelevation variance, the deviation of the curve's physical superelevation from the recommended superelevation value found in the AASHTO A Policy on Geometric Design of Highways and Streets (Green Book). Based on the values provided, the superelevation variance for the realigned curve is zero; Equation 10-14 assigns it a CMF of 1.0. For both the existing condition and the Design Exception scenario, the Green Book dictates a superelevation of 6 percent for a 1,550-foot curve at a speed of 60 mph; therefore, the 5 percent curve has a superelevation variance of 0.01 ft/ft. Calculations with Equation 10-15 are shown below:

$$CMF_{4r} = 1.00 + 6 \times (SV - 0.01) \qquad \text{HSM Equation 10-15 (p. 10-28)}$$

$$\text{Existing, D.E.: } CMF_{4r} = 1.00 + 6 \times (0.01 - 0.01) = 1.00$$

The roadside hazard rating will be improved in the realignment scenario through the removal of trees around the curve. The calculation of the roadside design CMF (CMF_{10r}) is done using equation 10-20 from the HSM (p. 10-30). The base value of roadside hazard rating is 3; all other values are calculated as follows:

$$CMF_{10r} = \frac{e^{(-0.6869+0.0668xRHR)}}{e^{(-0.4865)}} \qquad \text{HSM Equation 10-20 (p. 10-30)}$$

$$\text{Existing, D.E.: } CMF_{10r} = \frac{e^{(-0.6869+0.0668x5)}}{e^{(-0.4865)}} = 1.143$$

$$\text{Realignment: } CMF_{10r} = \frac{e^{(-0.6869+0.0668x3)}}{e^{(-0.4865)}} = 1.0$$

With each of the CMFs successfully calculated, the Combined CMF for each scenario can now be computed:

$$CMF_{combined} = CMF_{1r} \times CMF_{2r} \times CMF_{3r} \times \ldots \times CMF_{12r}$$

$$\text{Existing: } CMF_{combined} = 1.00 \times 1.188 \times 1.108 \times 1.143 \times [\textstyle\sum 1.0] = 1.505$$

$$\text{D.E.: } CMF_{combined} = 1.00 \times 1.00 \times 1.108 \times 1.143 \times [\textstyle\sum 1.0] = 1.266$$

$$\text{Realignment: } CMF_{combined} = 1.00 \times 1.00 \times 1.041 \times 1.0 \times [\textstyle\sum 1.0] = 1.041$$

Applying a calibration factor (C_r) of 1.392 for roadways in the State of Alabama (*source: ALDOT*), the predicted crash frequencies for the three scenarios can be calculated for 2009:

$$N_{predicted} = N_{spf} \times C_r \times CMF_{combined}$$

$$\text{Existing: } N_{predicted} = 1.458 \times 1.392 \times 1.505 = 3.053$$

$$\text{D.E.: } N_{predicted} = 1.458 \times 1.392 \times 1.266 = 2.570$$

$$\text{Realignment: } N_{predicted} = 2.351 \times 1.392 \times 1.041 = 3.407$$

The outcomes for all 5 years are:

Year	AADT	$N_{observed}$	As-is	Design Exception	Realignment
			$N_{predicted}$	$N_{predicted}$	$N_{predicted}$
2009	17,600	27	3.05	2.57	3.41
2010	17,860	16	3.10	2.61	3.46
2011	18,130	15	3.14	2.65	3.51
2012	18,400	20	3.19	2.69	3.56
2013	18,680	22	3.24	2.73	3.62
	SUM	**100**	**15.73**	**13.24**	**17.55**

Because observed and predicted crash frequencies and a calibration factor are available, the expected crash frequency can be calculated. The expected crash frequency is obtained using the EB method to produce a more reliable estimate (reference HSM Appendix A-2, pp. A15-A23).

The first step is to calculate the weighting factor (*w*), which is a function of the overdispersion parameter (*k*) and the predicted crash frequency. The overdispersion parameter for the rural two lane, two-way road is calculated as follows:

$$k = \frac{0.236}{L}$$ HSM Equation 10-7 (p. 10-16)

Where: L = length of road in miles

Existing, D.E.: $k = \frac{0.236}{0.31} = 0.761$

Realignment: $k = \frac{0.236}{0.5} = 0.472$

Inserting the overdispersion parameter and predicted crash frequency into the weighting factor formula:

$$w = \frac{1}{1+k\times(\sum N_{predicted(all\ study\ years)})}$$ HSM Equation A-5 (p. A-19)

Existing: $w = \frac{1}{1+0.761\times(15.73)} = 0.077$

D.E.: $w = \frac{1}{1+0.761\times(13.24)} = 0.090$

Realignment: $w = \frac{1}{1+0.472\times(17.55)} = 0.108$

The expected average crash frequency for the 5-year study period can be calculated as follows:

$$N_{expected} = w \times N_{predicted} + (1.00 - w) \times N_{observed}$$ HSM Equation A-4 (p. A-19)

Existing: $N_{expected} = 0.077 \times 15.73 + (1.00 - 0.077) \times 100 = 93.50$

D.E.: $N_{expected} = 0.090 \times 13.24 + (1.00 - 0.090) \times 100 = 92.17$

Realignment: $N_{expected} = 0.108 \times 17.55 + (1.00 - 0.108) \times 100 = 91.12$

The expected average crash frequencies obtained for the 5-year study period are then annualized:

Existing: $93.50/5 = 18.70$

D.E.: $92.17/5 = 18.43$

Realignment: $91.12/5 = 18.22$

From the results, the design exception and realignment will result in a reduction of 0.27 (18.70-18.4=0.27) and 0.48 (18.70-18.22=0.48) crashes per year, respectively, in comparison with the existing conditions. The design exception crash prediction resulted in slightly more crashes mainly because the smaller radius of curvature and the roadside was not improved. However, the benefits and costs of each alternative should also be evaluated to make an informed decision.

Looking at the scope of improvements required for each of both scenarios, a basic cost estimate can be used to weigh the improvements in safety performance against the price of implementation. Using materials and price estimates for pavement, earthwork, and incidental construction, the shoulder replacement for the Design Exception scenario costs approximately $228,000, while the Realignment scenario costs approximately $897,000.

The benefits are calculated using the societal cost of crashes by severity. The HSM provides comprehensive crash costs for various severity types. However, the costs correspond to year 2001 and were increased to the current year using a growth rate of 3 percent. (For guidance on conducting economic appraisals, see HSM Chapter 7.)

Crash Type	**Comprehensive Crash Costs***	**Growth Rate, %**	**# Years****	**2015 Value**
Fatal (K)	$4,008,900	3%	14	$6,063,821
Disabling Injury (A)	$216,000	3%	14	$326,719
Evident Injury (B)	$79,000	3%	14	$119,495
Fatal /Injury (K/A/B)	$158,200	3%	14	$239,292
Possible Injury (C)	$44,900	3%	14	$67,915
PDO (O)	$7,400	3%	14	$11,193

*Comprehensive costs from a 2005 report in 2001 dollars (HSM 1st Ed. 2010 Appendix 4A)

**Converting 2001 dollars to 2015 dollars -- 14 years

The observed crash data provided are divided into KAB, C, and PDO crashes. Therefore, the societal cost of crashes in the last three rows highlighted in gray will be used for the calculations. The proportion of crashes was obtained from the observed data, and applied to the annual expected average crash reduction. Total KABCO for Design exception was 1.2 crashes/year, and for Realignment was 1.1 crashes/year. These totals were broken down into the three severity categories shown below using the proportions from the observed crash data.

Crash Severity	**Average Observed Crashes/year**	**Proportion of Crashes by Severity**	**Design Exception Crashes Reduced**	**Realignment Crashes Reduced**
Fatal/Injury (KAB)	2	10%	0.03	0.05
Possible Injury (C)	3	15%	0.04	0.07
PDO (O)	15	75%	0.20	0.36
Total KABCO	**20**	**100%**	**0.27**	**0.48**

A service life of 20 years was assumed for both the shoulder widening and the realignment. The benefits need to be extrapolated to match the improvements' service life. This was done using the conversion from uniform series to present worth value.

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

Where: A = Annual amount
i = Discount rate
n = Service life

The costs are a one-time payment; hence no additional calculation is required. The Benefit-Cost ratios are calculated as shown on the next page:

Service Life (yrs) 20

Discount Rate 3%

Design Exception Alternative	**Project Benefits**				
	Crash Severity	**Annual Crash Reduction**	**Cost per crash**	**Annual Benefit**	**Total Benefit**
	Fatal/Injury (KAB)	0.03	$ 239,292	$ 6,150	$ 91,492
	Possible Injury (C)	0.04	$ 67,915	$ 2,618	$ 38,951
	PDO (O)	0.19	$ 11,193	$ 2,157	$ 32,098
	Subtotal	0.26		$ 10,925	$ 162,541
	Project Costs				
	Improvement		**Service Life**	**Initial Cost**	**Total Cost**
	Design Exception		20	$ 228,000	$ 228,000
	Benefit Cost Ratio				
Benefit	$ 162,541	**Cost**	$ 228,000	**B/C=**	**0.71**

Realignment Alternative	**Project Benefits**				
	Crash Severity	**Annual Crash Reduction**	**Cost per crash**	**Annual Benefit**	**Total Benefit**
	Fatal/Injury (KAB)	0.05	$ 239,292	$ 11,137	$ 165,691
	Possible Injury (C)	0.07	$ 67,915	$ 4,741	$ 70,539
	PDO (O)	0.35	$ 11,193	$ 3,907	$ 58,128
	Subtotal	0.47		$ 19,786	$ 294,358
	Project Costs				
	Improvement		**Service Life**	**Initial Cost**	**Total Cost**
	Realignment		20	$ 897,000	$ 897,000
	Benefit Cost Ratio				
Benefit	$ 294,358	**Cost**	$ 897,000	**B/C=**	**0.33**

From the evaluation, the expected average crash frequency for both improvements is similar, but after factoring the cost of implementing the two alternatives in the field, the Design Exception proves to be more effective at reducing crashes for a lower investment. However, both projects have a B/C ratio lower than 1, which indicates that the projects are not completely cost-effective. Analysts should think carefully about advocating projects that have a B/C ratio less than 1.0.

9.3.1.4 Example 4: Evaluation of Installation of Cycle Track at Various Distances from the Main Road

Problem

An urban intersection is under consideration for the installation of a cycle track along the major roadway. The predicted average crash frequency of the existing facility without bicycle accommodations is 22 vehicle/bicycle crashes per year. Compare the change in predicted average crash frequency between the installation of a cycle track immediately adjacent to the edge of vehicle travel lanes (0-foot offset) and the installation of a cycle track buffered from vehicle travel lanes by a parking lane (8-foot offset). (**Be aware this example problem utilizes CMFs based on metric values.)

Background

CMFs can be used comparatively to measure the effectiveness of crash mitigation treatments relative to one another. This example will compare the effectiveness of installing a cycle track at different lateral clearances from the edge of motorized vehicle travel lanes.

The current edition of the HSM does not provide crash modification factor information for cycle track offsets. Therefore, this example will utilize two CMFs from the CMF Clearinghouse: CMF ID 4033, Installation of a Cycle Track 0-2m From the Side of the Main Road With Cyclist Priority at Intersections; and CMF ID 4034, Installation of a Cycle Track 2-5m From the Side of the Main Road With Cyclist Priority at Intersections.[2] (8 feet is approximately 2.4 meters.)

Data Requirements

- Existing bicycle accommodation: none
- Proposed bicycle accommodation (Alt A): cycle track adjacent to traffic, 0-foot offset
- Proposed bicycle accommodation (Alt B): cycle track buffered by parking lane, 8-foot offset

Analysis

Based on the analysis provided for cycle track installation, the CMF for cycle track 0-2 meters from the road is 1.03 and the CMF for cycle track 2-5 meters from the road is 0.55. It should be noted that these CMFs apply to all crash severities for all roadway types in an urban or suburban setting.

The predicted average crash frequency for the travel lane-adjacent cycle track can be calculated as:

$$crashes_{\mathrm{Pr}(0m)} = CMF \times crashes_{Ex}$$
$$crashes_{\mathrm{Pr}(0m)} = 1.03 \times 22 = 22.6$$

[2] From *Road Factors and Bicycle/Motor Vehicle Crashes at Unsignalized Priority Intersections,* Schepers et al., 2011
http://www.cmfclearinghouse.org/detail.cfm?facid=4033, http://www.cmfclearinghouse.org/detail.cfm?facid=4034

The predicted average crash frequency for the parking lane-offset cycle track can be calculated as:

$$crashes_{\mathrm{Pr}(2.4m)} = CMF \times crashes_{Ex}$$
$$crashes_{\mathrm{Pr}(2.4m)} = 0.55 \times 22 = 12.1$$

Based on the demonstrated calculations, the predicted average crash frequency is 23 crashes per year for all intersection crashes with a travel lane-adjacent cycle track, and 12 crashes per year for a parking lane-offset cycle track.

A brief note on the CMF for the installation of bicycle lanes at a distance of 0-2 meters from the roadway, as the CMF greater than 1 may suggest that this countermeasure is counter-intuitive from a safety standpoint. Numerous studies have demonstrated that the installation of bicycle facilities along a roadway without existing bicycle accommodation increases the volume of cyclists using the roadway, which in turn increases the *exposure* (or opportunity) for vehicle/bicycle conflict.

9.3.2 HSM in the Detail/Final Design Stage

Six examples are included:

- Example 5: Evaluation of Median Barrier Types.
- Example 6: Value Engineering – Modifying Shoulder Widths.
- Example 7: Value Engineering – Reduce Acceleration Lane Length.
- Example 8: Changing Speed Limit.
- Example 9: Change Intersection Skew Angle.

9.3.2.1 Example 5: Evaluation of Median Barrier Types

Problem

A divided multi-lane highway without a median barrier has a bi-directional AADT of 55,000 vehicles per day and an expected average crash frequency of 42 injury-severity crashes per year. Using a 95th percentile confidence interval, compare the change in expected crash frequency between the installation of a steel median barrier and the installation of a cable median barrier.

Background

CMFs can be used comparatively to measure the effectiveness of crash mitigation treatments relative to one another. This example will compare the effectiveness of two different types of median barrier.

CMFs for the Potential Crash Effects of Installing Median Barrier can be found in Table 13-23 of the HSM (p. 13-24). Be sure to note the barrier type, crash severity, and that the roadway falls within the designated AADT range.

This example will calculate the 95th percentile confidence interval, indicating that there is 95 percent chance the expected average crash frequency will occur within this range.

Data Requirements

- Existing expected average crash frequency: 42 crashes per year
- Existing median barrier: none
- Proposed median barrier (Alt A): steel median barrier
- Proposed median barrier (Alt B): cable median barrier

Analysis

Based on Table 13-23, the CMF for installing steel median barrier is 0.65 with a standard error of 0.08. The CMF for installing cable median barrier is 0.71 with a standard error of 0.1.

To calculate the 95th percentile confidence interval, the standard error should be multiplied by 1.96 (reference Table 9-5: Cumulative Probability Factors for various Confidence Intervals). This value should then be added to or subtracted from the CMF to find the upper and lower boundaries, respectively, of the confidence interval. Therefore, the 95th percentile confidence interval for installing steel median barrier can be calculated as:

$$[crashes_{lo}; crashes_{hi}] = [CMF \pm (error_{std} \times 1.96)] \times crashes_{Ex}$$ HSM Equation 3-8 (p. 3-22)

$$[crashes_{lo}; crashes_{hi}] = [0.65 \pm (0.08 \times 1.96)] \times 42$$

$$crashes_{lo} = 20.7$$

$$crashes_{hi} = 33.9$$

Subsequently, the 95th percentile confidence interval for installing cable median barrier is:

$$[crashes_{lo}; crashes_{hi}] = [0.71 \pm (0.1 \times 1.96)] \times 42$$ HSM Equation 3-8 (p. 3-22)

$$crashes_{lo} = 21.6$$

$$crashes_{hi} = 38.1$$

Based on the calculation of the confidence interval, it can be stated with 95 percent confidence that the expected average crash frequency for injury-severity crashes following the installation of steel median barrier will be between 21 and 34 crashes per year. Likewise, the expected average crash frequency for injury-severity crashes following the installation of cable median barrier will be between 22 and 38 crashes per year.

The confidence interval and standard error are important to note when comparing two countermeasures. On the surface, the comparison of the two CMFs in this example would suggest the steel median barrier is six (6) percent more effective in reducing injury-severity crashes than the cable median barrier. However, once standard error is incorporated, a large overlap in the confidence intervals can be seen, indicating that one cannot state with 95% confidence that the steel median barrier will be more effective at reducing injury-severity crashes than cable median barrier.

9.3.2.2 Example 6: Value Engineering – Modifying Shoulder Widths

Problem

A two-lane, two-way rural roadway with 12-foot travel lanes, 8-foot paved shoulders, and a bi-directional AADT of 1,600 vehicles per day has a predicted average total crash frequency of 25 crashes per year. Sixty-four (64) percent of crashes are due to single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes. Determine the difference in predicted average total crash frequency if the paved shoulders are reduced to 4 feet.

Background

The Shoulder Width and Type CMF is calculated using HSM Equation 10-12 (HSM p. 10-27). As the name suggests, the CMF is a composite of factors for lateral shoulder width and shoulder material type. This CMF applies only to crashes that are most likely to be affected by shoulder width and type including single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes.

Calculating the proportion of related crashes is part of the required input for determining the effectiveness of modifying the shoulder width and type.

Data Requirements

- Predicted average crash frequency: 25 crashes per year
- Proportion of related crashes: 0.64
- AADT: 1,600 vehicles/day
- Shoulder type: pavement
- Existing shoulder width: 8 feet
- Proposed shoulder width: 4 feet

Analysis

The shoulder type factor for pavement shoulder is 1.00, regardless of width (HSM Table 10-10 [HSM p. 10-25]). Because the shoulder type is the same in both the existing and proposed conditions, this factor will remain unchanged between the two scenarios.

Table 10-9 in the HSM (p. 10-25) provides the factor calculation for shoulder width. The CMFs shown apply only to single vehicle run-off road, multiple vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes:

Shoulder width	**AADT (vehicles per day)**		
	< 400	**400 to 2000**	**> 2000**
0 ft	1.10	$1.10 + 2.5 * 10^{-4} * (AADT - 400)$	1.50
2 ft	1.07	$1.07 + 1.43 * 10^{-4} * (AADT - 400)$	1.30
4 ft	1.02	$1.02 + 8.125 * 10^{-5} * (AADT - 400)$	1.15
6 ft	1.00	1	1.00
8 ft or more	0.98	$0.98 + 6.875 * 10^{-5} * (AADT - 400)$	0.87

Per the table above, for the existing condition with an AADT of 1,600 vehicles per day and a width of 8 feet, the following equation will be used:

$$CMF_{wra} = 0.98 + 6.875 \times 10^{-5} \times (AADT - 400)$$
$$CMF_{wra} = 0.98 + 6.875 \times 10^{-5} \times (1600 - 400)$$
$$CMF_{wra\,(Pr)} = 1.0625$$

For the proposed condition with an AADT of 1,600 vehicles per day and a width of 4 feet, the following equation (from the table above) will be used:

$$CMF_{wra} = 1.02 + 8.125 \times 10^{-5} \times (AADT - 400)$$
$$CMF_{wra} = 1.02 + 8.125 \times 10^{-5} \times (1600 - 400)$$
$$CMF_{wra\,(Ex)} = 1.1175$$

Using Equation 10-12, the CMF for each scenario can be calculated based on the 64 percent of related crashes. (This equation adjusts the CMFs to determine total crashes.)

$$CMF_{2r} = (CMF_{wra} \times CMF_{tra} - 1.0) \times p_{ra} + 1.0$$ HSM Equation 10-12 (p. 10-27)

Existing: $CMF_{2r} = (1.0625 \times 1.0 - 1.0) \times 0.64 + 1.0 = 1.04$

Proposed: $CMF_{2r} = (1.1175 \times 1.0 - 1.0) \times 0.64 + 1.0 = 1.0752$

The difference in predicted crashes can now be calculated:

$$\Delta = crashes_{ex} \times \left(\frac{CMF_{2r\,(proposed)}}{CMF_{2r\,(existing)}} - 1 \right)$$

$$\Delta = 25 \times \left(\frac{1.0752}{1.04} - 1 \right) = \pm 0.85$$

Based on the calculation of the CMF for both the existing and proposed shoulder widths, the predicted average crash frequency will increase by 0.85 crashes per year due to the shoulder reduction. It should be noted that while the percentage of related crash types was used in the calculation of the CMF, the CMF is for total crashes; subsequently, the 0.85 crash per year increase is for *all* crash types.

9.3.2.3 Example 7: Value Engineering – Reduce Acceleration Lane Length

Problem

A grade-separated interchange has an entrance ramp with a proposed acceleration lane length of 1,600 feet. Determine the percent change in total predicted average crash frequency if the length of the acceleration lane is reduced by 50 percent.

Background

The Modify Speed Change Lane Design CMF is calculated using HSM Equation 15-1 (HSM p. 15-6) for total crashes related to acceleration lane length. (Equation 15-2 can be used to determine the acceleration lane CMF specific to fatal-and-injury crashes.) It should be noted that for the CMF, the length of the acceleration lane is measured in miles from the nose of the gore area to the end of the lane drop taper.

Data Requirements

- Existing acceleration lane length: 1,600 feet
- Proposed acceleration lane length: 0.50 × 1,600 = 800 feet

Analysis

The CMF for acceleration length requires the length of the acceleration lane to be in miles. Converting from feet, the acceleration lane lengths are:

$$L_{accel\,(existing)} = \frac{1600ft}{5280ft/mi} = 0.3030mi$$

$$L_{accel\,(proposed)} = \frac{800ft}{5280ft/mi} = 0.1515mi$$

For the existing condition, the acceleration lane length CMF is:

$$CMF_{(existing)} = 1.296 \times e^{(-2.59 \times L_{accel})}$$ HSM Equation 15-1 (p. 15-6)

$$CMF_{(existing)} = 1.296 \times e^{(-2.59 \times 0.3030)} = 0.5913$$

For the proposed condition, the acceleration lane length CMF is:

$$CMF_{(proposed)} = 1.296 \times e^{(-2.59 \times L_{accel})}$$

$$CMF_{(proposed)} = 1.296 \times e^{(-2.59 \times 0.1515)} = 0.8753$$

The percent change in total predicted crash frequency can be calculated as follows:

$$\Delta = \frac{CMF_{(proposed)}}{CMF_{(existing)}} - 1$$

$$\Delta = \frac{0.8753}{0.5913} - 1 = +0.480$$

Based on the calculation of the CMF for both the existing and proposed acceleration lane lengths, the predicted average crash frequency will increase by 48 percent if the acceleration lane length is reduced from 1,600 feet to 800 feet.

9.3.2.4 Example 8: Changing Speed Limit

Problem

A stretch of roadway has an expected average crash frequency of 32 total crashes per year. Determine the change in expected average crash frequency for all crashes if the posted speed is reduced from 45 MPH to 35 MPH.

Background

The current edition of the HSM does not provide a CMF for changing a posted speed limit; therefore, this example will utilize CMF ID 1239 from the CMF Clearinghouse, Lower Posted Speed by 10 MPH.[3] While a multitude of speed change CMFs are available from the CMF Clearinghouse, this CMF has been chosen as it best fits the requirements designated in the problem statement.

Data Requirements

- Existing expected average crash frequency: 32 total crashes per year
- Existing posted speed limit: 45 MPH
- Proposed posted speed limit: 35 MPH

Analysis

Based on the analysis provided for CMF 1239, the CMF for the reduction of the posted speed by 10 MPH is 0.96. Note that the CMF does not have an associated standard error; therefore, a confidence interval cannot be calculated when using this particular CMF.

The change in expected average crash frequency following the reduction of the posted speed can be calculated as:

$$crashes_{Pr} = \left(\frac{CMF_{Pr}}{CMF_{Ex}} - 1\right) \times crashes_{Ex}$$

$$crashes_{Pr} = \left(\frac{0.96}{1.0} - 1\right) \times 32 = -1.28$$

Based on the demonstrated calculations, the expected average crash frequency for all crashes is reduced by 4 percent or 1.28 crashes per year.

[3] From *Effects of Raising and Lowering Speed Limits on Selected Roadway Sections,* Parker, 1997 http://www.cmfclearinghouse.org/detail.cfm?facid=1239

9.3.2.5 Example 9: Change Intersection Skew Angle

Problem

A three-leg intersection with minor-road stop control on a rural multilane highway with an existing skew of 35 degrees currently has an expected average crash frequency of 20 crashes per year. Determine the expected average crash frequency if the minor road is made perpendicular to the highway (skew angle of zero).

Background

The Reduce Intersection Skew Angle CMF can be found in section 14.6.2.1 (p. 14-16) of the HSM. For a three-leg intersection on a rural multilane highway with minor-road stop control, HSM Equation 14-3 (HSM p. 14-19) is used to calculate the CMF, which applies to total intersection crashes. Additional equations are available for calculating intersection skew CMFs on rural two-lane highways and four-leg intersections, as well as for fatal-and-injury crashes only.

Data Requirements

- Existing expected average crash frequency: 20 crashes per year
- Existing intersection skew: 35 degrees
- Proposed intersection skew: 0 degrees

Analysis

For the existing condition, the skew angle CMF is:

$$CMF_{Ex} = \frac{0.016 \times skew}{(0.98 + 0.016 \times skew)} + 1.0$$

HSM Equation 14-3 (p. 14-19)

$$CMF_{Ex} = \frac{0.016 \times 35}{(0.98 + 0.016 \times 35)} + 1.0 = 1.3636$$

For the proposed condition, the skew angle CMF is:

$$CMF_{Pr} = \frac{0.016 \times skew}{(0.98 + 0.016 \times skew)} + 1.0$$

$$CMF_{Pr} = \frac{0.016 \times 0}{(0.98 + 0.016 \times 0)} + 1.0 = 1.0$$

The expected average crash frequency of the proposed condition can be calculated as a percentage of the expected average crash frequency of the existing condition:

$$crashes_{Pr} = \frac{CMF_{Pr}}{CMF_{Ex}} \times crashes_{Ex}$$

$$crashes_{Pr} = \frac{1.0}{1.3636} \times 20 = 14.67\ crashes\ per\ year$$

Based on the calculation of the CMF for both the existing and proposed intersection skew angles, the expected average crash frequency will be 15 crashes per year if the intersection of the minor roadway is made perpendicular with the highway.

9.3.3 HSM in the Pre-Opening Stage

Three examples are included:

- Example 10: Install Advance Warning Signs.
- Example 11: Add Retroreflective Sheeting to Signal Backplates.
- Example 12: Install Chevron Signs and Curve Warning Signs.

9.3.3.1 Example 10: Install Advance Warning Signs

Problem

A signalized intersection located just beyond a blind curve has an expected average crash frequency of 60 angle-type crashes per year. Determine the change in expected average crash frequency of angle-type crashes if "SIGNAL AHEAD" warning signs are installed in advance of the curve.

Background

The current edition of the HSM does not provide crash modification factor information for advance warning signs on signalized intersection approaches. Therefore, this example will utilize CMF ID 1684 from the CMF Clearinghouse, Install Advance Warning Signs (Positive Guidance).[4]

Data Requirements

- Existing expected average crash frequency: 60 crashes per year
- Existing condition: no advance warning signs
- Proposed condition: "SIGNAL AHEAD" warning signs installed on intersection approaches

Analysis

Based on the analysis provided, the CMF for the installation of "SIGNAL AHEAD" advance warning signs is 0.65 for angle-type crashes of all severities.

The expected average crash frequency following the installation of the advance warning signs can be calculated as:

$$crashes_{Pr} = \left(\frac{CMF_{Pr}}{CMF_{Ex}} - 1\right) \times crashes_{Ex}$$

$$crashes_{Pr} = \left(\frac{0.65}{1.0} - 1\right) \times 60 = -21$$

Based on the demonstrated calculations, the expected change in average crash frequency for angle-type crashes is a decrease of 21 crashes per year.

9.3.3.2 Example 11: Add Retroreflective Sheeting to Signal Backplates

Problem

An urban signalized intersection has an expected average crash frequency of 20 total crashes per year. Determine the 95th percentile confidence interval for expected average crash frequency of all crashes following the installation of retroreflective sheeting on the traffic signal backplates.

Background

This example will utilize CMF ID 1410 from the CMF Clearinghouse, Add 3-inch Yellow

[4] From *Low-Cost Safety Improvements Chapter 27, The Traffic Safety Toolbox: A Primer on Traffic,* Polanis, 1999
http://www.cmfclearinghouse.org/detail.cfm?facid=1684

Retroreflective Sheeting to Signal Backplates.[5]

Data Requirements

- Existing expected average crash frequency: 20 crashes per year
- Existing signal head backplate: non-reflective surface
- Proposed signal head backplate: 3-inch yellow retroreflective sheeting

Analysis

Based on the analysis provided, the CMF for adding 3-inch yellow retroreflective sheeting to the signal backplates is 0.85 with an unadjusted standard error of 0.005.

To calculate the 95th percentile confidence interval, the standard error should be multiplied by 1.96 (reference Table 9-5: Cumulative Probability Factors for various Confidence Intervals). This value should then be added to or subtracted from the CMF to find the upper and lower boundaries, respectively, of the confidence interval. Therefore, the 95th percentile confidence interval for adding 3-inch yellow retroreflective sheeting to the signal backplates can be calculated as:

$$[crashes_{lo}; crashes_{hi}] = [CMF \pm (error_{std} \times 1.96)] \times crashes_{Ex}$$ HSM Equation 3-8 (p. 3-22)

$$[crashes_{lo}; crashes_{hi}] = [0.85 \pm (0.005 \times 1.96)] \times 20$$

$$crashes_{lo} = 16.80$$

$$crashes_{hi} = 17.20$$

Based on the calculation of the confidence interval, it can be stated with 95 percent confidence that the expected average crash frequency following the installation of the 3-inch yellow reflective sheeting will be 17 crashes per year. It should be noted that a CMF with a very small standard error "indicates that the CMF is unlikely to change substantially with new research" (HSM p. D-4), suggesting a high level of reliability associated with the CMF's application.

9.3.3.3 Example 12: Install Chevron Signs and Curve Warning Signs

Problem

A sharp curve on a principal arterial with an AADT of 12,000 has an expected average crash frequency of 40 crashes per year. Determine the likely change in the expected average crash frequency, using a 95th percentile confidence interval, following the installation of curve warning and chevron signs along the curve.

Background

While the current edition of the HSM has crash modification factors for the installation of combination horizontal alignment/advisory speed signs in Table 13-30 (HSM p. 13-30), it does not provide a CMF for the installation of chevron signs on horizontal curves; however, Section 13A.6.1.1 states "installing chevron signs on horizontal curves in urban or suburban arterials appears to reduce crashes of all types." This example will utilize CMF ID 1905 from the CMF Clearinghouse, Install Chevron Signs and Curve Warning Signs.[6]

[5] From *Safety Impact of Increased Traffic Signal Backboards Conspicuity*, Sayed et al., 2005 http://www.cmfclearinghouse.org/detail.cfm?facid=1410

[6] Install chevron signs and curve warning signs, from *Safety Evaluation of Curve Delineation Improvements An Empirical Bayes Observational Before-After Study,* Montella, 2009 http://www.cmfclearinghouse.org/detail.cfm?facid=4177

Data Requirements

- Existing expected average crash frequency: 40 crashes per year
- Existing condition: no curve delineation treatment
- Proposed condition: curve warning signs in advance of curve and chevron signs along curve

Analysis

Based on the analysis provided, the CMF for installing chevron signs and curve warning signs is 0.592 with an unadjusted standard error of 0.1. It should be noted that this CMF applies to principal arterials and other freeways or expressways with AADT in the range of 10,434-13,975.

To calculate the 95th percentile confidence interval for a given CMF, the standard error should be multiplied by 1.96. This value should then be added to or subtracted from the CMF to find the upper and lower boundaries, respectively, of the confidence interval. Therefore, the 95th percentile confidence interval for expected average crash frequency following the installation of the chevron signs and curve warning signs can be calculated as:

$$[crashes_{lo}; crashes_{hi}] = [CMF \pm (error_{std} \times 1.96)] \times crashes_{Ex}$$ HSM Equation 3-8 (p. 3-22)

$$[crashes_{lo}; crashes_{hi}] = [0.592 \pm (0.1 \times 1.96)] \times 40$$

$$crashes_{lo} = 15.84$$

$$crashes_{hi} = 31.52$$

Based on the calculation of the confidence interval, it can be stated with 95 percent confidence that the expected average crash frequency following the installation of the chevron signs and curve warning signs will be between 16 and 32 crashes per year.

9.3.4 HSM in Post-Opening Stage and Existing Conditions

Five examples are included:

- Example 13: Install Fluorescent Curve Signs.
- Example 14: Changing Left Turn Phasing to Flashing Yellow Arrow.
- Example 15: Implement Safe Routes to School Program.
- Example 16: Install Pedestrian Countdown Timer.

9.3.4.1 Example 13: Install Fluorescent Curve Signs

Problem

A sharp curve on an undivided rural highway with an AADT of 6000 has an expected average crash frequency of 27 crashes per year. Determine the likely change in the expected average crash frequency for all crashes, using a 95th percentile confidence interval, following the replacement of the existing curve signs with fluorescent sheeting curve signs.

Background

The current edition of the HSM does not provide a CMF for the installation or upgrading of curve signs with fluorescent sheeting; therefore, this example will utilize CMF ID 2431 from the CMF Clearinghouse, Install New Fluorescent Curve Signs or Upgrade Existing Curve Signs to Fluorescent Sheeting.[7]

[7] From *Safety Evaluation of Improved Curve Delineation,* Srinivasan et al., 2009 http://www.cmfclearinghouse.org/detail.cfm?facid=2431

Data Requirements

- Existing expected average crash frequency: 27 crashes per year
- Existing condition: non-reflective curve signs
- Proposed condition: curve signs with reflective sheeting

Analysis

Based on the analysis provided, the CMF for installing chevron signs and curve warning signs is 0.82 with an unadjusted standard error of 0.077. It should be noted that this CMF applies to undivided rural highways with AADT in the range of 895-20,479.

To calculate the 95th percentile confidence interval for a given CMF, the standard error should be multiplied by 1.96. This value should then be added to or subtracted from the CMF to find the upper and lower boundaries, respectively, of the confidence interval. Therefore, the 95th percentile confidence interval for expected average crash frequency following the installation of the chevron signs and curve warning signs can be calculated as:

$$[crashes_{lo}; crashes_{hi}] = [CMF \pm (error_{std} \times 1.96)] \times crashes_{Ex}$$ HSM Equation 3-8 (p. 3-22)

$$[crashes_{lo}; crashes_{hi}] = [0.82 \pm (0.077 \times 1.96)] \times 27$$

$$crashes_{lo} = 18.07$$

$$crashes_{hi} = 26.21$$

Based on the calculation of the confidence interval, it can be stated with 95 percent confidence that the expected average crash frequency following the installation of the chevron signs and curve warning signs will be between 18 and 26 crashes per year.

9.3.4.2 Example 14: Changing Left Turn Phasing to Flashing Yellow Arrow

Problem

A four-leg signalized urban intersection has an AADT of 12,000 vehicles per day on the major road and 8,000 vehicles per day on the minor road. The intersection has an expected average crash frequency of 45 crashes per year, 40 percent of which are left-turn crashes. Determine the expected average crash frequency for both total crashes and left-turn crashes if the existing protected-permissive left turn phasing for each approach is changed to a flashing yellow arrow.

Background

The current edition of the HSM does not provide CMF information for a left-turn flashing yellow arrow at intersections; therefore, this example will utilize CMF ID 4176 (for total crashes) and CMF ID 4177 (for left-turn crashes) from the CMF Clearinghouse, Changing Left Turn Phasing from Protected-Permissive to Flashing Yellow Arrow (FYA).[8] Special attention should be given to the existing left-turn signal phasing, as there are different CMFs for a variety of existing left-turn signal phases (protected only, permissive only, protected-permissive, etc.)

Data Requirements

- Existing expected average crash frequency, total crashes: 45 crashes per year
- Existing expected average crash frequency, left-turn crashes: 45 × 0.4 = 18 crashes per year

[8] Changing left turn phasing from protected-permissive to flashing yellow arrow (FYA), from *Evaluation of Safety Strategies at Signalized Intersections,* Srinivasan et al., 2011 http://www.cmfclearinghouse.org/detail.cfm?facid=4176, http://www.cmfclearinghouse.org/detail.cfm?facid=4177

- Existing left-turn signal phasing: protected-permissive
- Proposed left-turn signal phasing: flashing yellow arrow

Analysis
Based on the analysis provided for changing left turn phasing from protected-permissive to flashing yellow arrow, the CMF for all intersection crashes is 0.922 and the CMF for left-turn crashes is 0.806. It should be noted that these CMFs apply to four-leg intersections with major road AADT in the range of 8,260 to 43,000 and minor road AADT in the range of 600 to 13,745.

The expected average crash frequency for all intersection crashes following the implementation of flashing yellow arrows can be calculated as:

$$crashes_{\mathrm{Pr}(total)} = CMF \times crashes_{\mathrm{Ex}(total)}$$
$$crashes_{\mathrm{Pr}(total)} = 0.922 \times 45 = 41.49$$

The expected average crash frequency for left-turn crashes following the implementation of flashing yellow arrows can be calculated as:

$$crashes_{\mathrm{Pr}(LT)} = CMF \times crashes_{\mathrm{Ex}(LT)}$$
$$crashes_{\mathrm{Pr}(LT)} = 0.806 \times 18 = 14.51$$

Based on the demonstrated calculations, the expected average crash frequency is 41 crashes per year for all intersection crashes, and 15 crashes per year for left-turn crashes.

9.3.4.3 Example 15: Implement Safe Routes to School Program

Problem
A roadway located in close proximity to an elementary school has an expected average crash frequency of 5 bicycle and pedestrian crashes per year. Determine the likely change in the expected average crash frequency, using a 95th percentile confidence interval, following the implementation of a Safe Routes to School program.

Background
The current edition of the HSM does not provide CMF information for Safe Routes to School programs; therefore, this example will utilize CMF ID 2205 from the CMF Clearinghouse, Implement Safe Routes to School Program (Age 5-12).[9]

Data Requirements

- Existing expected average crash frequency, bicycle and pedestrian type: 5 crashes per year
- Existing safety program: none
- Proposed safety program: Safe Routes to School

Analysis
Based on the analysis provided, the CMF for the implementation of a Safe Routes to School Program (for ages 5-12) is 0.724 for both pedestrian and bicycle-type crashes of all severities, with an unadjusted standard error of 0.0651.

To calculate the 95th percentile confidence interval for a given CMF, the standard error

[9] Implement Safe Routes to School Program (Age 5-12), from *Pedestrian and Bicyclist Safety Effects of the California Safe Routes to School Program*, Guiterrez et al., 208 http://www.cmfclearinghouse.org/detail.cfm?facid=2205

should be multiplied by 1.96 (reference Table 9-5: Cumulative Probability Factors for various Confidence Intervals). This value should then be added to or subtracted from the CMF to find the upper and lower boundaries, respectively, of the confidence interval. Therefore, the 95th percentile confidence interval for expected average crash frequency following the implementation of a Safe Routes to School Program can be calculated as:

$$[crashes_{lo}; crashes_{hi}] = [CMF \pm (error_{std} \times 1.96)] \times crashes_{Ex} \quad \text{HSM Equation 3-8 (p. 3-22)}$$

$$[crashes_{lo}; crashes_{hi}] = [0.724 \pm (0.0651 \times 1.96)] \times 5$$

$$crashes_{lo} = 2.98$$

$$crashes_{hi} = 4.26$$

Based on the calculation of the confidence interval, it can be stated with 95 percent confidence that the expected average crash frequency following the implementation of a Safe Routes to School Program will be between 3 and 4 crashes per year.

9.3.4.4 Example 16: Install Pedestrian Countdown Timer

Problem

A signalized intersection has an expected average crash frequency of 12 vehicle/pedestrian-type crashes per year. Determine the change in expected average crash frequency for vehicle/pedestrian crashes if pedestrian countdown timers are installed at the intersection.

Background

This example will utilize CMF ID 5272 from the CMF Clearinghouse, Install Pedestrian Countdown Timer. It should be noted that unlike previous examples utilizing CMFs from the CMF Clearinghouse, the prior (base) condition for CMF ID 5272 is listed as “unknown.” This example will assume the base condition to be the non-presence of any pedestrian signal, as the source material references a 2007 FHWA study showing the addition of countdown timers to existing pedestrian signals reduces crashes by 25 percent (Van Houten et al., p. 19).[10]

Data Requirements

- Existing expected average crash frequency: 12 crashes per year
- Existing pedestrian signalization: none
- Proposed pedestrian signalization: pedestrian signal head with countdown timer

Analysis

Based on the analysis provided, the CMF for the installation of pedestrian countdown timers is 0.3. Note that the CMF does not have an associated standard error; therefore, a confidence interval cannot be calculated when using this particular CMF.

The change in expected average crash frequency following the installation of the pedestrian countdown timers can be calculated as:

$$crashes_{Pr} = \left(\frac{CMF_{Pr}}{CMF_{Ex}} - 1\right) \times crashes_{Ex}$$

$$crashes_{Pr} = \left(\frac{0.3}{1.0} - 1\right) \times 12 = -8.4$$

Based on the demonstrated calculations, the expected average crash frequency for vehicle/pedestrian crashes is reduced by 70 percent or 8.4 vehicle/pedestrian crashes.

[10] Install pedestrian countdown timer, from *Evaluating pedestrian safety improvements,* Van Houten et al., 2012 http://www.cmfclearinghouse.org/detail.cfm?facid=5272

Works Cited

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Nabors, D., Gross, F., Moriarty, K., Sawyer, M., & Lyon, C. (2012). *Road Safety Audits: An Evaluation of RSA Programs and Projects.* Washington, DC: FHWA Office of Safety.

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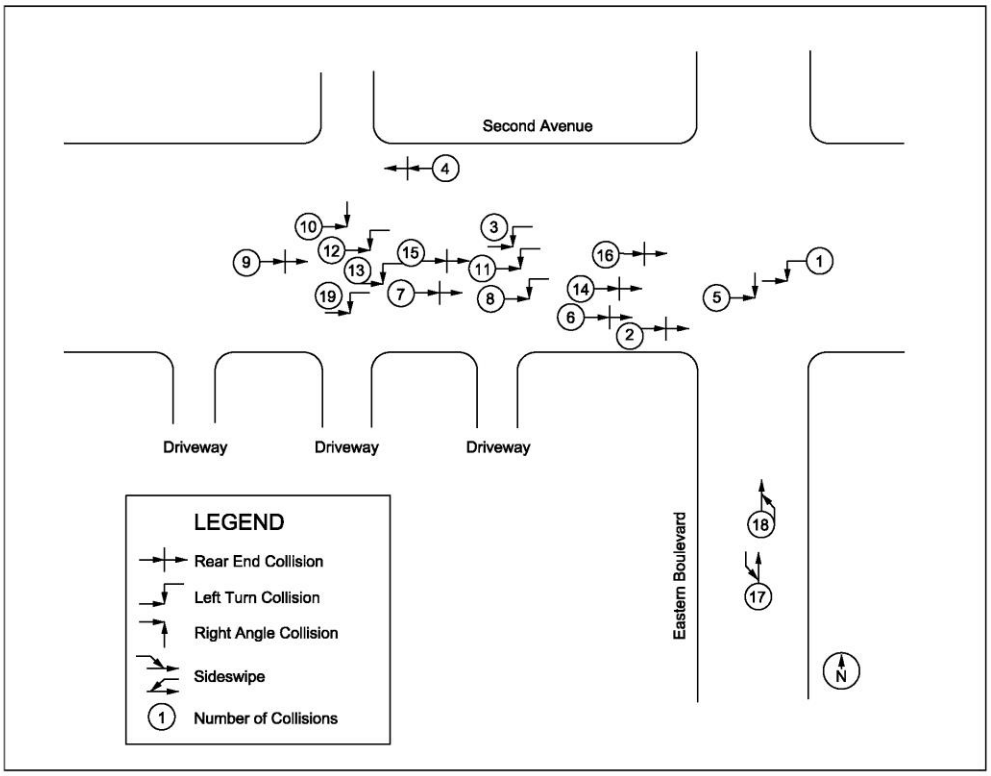
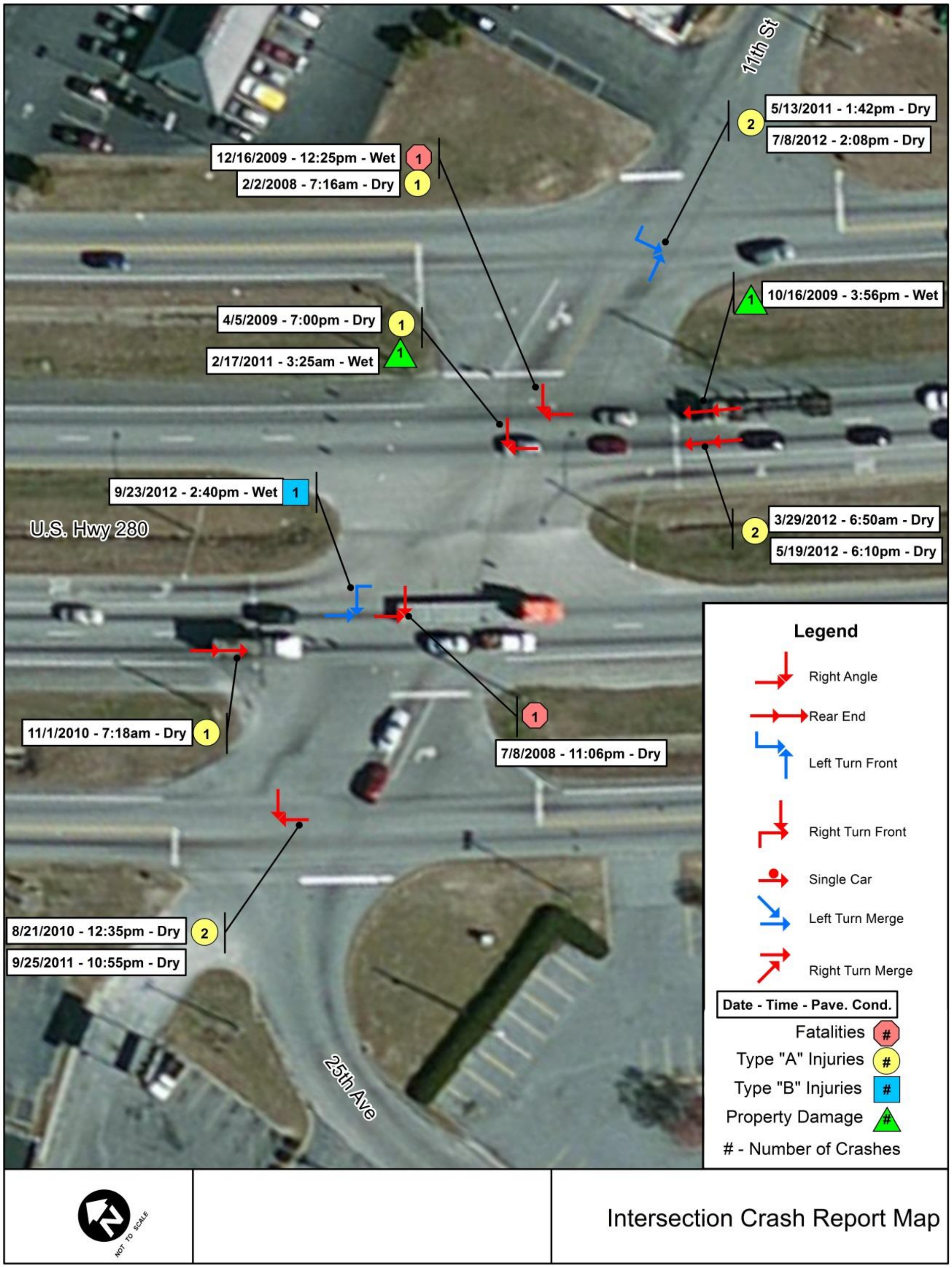
Appendix A

Sample Collision/Crash Diagrams

Sample Segment Collision Diagram without Aerial Photography



Sample Intersection Collision Diagram with Aerial Photography



Appendix B

Sample Documents

ALABAMA
DEPARTMENT OF TRANSPORTATION
CONSTRUCTION BUREAU
1409 COLISEUM BOULEVARD, G-101
MONTGOMERY, ALABAMA 36110
PHONE (334) 242-6216
FAX (334) 264-3727

ROBERT BENTLEY
GOVERNOR

JOHN R. COOPER
TRANSPORTATION DIRECTOR

April 21, 2016 ****EXAMPLE RSA COVER LETTER****

Mr. John Smith
Region Engineer
Alabama Department of Transportation
P. O. Box 1234
Birmingham, AL 35202-2745

ATTN: Ms. Jane Jones

RE: State Route 123, From State Route 11 to State Route 22
Shelby County, Mile Post 1.23 to Mile Post 9.87
Project No. XX-000-000-000

A study of State Route 123 was initiated by the Alabama Department of Transportation as a candidate safety project. State Route 123 from mile post 1.23 to mile post 9.87 is classified as a two (2) lane rural major collector with lane widths of eleven (11) feet and shoulder widths of one (1) foot to three (3) feet. State Route 123 was added to the Highway Safety Improvement Program (HSIP) list and qualifies because the severe crash rate of 0.174 exceeds the statewide average severe crash rate of 0.161 for a rural major collector.

The total estimated cost of the improvements listed in the report is $100,000. No right-of-way acquisition is anticipated. A maintenance agreement is not required. A local match is not required. These improvements will be let to contract.

If you should need any further information, please contact me at (205) 555-1234 or email at email@dot.state.al.us.

SA/bd

Attachment
CC: John Doe, Jim Black, Anne Brown, File

This document is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

Alabama Department of Transportation
Road Safety Assessment (RSA) Application

1. Contact Person:

   Name: ______________________________

   Title & Agency: ______________________________

   Address: ______________________________

   Phone: ______________________________

   Email: ______________________________

2. Type of RSA requested (existing facility, planning, design, or construction): ______________

3. Specify location of proposed RSA project (intersection, spot location, road segment, or new facility):

   Route(s) Name: ______________________________

   Is the facility a State Route __________ or a Local / County Route __________

   Specify the road's maintaining agency: ______________________________

   Segment/Intersection Description: ______________________________

   ____

4. Describe any previously approved improvement plans, including stage *(scoping, design, construction, etc.)* for this location:

   ____

   ____

   ____

5. Reasons for requesting RSA: ______________________________

   ____

   ____

6. For an existing facility, please describe the crash experience for the most recent 5-year period:

   # total crashes: __________ # fatal crashes: __________ # injury crashes: __________

7. Describe any unusual or outstanding safety issues: ______________________________

   ____

8. Does your agency systematically identify and rank safety concerns? ________ y / n

   If yes, where does this location rank within your agency's overall ranked locations? __________________

9. Average Daily Traffic (ADT) volume for road(s): ____

10. If applicable, list the time and/or conditions (day, month, hour, weather, lighting, etc.) when safety concerns are most prevalent:

    ____

11. Describe any future development planned for this area: ____

    ____

12. Please attach a photo and/or map to identify the location.

13. Is funding support being requested from ALDOT? __________ (y / n)

    What is the estimated amount of funds needed to conduct the RSA? _______________

14. The following person(s) have authority to respond to and implement the RSA findings:

Printed Name	Printed Name
Signature	Signature
Date	Date

Submit Application to:

Mr. Tim Barnett, P.E., PTOE
State Safety Operations Engineer
Alabama Department of Transportation
1409 Coliseum Boulevard
Montgomery, AL 36110
Phone: (334) 353-6414
Email: barnettt@dot.state.al.us

Approval:

_________________________________ __________________
Tim Barnett Date

Distribution of approved form to:

Project Owner(s): ____

ALDOT Region or Area: ____________________________________

This document is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

Alabama Department of Transportation
Road Safety Review (RSR) Application

1. Contact Person:

   Name: ______________________________

   Title & Agency: ______________________________

   Address: ______________________________

   Phone: ______________________________

   Email: ______________________________

2. Type of RSR requested (existing facility, planning/permitting, construction work zone):

   ____

3. Specify location of proposed RSR project (intersection, spot location, road segment):

   Route(s) Name: ______________________________

   Is the facility a State Route __________ or a Local / County Route __________

   Specify the road's maintaining agency:

   ____

   Segment/Intersection Description: ______________________________

   ____

4. Describe any previously approved improvement plans, including stage (scoping, design, construction, etc.) for this location:

   ____

   ____

   ____

5. Reasons for requesting RSR: ______________________________

   ____

   ____

6. For an existing facility, please describe the crash experience for the most recent 5-year period:

   # total crashes: __________ # fatal crashes: __________ # injury crashes: __________

7. Describe any unusual or outstanding safety issues: ______________________________

   ____

This document is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

8. Does your agency systematically identify and rank safety concerns? ________ y/n

   If yes, where does this location rank within your agency's overall ranked locations? __________________

9. Average Daily Traffic (ADT) volume for road(s): ____

10. If applicable, list the time and/or conditions (day, month, hour, weather, lighting, etc.) when safety concerns are most prevalent:
    ____

11. Describe any future development planned for this area: ____

    ____

12. Please attach a photo and/or map to identify the location.

13. The following person(s) have authority to respond to and implement the RSR findings:

Printed Name	Printed Name
Signature	Signature
Date	Date

Submit Application to Project Owner:

Approval:

____
Signature

_________________________________ ____________________
Printed Name Date

Distribution of approved form to:

Project Requestor: _______________________________________
ALDOT Region or Area: _____________________________________
ALDOT Traffic & Safety Operations Section

This document is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

Appendix C

Software Tools

Roadway Improvement Safety Evaluation (RISE)

The RISE software combines aspects of CARE (*discussion below*) and Safety Analyst (*FHWA software using HSM approaches*) toward crash assessment. The initial deployment in Alabama focused on crash assessment for pavement overlay pavement rehabilitation projects. A later version covers various crash types' assessments and other roadway project types.

Critical Analysis Reporting Environment (CARE)

The Center for Advanced Public Safety created a data analysis software package called Critical Analysis Reporting Environment (CARE) to identify and develop countermeasures for traffic safety issues. CARE is accessed via this link.

http://caps.ua.edu/care.aspx.

Significant information can be retrieved from this traffic safety software by using advance analytical and statistical techniques. Although traffic safety was the original usage for the software, it has become applicable to a variety of other uses including database for emergency medical services, questionnaires, and criminal justice. The CARE software for traffic safety applications is free and can be downloaded or installed from the CARE Online Analysis Web site. The program can assist in traffic safety by inputting the state data in to the dataset, which is then read by CARE's Extract-Translate-Load (ETL).

Some of the main functions of CARE are:

- Statistical Generation – retrieve information and create filters for the database to generate statistics
- Data Analysis – produce charts and graphs from database variables
- Information Mining Capability – automatically generate information from data by specifying the filter
- Non-categorical variables – can be specified
- Narrative Data Searching – ability to process narrative descriptions
- Report and collision diagram – ability to generate figures
- GIS Integration – ESRI/ArcGIS is integrated into CARE

Additional enhancements to CARE will support HSM methodologies and referred to as the "CARE+" model.

Interactive Highway Safety Design Model

The Interactive Highway Safety Design Model (IHSDM) was designed by FHWA (2007) with the sole purpose of being a useful software analysis tool that evaluates safety and operational effects of geometric design decisions. Data from different platforms can be uploaded into IHSDM, including GEOPAK, Micro Station, ASCII Text, and Microsoft Excel spreadsheets. The program is available for the analysis of two-lane rural highways; however expansion for use in four-lane rural highways is underway. Documentation of IHSDM is available online at

http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/6288/THESIS%20FINAL%20houghton.pdf.txt?sequence=3 (r*efer to Chapter 7*).

The IHSDM is made up of six main modules:

- Crash Prediction Module – implements the HSM predictive methods to estimate the predicted and expected average crash frequency of two-lane rural roads, multilane rural highways, and urban and suburban arterials.
- Design Consistency Module – analyzes safety issues on horizontal curves. This module evaluates a speed profile model, free-flow speeds, and passenger vehicle speeds. The speed profile model evaluates 85th percentile speeds on horizontal and vertical curves, and tangent speeds, among others.
- Driver and Vehicle Module – evaluates the operation of vehicles on the roadway to determine the possibility of loss of control using performance and vehicle dynamics models.
- Intersection Review Module – assesses intersection elements. Evaluation can be conducted in four different categories: intersection configuration, horizontal alignment, vertical alignment, and intersection sight distance.
- Policy Review Module – evaluates the roadway design for compliance with design standards. It contains design standards for multiple editions of the AASHTO geometric design guide. The module checks for compliance for roadway cross sections, horizontal and vertical alignments, and sight distance.
- Traffic Analysis Module – predicts traffic conditions for current or future traffic volumes at roadway projects with the use of TWOPAS traffic simulation software.

TWOPAS uses geometric data from other modules, and implements the Highway Capacity Manual procedures. It can determine the average speed and percent time spent following for roadway design.

Appendix D

Sample Crash Data Calculations

Calculating Crash Frequency and Crash Rate

Given:

- 35 intersection-related crashes in the study period
- 5 years of data
- 7,000 vehicles entering the intersection daily

Find: Crash Frequency and Crash Rate

Equation:

$$\boldsymbol{Crash\ Frequency\ =\ C/N}$$

Solution:

$$\boldsymbol{Crash\ Frequency\ = \frac{C}{N} = \frac{35}{5} = 7\ crashes/year}$$

Equation:

$$\boldsymbol{Crash\ Rate\ (R) = \frac{1,000,000\ x\ C}{365\ x\ N\ x\ V}}$$

Solution:

$$\boldsymbol{Crash\ Rate\ (R) = \frac{1,000,000\ x\ C}{365\ x\ N\ x\ V} = \frac{1,000,000\ x\ 35}{365\ x\ 5\ x\ 7,000}\ = 2.74\ crashes/MEV}$$

Where:

R = Crash rate for the intersection expressed as crashes per million entering vehicles (MEV)

C = Total number of intersection-related crashes in the study period

N = Number of years of data

V = Traffic volumes entering the intersection daily

Note: To find the crash rate for a road segment instead of an intersection use the following equation:

$$\boldsymbol{R = \frac{100,000,000\ x\ C}{365\ x\ N\ x\ V\ x\ L}}$$

Where L = Length of the roadway segment in miles

Appendix E

RSA and RSR Steps

RSA Steps:

Step	Date Completed	Notes
1. Identify project or site to be assessed		
2. Select RSA team members		
3. Assemble Data		
a. Traffic Volumes		
b. Crash Data, including crash reports		
c. Miscellaneous (speed data, signal timing, roadway plans etc.)		
4. Analyze background data		
5. Invite team members, distribute pertinent background information, and schedule pre-assessment meeting.		
6. Issue invitations to Kick-Off meeting		
7. Team Meeting & Data Review		
8. Field Review		
9. Analyze safety issues and identify countermeasures		
10. Post-assessment review meeting		
11. Draft RSA Report		
12. Distribute report for review		
13. Address comments and finalize report		
a. Final approval		
b. Owner issues response report		

RSR Steps:

Step	Date Completed	Notes
1. Select RSR team members		
2. Assemble Data		
a. Traffic Volumes		
b. Crash Data, including crash reports		
c. Miscellaneous (speed data, signal timing, roadway plans etc.)		
3. Analyze background data		
4. Field Review		
5. Analyze safety issues and identify countermeasures		
6. Prepare summary report		
7. Address comments and finalize report		
8. Final approval		
9. Owner issues response report		

Appendix F

RSA & RSR Examples

<u>This sample document is intended to serve as a guide for preparation of a Road Safety Assessment report. BLUE TEXT is used to show example templates and prompts to guide the RSA/RSR author. BLACK TEXT is used to provide an actual example of report text, tables, and figures. The road segment location, observations, and recommendations in this report are fictitious.</u>

This is an example Road Safety Assessment Report for a road segment.

ROAD SAFETY ASSESSMENT REPORT

Road Name
From Mile Point XX.X to Mile Point XX.X
XX County

PREPARED BY
(CONSULTANT) FOR
ALABAMA DEPARTMENT OF TRANSPORTATION

Approved by:	Signature	Date

This report is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

ADMONITION

This document is exempt from open records, discovery or admission under Alabama Law and 23 U.S.C. §§ 148(h)(4) and 409). The collection of safety data is encouraged to actively address safety issues on regional, local, and site specific levels. Congress has laws, 23 U.S.C. § 148(h)(4) and 23 U.S.C. § 409 which prohibit the production under open records and the discovery or admission of crash and safety data from being admitted into evidence in a Federal or state court proceeding. This document contains text, charts, tables, graphs, lists, and diagrams for the purpose of identifying and evaluating safety enhancements in this region. These materials are protected under 23 U.S.C. §409 and 23 U.S.C. § 148(h)(4). In addition, the Supreme Court in *Ex parte Alabama Dept. of Trans., 757 So. 2d 371* (Ala. 1999) found that these are sensitive materials exempt from the Alabama Open Records Act.

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APPENDICES

- ☐ *Insert additional appendices as appropriate.*

Executive Summary

☐ *List of identified concerns*

This segment was identified as a safety need by the ALDOT Traffic and Safety Operations Section. State Route 22 is a rural highway on the state maintained system. The studied segment of State Route 22 extends from mile point 5.75 at Creek Road to mile point 6.37 at Shinbone Road, a distance of 0.62 miles. The segment is located in unincorporated Surry County. The road has two (2) travel lanes with lane widths of ten (10) feet and shoulders of two (2) feet or less in width. The posted speed limit is 45 miles per hour.

Field observations documented concerns related to intersection geometry, intersection sight distance, and condition of signing and striping. A total of seven (7) crashes occurred in this road segment over a recent five year period, with one (1) fatal crash, one (1) non-incapacitating injury crash, and five (5) property damage only crashes.

☐ *Location map with numbering to show where each deficiency is located*

Figure 1 provides an aerial map of the studied road segment and a listing of observed deficiencies.

☐ *Recommended improvements*

Based on analysis of crash history, traffic volumes, land uses, geometric features, and field observations, the Road Safety Assessment (RSA) team has identified the following improvements for implementation. These mitigations are described in more detail and illustrated in the Improvements section of this report.

- Improve geometric alignment at the intersection of State Route 22 and State Route 33 by removing the flared connector to create one 90-degree intersection. Upgrade all striping and signage in advance of and at the intersection.
- Improve retroreflectivity of signage and striping at the intersection of Creek Road and State Route 22 to improve nighttime visibility.
- Install enhanced guardrail delineation on an existing section of guardrail located between Creek Road and Shinbone Road to improve nighttime visibility.
- Improve retroreflectivity of signage and striping at the intersection of Shinbone Road and State Route 22 to improve nighttime visibility.

The estimated cost of improvements in this report is $51,500. No right-of-way is required.

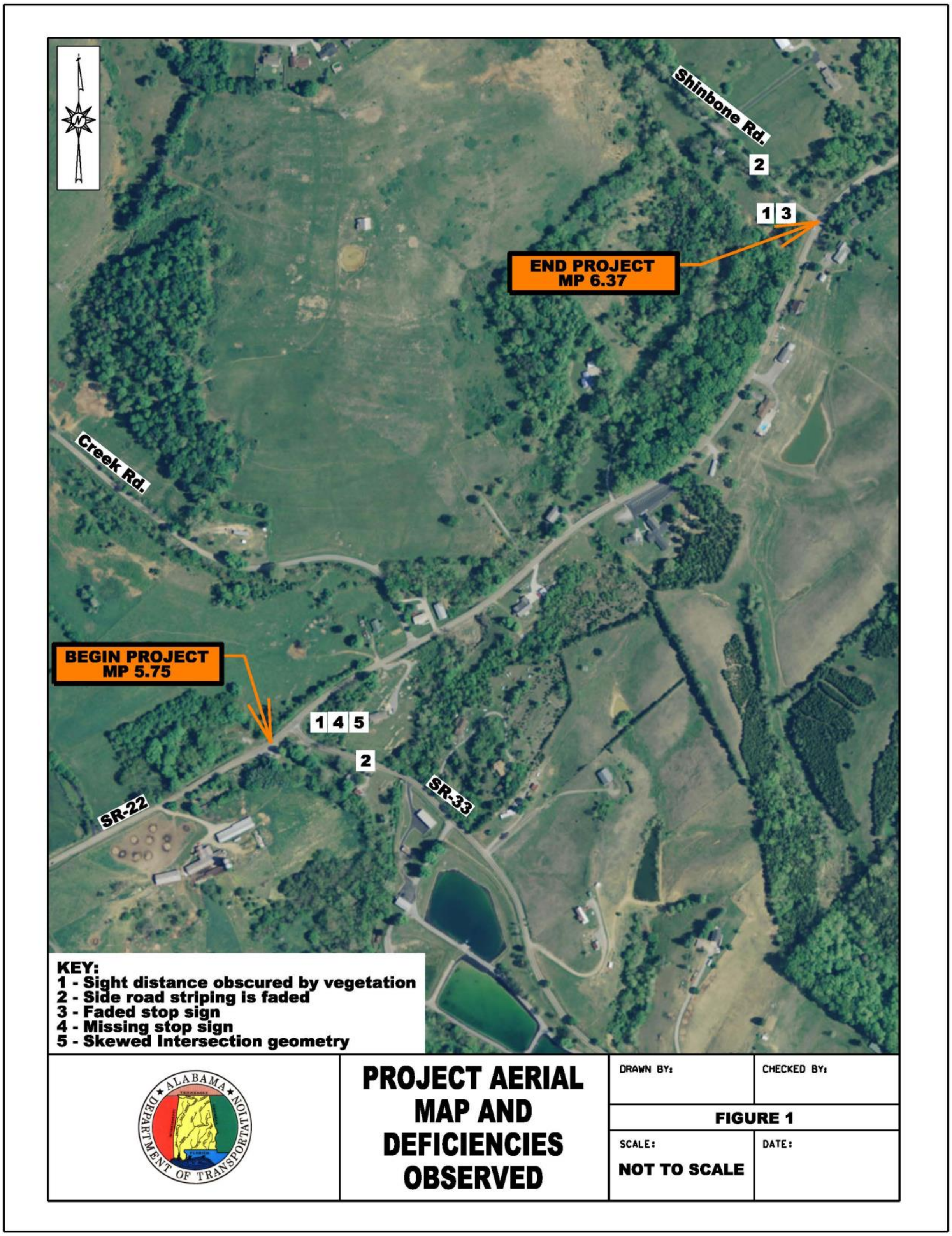

Figure 1: Project Aerial Map and Deficiencies

Funding Disclaimer

- *Report does not guarantee any particular funding*
- *All projects must meet the criteria of a particular funding source*

The mitigations documented in this report were identified for implementation by the RSA team and do not represent any commitment for implementation from the maintaining agency or concurrence for any particular funding source. All projects that are implemented as a result of an RSA must meet the individual criteria of the associated funding source.

Introduction and Project Description

☐ *Define an RSA*

A Road Safety Assessment (RSA) is a formal examination of a road's safety performance by an independent and multidisciplinary team. This RSA was conducted by a consultant under the authority of the ALDOT Traffic and Safety Operations Section.

☐ *Describe the process followed (time, date, location, etc. with condensed outline of the general RSA process*

☐ *Identify the project owner*

This segment of State Route 22 in Surry County (Figures 2 and 3) was identified as a safety need by ALDOT's Traffic and Safety Operations Section as having an overrepresentation of crashes and was included in a statewide study of horizontal curves with crash history. The subject road segment is located in Surry County but is a state route maintained by ALDOT.

A summary of action items accomplished for this RSA follows:

- Contract for preparation of an RSA was executed on October 28, 2014.
- Background data, including traffic volumes, aerial photography, geometric features, and crash history, was assembled and reviewed.
- A preliminary RSA briefing of the RSA team with the County Engineer and ALDOT staff was held at 1:00 PM on Friday, November 14, 2014 at the ALDOT Area office.
- Additional information on utilities was gathered as a result of the preliminary briefing meeting.
- A field review was conducted by the RSA team on November 25, 2014.
- Field observations and measurements were reviewed for potential risk factors and countermeasures. The RSA team developed and prioritized mitigations for the identified deficiencies.
- On December 5, 2014, the RSA team conducted a post-assessment meeting with the County Engineer and ALDOT staff to present and discuss the recommended countermeasures.
- Comments from the post-assessment meeting were addressed and incorporated into this report document.

☐ *Identify the project location, project phase and why the RSA is warranted*

The location assessed in this effort is an existing state roadway in full operation that was identified as a safety need through ALDOT.   The route segment is 0.62 miles long functioning as a two (2) lane rural roadway with lane widths of ten (10) feet and shoulders of two (2) feet or less.

☐ *Insert a Vicinity Map – Include pertinent data as needed*
- *Street Names*
- *Traffic Generators*
- *Congestion Hot Spots*

☐ *Insert a Project Aerial Map*

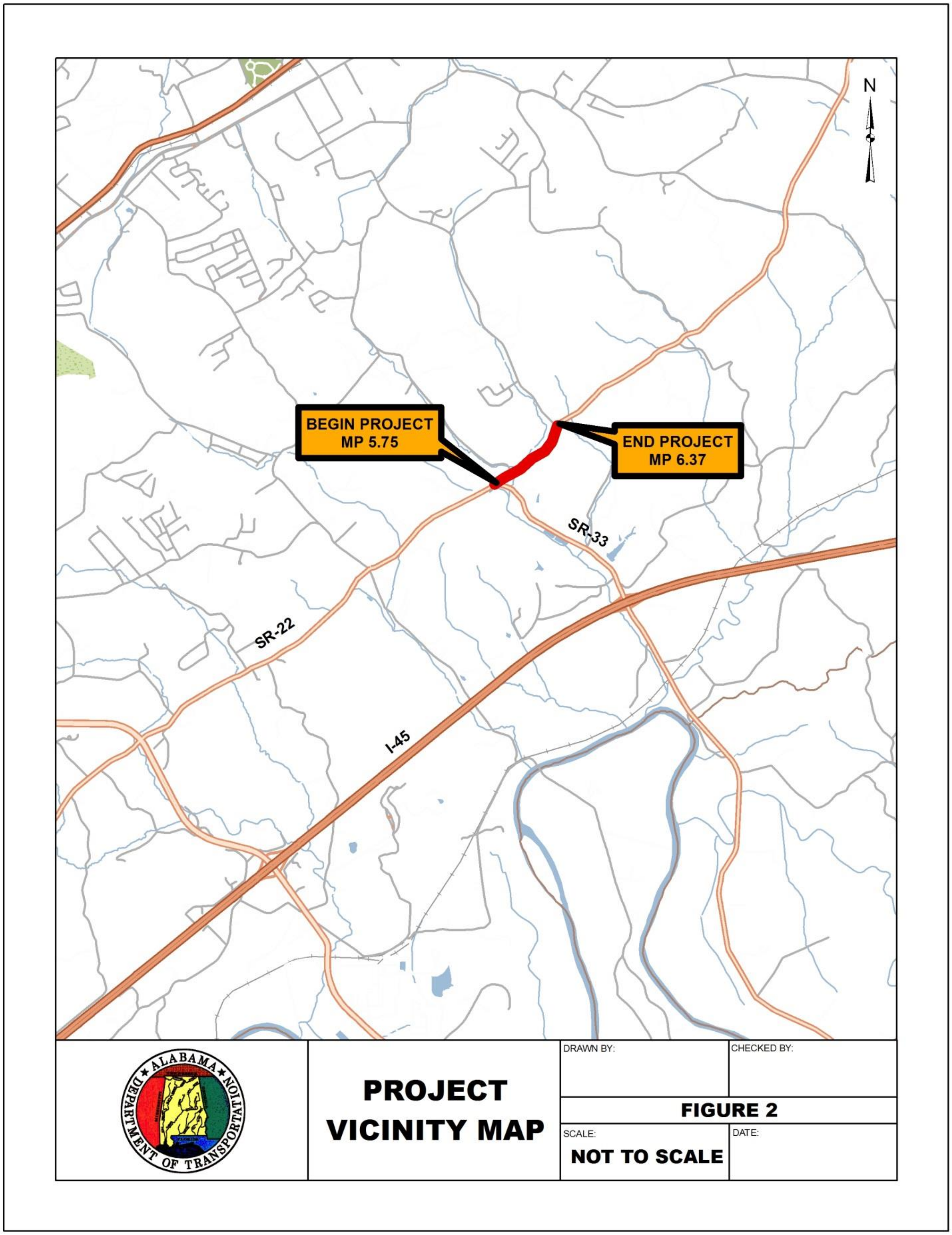

Figure 2: Project Vicinity Map

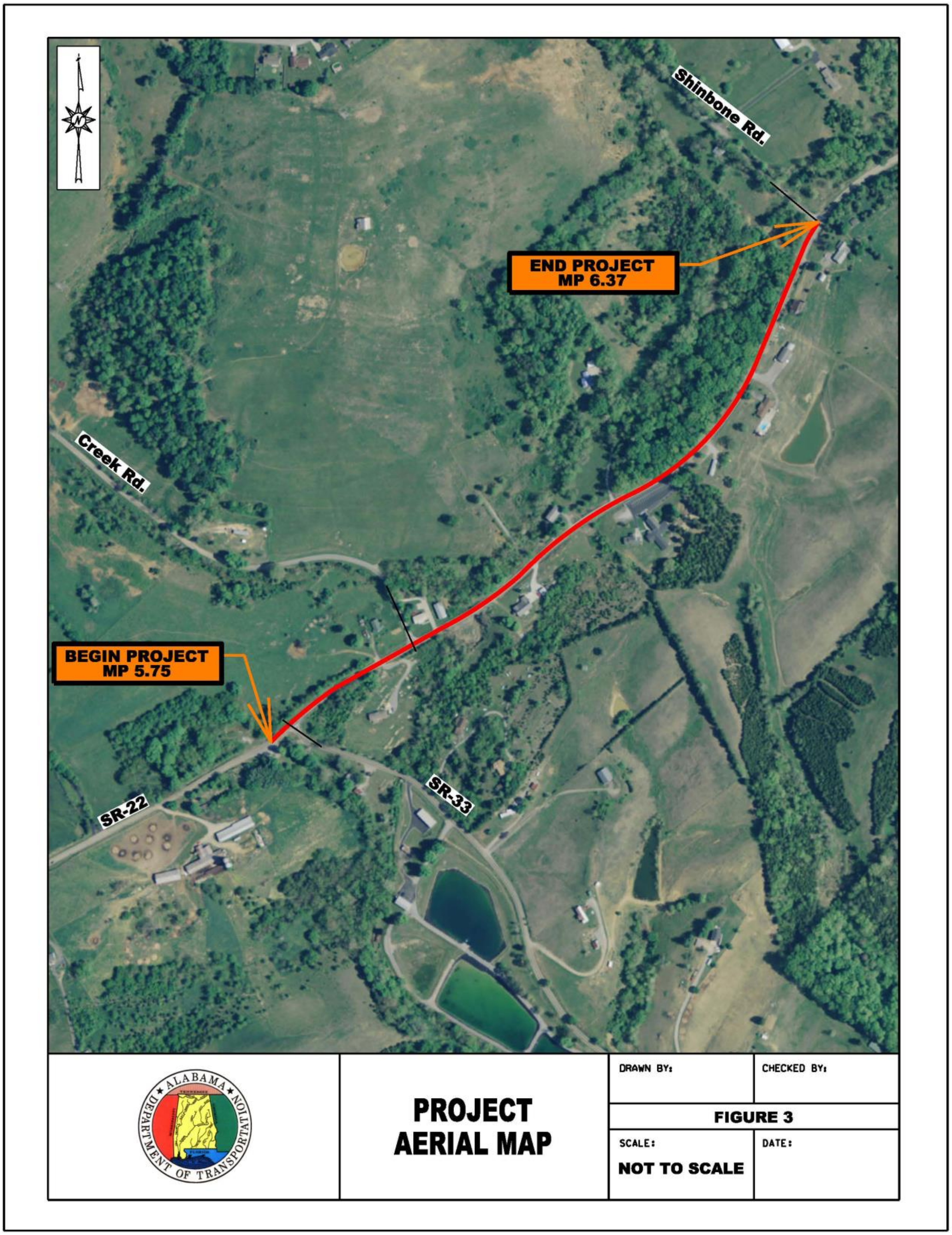

Figure 3: Project Aerial Map

RSA Team

☐ *Identify RSA team members by name, organization/office, professional titles, role on the RSA team (leader, member, observer), and fields or specialties they represent (design, safety, operations, etc.). This is the standard format of RSA Team Roles and Specialties to be used.*

An RSA team evaluated the study area to determine appropriate safety measures. The following is a summary of the RSA team members by name, team role, and specialty.

Table 1: RSA Team Members

Name	Organization	Title	RSA Team Role	Specialty
John Doe	Ace Engineers	Project Manager	RSA Team Leader	Road Safety /Traffic Operations
Josh Johnson	Ace Engineers	Traffic Designer	RSA Team Member	Road Safety /Traffic Operations
Steve White	ALDOT	District Manager	RSA Team Member	Maintenance/Construction
Jane Smith	ALDOT	Preconstruction Engineer	RSA Team Member	Roadway Design
Chuck Jackson	ALDOT	State Safety Operations Engineer	RSA Team Member	Road Safety
William Hall	ALDOT	Maintenance Engineer	RSA Team Member	Maintenance
Tom Parker	ALDOT	Traffic Engineer	RSA Team Member	Traffic Engineering

Data Reviewed and Site Characteristics

Identify all documents and data considered during the RSA process

☐ Road Inventory Database
☐ Traffic Counts
☐ Crash Data
☐ Construction plans, if available

The Annual Average Daily Traffic (AADT) for the current year along the roadway segment is 1,440 vehicles per day. The roadway is located in a rural setting with residential and agricultural land uses abutting the roadway. Drainage is accommodated by roadside ditches that vary in width and depth throughout the segment. Two creeks, Slop Branch and Hale Branch, converge on the north side of State Route 22 and cross under the road via a concrete box culvert. There are no pedestrian or bicycle accommodations along the road or at any of its intersections with cross streets. All intersections along the studied road segment are controlled by side-street stop signs.

Summarize and discuss findings from the crash analysis.

A five (5) year crash summary from the CARE database and a review of actual crash reports for severe crashes indicated the following:

- Seven (7) total crashes were reported on this roadway segment
- One (1) non-incapacitating injury crash
- One (1) fatal crash, involving one fatality

If possible, include a summary table that lists the crashes by location, type, environmental conditions, and driver factors. If too numerous to list individually, the author may choose to group crashes by type and list the number of occurrences by that type.

Table 2: Summary of Crash Data

Crash Report No.	M.P.	Location SR-22	Driver Condition	Alcohol or Drugs Involved	Lighting Condition	Weather	Driver Age	Fixed/Not Fixed Object	Collision	Driver Action	Crash Type
2602826	5.8	At Creek Rd.	Normal/ Normal	No/No	Dark	Rain	55/31	Not Fixed Object	Vehicle	Failure to Yield	Non-Incap. Injury
9000486	5.8	At SR-33	Normal/ Normal	No/No	Daylight	Cloudy	33/42	Not Fixed Object	Vehicle	Rear-end	Property Damage
0618697	5.8	At SR-33	Normal/ Normal	No/No	Daylight	Rain	60/75	Not Fixed Object	Vehicle	Rear-end	Property Damage
8072278	5.9	Along Roadway	Normal	No	Daylight	Clear	26	Fixed Object	Deer	Straight	At Creek Road
2334577	6.0	Along Roadway	DUI	Yes	Dark	Clear	72	Fixed Object	Tree	Ran off Road	Property Damage
7223456	6.3	At Shinbone Rd.	Normal/ Normal	No/No	Daylight	Cloudy	24/28	Not Fixed Object	Vehicle	Failure to Yield	Property Damage
2703396	6.3	At Shinbone Rd.	Normal/ Normal	No/No	Daylight	Rain	39/16	Not Fixed Object	Vehicle	Failure to Yield	Fatality

Crash severity by location along the segment is shown in Figure 4.

☐ Project Aerial Map with locations of crashes and crash types

Insert an aerial map that shows locations of crashes by crash type. This could be done using a dot style format or with a traditional crash diagram style. The dot style format (see Figure 4) is most helpful for long road segments and large scale mapping.

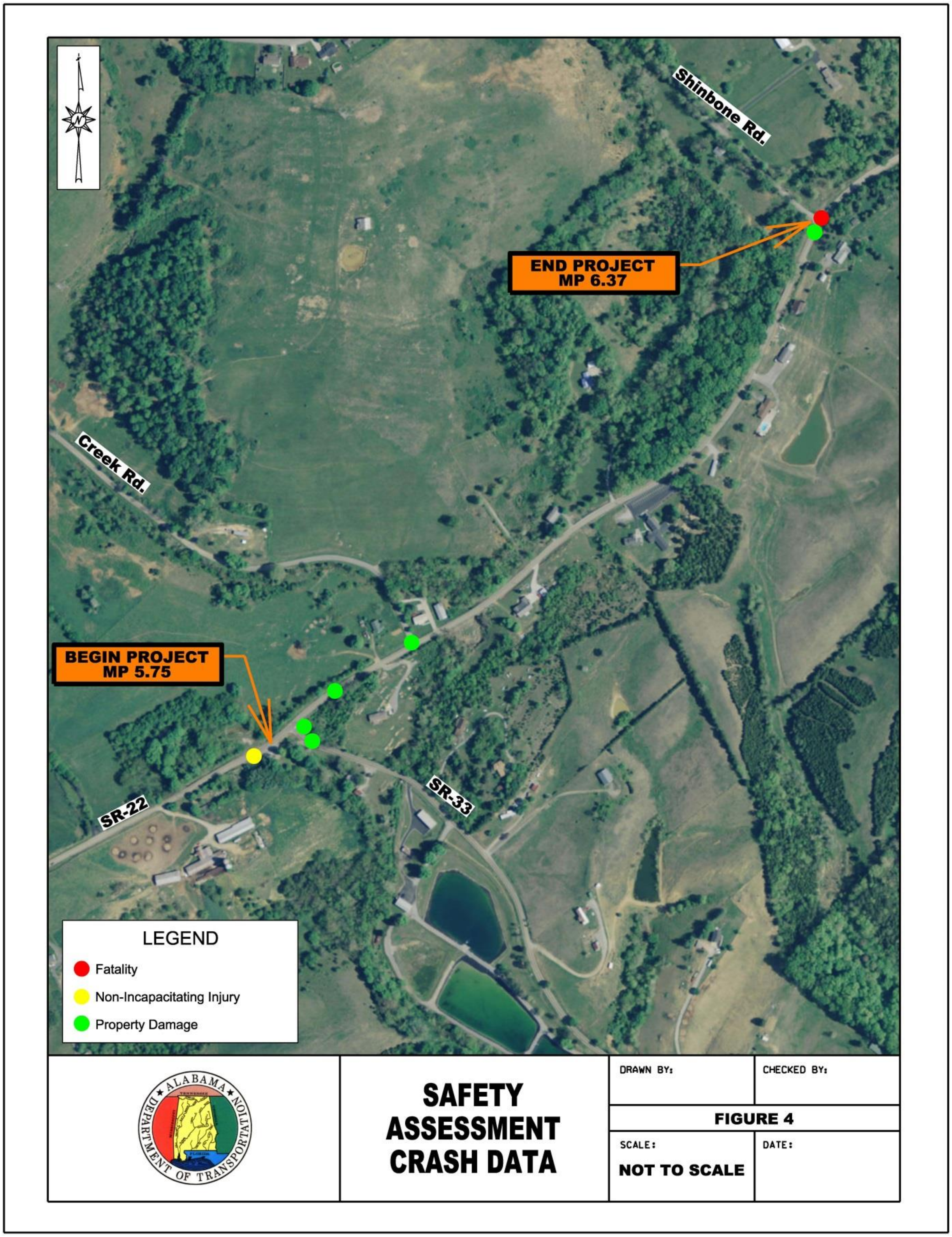

Figure 4: Safety Assessment Crash Data

Site Visit

- ☐ *Identify date, weather conditions, time, light conditions, attendees for site visit*
- ☐ *Photographs*

The RSA team conducted a field review of State Route 22 from mile point 5.75 to mile point 6.37 at 2:00 p.m. on November 25, 2014. All members of the team were present for the review. The review was conducted during clear weather conditions on a weekday while traffic conditions were normal. Due to questions concerning the quality of nighttime visibility, the RSA team leader and other members from the lead consultant firm conducted additional observations after sunset on November 25.

Photographs were taken at multiple locations along the roadway. The figures on pages 11-23 include a photo location guide (Figures 5A, 5B, and 5C) and photos taken during the review.

- ☐ *Describe conditions observed on site visit*

The following is a summary of observations concerning the subject segment of State Route 22 noted by the RSA team during the field review.

- The route is a two (2)-lane rural major collector. (State Route 33 is also a two (2)-lane rural major collector.)
- The posted speed limit is 45 miles per hour.
- Travel lanes are primarily ten (10) feet wide asphalt.
- Outside shoulders are two (2) feet wide or less.
- The majority of the crashes occurred at the intersection SR-22 and Creek Road.
- Traffic signing and pavement markings are in good condition.
- The sight distance at the intersection of State Route 22 with State Route 33 is not adequate for the prevailing speeds. Sight distance will be improved with the removal of roadside vegetation.
- The striping along the side roads are faded, as is the stop sign on Shinbone Road. The stop sign at Creek Road is in good condition. The faded striping and sign are not easily visible at night.
- Sight distance at the Creek Road and Shinbone Road intersections can be increased by pulling the existing stop bar back approximately ten (10) feet.
- A cedar tree obstructs the view of the Shinbone Road sign for traffic on State Route 22.

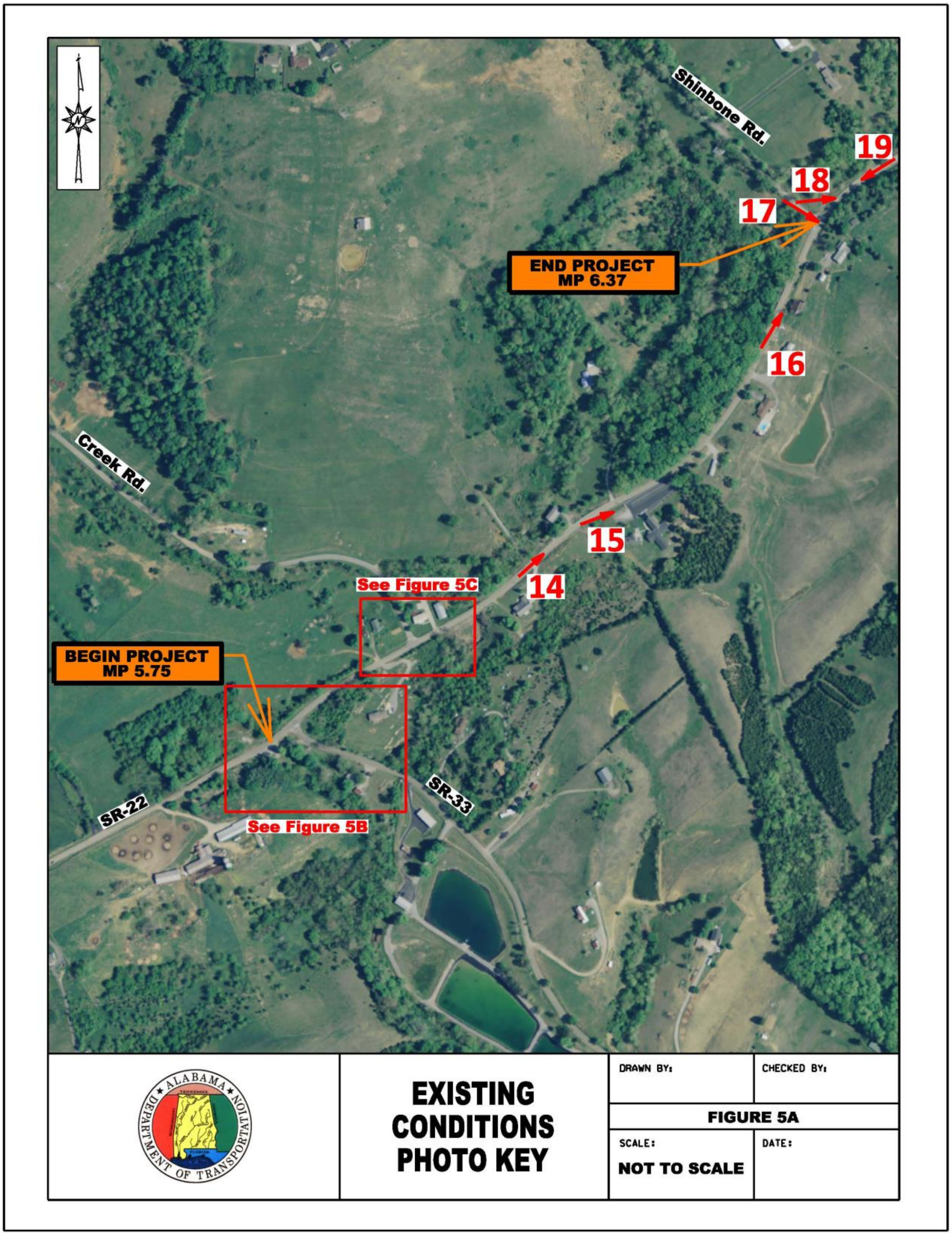

Figure 5A: Existing Conditions Photo Key

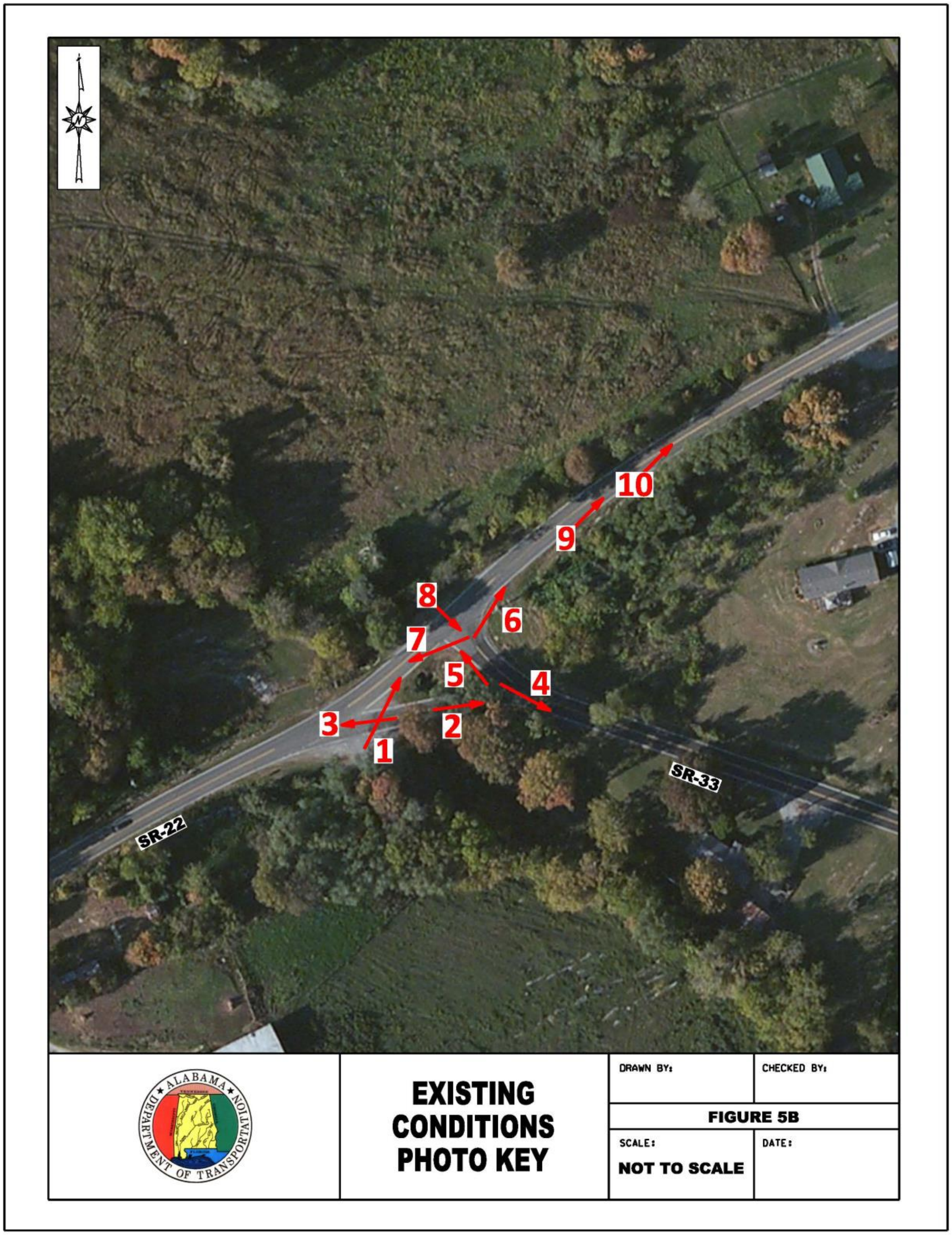

Figure 5B: Existing Conditions Photo Key

Figure 5C: Existing Conditions Photo Key

Photos taken on Thursday, November 17, 2014

Photo 1:
Looking northeast along SR-22 approaching SR-33

Photo 2:
Looking east along SR-22 approaching SR-33

Photo 3:
Looking southwest along SR-33 at the SR-22 intersection

Photo 4:
Looking eastbound along SR-33 just south of SR-22

Photo 5:
Looking northbound along SR-33 at the intersection with SR-22

Photo 6:
Looking northeast along SR-22 at the intersection with SR-33

Photo 7:
Looking southwest along SR-33 at the intersection with SR-22

Photo 8:
Looking southeast along SR-33 at the intersection with SR-22

Photo 9:
Looking northeast along SR-22 approaching Creek Road

Photo 10:
Looking northeast along SR-22 approaching Creek Road

Photo 11:
Looking north along SR-22 approaching Creek Road

Photo 12:
Looking southbound on Creek Road toward the intersection with SR-22

Photo 13:
Looking northeast atSR-22 from Creek Road

Photo 14:
Looking northeast along SR-22

Photo 15:
Looking northeast along SR-22

Photo 16:
Looking northeast along SR-22

Photo 17:
Looking southwest at SR-22 from Shinbone Rd.

Photo 18:
Looking northeast at SR-22 from Shinbone Rd.

Photo 19:
Existing advance warning sign looking east along SR-22 approaching Shinbone Rd.

Photo 20:
Existing advance warning sign looking east along SR-22 approaching SR-33

Safety Concerns and Risk Analysis

- *Outline safety concerns*
- *Present results of risk analysis (crash trends or patterns)*
- *RSA/RSR team findings by identified problem and associated crash type*

A total of seven (7) crashes occurred along this section of State Route 22, with one (1) non-incapacitating injury crash, one (1) fatal crash, and five (5) property damage only crashes. Figure 6 below illustrates the crash types through the segment. The crashes shown here are the same as the crashes shown in Figure 4.

Field observations noted sight distance limitations at the intersections of State Route 22 with State Route 33 and with Shinbone Road. Side road striping is faded and stop sign maintenance is needed on State Route 33 and Shinbone Road. Due to the rural setting and lack of roadway lighting, visibility of pavement markings, guardrail, and signage is poor at night. Better retroreflectivity would help drivers navigate curves and intersections. Ensure curve signage is as outline in the 2009 MUTCD.

Improvements

- *Outline improvements for each safety deficiency*
- *Provide low, intermediate, and high cost options*
- *Include cost estimates (for existing facilities)*

After obtaining input and concurrence with the RSA team members, the following improvements were identified for implementation as illustrated on Figures 7A and 7B.

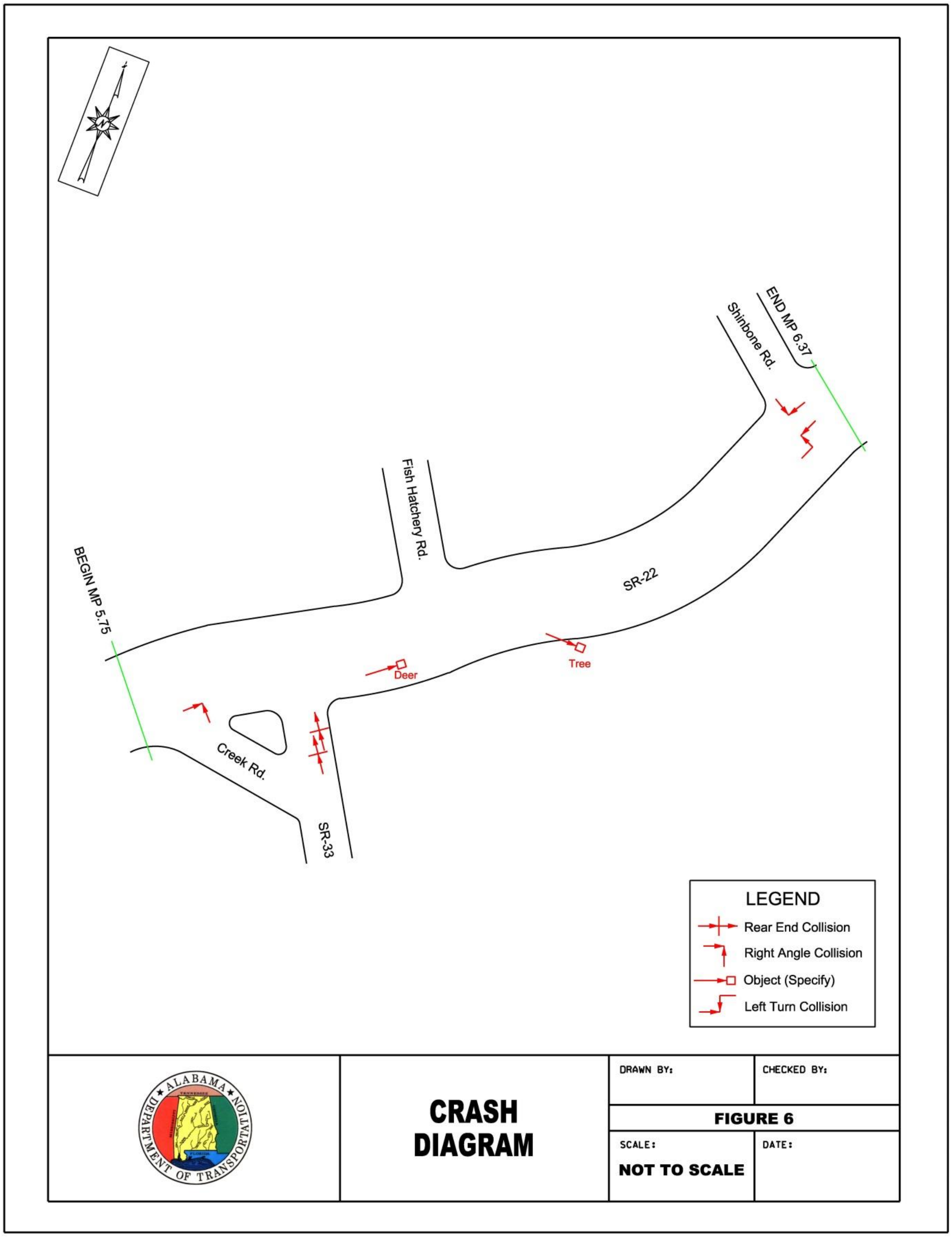

Figure 6: Crash Diagram

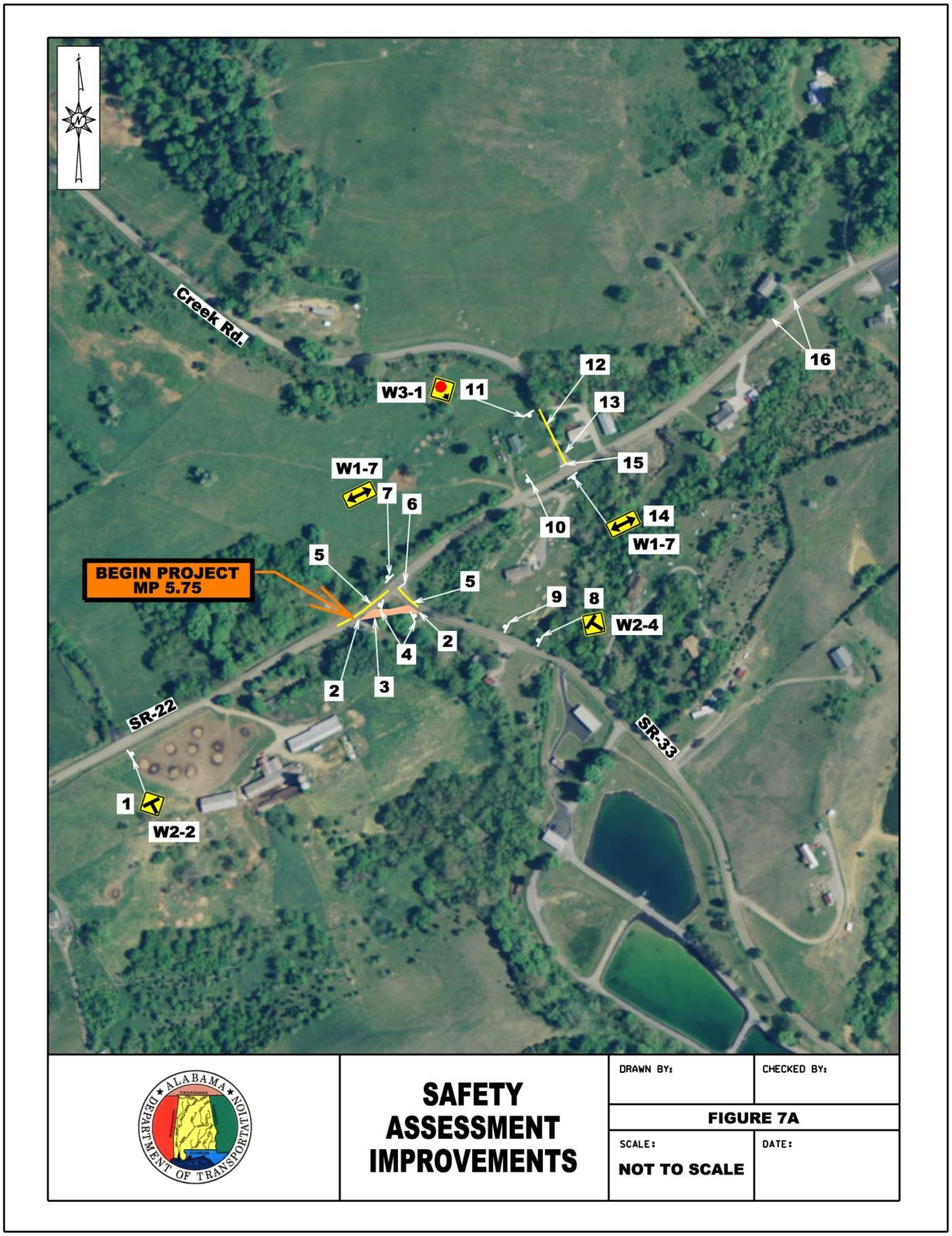

Figure 7A: Safety Assessment Improvements

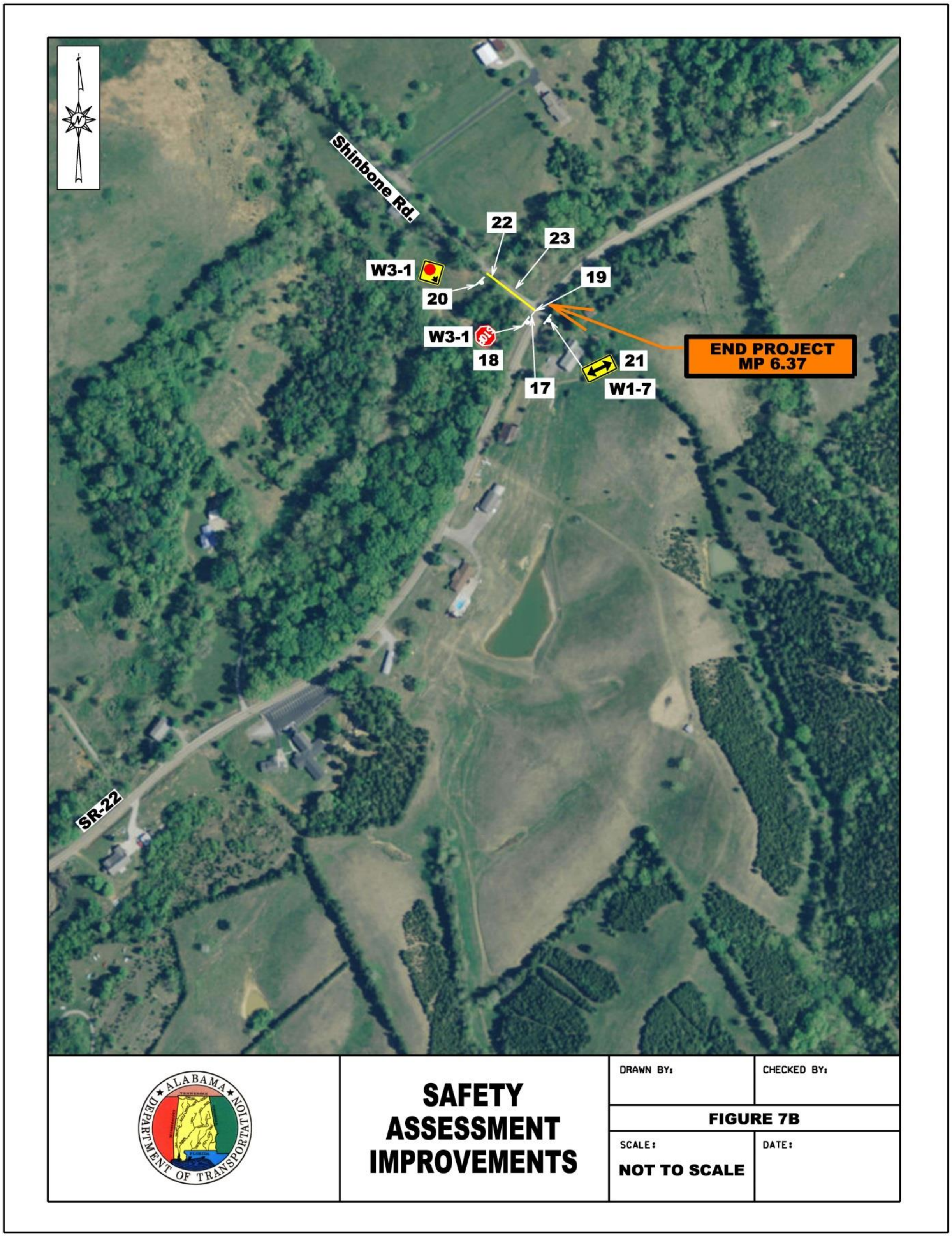

Figure 7B: Safety Assessment Improvements

Figure 7A

1. Remove one (1) Side Road (W2-3) sign and replace with one (1) 36"x36" Side Road (W2-2) sign on State Route 22 in its current location, approximately 875' to the west of the intersection with State Route 33.
2. Install edge lines with rumbles strips on State Route 22 and State Route 33 where the connecting road is being removed.
3. Remove the existing 100' of road connecting State Route 22 and State Route 33. Scarify, obliterate, and apply topsoil and seeding for the entire length of the connector. Remove the existing box bridge, hazard markers and guardrail.
4. Remove two (2) Stop (R1-1) signs along connector between State Route 22 and State Route 33.
5. Install thermoplastic centerline markings on State Route 22 prior to the intersection with State Route 555. Install thermoplastic centerline markings on State Route 33 prior to the intersection with State Route 22.
6. Install one (1) thermoplastic stop bar on State Route 33 at the intersection with State Route 22.
7. Install one (1) Two-Direction Large Arrow (W1-7 and W1-7A) sign facing traffic at the State Route 33 and State Route 22 intersection.
8. Remove one (1) Y-Symbol (W2-5) sign and replace with one (1) 36"x36" T-Symbol (W2-4) sign on State Route 33 in its location.
9. Reset existing Stop Ahead (W3-1) sign on State Route 33 in its current location. Install one (1) 12" solar powered flashing red beacon under and above the sign.
10. Reset existing Side Road Left (W2-2) sign on State Route 22 with two (2) posts. Sign to be located 525 feet prior to the intersection with State Route 33 and install one (1) 12" solar powered flashing yellow beacon under and above the sign.
11. Install one (1) 36"x36" Stop Ahead (W3-1) sign on Creek Road, approximately 175' from the State Route 22 intersection.
12. Install thermoplastic centerline markings along Creek Rd.
13. Install white thermoplastic pavement markings along the outside edge of travel lanes of Creek Road prior to the intersection with State Route 22.
14. Install one (1) 48"x24" Two-Direction Large Arrow (W1-7) sign facing traffic at the Creek Road and State Route 22 intersection.
15. Remove existing stop bar and install one (1) thermoplastic stop bar on Creek Road at the intersection with State Route 22. Stop bar to be installed approximately ten (10) feet prior to the current location.
16. Install white reflective markers on the northbound and southbound guardrails.

Figure 7B

17. Install one (1) 36"x12" Street Name (D3-1) sign for Shinbone Road at the northwest corner of the intersection of Shinbone Road and State Route 22.
18. Remove and replace one (1) 36"x36" Stop (R1-1) sign on Shinbone Road at the intersection with State Route 22.
19. Remove existing stop bar and install one (1) thermoplastic stop bar on Shinbone Road at the intersection with State Route 22. Stop bar to be installed approximately ten (10) feet prior to the current location.

20. Install one (1) 36”x36” Stop Ahead (W3-1) sign on Shinbone Road, approximately 175’ from the intersection with State Route 22.
21. Install one (1) 48”x24” Two-Direction Large Arrow (W1-7 and W1-7A) sign facing traffic at the Shinbone Road and State Route 22 intersection.
22. Install thermoplastic centerline markings along Shinbone Road for 175’ prior to the intersection with State Route 22.
23. Install white thermoplastic pavement marking edge lines on Shinbone Road for 100’ prior to the intersection with State Route 22.

The estimated cost of improvements in this report is $51,500. No right-of-way is required.

Conclusion

- *Summarize identified risks*
- *Recommend mitigations(if the mitigations include short and long term improvements or if multiple options are noted, select the most appropriate of the proposed mitigations and list them here)*

Based upon the data analyses and site review, the RSA team identified the aforementioned improvements for implementation by the project owner. The team identified pavement removal, signing, striping, and guardrail delineation to address crash occurrences.

Check Listing of Required Elements:

- ☐ Cover Page
- ☐ Disclaimer
- ☐ Table of Contents
- ☐ Executive Summary
- ☐ Project Aerial Map and Deficiencies Observed (Figure 1)
- ☐ Project Vicinity Map (Figure 2)
- ☐ Project Aerial Map (Figure 3)
- ☐ Introduction and Project Description (Background)
- ☐ RSA Team
- ☐ RSA Team Members (Table 1)
- ☐ Data Reviewed and Site Characteristics
- ☐ Summary of Crash Data (Table 2)
- ☐ Safety Assessment Crash Data (Figure 4)
- ☐ Site Visit
- ☐ Existing Conditions Photo Key (Figure 5) and Field Review Photos
- ☐ Safety Concerns and Risk Analysis
- ☐ Crash Diagram (Figure 6)
- ☐ Improvements
- ☐ Safety Assessment Proposed Improvements (Figure 7)
- ☐ Conclusion
- ☐ Appendix (Crash Reports, CARS Evaluation Associated with RSA, etc.)

This sample document is intended to serve as a guide for preparation of a Road Safety Assessment report. BLUE TEXT is used to show example templates and prompts to guide the RSA/RSR author. BLACK TEXT is used to provide an actual example of report text, tables, or figures. The intersection location, observations, and recommendations in this report are fictitious.

This is an example Road Safety Assessment Report for an Intersection with Pedestrian Features.

ROAD SAFETY ASSESSMENT REPORT

Intersection Name

XX County

PREPARED BY
(CONSULTANT) FOR
ALABAMA DEPARTMENT OF TRANSPORTATION

Approved by:	Signature	Date

This report is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

ADMONITION

This document is exempt from open records, discovery or admission under Alabama Law and 23 U.S.C. §§ 148(h)(4) and 409). The collection of safety data is encouraged to actively address safety issues on regional, local, and site specific levels. Congress has laws, 23 U.S.C. § 148(h)(4) and 23 U.S.C. § 409 which prohibit the production under open records and the discovery or admission of crash and safety data from being admitted into evidence in a Federal or state court proceeding. This document contains text, charts, tables, graphs, lists, and diagrams for the purpose of identifying and evaluating safety enhancements in this region. These materials are protected under 23 U.S.C. §409 and 23 U.S.C. § 148(h)(4). In addition, the Supreme Court in *Ex parte Alabama Dept. of Trans., 757 So. 2d 371* (Ala. 1999) found that these are sensitive materials exempt from the Alabama Open Records Act.

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FIGURES

TABLES

APPENDICES

Executive Summary

☐ *List of identified concerns*

The intersection of Warren Street and College Street in downtown Mayberry, Surry County, was identified as a safety need by ALDOT's North Region office for having an overrepresentation of crashes. This intersection has an existing traffic signal and is formed by the intersection of Warren Street and College Street. Both roadways are two (2) lane rural collectors with pavement width varying from forty-seven and a half (47.5) feet to fifty-two (52) feet with on-street parallel and angled parking located on each approach to the intersection.

Field observations documented concerns related to the intersection's traffic control, pedestrian accommodations, and conflicts between parking areas and the travel lanes. A total of ten (10) crashes occurred at the intersection over a recent five (5) year period, with two (2) non-incapacitating injury crashes, one (1) incapacitating injury crash, and seven (7) property damage only crashes. Two (2) of the injury crashes involved pedestrians.

☐ *Location map with numbering to show where each deficiency is located*

Figure 1 provides an aerial map of the subject intersection and a listing of observed deficiencies.

☐ *Recommended improvements*

Based on analysis of crash history, traffic volumes, land uses, geometric features, and field observations, the Road Safety Assessment (RSA) team has identified the following improvements for implementation. These mitigations are described in more detail and illustrated in the Improvements section of this report.

- Improve pedestrian accommodations at the intersection by creating curb extensions in the northwest and southeast quadrants, upgrading curb ramps, installing new stop lines, installing new longitudinal crosswalk markings, and installing pedestrian countdown signal heads.
- Remove parking spaces in the corners adjacent to the intersection to prevent parking maneuvers from encroaching into the intersection.
- Replace the existing traffic signal. The types and locations of the signal heads shall be in compliance with the 2009 edition of the Manual on Uniform Traffic Control Devices (MUTCD).
- Stripe two (2) new ADA-compliant parking spaces on Warren Street.

The estimated cost of improvements in this report is $152,200. No right-of-way is required.

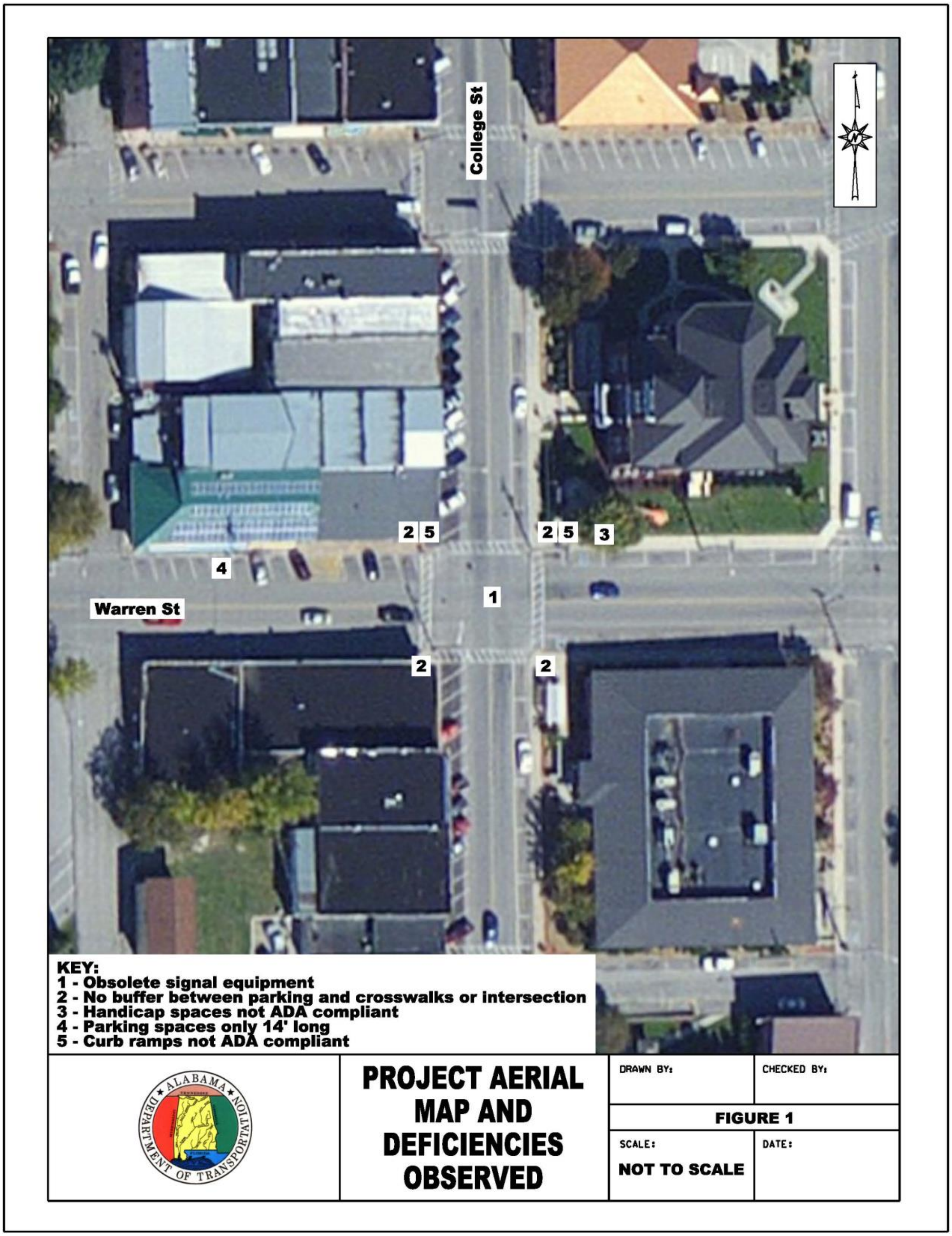

Figure 1: Project Aerial Map and Deficiencies

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The mitigations documented in this report are the recommendations of the RSA team and do not represent any commitment for implementation from the maintaining agency or concurrence for any particular funding source. All projects that are implemented as a result of an RSA must meet the individual criteria of the associated funding source.

Introduction and Project Description

☐ *Define an RSA*

A Road Safety Assessment (RSA) is a formal safety performance examination of an existing or future road or intersection by an independent audit team. This RSA was conducted by a consultant under the authority of the ALDOT North Region.

☐ *Describe the process followed (time, date, location, etc. with condensed outline of the general RSA process)*

☐ *Identify the project owner*

The intersection of Warren Street and College Street in downtown Mayberry was identified as a safety need by ALDOT's North Region office as having an overrepresentation of crashes. Although the subject intersection is located within the city limits of Mayberry, Warren Street and College Street are owned and maintained by Surry County. Based on the identified safety concerns, a consultant was contracted to conduct an RSA.

The following is a summary of action items accomplished for this RSA:

- Contract for preparation of an RSA was executed on October 28, 2014.
- Background data, including traffic volumes, aerial photography, geometric features, and crash history, was assembled and reviewed.
- A preliminary RSA briefing of the RSA team with the County Engineer and ALDOT staff was held at 1:00 PM on Friday, November 14, 2014 at the local area office.
- Additional information on utilities was gathered as a result of the preliminary briefing meeting.
- A field review was conducted in Mayberry by the RSA team on November 25, 2014.
- Field observations and measurements were reviewed and countermeasures were developed and prioritized.
- On December 5, 2014, the RSA team conducted a post-assessment meeting with the County Engineer and ALDOT staff to present and discuss the recommended countermeasures.
- Comments from the post-assessment meeting were addressed and incorporated into this report document.

☐ *Identify the project location, project phase and why the RSA is warranted*

Warren Street and College Street form an existing four-way intersection in downtown Mayberry in Surry County, Alabama. The intersection is controlled by an existing traffic signal that does not comply with the 2009 edition of the MUTCD and includes obsolete equipment for which replacement parts are no longer available. Both roadways are two (2) lane rural collectors with pavement width varying from forty-seven and a half (47.5) feet to fifty-two (52) feet. On-street parallel and angled parking spaces are located on each street.

☐ *Insert a Vicinity Map – Include pertinent data as needed*
- *Street Names*
- *Traffic Generators*
- *Congestion Hot Spots*
- *Other*

☐ *Insert a Project Aerial Map*

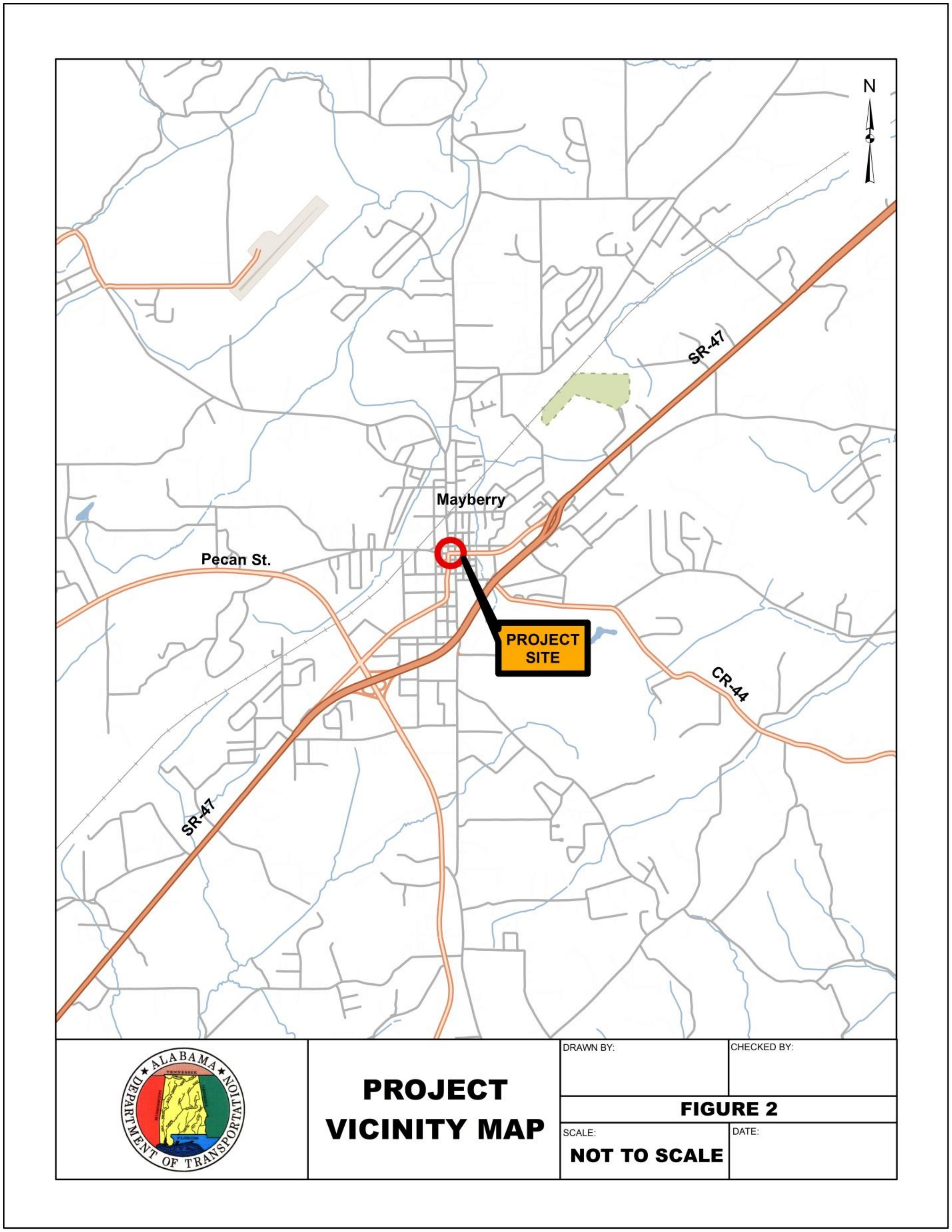

Figure 2: Project Vicinity Map

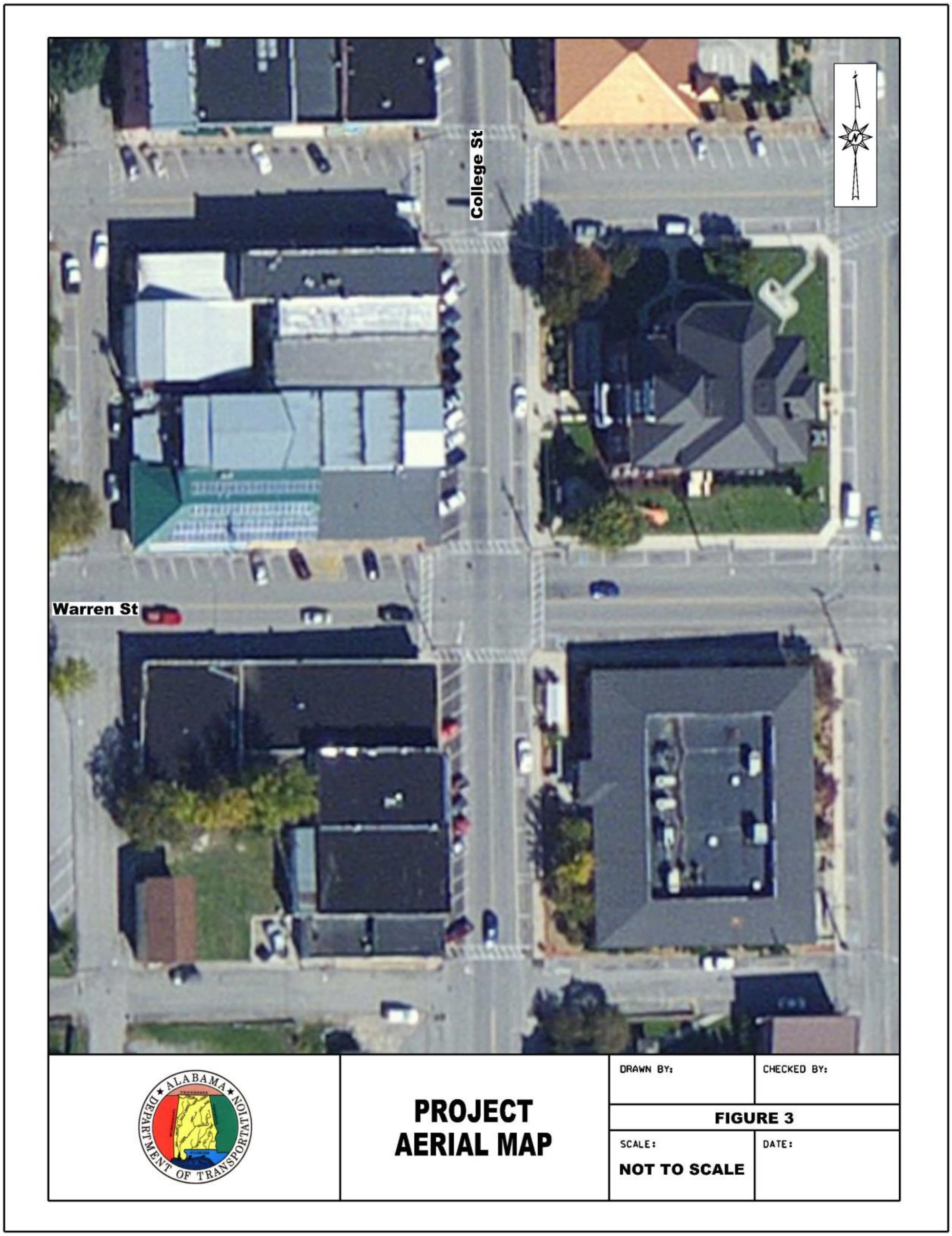

Figure 3: Project Aerial Map

RSA Team

- ☐ *Identify RSA team members by name, organization/office, professional titles, role on the RSA team (leader, member, observer), and fields or specialties they represent (design, safety, operations, etc.). This is the standard format of RSA Team Roles and Specialties to be used.*

An RSA team evaluated the study area to determine appropriate safety measures. The following is a summary of the RSA team members by name, team role, and specialty.

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Name	Organization	Title	RSA Team Role	Specialty
John Doe	Ace Engineers	Project Manager	RSA Team Leader	Road Safety /Traffic Operations
Josh Johnson	Ace Engineers	Traffic Designer	RSA Team Member	Road Safety /Traffic Operations
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Chuck Jackson	ALDOT	State Safety Operations Engineer	RSA Team Member	Road Safety
William Hall	ALDOT	Maintenance Engineer	RSA Team Member	Maintenance
Tom Parker	ALDOT	Traffic Engineer	RSA Team Member	Traffic Engineering

Data Reviewed and Site Characteristics

Identify all documents and data considered during the RSA process

- ☐ *Road Inventory Database*
- ☐ *Traffic Counts*
- ☐ *Crash Data*
- ☐ *Construction plans, if available*
- ☐ *Other*

The 2014 AADT (Annual Average Daily Traffic) for Warren Street near the intersection is 7,435 vehicles. The AADT on College Street for the same year is 3,650 vehicles. The intersection is located in an urban setting with commercial and government land uses adjacent to the intersection. Drainage is accommodated by roadside sewer drains. There are pedestrian crosswalks, but the curb ramps are not ADA compliant. The intersection is signalized. *(If turning movement count data is available, include it as well.)*

Summarize and discuss findings from the crash analysis.

A five (5) year crash summary from the CARE database and a review of actual crash reports for severe crashes indicated the following crash history:

- Ten (10) crashes were reported for this intersection
- Two (2) non-incapacitating injury crash
- One (1) incapacitating injury crash
- Two of the injury crashes (1 non-incapacitating and 1 incapacitating) involved pedestrians.

- Crash reports for the pedestrian involved crashes both indicated the driver failed to see the pedestrian in the crosswalk.
- Five (5) crash reports indicated the driver failed to comply with the red signal indication.

If possible, include a summary table that lists the crashes by location, type, environmental conditions, and driver factors. If too numerous to list individually, the author may choose to group crashes by type and list the number of occurrences by that type.

Table 2: Summary of Crash Data

Crash Report No.	Travel Direction 1	Travel Direction 2	Driver Condition	Alcohol or Drugs Involved	Lighting Condition	Weather	Driver Age	Fixed/Not Fixed Object	Collision	Driver Action	Crash Type
2602826	EB	EB	Normal/ Normal	No/No	Dark	Rain	55/31	Not Fixed Object	Vehicle	Rear-end	Property Damage
9000486	NB	NB	Normal/ Normal	No/No	Daylight	Cloudy	33/42	Not Fixed Object	Vehicle	Rear-end	Property Damage
0618697	NB	NB	Normal/ Normal	No/No	Daylight	Rain	60/75	Not Fixed Object	Vehicle	Rear-end	Property Damage
8072278	NB	EB	Normal/ Normal	No	Daylight	Clear	26/19	Not Fixed Object	Vehicle	Failure to Yield	Non-Incap. Injury
2334577	NB	EB	Normal/ Normal	Yes	Dark	Clear	72/41	Not Fixed Object	Vehicle	Failure to Yield	Property Damage
7223456	NB	EB	Normal/ Normal	No/No	Daylight	Cloudy	24/28	Not Fixed Object	Vehicle	Failure to Yield	Property Damage
2703396	NB	WB	Normal/ Normal	No/No	Daylight	Rain	39/16	Not Fixed Object	Vehicle	Failure to Yield	Property Damage
1355789	SB	WB	Normal/ Normal	No/No	Daylight	Rain	52/29	Not Fixed Object	Vehicle	Failure to Yield	Property Damage
2466883	WB	-	Normal	No	Dark	Cloudy	34	Not Fixed Object	Pedestrian	Failure to Yield	Incap. Injury
1885542	SB	-	Normal	No	Dark	Cloudy	34	Not Fixed Object	Pedestrian	Failure to Yield	Non-Incap. Injury

Crash severity by location around the intersection is shown in Figure 4.

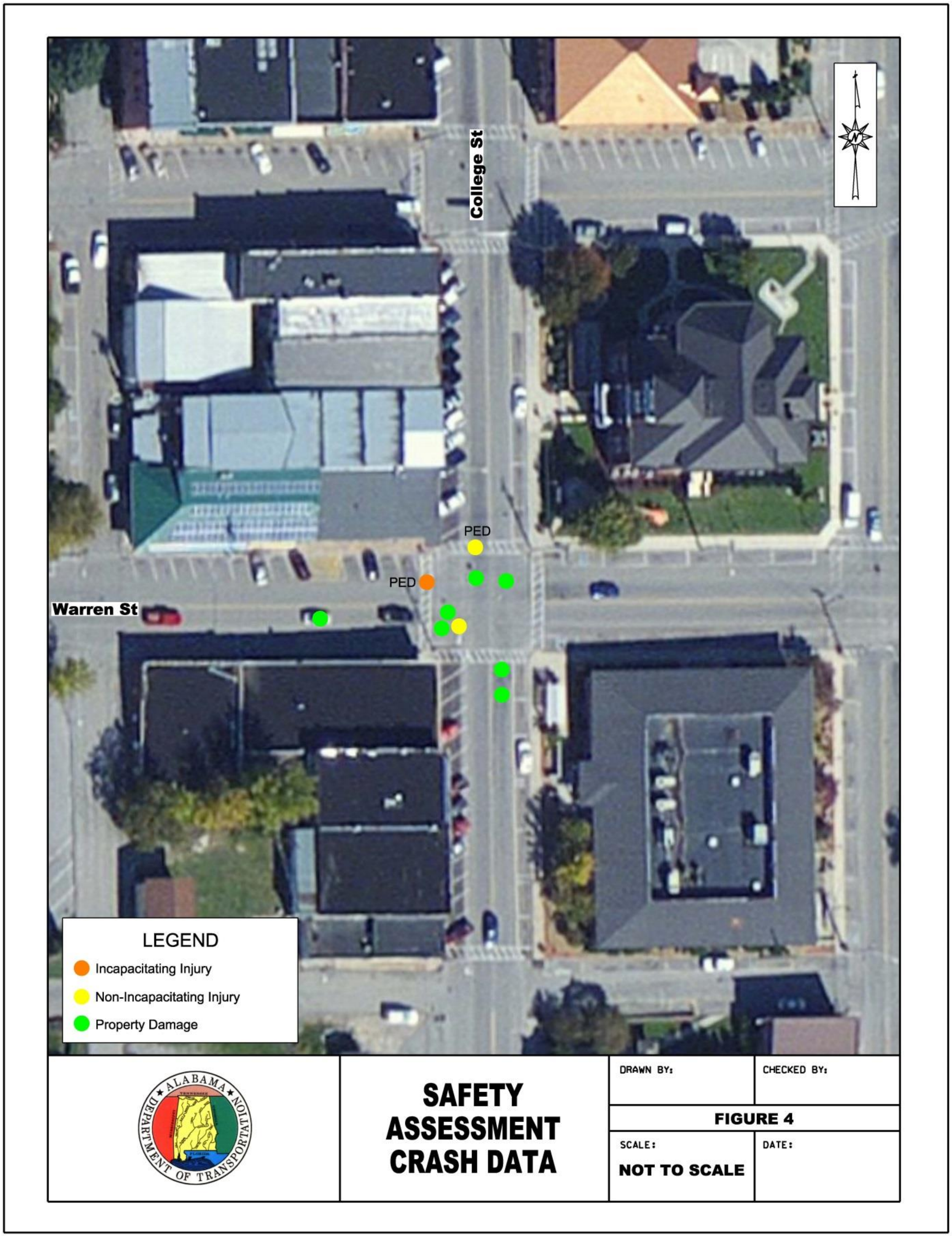

Figure 4: Safety Assessment Crash Data

Site Visit

- ☐ *Identify date, weather conditions, time, light conditions, attendees for site visit*
- ☐ *Include Photographs*

The RSA team conducted a field review at the subject intersection in Mayberry at 1:00 p.m. on November 25, 2014. All members of the team were present for the review. The review was conducted during clear weather conditions and on a weekday while traffic conditions in the downtown area were normal.

Photographs were taken at multiple locations surrounding the Warren Street and College Street intersection. The following figures include a photo location guide (Figure 5) and photos taken during the review.

- ☐ *Describe conditions observed on site visit*

The following is a summary of observations noted by the RSA team during the field review:

- Both roadways are two (2)-lane rural collectors.
- Posted speed limit of 35 miles per hour for Warren Street and 25 mph on College Street.
- The eastern leg of Warrant Street is 52 feet wide with parallel parking on both sides, and the western leg is 48 feet with parallel parking and angled street parking.
- College Street is 47.5 feet wide with angled parking on the western side and parallel parking on the eastern sited.
- The on-street parking for both Warren Street and College Street are directly adjacent to the crosswalks.
- There are two (2) parallel handicapped parking spaces on the eastern side of the intersection on Warren Street. The handicapped spaces do not meet ADA guidelines. The required eight (8) foot wide parking space and five (5) foot wide access aisle is not met.
- The angled parking on the western side of Warren Street is approximately only fourteen (14) feet long and parked vehicles extend into the intersection. There is an existing loading area located on Warren Street for the building located on the northwest quadrant.
- ADA compliant handicapped ramps are not present at the northeast and northwest quadrants of the intersection.
- The angled parking spaces on Warren Street are nine (9) feet long, and parked vehicles extend into the travel lane, especially close to the intersection.
- The existing traffic signal equipment is obsolete and not in compliance with the 2009 MUTCD. Replacement parts are unavailable for the City.
- Existing utility wood poles are located in the northeast and southwest quadrants of the intersection. The existing signal is strung across the center of the intersection diagonally attached to the two poles. Both poles are located on the corner of the sidewalk close to the edge of pavement. In addition to the utility lines running diagonally across the intersection, utility lines run on the northern side of Warren Street and the western and eastern sides of College Street.

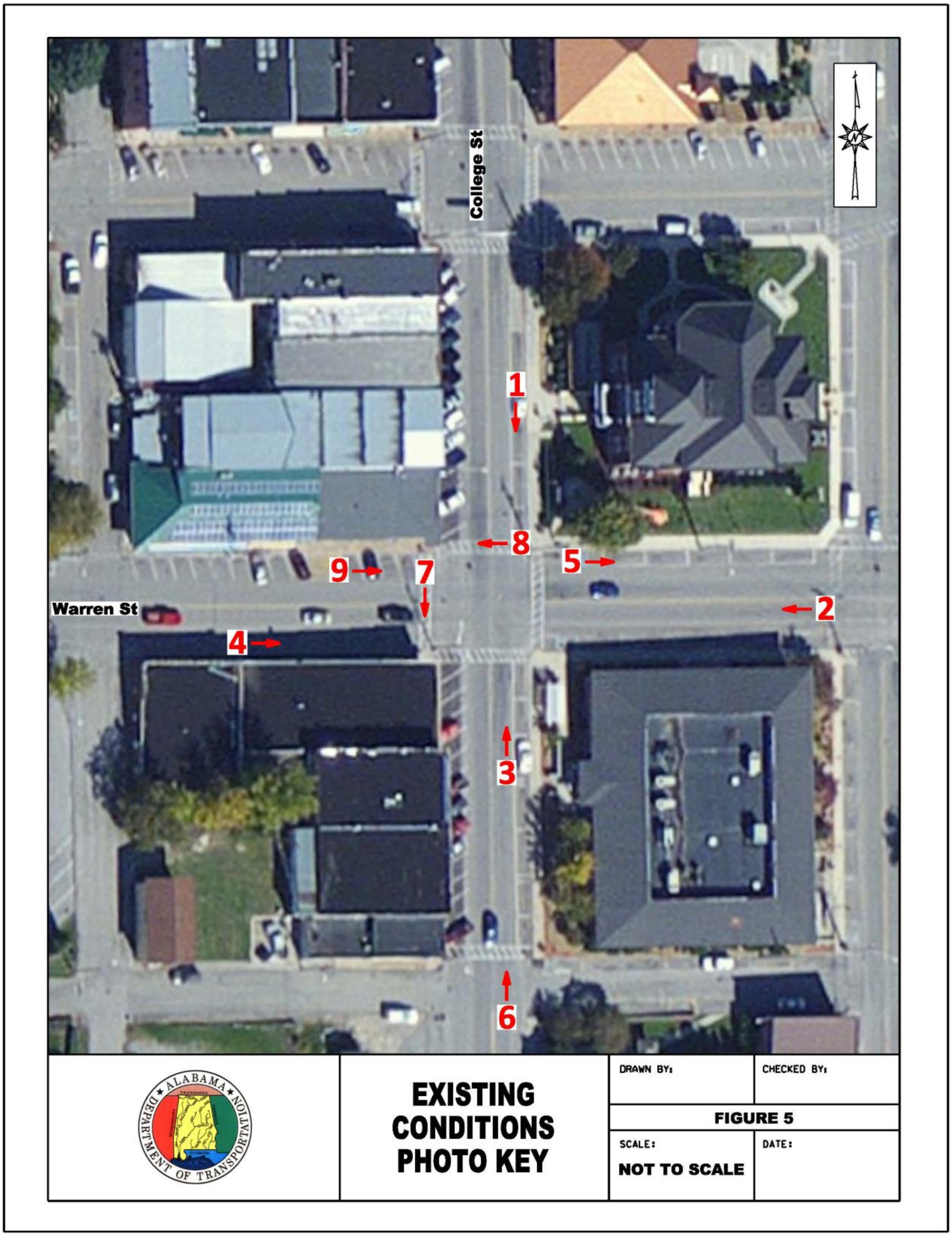

Figure 5: Existing Conditions Photo Key

Photos taken on Tuesday, November 25, 2014

Photo 1:
Looking south on College Street towards the intersection with Warren Street.

Photo 2:
Looking west on Warren Street towards the intersection with College Street.

This report is prepared solely for the purpose of identifying, evaluating, and planning safety improvements on public roads; and is therefore exempt from open records, discovery or admission under Alabama law and 23 U.S.C. §§ 148(h)(4), and 409.

Photo 3:
Looking north on College Street towards the intersection with Warren Street.

Photo 4:
Looking east on Warren Street towards the intersection with College Street.

Photo 5:
Looking east down the northern side of Warren Street.

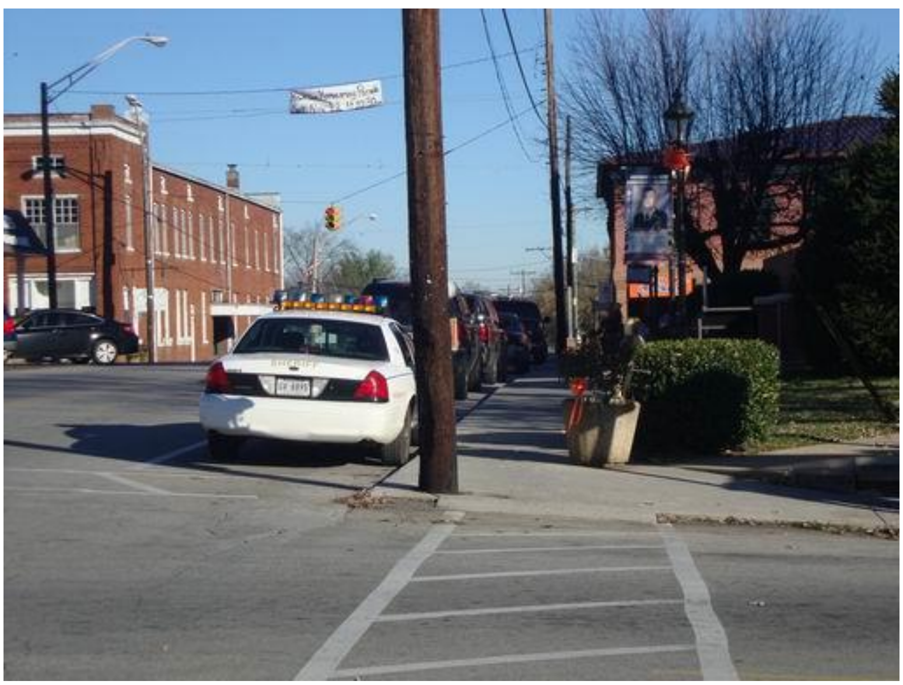

Photo 6:
Looking north down College Street towards the northeast quadrant of the intersection.

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Photo 7:
Looking south down College Street towards the southwest quadrant of the intersection.

Photo 8:
Looking west across College Street towards the northwest quadrant of the intersection.

Photo 9:
Looking east down the northern side of Warren Street just prior to the intersection

Safety Concerns and Risk Analysis

- *Outline safety concerns*
- *Present results of risk analysis (Crash trends or patterns)*
- *RSA/RSR team findings by identified problem and associated crash type*

A total of ten (10) crashes occurred at this intersection, with two (2) non-incapacitating injury crashes, one (1) incapacitating crash, and seven (7) property damage only crashes. Two (2) of the injury crashes involved pedestrians where the drivers had failed to see the pedestrian in the crosswalk. Five (5) crash reports indicated the driver failed to comply with the red signal indication. Figure 6 below illustrates the crash types at the intersection. The crashes shown here are the same as the crashes shown in Figure 4.

Field observations confirm that motorist view of pedestrians in crosswalks is obscured by the presence of on-street parking immediately adjacent to the crosswalks. In addition to the pedestrian visibility issues, the pedestrian facilities present at the intersection and adjacent to marked handicapped parking are not ADA compliant.

The existing traffic signal at the intersection does not conform to the standards for lens size, number of signal heads, or head placement, per the 2009 edition of the MUTCD. The equipment is obsolete and should be replaced.

Improvements

- *Outline mitigation measures for each safety deficiency*
- *Provide low, intermediate, and high cost options*
- *Include cost estimates (for existing facilities)*

After obtaining input and concurrence with the RSA team members, the following improvements were identified for implementation as illustrated on Figure 7.

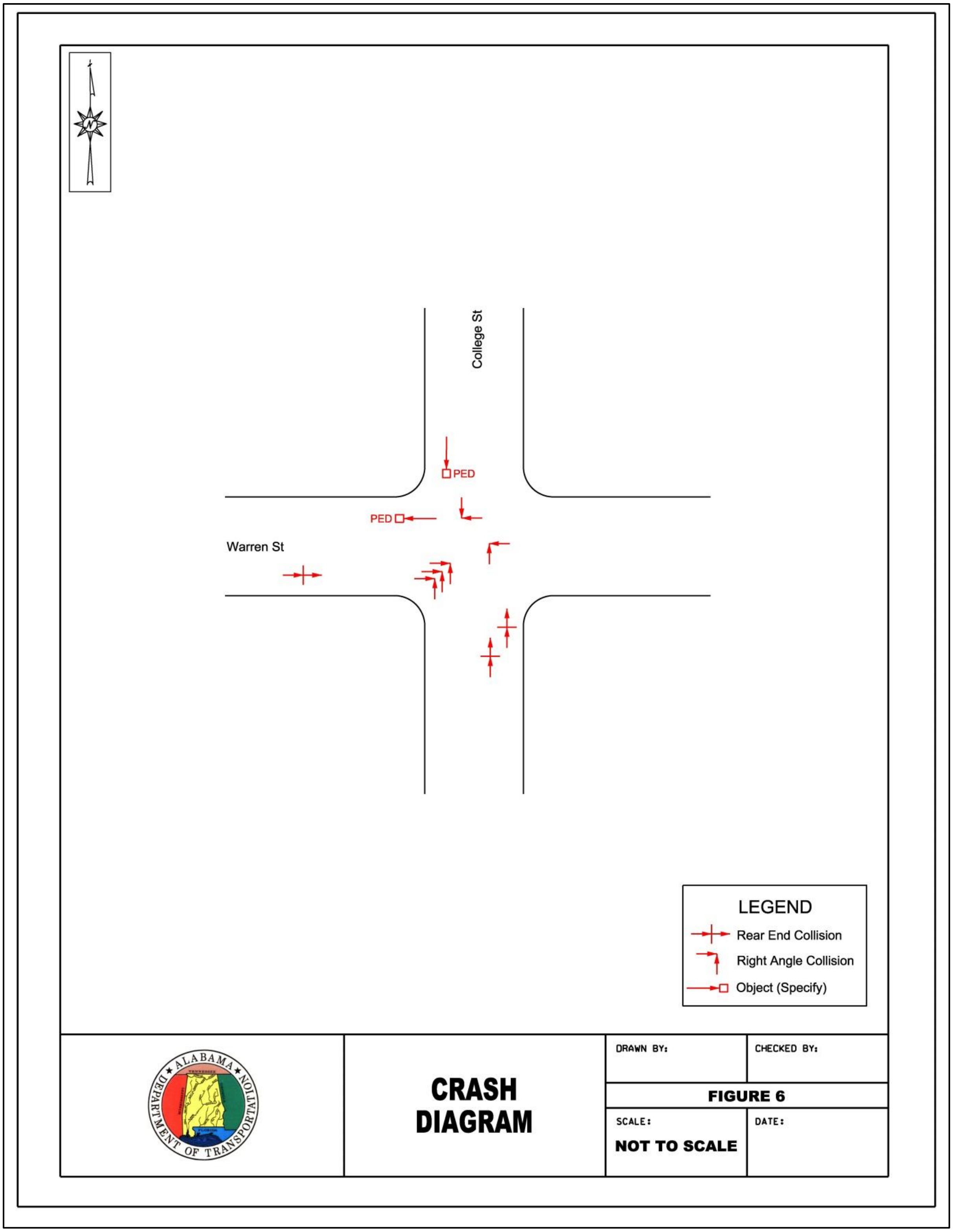

Figure 6: Crash Diagram

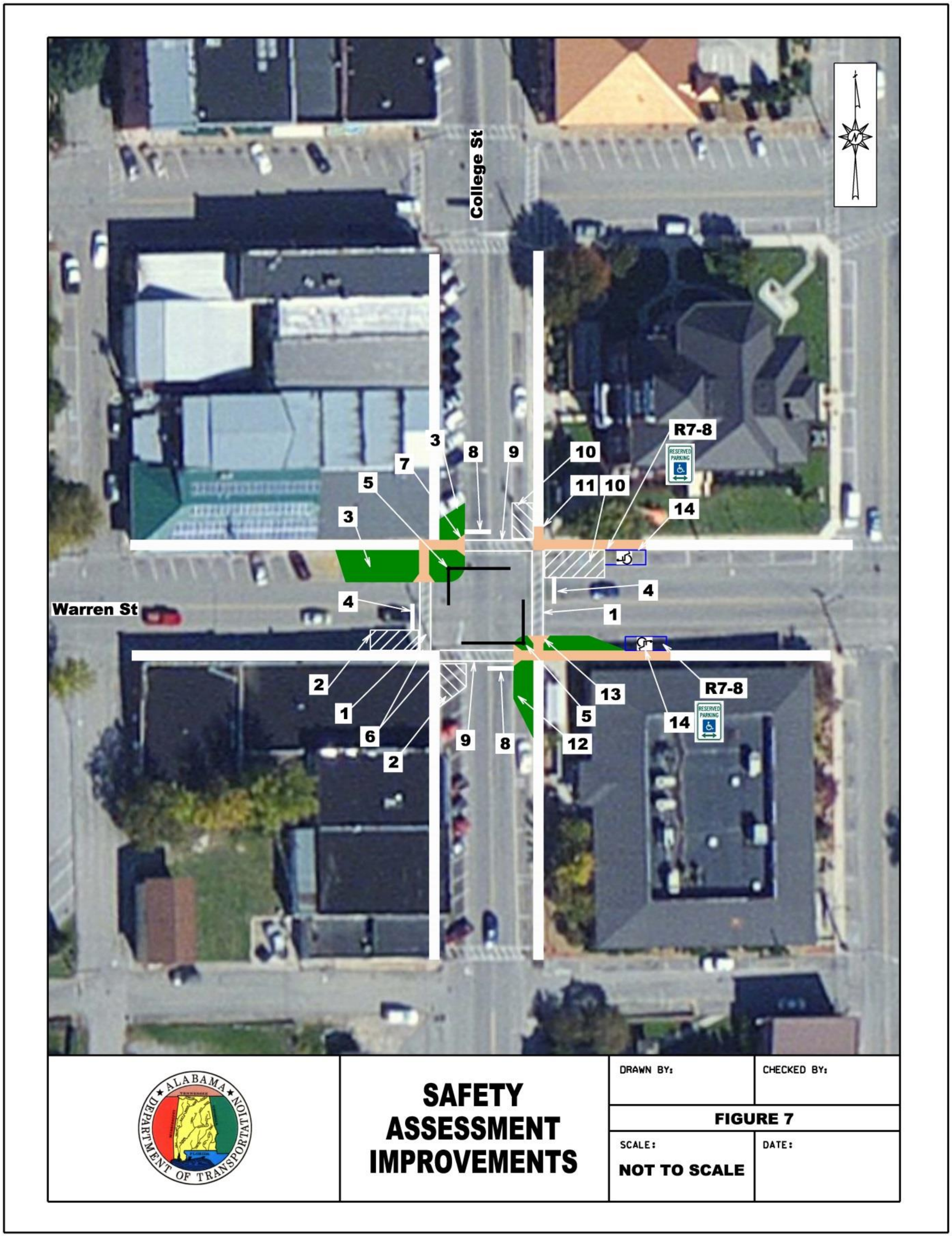

Figure 7: Safety Assessment Improvements

Restripe two (2) crosswalk markings with transverse lines across Warren Street.

1. In the southwest quadrant of the intersection, eliminate one (1) parallel parking space on Warren Street and remove two (2) angled parking spaces on College Street to prevent parking maneuvers from encroaching into the intersection and improve visibility of pedestrians at the intersection.
2. Install approximately 130 feet of new curb to form a new curb extension in the northwest quadrant of the intersection. This will necessitate the removal of four (4) parking spaces on Warren Street and two (2) on College Street.
3. Install two (2) thermoplastic stop bars across Warren Street approaches to the intersection.
4. Remove the existing signal head and wiring and replace with two (2) double mast arm poles. Each pole shall have two (2) mast arms, four (4) L.E.D. signal heads with retroreflective backplates, two (2) pedestrian push buttons, and two (2) pedestrian countdown signal heads in conformance with the 2009 Manual on Uniform Traffic Control Devices (MUTCD). Poles are to be located in the northwest and southeast quadrants of the intersection.
5. Install truncated domes on the existing curb ramps at the southwest corner of the intersection per ADA guidelines.
6. Remove approximately 70 square feet of concrete sidewalk at the northwest corner of the intersection and install two (2) new ADA-compliant perpendicular curb ramps. New ramps should include a truncated dome surface. Pour concrete sidewalk to connect the new ramps to the existing sidewalk.
7. Install two (2) thermoplastic stop bars across College Street approaches to the intersection.
8. Restripe two (2) crosswalk markings with transverse lines across College Street.
9. Eliminate two (2) parallel parking spaces on the northeast quadrant with striping. This will prevent parking and unparking maneuvers from encroaching into the intersection and improve visibility of pedestrians at the intersection.
10. Remove approximately 90 square feet of existing sidewalk and ramp in the northeast quadrant and replace with one (1) new ADA-compliant parallel ramp.
11. Install approximately 128 feet of new curb to form a new curb extension in the southeast quadrant of the intersection. The new curb extension will eliminate two (2) parallel parking spaces on Warren Street and two (2) on College Street.
12. Remove approximately 80 square feet of concrete sidewalk at the southeast corner of the intersection and install two (2) new ADA-compliant perpendicular curb ramps. New ramps should have a truncated dome surface. Pour an additional 120 square feet of concrete sidewalk to connect the new ramps to the existing sidewalk.
13. Stripe two (2) new ADA-compliant parallel parking spaces on Warren Street with blue thermoplastic striping and two handicapped symbols and signs. Remove a total of 600 square feet of existing sidewalk and replace with two (2) new ADA-compliant parallel parking spaces and new sidewalk. The new ramp should allow the sidewalk to be flush with the entire length of the parking stalls to provide at least an eight (8) feet wide parking space and five (5) feet of required loading space.

The estimated cost of improvements in this report is $152,200. No right-of-way is required.

Conclusion

- *Summarize identified risks*
- *Recommend mitigations (if the mitigations include short and long term improvements or if multiple options are noted, select the most appropriate of the proposed mitigations and list them here)*

Based upon the data analyses and site review, the RSA team identified the aforementioned improvements for implementation by the project owner. The team identified modifications to pedestrian accommodations, pavement markings and striping, sidewalk improvements, and signal heads to address the crash occurrences.

Check Listing of Required Elements:

- ☐ Cover Page
- ☐ Disclaimer
- ☐ Table of Contents
- ☐ Executive Summary
- ☐ Project Aerial Map and Deficiencies Observed (Figure 1)
- ☐ Project Vicinity Map (Figure 2)
- ☐ Project Aerial Map (Figure 3)
- ☐ Introduction and Project Description (Background)
- ☐ RSA Team
- ☐ RSA Team Members (Table 1)
- ☐ Data Reviewed and Site Characteristics
- ☐ Summary of Crash Data (Table 2)
- ☐ Safety Assessment Crash Data (Figure 4)
- ☐ Site Visit
- ☐ Existing Conditions Photo Key (Figure 5) and Field Review Photos
- ☐ Safety Concerns and Risk Analysis
- ☐ Crash Diagram (Figure 6)
- ☐ Improvements
- ☐ Safety Assessment Proposed Improvements (Figure 7)
- ☐ Conclusion
- ☐ Appendix (Crash Reports, etc.)

This sample document is intended to serve as a guide for preparation of a Road Safety Review summary memorandum. BLUE TEXT is used to show example templates and prompts to guide the RSR author. BLACK TEXT is used to provide an actual example of report text, tables, and figures. The road segment location, observations, and recommendations in this report are fictitious.

This is an example Road Safety Review memorandum for a road segment.

Road Safety Review Memorandum

Subject: **CR-216 (Creek View Road), From Mile Point 26.1 to Mile Point 26.2, Surry County**
Prepared by: **John Doe, P.E., Surry County Engineer**
Date: **February 18, 2015**

☐ *Insert engineer's seal and signature*

ADMONITION

This document is exempt from open records, discovery or admission under Alabama Law and 23 U.S.C. §§ 148(h)(4) and 409). The collection of safety data is encouraged to actively address safety issues on regional, local, and site specific levels. Congress has laws, 23 U.S.C. § 148(h)(4) and 23 U.S.C. § 409 which prohibit the production under open records and the discovery or admission of crash and safety data from being admitted into evidence in a Federal or state court proceeding. This document contains text, charts, tables, graphs, lists, and diagrams for the purpose of identifying and evaluating safety enhancements in this region. These materials are protected under 23 U.S.C. §409 and 23 U.S.C. § 148(h)(4). In addition, the Supreme Court in *Ex parte Alabama Dept. of Trans.,* 757 So. 2d 371 (Ala. 1999) found that these are sensitive materials exempt from the Alabama Open Records Act.

Summary

☐ *List the identified concerns and recommended improvements*

This segment of CR-216 (Creek View Road) was identified as a safety need based on crash history. CR-216 is a rural two-lane county road that connects the communities of Brockton and Camp Hill (See Figure 1). The studied segment of CR-216 extends from mile point 26.1 to mile point 26.2 and contains a horizontal curve.

Field observations noted only one curve warning sign with no advisory speed plaque. A total of five (5) run-off-road crashes occurred in this road segment over a recent five year period.

Based on analysis of crash history, traffic volumes, land uses, geometric features, and field observations, the Road Safety Review (RSR) team identified a need for installation of curve warning signs with 30 mph advisory speed plaque and chevrons per the 2009 MUTCD.

The estimated cost of these improvements is $2,000. No right-of-way is required.

☐ *Insert a Vicinity Map – Include pertinent data as needed*
- *Street Names*
- *Traffic Generators*
- *Congestion Hot Spots*

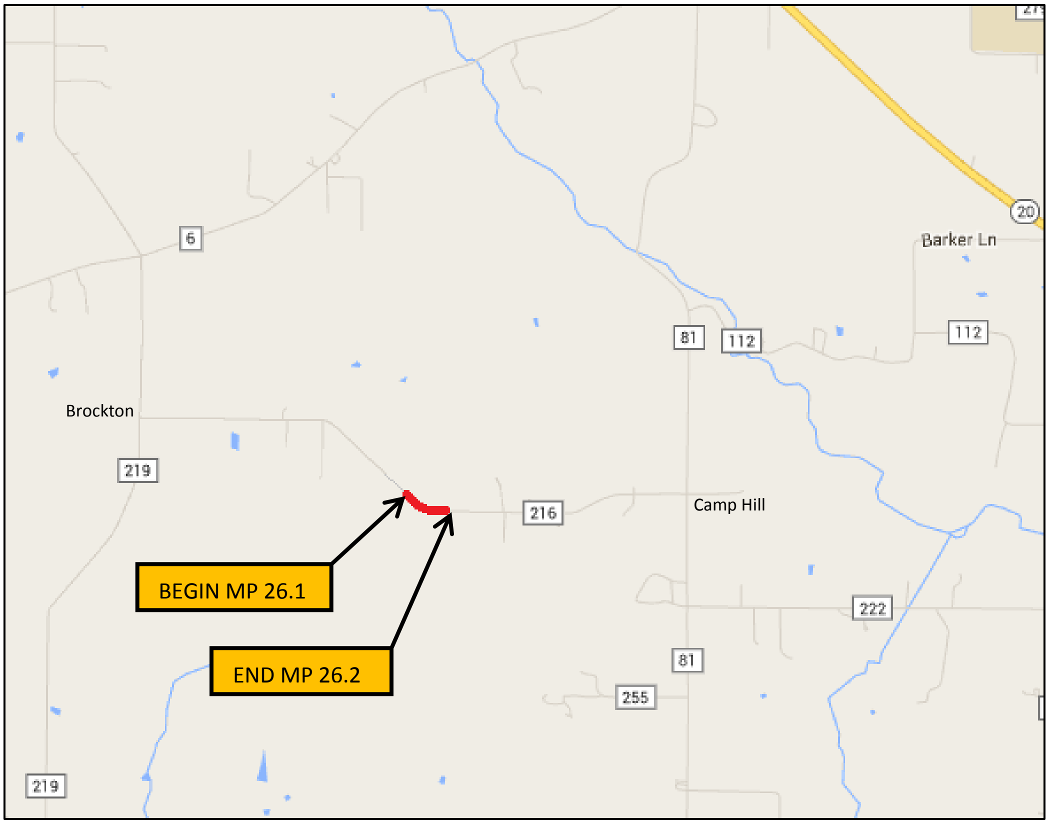

Figure 1: Project Vicinity Map

Introduction and Project Description

- ☐ *Define an RSR*
- ☐ *Describe the process followed (time, date, location, etc.) with condensed outline of the general RSA process*
- ☐ *Identify the project owner and why the RSR is warranted*

A Road Safety Review (RSR) is an examination of a road's safety performance by a team of design and/or safety engineers. This RSR was conducted by a team of representatives from Surry County and Alabama Department of Transportation (ALDOT). CR-216 is owned and maintained by Surry County.

This segment of CR-216 was identified as a safety need based on a history of run-off-road crashes. As part of the RSR, the following actions/field tasks were accomplished:

- Background data, including traffic volumes, aerial photography, geometric features, and crash history, was assembled and distributed to all team members for review.
- A field review was conducted by the RSR team on February 3, 2015.
- Field observations and measurements were reviewed for potential risk factors and countermeasures. The RSR team developed improvements for the identified deficiencies.
- The RSR team leader incorporated the team's observations and identified improvements in this memorandum.

RSR Team

- ☐ *Identify RSR team members by name, organization/office, professional titles and area of experience.*

The RSR team included the following individuals:

Table 1: RSR Team Members

Name	Organization	Title	RSA Team Role	Specialty
John Doe	Surry County	County Engineer	RSR Team Leader	Road Design / Maintenance
Susan Jones	Surry County	Assistant County Engineer	RSR Team Member	Traffic Operations
Chuck Jackson	ALDOT	State Safety Operations Engineer	RSR Team Member	Road Safety

Data Reviewed and Site Characteristics

- ☐ Identify all documents and data considered during the RSA process
  - Road Inventory Database
  - Traffic Counts
  - Crash Data
  - Construction plans, if available

The Annual Average Daily Traffic (AADT) for the current year along the studied portion of CR-216 is 1,100 vehicles per day. The roadway is located in a rural setting with adjacent residential and agricultural land uses. The road has two (2) travel lanes with lane widths of eleven (11) feet and paved shoulders of two (2) feet in width. The posted speed limit is 45 miles per hour.

Drainage is accommodated by roadside ditches. There are no pedestrian or bicycle accommodations along the roadway, and there are no intersections within the vicinity of the studied segment.

- ☐ *Summarize and discuss findings from the crash analysis.*

A five (5) year crash summary from the CARE database and a review of actual crash reports for severe crashes indicated the following:

- Six (6) total crashes were reported on this roadway segment
- One (1) incapacitating injury crash
- One (1) non-incapacitating injury crash
- Four (4) property damage only crashes

If possible, include a summary table that lists the crashes by location, type, environmental conditions, and driver factors. If too numerous to list individually, the author may choose to group crashes by type and list the number of occurrences by that type.

Table 2: Summary of Crash Data

Crash Report No.	M.P.	Location SR-22	Driver Condition	Alcohol or Drugs Involved	Lighting Condition	Weather	Driver Age	Fixed/Not Fixed Object	Collision	Driver Action	Crash Type
2602826	26.1	Along Roadway	Normal/ Normal	No/No	Dark	Clear	55	Fixed Object	Tree	Ran off Road	Non-Incap. Injury
9000486	26.15	Along Roadway	Normal/ Normal	No/No	Daylight	Cloudy	33	Fixed Object	Tree	Ran off Road	Property Damage
0618697	26.15	Along Roadway	Normal/ Normal	No/No	Daylight	Clear	60	Fixed Object	Tree	Ran off Road	Incap. Injury
2334577	26.15	Along Roadway	DUI	Yes	Dark	Clear	72	Fixed Object	Tree	Ran off Road	Property Damage
7223456	26.15	Along Roadway	Normal/ Normal	No/No	Daylight	Cloudy	24	Fixed Object	Tree	Ran off Road	Property Damage
1678224	26.2	Along Roadway	Normal/ Normal	No/No	Dark	Clear	29	Not Fixed Object	Deer	Straight	Property Damage

☐ Insert a map or diagram of crash locations and crash types. This could be done using a dot style format or with a traditional crash diagram.

Figure 2 presents a collision diagram of the crashes cited in Table 2.

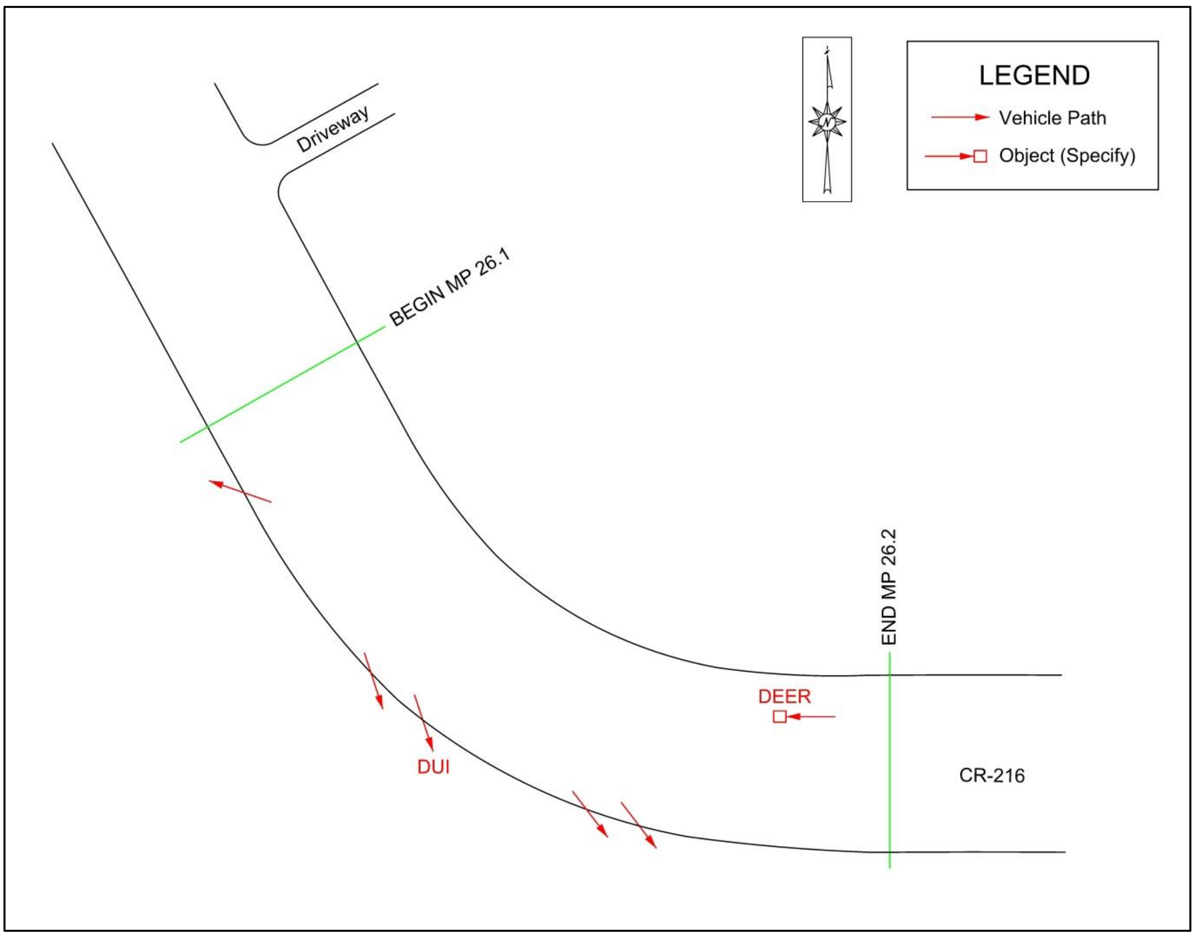

Figure 2: Crash Diagram

Site Visit

- ☐ *Identify date, weather conditions, time, light conditions, attendees for site visit*
- ☐ *Photographs (optional)*

The RSR team conducted a field review of CR-216 from mile point 26.1 to mile point 26.2 at 2:00 p.m. on February 3, 2015. All members of the team were present for the review. The review was conducted during clear weather conditions on a weekday while traffic conditions were normal.

The following photographs were taken along the roadway:

CR-216 looking east at mile point 26.1

CR-216 looking west at mile point 26.2

☐ *Describe conditions observed on site visit*

The following is a summary of observations noted by the RSR team during the field review.

- The route is a two (2)-lane rural major collector.
- The posted speed limit is 45 miles per hour.
- Travel lanes are eleven (11) feet wide asphalt.
- Outside paved shoulders are two (2) feet wide.
- Five (5) of the six (6) recorded crashes were run-off-road.
- Pavement markings are in good condition.
- There is one faded and worn curve warning sign posted in the westbound direction with no advisory speed plaque.
- A curve evaluation conducted with the Reiker CARS electronic ball bank system indicates the curve should be posted with an advisory 30 mph speed.

Safety Concerns and Risk Analysis

- *Outline safety concerns*
- *Present results of risk analysis (crash trends or patterns)*
- *RSR team findings by identified problem and associated crash type*

Five (5) of the studied crashes were run-off-road type crashes that occurred in a curve, and one (1) of the studied crashes was animal-involved. Field observations noted one faded and worn curve warning sign in place on the westbound approach. The curve warning sign was not posted with an advisory speed plaque, and no chevron signs were in place on the curve. Curve signage for eastbound and westbound directions needs to be brought into conformance with the 2009 MUTCD.

Improvements

- *Outline improvements for each safety deficiency*
- *Provide low, intermediate, and high cost options if needed*
- *Include cost estimates (for existing facilities)*

The RSR team members identified the following improvements for implementation:

1. Remove one (1) Curve (W1-2) sign and replace with one (1) 36”x36” Turn (W1-1) sign and one (1) 24”x30” Advisory Speed 30 MPH (W13-1) plaque on the westbound approach.
2. Install one 36”x36” Turn (W1-1) sign and one (1) 24”x30” Advisory Speed 30 MPH (W13-1) plaque on the eastbound approach.
3. Install five (5) sets of double-sided 24”x30” Chevron (W1-8) signs at 80 feet spacing in the curve. Install reflective yellow strips on each side of the sign posts.

All signs are to be installed per the 2009 MUTCD. The estimated cost of improvements in this report is $2,000. No right-of-way is required.

☐ *If needed, a signature box for approval can be provided*

Approved by:	Signature	Date

Check Listing of Required Elements:

- ☐ Admonition
- ☐ Summary
- ☐ Project Vicinity Map (Figure 1)
- ☐ Introduction and Project Description
- ☐ RSR Team Members (Table 1)
- ☐ Data Reviewed and Site Characteristics
- ☐ Summary of Crash Data (Table 2)
- ☐ Crash Diagram (Figure 2)
- ☐ Site Visit
- ☐ Safety Concerns and Risk Analysis
- ☐ Improvements

Optional Attachments:

- ☐ Crash Reports
- ☐ CARS Evaluation

Appendix G

Prompt Lists for Project Stages

Checklist 1: Feasibility / Concept Stage Assessment

1.1 General Topics

1. Scope of Project / Function / Traffic Mix	Yes	No	Comment
Consider the intended function of the design. Is the design consistent with the function of the road?			
Will the proposed design adequately accommodate: – Cars? – Motorcycles? – Pedal bicyclists? – Pedestrians? – Heavy vehicles? – Buses?			
Is the expected mix of traffic adequately accommodated?			
Will the proposed design be consistent with adjacent roads, land forms and traffic management?			
Review all pertinent documentation to gain an understanding of the scope of the project objectives, user characteristics, design vehicles, access, adjacent development, existing network information, and future network expansion. Have all issues that would affect safety performance been addressed? If not, what issues remain?			

2. Type and Degree of Access to Property and Developments	Yes	No	Comment
Is the degree of access control consistent with the road's function and with other sections of the road?			
Will sight distances be satisfactory? – At intersections? – At property accesses?			
Is the design speed (or the likely vehicle speeds) compatible with the number and type of intersections / property access points? (for assistance refer to the Alabama Access Management Manual)			
Does the width of the right-of-way satisfy access requirements?			
Check width of right-of-way as affected by access requirements. If turn lanes will be needed, is right-of-way adequate for turn lanes?			
Are there any upstream or downstream factors which may affect access?			
Will there be "visual clutter" (excessive commercial signing or lighting) beyond the right-of-way?			

3. Major Generators of Traffic	Yes	No	Comment
Are all major generators of traffic (including housing or shopping centers) far enough away from the roadway to avoid unsafe influences on the form of the design (e.g. traffic queues that spill back into intersections)?			
Have existing or alternative accesses been arranged to ensure existing suburbs/areas are not cut off by the development of the scheme/works?			
Are the accesses for significant traffic generators far enough away from intersections for safety?			
Is sight distance to and from accesses to significant traffic generators adequate?			
Will the proposed scheme be consistent with adjacent roads, land forms and traffic management?			

4. Staging Requirements	Yes	No	Comment
Will this design be implemented in one stage only?			
If the design is to be implemented in more than one stage, has safety been given a high priority: – in transitions between stages? – in transitions to existing roads?			
Will the work avoid problems with safety standards elsewhere during construction?			
Can the effects of staging the construction of the project or dividing it into several contracts be safely accommodated?			

5. Future Work	Yes	No	Comment
Will the route be free of compromises in safety if there is to be: – future widening? – the addition of a complete second roadway? – after realignments? – major geometric changes at intersections? – linear extensions of the scheme?			

6. Wider Network Effects	Yes	No	Comment
If any harmful safety effects of this scheme upon the surrounding road network have been identified, have those effects been adequately dealt with?			

1.2 Design Issues (General)

1. Route Choice	Yes	No	Comment
If the route follows existing roads what are the effects of this?			
If the route is in 'green fields' (undeveloped corridor), is the alignment safe? Could it be safer?			
Does the scheme fit in with the physical constraints of the landscape?			
Does the scheme take account of major network considerations?			
Are design parameters consistent in alignment, cross section, interchanges, and intersections?			
Can the facility accommodate movements of heavy/public transportation vehicles where required? – vertical and horizontal clearance? – turning radii? – shoulder widths? – operational capacity?			
Is there adequate signage of heavy vehicle/public transportation activity? (e.g. truck routes, bus stops)			
Can the facility accommodate movements of road maintenance and emergency vehicles? – vertical and horizontal clearance? – turning radii? – shoulder widths?			
Are medians and cross overs visible and in adequate locations for these vehicles?			
Can shoulders accommodate slow-moving vehicles where required? – width? – structural capacity? – continuity?			
Is there appropriate signing of slow-moving vehicles if they are likely to occur?			
Is adjacent trail signage, if present, located so as not to cause confusion to road users?			
Check signage and visibility of points where trails cross the highway. Are they signed appropriately?			
Has adequate stopping sight distance been considered where trails cross the highway?			
Could headlight from an oncoming ATV confuse motorists?			
Are shoulders wide enough to accommodate cyclists/pedestrians where required?			
Are shoulders/sidewalks provided on bridges?			

2. Impact of Continuity with the Existing Network	**Yes**	**No**	**Comment**
Are all sections/transitions where the proposed road scheme connects with the existing network free of potential problems?			

3. Broad Design Standards	**Yes**	**No**	**Comment**
Have the appropriate design standards been used with regard to the scope of the project and its function in relation to the traffic composition?			
Does the geometric plan and profile meet design guidelines?			
Has the appropriate design vehicle been used?			
Does the proposed project have a suitable cross section for the ultimate requirements of the road relative to: – classification? – design speed? – level of service/peak service volumes?			
Can adjustments in dimensions be made for future expansion possibilities?			

4. Design Speed	**Yes**	**No**	**Comment**
Has the appropriate design speed been selected with regard to: – horizontal and vertical alignment? – visibility? – merging? – weaving? – decelerating or accelerating traffic at intersections?			
Is sight distance generally satisfactory: – at intersections? (if not, what implications?) – at entry and exit ramps? – at property entrances? – at emergency vehicle access points?			
If posted speed limits will change along the route, are proper transitions provided?			
Is the designated speed limit, if any, on the proposed road appropriate?			
Is the designated or intended speed limit consistent with the design speed?			
Is the design speed appropriate for horizontal and vertical alignment, visibility, etc.?			
Are the design speed and the posted speed compatible?			
Is the posted speed on each curve appropriate to the curve radii?			
Is the traffic following the posted speed?			

5. Design Volume and Traffic Characteristics	Yes	No	Comment
Is the design appropriate for the design volume of traffic?			
Is the design appropriate to accommodate special users in the traffic mix? – heavy vehicles? – bicyclists? – pedestrians?			
Will the scheme accommodate unforeseen or large increases in traffic volume or mix of vehicles?			
Is the classification and design for the proposed project's design volume and traffic composition appropriate?			
Is the design of the proposed project flexible enough to accommodate unforeseen increases in volume or changes in traffic characteristics?			

1.3 Intersections & Interchanges

1. Number and Type of Intersections	Yes	No	Comment
Are all aspects of intersections (e.g, spacing, type, layout, etc.) appropriate with respect to: – the broad concept of the project? – the function of this road and intersecting roads? – the traffic mix on this road and intersecting roads?			
Is the frequency of intersections appropriate: – for safe access? – to avoid impacts on the surrounding network? – for emergency vehicle access?			
Have all physical, visibility or traffic management constraints which would influence the choice or spacing of intersections, been considered?			
Has the vertical and/or horizontal alignment been taken into account with regard to the type or spacing of intersections?			
Are all of the proposed intersections necessary or essential?			
Can any unnecessary intersections be removed or can access be achieved more safely by changes on the surrounding road network?			
Will the angle of the intersecting roads and the sight lines be adequate for the safety of all road users?			
Is the movement of vulnerable road users safely accommodated at all intersections?			
Is the movement of heavy vehicles safely accommodated at all intersections?			
Can intersection designs accommodate all design vehicle classifications?			
Is there sufficient spacing between intersections?			

2. Interchanges	Yes	No	Comment
Is the interchange design appropriate with respect to the following: – topography? – environment? – traffic operations?			
Is the interchange layout consistent with other designs throughout the corridor or network?			
Is spacing between interchanges in the network sufficient?			
Is the number of lanes appropriate for safe operations and to accommodate variations in traffic patterns?			
Is there coordination of lane balance and basic lanes?			
Is lane continuity maintained?			

1.4 Environmental Constraints

1. Safety Aspects of the Environment	Yes	No	Comment
Is the surrounding terrain free of physical or vegetation defects which could affect the safety of the scheme (e.g., heavy planting, forestry, deep cuttings, steep or rocky bluffs which constrain the design)?			
Have effects like wind, mist, ice, fog, sun angles at sunrise and sunset been given adequate consideration?			
Do the gradients, curves and general design approaches fit with the likely weather or environmental aspects of the terrain (e.g., fog-prone areas)?			
Has safety been considered in the location of environmental impact mitigation features (e.g., noise walls)?			
Does the scheme deal adequately with potential animal conflicts (e.g., sheep, cattle, etc.)?			
Will the scheme perform safely at night when it is wet or there is fog?			
Are visual distractions such as scenic vistas adequately dealt with (e.g., by providing areas for people to stop safely)?			
Are there any known animal travel/migration routes in surrounding areas which could affect design?			

1.5 Physical Objects

1. Safety Aspects of Physical Objects	Yes	No	Comment
Are unprotected median widths appropriate for light poles?			
Are traffic signal and other service poles positioned appropriately?			
Consider the location of services and utilities with respect to the project (i.e., buried and overhead). Does the project appropriately handle utilities with regard to: – clear zone? – vertical clearance for overhead wires?			
Is the type of median chosen appropriate for the available width?			
Do barriers possess the proper geometrical configuration?			
Are slopes of grass median traversable?			
Are median barriers sufficiently offset from the roadway and in the correct range of values?			
Do roadside barriers and bridge barriers meet the appropriate crash test performance level that is consistent with the roadway classification?			
Is there sufficient width for overpass/underpass piers and light standards?			
Is the spacing between median crossovers appropriate and consistent with the Alabama Access Management Guide?			

1.6 Any Other Matters

1. Safety Aspects Not Already Addressed	Yes	No	Comment
Has the possibility of water ponding been adequately dealt with?			
Have any at-grade railroad crossings been identified, and are they treated adequately?			
Have other distractions (for example, low-flying aircraft, advertising, etc.) been adequately dealt with?			
Has the need for pull-offs or parking (for example, for tourist routes, trucks, picnic or rest areas) been considered?			
Has the potential of the location to attract roadside stalls been considered?			
Will there be special events? Have any consequent unusual or hazardous conditions been considered?			

Have all classes of pedestrians that could be seriously affected by the proposal been considered and accommodated as needed (e.g., school children or senior adults)?			
Have any existing safety or accident problems on the existing network been addressed? (Not carried over to the new scheme.)			
Has the issue of providing lighting for the design been considered?			
Has the need for drivers to stop been considered (e.g., breakdown, rest areas, truck parking, enforcement)?			
Are there any other matters which may have a bearing on safety?			

Checklist 2: Schematic/Preliminary Design Stage Assessment

2.1 General Topics

1. Changes Since Previous Assessment	Yes	No	Comment
Do the conditions for which the scheme was originally designed still apply (e.g. no changes to the surrounding network, area activities or traffic composition)?			
Has the general form of the project design remained unchanged since the previous assessment (if any)?			
Check for changes in the scope of the project. Have scope changes been assessed for impacts to safety?			
Check for changes in the conditions for which the project was designed. Have all changes been assessed for impacts to safety?			

2. Landscaping	Yes	No	Comment
If any landscaping proposals are available, are they compatible with safety requirements (e.g., sight lines and hazards in clear zones)?			

3. Access to Property and Developments	Yes	No	Comment
Can all accesses be used safely (entry and exit/merging)?			
Is the design free of any downstream or upstream effects from points of access, particularly near intersections?			
Have rest areas and truck parking accesses been checked for adequate sight distance, etc.?			
Is the ROW sufficient to accommodate addition of left or right turn lanes?			
Does the scheme address potential safety issues that might occur due to upstream or downstream influences?			
Does the scheme minimize the effects of “visual clutter” (excessive commercial signing or lighting) beyond the ROW?			

4. Adjacent Developments	Yes	No	Comment
Does the design handle accesses to major adjacent generators of traffic and developments safely?			
Is the driver’s perception of the road ahead free of misleading effects of any lighting or traffic signals on an adjacent road?			

5. Emergency Vehicles and Access	Yes	No	Comment
Has provision been made for safe access and movements by emergency vehicles?			
Does the design and positioning of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic?			

6. Future Widening and/or Realignments	Yes	No	Comment
If the scheme is only a stage towards a wider or divided roadway is the design adequate to impart this message to drivers? (Is the reliance on signs minimal/ appropriate, rather than excessive?)			
Is the transition between single and divided roadway (either way) handled safely?			

7. Staging of the Work	Yes	No	Comment
If the scheme is to be staged or constructed at different times: – are the construction plans and program arranged to ensure maximum safety? – do the construction plans and traffic control plans include specific safety measures, signing, adequate transitional geometry, etc. for any temporary arrangements?			
If the construction is to be split into several contracts, are they arranged safely?			

8. Maintenance	Yes	No	Comment
Can maintenance vehicles be safely parked to conduct maintenance activities?			

9. Hazard Management	Yes	No	Comment
Have all existing and potential hazards been identified?			

2.2 Design Issues (General)

1. Design Standards	Yes	No	Comment
Is the design speed and speed limit appropriate (e.g., consider the terrain and function of the road)?			
Has the appropriate design vehicle been used?			
Are design parameters consistent with alignment, cross section, interchanges, and intersections?			
Is the design speed appropriate for horizontal and vertical alignment, visibility, etc.?			
Is the design speed compatible with the posted speed?			
Is the posted speed on each curve adequate?			
Is the traffic following the posted speed?			

2. Typical Cross Sections	Yes	No	Comment
Are lane widths, shoulders, medians and other cross section features adequate for the function of the road?			
Is the width of traffic lanes and roadway suitable in relation to: – alignment? – traffic volume? – vehicle dimensions? – the speed environment? – combinations of speed and traffic volume?			
Are passing/climbing lanes provided if needed?			
Have adequate clear zones been achieved?			
Is the functional classification and design for the proposed project appropriate for the design volume and traffic composition?			
Is the design of the proposed project flexible enough to accommodate unforeseen increases in volume or changes in traffic characteristics?			

3. Effect of Cross Sectional Variation	Yes	No	Comment
Is the design free of undesirable variations in cross section design?			
Are cross-slopes safe (particularly where sections of existing highway have been used or there have been compromises to accommodate accesses, etc.)?			
Does the cross section avoid unsafe compromises such as narrowing at bridge approaches or past physical features?			
Does the proposed project have a suitable cross section for the ultimate requirements of the road relative to: – functional classification? – design speed? – level of service/peak service volumes?			
Can adjustments in dimensions be made for future expansion possibilities?			

4. Roadway Layout	Yes	No	Comment
Are traffic management features designed to avoid creating unsafe conditions?			
Is the layout of road markings and reflective materials able to deal satisfactorily with changes in alignment (particularly where the alignment may be substandard)?			

5. Shoulders and Edge Treatment	Yes	No	Comment
Are the following safety aspects of shoulder provision satisfactory: – provision of treated or untreated shoulders? – width and treatment on embankments? – cross-slope of shoulders?			
Are the shoulders likely to be safe if used by slow moving vehicles or bicyclists?			
Are any rest areas and truck parking areas safely designed?			

6. Effect of Departures from Standards or Guidelines	Yes	No	Comment
For any approved departures from standards or guidelines, is safety maintained?			
For any hitherto undetected departures from standards, is safety maintained?			

2.3 Alignment Details

1. Geometry of Horizontal and Vertical Alignment	Yes	No	Comment
Do the horizontal and vertical designs fit together correctly?			
Is the design free of visual cues that would cause a driver to misread the road characteristics (for example, visual illusions, subliminal delineation such as lines of trees, poles, etc.)?			
Does the alignment provide for speed consistency?			
Are horizontal and vertical curves minimized?			
Do excessive grades affect heavy vehicle operations and service levels?			
Is the design free of feature combinations that create safety concerns (e.g. small radius horizontal curve at end of long tangent)?			
Do crown and cross slope designs provide sufficient storm water drainage and facilitate de-icing treatments?			
Are cross slopes across adjacent traffic lanes consistent?			
If a transition curve is required between a tangent and a circular curve, has it been included?			
Is the superelevation with transition curves suitable in relation to effects of drainage?			
Does the design address potential issues that could occur from excessive grades that would be unsafe in adverse weather conditions?			
Is a climbing lane provided where overtaking and passing maneuvers are limited due to terrain?			
Is a climbing lane provided in areas where the design gradient exceeds the critical length of the grade?			
Are escape lanes provided where necessary on steep down grades. If not, are escape lanes feasible?			
Is there adequate provision of passing opportunities?			
Is there sufficient spacing between passing zones?			
Have the interaction of horizontal and vertical alignments in the road (i.e., roller coaster alignments, sequencing of horizontal/vertical curves, etc.) been checked?			

2. Visibility / Sight Distance	Yes	No	Comment
Are horizontal and vertical alignments consistent with the visibility requirements?			
Will the design be free of sight line obstructions such as: – safety fences or barriers? – boundary fences? – street furniture? – parking facilities? – signs? – landscaping? – bridge abutments? – parked vehicles in pull-offs or at the curb? – queued traffic?			
Are railroad crossings, bridges and other hazards all conspicuous?			
Is the design free of any other local features which may affect visibility?			
Are adequate passing opportunities provided?			
Is adequate stopping sight distance is provided throughout the length of the project?			
Is appropriate decision sight distance provided for interchange and intersection signing throughout the project?			

3. New and Existing Road Interface	Yes	No	Comment
Does the interface occur well away from any hazard? (for example, a crest, a curve, a roadside hazard or where poor visibility/distractions may occur.)			
If roadway standards differ, is the change accomplished safely?			
Is the transition where the road environment changes (e.g., urban to rural; restricted to unrestricted; lit to unlit) done safely?			
Has the need for advance warning been considered?			
Is the lane width sufficient for road design / classification?			

4. Readability of the Alignment by Drivers	Yes	No	Comment
Will the general layout, function and broad features be recognized by drivers in sufficient time?			
Will approach speeds be suitable and can drivers correctly track through the scheme?			

2.4 Intersections

1. Visibility To and Visibility At Intersections	Yes	No	Comment
Are horizontal and vertical alignments at the intersection or on the approaches to the intersection consistent with the visibility requirements? (i.e., side street visible)			
Will drivers be aware of the presence of the intersection (especially on the minor road approach)?			
Will the design be free of sight line obstructions due to: – safety fences or barriers? – boundary fences? – street furniture? – parking facilities? – signs? – landscaping? – bridge abutments?			
Are railroad crossings, bridges and other hazards near intersections conspicuous?			
Will intersection sight lines be obstructed by permanent or temporary features such as parked vehicles in pull-offs, or by parked or queued traffic generally?			
Are all sight distances adequate for all movements and road users?			

2. Layout, Including the Appropriateness of Type	Yes	No	Comment
Is the type of intersection selected (cross roads, T, roundabout, signalized, etc.) appropriate for the function of the two roads?			
Are the proposed controls (Yield, Stop, Signals, etc.) appropriate for the particular intersection?			
Are intersection geometric designs appropriate for all vehicle movements?			
Are the lane widths and turning paths adequate for all vehicles?			
Is the design free of any upstream or downstream geometric features that could affect safety (for example, merging of lanes)?			
Are the approach speeds consistent with the intersection design?			
Where a roundabout is proposed: – have pedal bicycle movements been considered? – have pedestrian movements been considered? – are details regarding the circulating roadway sufficient?			

Is there sufficient spacing between intersections?			
Does horizontal/vertical alignment affect the location/spacing of the intersections?			
Are intersections and accesses adequate for all permitted vehicle movements?			
Are the lane widths adequate for all vehicle classes?			
Have any upstream and downstream features which may affect safety been checked (i.e., “visual clutter”, angle parking, high volume driveways)?			
Have the appropriate number of lanes (left, through, right) been provided?			

3. Readability by Drivers	Yes	No	Comment
Will the general type, function and broad features of the intersection be perceived correctly by drivers?			
Are the approach speeds and likely positions of vehicles as they track through the scheme safe?			
Is the design free of sunrise or sunset problems that may create a hazard for motorists?			

2.5 Interchanges

1. Layout, Including the Appropriateness of Type	Yes	No	Comment
Is spacing between interchanges in the network sufficient?			
Are length and number of weaving lanes appropriate?			
Is the design speed appropriate for site limitations, ramp configurations, and vehicle mix?			
Is there adequate distance between successive entrance and exit noses?			
Is the off-ramp length adequate for deceleration?			
Is adequate sight and decision sight distance provided?			
Is the on-ramp length appropriate for acceleration and safe and convenient merging with through traffic?			

If spiral curves are warranted, do spirals begin and end at appropriate locations?			
Is the length of acceleration adequate for traffic composition (i.e. truck, buses, etc.)?			
Is there an adequate view of the speed change lane at the nose?			
Is visibility unobscured by traffic barriers and other obstructions?			
Is there coordination of lane balance and basic lanes?			
Is lane continuity maintained?			

2.6 Special Road Users

1. Adjacent Land Equipment (e.g. tractors)	Yes	No	Comment
Will the scheme be free of adverse effects from use by slow moving farm or similar equipment? (If not, what special measures are needed?)			

2. Pedestrians	Yes	No	Comment
Have pedestrian needs been satisfactorily considered?			
Are pedestrian underpasses or overpasses sited to provide maximum use? (i.e., is the possibility of pedestrians crossing at grade in their vicinity minimized?)			
Has specific provision been made for pedestrian crossings, school crossings or pedestrian signals?			
Where present, are these facilities sited to provide maximum use with safety?			
Are pedestrian refuges/curb extensions provided where needed?			
Has specific consideration been given to provisions needed for special groups (e.g., young, elderly, disabled, deaf or blind)?			

3. Bicyclists	Yes	No	Comment
Have the needs of bicyclists been satisfactorily considered, especially at intersections?			
Have bicycle lanes been considered?			

Are all bicycle facilities of standard or adequate design?			
Where a need for shared pedestrian/bicycle facilities exists, have potential conflicts between modes been adequately addressed?			
Where bicycle travel paths terminate at intersections or adjacent to the roadway, has the transition treatment been handled safely?			
Have any needs for special bicycle facilities been satisfactorily considered (e.g., bicycle signals)?			

4. Motorcyclists	**Yes**	**No**	**Comment**
Has the location of devices or objects that might destabilize a motorcycle been avoided on the road surface?			
Has barrier curb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or safely shielded?			

5. Equestrians and Stock	**Yes**	**No**	**Comment**
Have the needs of equestrians been considered, including the use of roadside or shoulders and rules regarding the use of the roadway?			
Can underpass facilities be used by equestrians/stock?			

6. Public Transportation	**Yes**	**No**	**Comment**
Have the needs of public transportation users been considered?			
Have the maneuvering needs of public transportation vehicles been considered?			
Are bus stops well positioned for safety?			

7. Road Maintenance Vehicles	**Yes**	**No**	**Comment**
Has provision been made for road maintenance vehicles to be used safely at the site?			

2.7 Lighting, Signs, Pavement Markings and Delineation

1. Lighting	Yes	No	Comment
Will safety be maintained if the project does not include street lighting?			
Is the design free of features that make illuminating sections of the road difficult (e.g., shadow from trees or over bridges)?			
Have the potential locations for light poles been considered for consistency with clear zone requirements?			
Are breakaway or slip-base poles to be provided?			
Are any special needs created by ambient lighting?			
If standard lighting features are provided, will safety adequately provided?			
Have the safety consequences of vehicles striking lighting poles (of any type) been considered?			

2. Signs	Yes	No	Comment
Are signs appropriate for their location?			
Are signs located where they can be seen and read in adequate time?			
Will signs be readily understood?			
Are signs located so that visibility to and from accesses and intersecting roads is maintained?			
Are signs appropriate to the driver's needs (e.g., destination signs, advisory speed signs, etc.)?			
Have the safety consequences of vehicles striking sign posts been considered?			
Are signs located so that drivers' sight distance is maintained?			
Are any signs to be located in the clear zone breakaway or adequately shielded by a crash barrier?			

3. Pavement Marking and Delineation	Yes	No	Comment
Has the appropriate standard of delineation and marking been adopted?			
Are the proposed markings consistent with the markings in the adjoining section of the roadway?			
Are the previous/adjacent markings to be upgraded?			

2.8 Traffic Management

1. Traffic Flow and Access Restrictions	Yes	No	Comment
Can traffic volumes from the proposed scheme be safely accommodated on existing sections of road?			
Have parking provision and parking control been adequately considered?			
Can any turn prohibitions be implemented without causing problems at adjacent intersections?			
Has the effect of access to future developments been considered?			
If traffic is likely to divert to other roads (e.g., to avoid a traffic control device), is safety maintained?			

2. Passing and Merges	Yes	No	Comment
Are passing sight distance and stopping sight distance adequate?			
Have suitable shoulder widths been provided at lane drop merges?			
Have standard signs and markings been provided for any lane drop?			
Has adequate sight distance been provided to any lane drop?			
Are shoulders wide enough opposite access points and intersections?			

3. Rest Areas and Stopping Zones	Yes	No	Comment
Are there sufficient roadside stopping areas, rest areas and truck parking areas?			
Are any entries and exits to rest areas or truck parking areas safe?			
Are rest areas/picnic sites placed at appropriate locations?			
Have appropriate signs been chosen and placed correctly to notify drivers of an upcoming rest area/picnic site?			

4. Construction and Operation	Yes	No	Comment
Can the traffic control be safely constructed?			
Have the maintenance requirements been adequately considered?			
Is safe access for construction vehicles to and from the work zone available?			

2.9 Additional Questions to be Considered for Developmental Purposes

1. Horizontal Alignment	Yes	No	Comment
Is visibility adequate for drivers and pedestrians at proposed accesses?			
Is adequate turning space provided for the volume and speed of traffic?			
Are curve radii and forward visibility satisfactory?			
Are sight and stopping distances adequate?			

2. Vertical Alignment	Yes	No	Comment
Are gradients satisfactory?			
Are sight and stopping distances adequate?			

3. Parking Provision	Yes	No	Comment
Is on-site parking adequate to avoid on-street parking and associated risks?			
Are parking areas conveniently located?			
Is adequate space provided in parking areas for circulation and intersection sight distance?			

4. Servicing Facilities	Yes	No	Comment
Are off street loading/unloading areas adequate?			
Are turning facilities for large vehicles provided in safe locations?			
Is emergency vehicle access adequate?			

5. Signs and Markings	Yes	No	Comment
Have necessary traffic signs and road markings been provided as part of a development?			
Will the signs and markings be clear in all conditions, including day/night, rain, fog, etc.?			

6. Landscaping	Yes	No	Comment
Does landscaping maintain visibility at intersections, curves, accesses and pedestrian locations?			
Has tree planting been avoided where vehicles are likely to run off the road?			

7. Traffic Management	Yes	No	Comment
Will the design keep travel speeds at the safe level?			
Are the number and location of accesses appropriate?			
Are the facilities for public transportation services safely located?			
Are any bicycle facilities safely located in respect to vehicular movements?			
Are pedestrian facilities adequate and safely located?			
Can the facility accommodate movements of heavy/public transportation vehicles where required? (e.g., clearances, turning radii, shoulder widths, operational capacity?)			
Is there adequate signage of heavy vehicle/public transportation activity?			
Can the facility accommodate movements of road maintenance and emergency vehicles (e.g., clearances, turning radii, shoulder widths)			
Are medians and cross overs visible and in adequate locations for road maintenance and emergency vehicles?			
Can shoulders accommodate slow-moving vehicles where required? – width? – structural capacity? – continuity?			
Is there appropriate signing of slow-moving vehicles as necessary?			
Has the visibility of adjacent trail signage been checked to avoid confusion to road users?			
Has the signage and visibility of points where trails cross the highway been checked and appropriately addressed?			
Has adequate stopping sight distance been considered where trails cross the highway?			
Could headlight of an oncoming ATV confuse motorists?			
Are shoulders wide enough to accommodate cyclists/pedestrians where required?			
Are shoulders/sidewalks provided on bridges?			

8. Other	Yes	No	Comment
Has appropriate street lighting been provided?			
Are any roadside hazards appropriately dealt with?			
Has safe pedestrian access to the development been provided?			

2.10 Physical Objects

1. Physical Objects	Yes	No	Comment
Are unprotected median widths appropriate for lighting poles?			
Are traffic signal and other service poles positioned appropriately per current guidelines?			
Consider the location of services and utilities with respect to the project (i.e. buried and overhead). Is there adequate clearance for overhead wires?			
Is type of median chosen appropriate for the width available?			
Do barriers possess the proper geometrical configuration?			
Are slopes of grass median adequate?			
Are median barriers sufficiently offset from the roadway?			
Are median barrier offsets in the correct range of values?			
Do roadside barriers and bridge barriers meet the appropriate crash test performance level that is consistent with the roadway classification?			
Is there sufficient width for overpass/underpass piers and light standards?			
Is there appropriate spacing between median crossovers?			

2.11 Any Other Matters

1. Safety Aspects Not Already Covered	Yes	No	Comment
Will there be special events? Have any consequent unusual or hazardous conditions been considered?			
If required, can the road be closed for special events in a safe manner?			
If applicable, are special requirements of scenic or tourist routes satisfied?			
Check the effects of rain, fog, snow, ice, wind on design features of the project.			
Are there any known animal travel/migration routes in surrounding areas which could affect design?			
Are fencing and underpasses installed where required?			
Ensure appropriate signing (i.e., cattle crossing, deer warning, etc.) where required.			

2. Bridge Structures	Yes	No	Comment
Is vertical clearance for underpasses sufficient? If not are height restrictions properly signed?			
Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?			
Are bridge abutments and parapets situated so as not to obstruct stopping and passing sight distances?			
Is signing required for delineation, weight restriction, or warning of deck freezing? Is it properly installed?			
Are drainage grates located so they do not interfere with cyclists?			
If shoulder widths are reduced across the structure, have warning signs been included?			
Is the proper clearance window provided at underpasses for height and width?			
Are the proper curb heights used for sidewalks, parapets and safety curbs on bridge structures?			
Are the proper drainage features incorporated into the design of underpasses, overpasses and bridge structures to prevent ponding?			
Does the concept minimize the possibility of a visual perception of narrowing or funneling at underpasses and overpasses due to abutment walls in relation to the traveled roadway?			
Do all the appropriate side clearances, median clearances and hazard clearances for bridges meet classification standards?			

Checklist 3: Detailed Design Stage Assessment

3.1 General Topics

1. Changes Since Previous Assessment	Yes	No	Comment
Do the conditions for which the scheme was originally designed still apply? (i.e. no significant changes to the surrounding network or area to be served, or traffic composition)			
Has the design of the project remained unchanged since previous assessment (if any)?			

2. Drainage	Yes	No	Comment
Are the road grades and cross-slopes adequate for satisfactory drainage?			
Are flat spots avoided or adequately dealt with at start/ end of superelevation?			
Has the possibility of surface flooding been adequately addressed, including overflow from surrounding or intersecting drains and water courses?			
Is inlet spacing adequate to limit flooding?			
Is inlet design safe for pedal bicycles (i.e. gaps not parallel with wheel tracks)?			
Will sidewalks drain adequately?			

3. Landscaping	Yes	No	Comment
Will drivers be able to see pedestrians (and vice versa) past or over the landscaping?			
Will intersection sight lines be maintained past or over the landscaping?			
Will safety be adequate with seasonal growth? (e.g., no obscuring of signs, shading or light effects, slippery surface, etc.)			
Will roadside safety be adequate when trees or plantings mature (no roadside hazard)?			
Has breakaway vegetation been used in possible run-off road areas?			
Is landscaping along the road in accordance with guidelines?			
Will required clearances and sight distances be restricted due to future plant growth?			

4. Services	Yes	No	Comment
Does the design adequately deal with buried and overhead services (especially in regard to overhead clearances, etc.)?			
Has the location of fixed objects or furniture associated with services been checked (including any loss of visibility, position of poles, and clearance to overhead wires)?			

5. Access to Property and Developments	Yes	No	Comment
Can all accesses be used safely?			
Is the design free of any downstream or upstream effects from accesses, particularly near intersections?			
Do rest areas and truck parking areas have adequate sight distance at access points?			
Are there any upstream or downstream factors which may affect access?			
Will there be "visual clutter" (excessive commercial signing or lighting) beyond the ROW?			
Check interaction between driveways and the road. Are driveways adequately designed for land use?			
Is there adequate space between driveways on the same side of street?			

6. Emergencies, Breakdowns, Emergency and Service Vehicle Access	Yes	No	Comment
Has provision been made for safe access and movements by emergency vehicles?			
Does the design and positioning of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic?			
Have broken-down vehicles or stopped emergency vehicles been adequately considered?			
Are median breaks on divided roadways safely located (i.e. frequency, visibility)?			

7. Future Widening and/or Realignments	Yes	No	Comment
If the scheme is only a stage towards a wider or divided roadway is the design adequate to impart this message to drivers? (Is the reliance on signs minimal/appropriate, rather than excessive?)			
Is the transition between single and divided roadway (either way) handled safely?			

8. Staging of Construction	Yes	No	Comment
If the scheme is to be staged or constructed at different times: – are the construction plans and program arranged to ensure maximum safety? – do the construction plans and program include specific safety measures (e.g., signing, adequate transitional geometry) for any temporary arrangements?			
If the construction is to be split into several sub-projects, is the order safe (i.e. the stages are not constructed in an order that creates unsafe conditions)?			
Can the effects of staging the construction of the project or dividing it into several contracts be safety accommodated?			

9. Adjacent Developments	Yes	No	Comment
Does the design handle accesses to major adjacent generators of traffic and developments safely?			
Is drivers' perception of the road ahead free of misleading effects of any lighting or traffic signals on an adjacent road?			
Has the need for screening against glare from lighting of adjacent property been adequately considered?			
Will traffic volume on nearby roads change as a result of this project?			
If traffic volume and flow have altered along adjacent roads, has a change in ROW been considered?			

10. Skid Resistance	Yes	No	Comment
Has the need for high friction surface treatment been considered where braking or good road adhesion is most essential (e.g., on gradients, curves, approaches to intersections and signals)?			

3.2 Design Issues (General)

1. Geometry of Horizontal and Vertical Alignment	Yes	No	Comment
Does the horizontal and vertical design fit together correctly?			
Is the vertical alignment consistent and appropriate throughout?			
Is the horizontal alignment consistent throughout?			
Is the alignment consistent with the function of the road?			
Is the design free of misleading visual cues (e.g., visual illusions, subliminal delineation like lines of poles)?			
Are design parameters consistent in alignment, cross section, interchanges, and intersections?			
Is the design speed appropriate for horizontal and vertical alignment, visibility, etc.?			
Is there continuity between the design speed and the posted speed?			
Is the posted speed on each curve adequate?			
Is the traffic following the posted speed?			

2. Typical Cross Sections	Yes	No	Comment
Are lane widths, shoulders, medians and other cross section features adequate for the function of the road?			
Is the width of traffic lanes and roadways suitable in relation to: – alignment? – traffic volume? – vehicle dimensions? – the speed environment? – combinations of speed and traffic volume?			
Are the shoulder widths adequate for stationary vehicles and errant vehicles?			
Is superelevation consistent with the road environment?			
Are the shoulder cross-slopes safe for vehicles to traverse?			
Are roadside slopes drivable for cars, trucks?			
If side slopes and columns are present under a bridge structure, are they appropriately shielded?			
Have adequate facilities been provided for pedestrians and bicyclists?			

3. Effect of Cross Sectional Variation	Yes	No	Comment
Is the design free of undesirable variations in cross section design?			
Are cross-slopes safe (particularly where sections of existing highway have been used, there have been compromises to accommodate accesses, at bridge narrowing, etc.)?			
Are curves with adverse cross-slope within appropriate limits?			
Is superelevation provided and sufficient at all locations where required?			
Determine if the proposed project has a suitable cross section for the ultimate requirements of the road including: – classification? – design speed? – level of service/peak service volumes?			
Can adjustments in dimensions be made for future expansion possibilities?			

4. Roadway Layout	Yes	No	Comment
Are all traffic management features designed so as to avoid creating unsafe conditions?			
Is the layout of road markings and reflective materials able to deal satisfactorily with changes in alignment (particularly where the alignment may be substandard)?			
Is there adequate provision for passing?			
Are passing lanes provided where required and safely commenced and ended?			
Are passing requirements satisfactory?			
Is the design free of sunrise/sunset problems?			
Have public transportation requirements been adequately accommodated?			
Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected?			

5. Shoulders and Edge Treatment	Yes	No	Comment
Are the following safety aspects of shoulder provision satisfactory: – provision of treated or untreated shoulders? – width and treatment on embankments? – cross-slope of shoulders?			
Are the shoulders likely to be safe if used by slow moving vehicles or bicyclists?			
Are shoulder widths adequate for all vehicles and road users?			
Is cross-fall of shoulder adequate for drainage?			
Is treatment of embankments sufficient?			
If shoulder drop-offs are present, have countermeasures been included to safely accommodate errant vehicles?			
Is shoulder surfacing appropriate for road classification?			
Are rumble strips properly installed where warranted?			

6. Effect of Departures from Standards or Guidelines	Yes	No	Comment
For any approved departures from standards or guidelines, is safety maintained?			
Are there any hitherto undetected departures from standards?			
For any hitherto undetected departures from standards, is safety maintained?			

7. Visibility and Sight Distance	Yes	No	Comment
Are horizontal and vertical alignments consistent with visibility requirements?			
Has an appropriate design speed been selected for visibility requirements?			

8. Environmental Treatments	Yes	No	Comment
Has safety been considered in the location of environmental features (e.g., noise fences)?			
Are there any known animal travel/migration routes in surrounding areas which could affect design?			
Are fencing and underpasses installed where required?			
Is appropriate signing (i.e., cattle crossing, deer warning, etc.) provided where required?			

3.3 Alignment Details

1. Visibility / Sight Distance	Yes	No	Comment
Are horizontal and vertical alignments consistent with the visibility requirements?			
Is the design free of sight line obstructions such as: – safety fences or barriers? – boundary fences? – street furniture? – parking facilities? – signs? – landscaping? – bridge abutments? – parked vehicles in pull-offs or at the curb? – queued traffic?			
Are all railroad crossings, bridges and other hazards conspicuous?			
Is the design free of any other local features which may affect visibility?			
Is the design free of overhead obstructions (e.g., road or rail overpasses, sign bridges, overhanging trees) which may limit sight distance at sag curves?			
Is visibility adequate at: – any pedestrian, bicycle or cattle crossings? – access roads, driveways, on and off ramps, etc.?			
Has the minimum sight triangle been provided at: – entry and exit ramps? – gore areas? – intersections? – roundabouts? – other conflict points?			
Are adequate passing opportunities provided?			
Is adequate stopping sight distance provided throughout the length of the project?			
Is decision sight distance provided for interchange and intersection signing throughout the project?			

2. New / Existing Road Interface	Yes	No	Comment
Have implications for safety at the interface been considered?			
Is the transition from old road to the new scheme satisfactory?			
If the existing road is of a lower standard than the new scheme, is there clear and unambiguous warning of the reduction in standard?			
Have the appropriate provisions for safety been made where sudden changes in speed are required?			
Is access or side friction handled safely?			
Does the interface occur well away from any hazard (e.g., a crest, a curve, a roadside hazard or where poor visibility/distractions may occur)?			
If roadway standards differ, is the change managed safely?			
Is the transition where the road environment changes (e.g., urban to rural; restricted to unrestricted; lit to unlit) done safely?			
Has the need for advance warning been considered?			
Do the horizontal and vertical alignments of the proposed facility co-ordinate effectively with those of existing facilities?			
Are road transition environments safe?			
Is advance warning required?			
Is there a sudden change in speed regime, access or side friction characteristics?			
Does the interface occur near hazards (e.g., crest, bend, etc.)?			
Is the lane width sufficient for road design / classification?			

3. Readability of the Alignment by Drivers	Yes	No	Comment
Will the general layout, function and broad features be recognized by drivers in sufficient time?			
Will approach speeds be suitable and will drivers correctly track through the scheme?			

4. Detail of Geometric Design	Yes	No	Comment
Are the design standards appropriate for all the requirements of the scheme?			
Is consistency of general standards and guidelines, such as lane widths and cross-slopes, maintained?			
Do crown and cross slope designs provide sufficient storm water drainage?			
Are cross slopes along adjacent traffic lanes consistent?			
If a transition curve is required between a tangent and a circular curve, has it been provided?			
Is the superelevation with transition curves suitable in relation to effects of drainage?			
Does the design address excessive grades that would be unsafe in adverse weather conditions?			
Is a climbing lane provided where overtaking and passing maneuvers are limited due to terrain?			
Is a climbing lane provided in areas where the design gradient exceeds the critical length of the grade?			
Are escape lanes provided where necessary on steep downgrades? If not, are escape lanes feasible?			
Is there adequate provision of passing opportunities?			
Is there sufficient spacing between passing zones?			
Has the interaction of horizontal and vertical alignments in the road been checked to avoid roller coaster alignments that create an uncomfortable shift between horizontal and vertical movement?			

5. Treatment at Bridges and Culverts	Yes	No	Comment
Is the geometric transition from the standard cross section to that on the bridge handled safely?			

3.4 Intersections

1. Visibility To and Visibility At Intersections	Yes	No	Comment
Are horizontal and vertical alignments at the intersection or on the approaches to the intersection consistent with the visibility requirements?			
Is the standard adopted for provision of visibility appropriate for the speed of traffic and for any unusual traffic composition?			
Will the design be free of sight line obstructions due to: – safety fences or barriers? – boundary fences? – street furniture? – parking facilities? – signs? – landscaping? – bridge abutments? – parked vehicles in pull-offs and at the curb? – queued traffic?			
Are railroad crossings, bridges and other hazards conspicuous?			
Is the design free of any other local features which may affect visibility?			
Does the horizontal and vertical alignment provide adequate visibility of the intersection?			
Are sight lines to the intersection unobstructed (consider signs, bridge abutments, buildings, landscaping, etc.)?			
Are all sight distances adequate for all movements and road users?			
Could sight lines be temporarily obstructed by parked vehicles, snow storage, seasonal foliage, etc.?			
Do grades at intersecting roadways allow desirable sight distance?			

2. Layout	Yes	No	Comment
Are intersections and accesses adequate for all vehicle movements?			
Has the appropriate design vehicle been used for turning dimensions?			
Are turning paths accommodated for all likely vehicle types? (Has the appropriate design vehicle been used?)			
Are intersections free of any unusual features which could affect road safety?			
Are pedestrian fences provided where needed (for example, to guide pedestrians or discourage parking)?			
Has pavement High Friction Surface Treatment been provided where needed?			

Have islands and signs been provided where required?			
With regard to vehicles which may park at or close to the intersection, can they do this safely or does this activity need to be re-located?			
Are safety hazards due to parked vehicles avoided?			
Are the lane widths adequate for all vehicle classes?			
Have upstream and downstream features which may affect safety been checked and addressed (i.e., “visual clutter”, angle parking, high volume driveways)?			
Are the appropriate number of lanes (left, through, right) provided and are they of appropriate length?			
Is there advance warning of approaching auxiliary lanes?			
Is sight distance for entering/leaving vehicles adequate?			
Are tapers installed where needed? Are they correctly aligned?			

3. Readability by Drivers	Yes	No	Comment
Will the existence of the intersection and its general layout, function and broad features be perceived correctly and in adequate time?			
Are the approach speeds and likely positions of vehicles tracking through the intersection safe?			
Is the design free of misleading elements?			
Is the design free of sunrise or sunset problems which may create a hazard for motorists?			
Are vehicle maneuvers obvious to all users?			
Have any potential conflicts in movements been addressed?			
Are pavement markings clearly visible in day and night time conditions?			
Have specifications for retro-reflectivity of pavement markings been checked?			
Will signs be visible and readable to approaching users?			
Is all signage (type and location) compliant with the current MUTCD?			
Are stop/yield signs used where appropriate?			
Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?			
Check location and number of signals. Are signals visible?			
Is traffic signal head placement consistent with the current MUTCD?			

Has the potential need for auxiliary signal heads been addressed?			
Are minimal green and clearance phases provided?			
Is the signal phasing plan consistent with adjacent intersections?			
Is adequate warning provided for signals not visible from an appropriate sight distance? (i.e., signs, flashing light, etc.)			
Are lateral rumble strips required and properly positioned?			
Are pavement markings appropriate for the intersection?			

4. Detailed Geometric Design	Yes	No	Comment
Can the layout safely handle unusual traffic compositions or circumstances?			
Does any median or any island safely account for: – vehicle alignments and paths? – future traffic signals? – pedestrian storage space and surface? – turning path clearance? – stopping sight distance to the nose? – traverseability by errant vehicles?			
Is adequate vertical clearance to structures provided (for example, power lines, shop awnings)?			
Is there sufficient spacing between intersections?			
Does horizontal/vertical alignment affect the location/spacing of the intersections?			
Are intersections and access driveways adequate for all permitted vehicle movements?			

5. Traffic Signals	Yes	No	Comment
Is the signal phasing/sequence safe?			
Is adequate time provided for traffic movements and pedestrian movements?			
Will the signal indications be visible (for example, not obstructed by trees, poles, signs or large vehicles)?			
Are indications for other approach directions adequately shielded from view?			
Are high-intensity signals and/or target boards provided if likely to be affected by sunrise/sunset?			
Does the vertical alignment provide satisfactory stopping sight distance to the intersection or back of queue?			
Are pedestrian facilities provided where they are required?			

Will approaching drivers be able to see pedestrians?			
Are partially or fully controlled turning phases required and provided?			
Are signal posts located where they are not an undue hazard?			
Are road markings for turning traffic satisfactory?			
Have adequate pedestrian phases been provided?			

6. Roundabouts	Yes	No	Comment
Is adequate deflection provided to reduce approach speeds?			
If splitter islands are needed, are they adequate for sight distance, length, pedestrian storage, etc.?			
Is the central island prominent?			
Can the appropriate design vehicle be accommodated?			
Are the central island details satisfactory (delineation, traverseability, conspicuousness)?			
Can pedestrians be seen by drivers in sufficient time?			
Can pedestrians determine whether vehicles are turning (no obstructions to sight lines)?			
Are direction markings required in approach lanes?			
Is the lighting adequate?			

7. Other Intersections	Yes	No	Comment
Has the need for curbed or painted islands and refuges been considered?			
Do intersections have adequate queue length/storage for turning movements (including in the center of a staggered intersection)?			

3.5 Interchanges

1. Interchanges	Yes	No	Comment
Is interchange layout consistent with other designs throughout the corridor or network?			
Does the location of the interchange service the needs of the surrounding community?			
Determine if spacing between interchanges in the network is sufficient.			
Are weaving lanes appropriate in number and length?			

Is the design speed appropriate for site limitations, ramp configurations, and vehicle mix?			
Adequate distance between successive entrance and exit noses?			
Is design of the gore and transition area adequate at exit/entrance terminals?			
Is the length of the exit ramp adequate for deceleration?			
Is adequate sight and decision sight distance provided?			
Are spiral curves warranted? If so, do spirals begin and end at appropriate locations?			
Is the length of the entrance ramp appropriate for acceleration and safe and convenient merging with through traffic?			
Is the length of acceleration adequate for traffic composition (i.e., truck, buses, etc.)?			
Is there an adequate view of the speed change lane at the nose?			
Is visibility unobscured by traffic barriers and other obstructions?			
Are service roads designed so as not to adversely affect traffic flow along the highway?			
Is there sufficient access to/from the service road?			
Is the number of lanes appropriate for safe operations and to accommodate variations in traffic patterns?			
Is there coordination of lane balance and basic lanes?			
Is lane continuity maintained?			
Is there advance warning of approaching auxiliary lanes?			
Is sight distance for entering/leaving vehicles appropriate?			
Are tapers installed where needed? Are they correctly aligned?			
Is the service road being used for its original intent?			

3.6 Special Road Users

1. Adjacent Land Equipment (e.g. tractors)	Yes	No	Comment
Are all accesses to and from adjacent land/properties safely designed for the associated traffic?			
Have the special needs of agriculture and stock movements been considered?			

2. Pedestrians	Yes	No	Comment
Can pedestrians cross safely at: – intersections? – signalized and pedestrian crossings? – refuges? – curb extensions? – bridges and culverts? – other locations?			
Is each crossing point satisfactory for: – visibility, for each direction? – use by the disabled? – use by the elderly? – use by children/schools?			
Is pedestrian fencing on sidewalks and medians required and provided for each crossing?			
Is fencing adequate on freeways?			
Are pedestrians deterred from crossing roads at unsafe locations?			
Are pedestrian-related signs appropriate and adequate?			
Are width and gradient of pedestrian paths, crossings, etc. satisfactory?			
Is surfacing of pedestrian paths, crossings, etc. satisfactory?			
Have handicap ramps been provided for each crossing?			
Have gutters been avoided at each crossing?			
Is lighting satisfactory for each crossing?			
Are crossings sited to provide maximum use?			
Is avoidance of a crossing unlikely (e.g., pedestrians using a more direct but less safe alternative)?			

3. Bicyclists	Yes	No	Comment
Have the needs of bicyclists been considered: – at intersections (particularly roundabouts)? – especially on higher speed roads? – on bicycle routes and crossings? – at freeway entry and exit ramps?			
Are shared bicycle way /sidewalk facilities (including underpasses and bridges) safe and adequately signed?			

4. Motorcyclists	Yes	No	Comment
Has the location of devices or objects that might destabilize a motorcycle been avoided on the road surface?			
Is the roadside clear of obstructions where motorcyclists may lean into curves?			
Will warning or delineation be adequate for motorcyclists?			
Has barrier curb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or are fixed objects properly shielded?			
Are all poles, posts and devices necessary? (If so, is shielding an option?)			
Are roadside drains and culverts traversable by motorcycle?			

5. Equestrians and Stock	Yes	No	Comment
Have the needs of equestrians been considered, including the use of roadside or shoulders and rules regarding the use of the roadway?			
Can underpass facilities be used by equestrians/stock?			

6. Freight Transportation	Yes	No	Comment
Have the needs of truck drivers been considered, including turning radii and lane widths?			
Have the needs of freight transportation been considered, adequately signed and accommodated?			

7. Public Transportation	Yes	No	Comment
Have the needs for public transportation been considered, adequately signed and accommodated?			
Have the needs of public transportation users been considered?			
Have the maneuvering needs of public transportation vehicles been considered?			
Are bus stops well positioned for safety?			

8. Road Maintenance Vehicles	Yes	No	Comment
Have the needs of road maintenance vehicles been considered, adequately signed and accommodated?			
Can maintenance vehicles be safely located for maintenance activities?			

3.7 Lighting, Signs, Pavement Markings and Delineation

1. Lighting	Yes	No	Comment
Is lighting required and, if so, has it been adequately provided?			
Is the design free of features which interrupt illumination (for example, trees or over bridges)?			
Have lighting poles been situated to avoid presenting a fixed roadside hazard?			
Are breakaway or slip-base poles to be provided?			
If ambient lighting creates special lighting needs, have these been satisfied?			
Is the lighting scheme free of confusing or misleading effects on signals or signs?			
Does the lighting adequately illuminate crossings, nearby sidewalks, refuges, etc.?			
Are all gore areas adequately illuminated?			
Are all merge areas adequately illuminated?			
Is the scheme free of any lighting dark spots?			
If there are locations with crash problems that are known to be amenable to treatment with improved lighting, has this lighting been provided?			

2. Signs	**Yes**	**No**	**Comment**
Are signs appropriate for their location?			
Are signs located where they can be seen and read in adequate time?			
Will signs be readily understood?			
Are signs appropriate to the driver's needs (for example, direction signs, advisory speed signs, etc.)?			
Are signs located so that drivers' sight distance is maintained?			
Are signs located so that visibility is maintained: – to/from accesses and intersecting roads? – to/from pedestrians and important features on the road?			
Have the consequences of vehicles striking signposts been considered?			
Are sign supports out of the clear zone? If not, are they: – breakaway? – shielded by barriers (e.g., guardrail, crash cushions)?			
Has an over-reliance on signs (in lieu of adequate geometric design) been avoided?			
Are signs on the new scheme consistent with those on the adjoining section of road (or will the previous signs need to be upgraded)?			
Have bases been installed at the proper height according to the current MUTCD?			
Are all necessary regulatory, warning and guide signs in place and visible?			
Is the location of signs (i.e., proper height, offset, distance in advance of hazard) correct per the current MUTCD?			
Will signs be clearly visible in all operating conditions (day, night, rain, fog, etc.)?			
Are breakaway bases provided where it’s impossible to locate extruded aluminum sign standards outside the clear zone?			
Are proper grades of retro-reflective sheeting used?			

3. Pavement Marking and Delineation	Yes	No	Comment
Are markings (lines, arrows, etc.) consistent with standard markings?			
Have any locations where standard markings might be confusing or misread been identified and treated in a way which considers users' likely responses?			
Are solid lines (no passing) provided where required?			
Are Raised Pavement Markers (RPMs) provided where necessary?			
Are curve warning signs, advisory speed plates or chevron alignment markers provided where required?			
Are markings on the new scheme consistent with those on the adjoining section of road (or will the previous markings need to be upgraded)?			
Are diagonal markings or chevrons painted where required?			
Will markings and delineation be visible at night time?			
Will markings and delineation be visible in wet weather?			
Has the need for rumble strips or rumble lines been considered?			
Have both high and low-beam cases been considered?			
Are guide posts of the breakaway type?			
Are center lines and edge lines clearly visible in day and night time conditions?			
Have old pavement markings been removed?			
Is retro-reflectivity of existing markings satisfactory?			
Are raised profile markings necessary?			
Is delineation adequate? Effective in all conditions?			
Are chevron markers placed correctly?			
Has retro-reflectivity been measured?			
Have breakaway or slip-base poles been used?			
Will luminaires create glare for road users on adjacent roads?			
Has the effect of adjacent road lighting on driver perception of the road been checked and managed?			
Do locations exist where lighting may interfere with traffic signals or signs?			
Has lighting for signs been provided where necessary?			
Is signage of horizontal alignment adequate where required?			

3.8 Physical Objects

1. Median Barriers	Yes	No	Comment
Have median barriers been considered and properly detailed?			
Have all design features that require special attention (e.g., end treatments) been considered?			
Are non-traversable or fixed object hazards placed outside the clear zone or appropriately shielded?			
Does the design appropriately address the potential risk for vehicles crossing over the median into the path of an opposing vehicle?			
Is type of median chosen appropriate for width available?			
Do barriers possess the proper geometrical configuration?			
Are slopes of grass median traversable?			
Are median barriers sufficiently offset from roadway?			
Are median barrier offsets in the correct range of values?			
Do roadside barriers and bridge barriers meet the appropriate crash test performance level that is consistent with the roadway classification?			
Is there sufficient width for overpass/underpass piers and light standards?			
Is spacing between median crossovers appropriate?			

2. Poles and Other Obstructions	Yes	No	Comment
Are all poles located well away from moving traffic?			
Have breakaway poles been included where required?			
Are median widths adequate to accommodate lighting poles or trees?			
Is the position of traffic signal controllers and other service apparatus satisfactory?			
Is the roadside clear of any other obstructions that may create a safety hazard?			
Have all necessary measures been taken to remove, re-locate or shield all hazards?			
Can roadside drains and channels be safely traversed by any vehicle that runs off the road?			
Are unprotected median widths appropriate for lighting poles?			
Are traffic signal and other service poles positioned appropriately?			
Consider the location of services and utilities with respect to the project (i.e. buried and overhead). Is adequate clearance provided for overhead wires?			

3. Guardrails	Yes	No	Comment
Are guardrails provided where necessary and properly detailed (e.g., at embankments, structures, trees, poles, drainage channels, bridge piers, gore areas)?			
Is the guardrail safe (i.e. unlikely to create a danger for road users including pedestrians, bicyclists, motorcyclists, etc.)?			
Are the end conditions of the guardrail safe and satisfactory?			
Is the guardrail designed according to standards for: – end treatments? – anchorages? – post spacing? – block outs? – post depth? – rail overlap? – stiffening at rigid obstacles?			
Is all guardrail necessary (i.e., what it shields is a greater hazard than the guardrail)?			
Is adequate protection provided where required (i.e., barriers, energy attenuators)?			
Is protection visible in all operating conditions?			
Are end treatments of guiderail properly treated (e.g. proper end treatments?			
Are dimensions (i.e., length) of protection appropriate?			
Are barrier treatments consistent throughout?			
Is there appropriate transition from one barrier to another?			
Are reflectorized tabs used to delineate guiderail?			

4. Bridges and Culverts	Yes	No	Comment
Are bridge barriers and culvert end walls safe regarding: – visibility? – ease of recognition? – proximity to moving traffic? – the possibility of causing injury or damage? – collapsible or breakaway ends? – signs and markings? – connection of guardrail? – roadside hazard protection?			
Is the bridge railing at the correct level and strong enough?			
Is the shoulder width on the bridge the same as on the adjacent road lengths?			

Is safe provision made for non-vehicular traffic over structures (for example, pedestrians, pedal bicycles, horses/stock, etc.)?			
Are all culvert end walls (including driveway culverts) drivable or outside the clear zone?			
Is vertical clearance for underpasses sufficient? If not, are height restrictions properly signed?			
Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?			
Are bridge abutments and parapets situated so as not to obstruct stopping and passing sight distances?			
Is signing required for delineation, weight restriction, or warning of deck freezing? Is it properly installed?			
Are drainage grates located so they do not interfere with cyclists?			
If shoulder widths are reduced across the structure, have warning signs been included?			
Is the proper clearance window provided at underpasses?			
Is the window providing the minimum clearances for height and width?			
Are the proper curb heights used for sidewalks, parapets and safety curbs on bridge structures?			
Are the proper drainage features incorporated into the design of underpasses, overpasses and bridge structures to prevent ponding?			
Does the design minimize the possibility of a visual perception of narrowing or funneling at underpasses and overpasses due to the location and type of abutment walls in relation to the traveled roadway?			
Are the toes of slope at abutments clear of the clear recovery zone for the classification of highway?			
Do all the appropriate side clearances, median clearances and hazard clearances for bridges meet classification standards?			
Have all unprotected objects (temporary or permanent) been removed from the required clear zone?			
Is the clear zone of adequate dimension?			
Are culverts at abutting driveways and intersecting roads shielded?			
Are proper active/passive signing and pavement markings in conformance with the current MUTCD?			

3.9 Additional Questions to be Considered for Development Proposals

1. Horizontal Alignment	Yes	No	Comment
Is visibility adequate for drivers and pedestrians at proposed accesses?			
Is adequate turning space provided for the volume and speed of traffic?			
Are curve radii and forward visibility satisfactory?			
Are sight and stopping distances adequate?			

2. Vertical Alignment	Yes	No	Comment
Are gradients satisfactory?			
Are sight and stopping distances adequate?			

3. Parking Provisions	Yes	No	Comment
Is on-site parking adequate to avoid on-street parking and associated risks?			
Are parking areas conveniently located?			
Is adequate space provided in parking areas for circulation and intersection sight distance?			

4. Servicing Facilities	Yes	No	Comment
Are off street loading/unloading areas adequate?			
If facilities for turning around large vehicles are provided, are they safely located?			
Is emergency vehicle access adequate?			

5. Signs and Markings	Yes	No	Comment
Have necessary traffic signs and road markings been provided as part of a development?			
Is vehicle priority (i.e. vehicle right of way) clearly defined at all the intersection points within the parking lot and access routes?			
Will the signs and markings be clear in all conditions, including day/night, rain, fog, etc.?			

6. Landscaping	Yes	No	Comment
Where there is landscaping, are clear sight lines maintained at intersections, curves, accesses and pedestrian locations?			
Has tree planting been avoided where vehicles are likely to run off the road?			

7. Traffic Management	Yes	No	Comment
Will the design keep travel speeds at a safe level?			
Are the number and location of accesses appropriate?			
Are the facilities for public transportation services safely located?			
Are bicycle facilities safely located in respect of vehicular movements?			
Are pedestrian facilities adequate and safely located?			
Are rest areas/picnic sites desirable? If yes, have they been provided?			
Is the number of rest areas/picnic sites within the project adequate?			
Do rest areas/picnic sites have safe access?			
Are rest areas/picnic sites placed at appropriate locations?			
Have appropriate signs been chosen and placed correctly to notify drivers of an upcoming rest area/picnic site?			
Can the facility accommodate movements of heavy/public transportation vehicles where required? (clearances, turning radii, shoulder widths, operational capacity?)			
Is there adequate signage of heavy vehicle/public transportation activity?			
Can the facility accommodate movements of road maintenance and emergency vehicles (clearances, turning radii, shoulder widths)?			
Are medians and cross overs visible and in adequate locations for these vehicles?			
Can shoulders accommodate slow-moving vehicles where required? – width? – structural capacity? – continuity?			
Is there appropriate signing of slow-moving vehicles as necessary?			
Is trail signage, if present, located so as not to cause confusion to road users?			
Check signage and visibility of points where trails cross the highway. Are they handled appropriately?			

Has adequate stopping sight distance been considered where trails cross the highway?			
If ATVs are expected to be in use, have precautions been taken to avoid situations where oncoming ATV headlights could confuse motorists?			
Are shoulders wide enough to accommodate cyclists/pedestrians where required?			
Are shoulders/sidewalks provided on bridges?			

8. Other	**Yes**	**No**	**Comment**
Has appropriate street lighting been provided?			
Are all roadside hazards appropriately dealt with?			
Has safe pedestrian access to the development been provided?			

3.10 Any Other Matters

1. Safety Aspects Not Already Covered	**Yes**	**No**	**Comment**
Will there be special events? Have any consequent unusual or hazardous conditions been considered?			
Is the road able to safely handle oversize vehicles, or large vehicles like trucks, buses, emergency vehicles, road maintenance vehicles?			
If required, can the road be closed for special events in a safe manner?			
If applicable, are special requirements of scenic or tourist routes satisfied?			
Does adequate skid resistance exist especially at curves, intersection approaches and steep grades?			
Has skid resistance testing been carried out?			

Checklist 4: Construction Stage Assessment

4.1 Work Zone

1. Work Zone	Yes	No	Comment
Is there clear, positive, understandable guidance through the work zone?			
Is the work zone free of hazards to the traveling public or construction personnel (i.e., blunt ends, drop-offs, etc.)?			
Is the area clear with regard to horizontal or vertical clearance issues?			
Can oversize/overweight vehicles be accommodated safely?			
Are all signs being used for maintenance and protection of traffic in conformance with the traffic control plan and current MUTCD?			
Are all cones, drums, barricades or other channelization devices acceptable and in conformance with the traffic control plan and the current MUTCD?			
Are all lighting devices working properly?			
Is pavement marking clearly visible in all lighting and weather conditions?			
Is an adequate clear zone maintained?			
Have accommodations been made for access by emergency service vehicles?			
Have accommodations been made for pedestrian, bicycle, and/or ADA access if applicable?			
Are warning lights in the work zone working properly and in conformance with the current MUTCD?			
Are advance flashing warning arrows located properly for visibility and safety?			
Are all lights functioning on flashing warning arrows?			
Is there proper wording on all variable message signs?			
Are there flashing lights on impact attenuation systems? If yes, are all lights functioning?			
If pavement markings are being changed, have old marking been removed so as not to create confusion for motorists?			
Are all members of the work force wearing the proper reflective equipment?			

Checklist 5: Post-Construction Stage Assessment

5.1 General Topics

1. Changes Since Previous Assessment / Translation of Design into Practice	Yes	No	Comment
Have any conditions that are changed since a previous audit been evaluated and addressed to avoid unintended safety concerns?			
Has the construction of the design been executed faithfully without creation of new safety concerns?			
Are design parameters consistent in alignment, cross section, interchanges, and intersections?			

2. Drainage	Yes	No	Comment
Does the water flow appear to be following the intended design?			
Is the road free of ponding or debris that might indicate a drainage problem?			
Is the drainage channel appropriate for topography and maintenance?			
Has the possibility of surface flooding or overflow from surrounding or intersecting drains and water courses been eliminated?			
Does the proposed roadway have sufficient drainage structures to handle water flow?			

3. Landscaping	Yes	No	Comment
Is vegetation/landscaping breakaway in locations where vehicles may run off the road?			
Is visibility maintained past or over vegetation/landscaping? Will clear sight lines continue once plants grow and mature?			

4. Utilities	Yes	No	Comment
Are all boxes, pillars, posts and lighting columns located outside the clear zone?			
If in the clear zone, are they made of breakaway materials?			

5. Access to Property and Developments	Yes	No	Comment
Are all accesses adequate, particularly in terms of design, location and visibility?			
Is the ROW width appropriate to accommodate turn lanes if required for accesses?			
Have any upstream or downstream factors which may affect access been checked and addressed?			
Have any negative safety issues related to "visual clutter" (excessive commercial signing or lighting) beyond the ROW been addressed?			
Check the interaction between driveways and the road. Are driveways adequately designed for the land use (e.g. width, radii)?			
Is the distance between driveways on the same side of the street sufficient to minimize conflicts between turning vehicles?			

6. Emergency Vehicles and Access	Yes	No	Comment
Has provision been made for safe access and movements by emergency vehicles?			

7. Roadside Slope Treatment	Yes	No	Comment
Will the roadside slope treatment prevent or limit debris falling on to the roadway?			

8. Shoulders and Edge Delineation	Yes	No	Comment
Are all delineators and reflectors correctly in place?			
Are shoulder widths appropriate for all vehicles and road users?			
Is cross-fall of shoulder adequate for drainage?			
Is treatment of embankments sufficient?			
If shoulder drop-offs are present, have countermeasures been included to safely accommodate errant vehicles?			
Is shoulder surfacing appropriate for the road classification?			
Are rumble strips properly installed where warranted?			

9. Signs and Pavement Markings	Yes	No	Comment
Are all signs and pavement markings correctly in place in accordance with the current MUTCD?			
Will signs and markings remain visible at all times (day and night)?			

Are new markings consistent with existing markings? (Check with adjacent road network).			
Have old signs and markings been removed?			
Have all signs and pavement markings been reviewed together to assure there are no conflicts that could cause driver confusion?			
Do the installed road markings have sufficient contrast with the road surface and are they clear of debris?			

10. Surface Treatment / Skid Resistance	Yes	No	Comment
Are all joints in surfacing free of excessive bleeding or low-skid resistance?			

11. Roadside Hazards	Yes	No	Comment
Is the scheme free of newly installed or overlooked roadside hazards?			
Is the scheme free of natural features (e.g., a bank, rock or major tree) that will be a roadside hazard or an obstruction to visibility?			

12. All Road Users	Yes	No	Comment
Consider the roadway environment, has the safe movement of all users been considered? – pedestrian movements? (pedestrians of all ages) – bicycle/non-motorized vehicle movements? – truck and bus movements? – motorcycle movements? – car movements?			

13. Speed Management	Yes	No	Comment
Has the appropriate speed limit been selected per the Alabama Speed Management Manual?			

5.2 Alignment Details

1. Visibility / Sight Distances	Yes	No	Comment
Are sight lines free of obstructions?			
Is the posted speed appropriate for horizontal and vertical alignment, visibility, etc.?			
Are the design speed and the posted speed compatible?			
Is the posted speed on each curve appropriate for its curvature?			

Is the traffic following the posted speed?			
If a transition curve is required between a tangent and a circular curve, is it present?			
Is the superelevation with transition curves suitable in relation to effects of drainage?			
If there are excessive grades that could be unsafe in adverse weather conditions, have measures been taken to prevent or mitigate the potential concern?			
Is a climbing lane provided where overtaking and passing maneuvers are limited due to terrain?			
Is a climbing lane provided in areas where the design gradient exceeds the critical length of the grade?			
Is there adequate provision of passing opportunities?			
Is there sufficient spacing between passing zones?			
Has the interaction of horizontal and vertical alignments in the road been checked to avoid roller coaster alignments that create an uncomfortable shift between horizontal and vertical movement?			
Is adequate stopping sight distance provided throughout the length of the project?			
Is adequate decision sight distance provided for interchange and intersection signing throughout the project?			
Are all sight distances adequate for all movements and road users?			
Are sight lines unobstructed by signs, bridge abutments, buildings, landscaping, etc.?			
Have measures been taken to assure that sight lines will not be temporarily obstructed by parked vehicles, seasonal foliage, etc.?			
Do grades at intersecting roadways allow desirable sight distance?			

2. New / Existing Road Interface	**Yes**	**No**	**Comment**
Have additional signs and/or markings been considered and provided?			
Do the horizontal and vertical alignments of the proposed facility co-ordinate effectively with those of existing facilities?			
If advance warning is needed, has it been provided?			
Is the facility free of sudden changes in speed regime, access or side friction characteristics?			
If the interface occurs near a hazard (i.e., crest, bend, etc.) has sufficient warning been provided for the hazard?			

Does the proposed project have a suitable cross section for the ultimate requirements of the road including: – classification? – design speed? – level of service/peak service volumes?			
Is the lane width sufficient for road design / classification?			
Do crown and cross slope designs provide sufficient storm water drainage and facilitate de-icing treatments?			
Are cross slopes across adjacent traffic lanes consistent?			
Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected?			
Is the pavement free of defects (e.g., potholes, rutting, etc.)?			
Is the pavement free of problems associated with segregation of mix. (i.e., pooling of bitumen, segregation of aggregates)?			
Is visibility of pavement markings and signs in wet conditions sufficient?			
If there are concerns associated with headlight glare/reflection during night time operations, have they been addressed?			
Is the pavement free of depression areas where ponding can occur?			
Does adequate skid resistance exist especially at curves, intersection approaches and steep grades?			
Has skid resistance testing been carried out?			

3. Readability by Drivers	Yes	No	Comment
Is the form and function of the road and its traffic management easily recognized under likely operating conditions (for example, under heavy traffic, minimal traffic, or poor visibility conditions)?			
Is the transition from existing conditions to new construction satisfactory (i.e., no uncertainty or ambiguity at the transition)?			
Is the roadway free of potential for confusion in the following areas: – where alignment changes? – where old pavement markings were removed? – where streetlight/tree lines don't follow road alignment?			

4. Bridges and Culverts	Yes	No	Comment
Are all markings and signs in place and conspicuous?			

Does the horizontal and vertical alignment conform with the approach roadways?			
Is vertical clearance at the underpass sufficient? If not, is the height restriction properly signed?			
Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?			
Are bridge abutments and parapets situated so as not to obstruct stopping and passing sight distance?			
If signing is required for delineation, weight restriction, or warning of deck freezing, is it properly installed?			
Are drainage grates located so they do not interfere with cyclists?			
If shoulder widths are reduced across the structure, have warning signs been installed if necessary?			
Is the proper clearance window provided at underpasses?			
Are the proper curb heights used for sidewalks, parapets and safety curbs on bridge structures?			
Are the proper drainage features incorporated into the design of underpasses, overpasses and bridge structures to prevent ponding?			
Has care been taken to minimize or avoid a visual perception of narrowing or funneling at underpasses and overpasses due to abutment walls in relation to the traveled roadway?			
Are the toes of slope at abutments clear of the clear recovery zone for the classification of highway?			
Do all the appropriate side clearances, median clearances and hazard clearances for bridges meet classification standards?			

5.3 Intersections

1. Visibility of Intersection	Yes	No	Comment
Will drivers approaching the intersection be aware of its presence (especially if required to yield)?			
Is there sufficient spacing between intersections to minimize driver confusion and avoid conflicts between turning vehicles?			
Is the location/spacing of intersections compatible with horizontal/vertical alignment so as to avoid sight distance problems?			
Are all intersections and accesses appropriate for all permitted vehicle movements?			
Are sight lines to the intersection unobstructed?			

2. Readability by Drivers	Yes	No	Comment
Is the form and function of the intersection clear to drivers on all approaches? (Check by driving through.)			
Are Yield or Stop lines visible for the required stopping sight distance?			
Are there sufficient visual cues to prevent overshooting into the conflicting traffic?			
Are vehicle maneuvers obvious to all users?			
Is the intersection free of potential conflicts in vehicle movements?			
Is the alignment of signal indications and general correctness of installation satisfactory?			
Are all applicable signal indications visible from each approach lane at the appropriate distances?			
Are all traffic signals functioning properly and safely?			
Are all pedestrian signals functioning correctly and safely?			
Are pavement markings clearly visible in day and night time conditions?			
Have specifications for retro-reflectivity of pavement markings been checked?			
Are signs visible and readable to approaching users?			
Is all signage (type and location) compliant with the current MUTCD?			
Have all signs called for on the design plans been installed?			
Are stop/yield signs used where appropriate?			
Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?			
Check location and number of signals. Are signals visible?			
Is traffic signal head placement consistent with the current MUTCD?			
Has the potential need for auxiliary signal heads been addressed?			
Are clearance phases provided?			
Is the signal phasing plan consistent with adjacent intersections?			
Is adequate warning provided for signals not visible from an appropriate sight distance? (i.e., signs, flashing light, =etc.)			
Are lateral rumble strips required and properly positioned?			

Are pavement markings appropriate for the intersection?			

3. Roundabouts and Approach Islands	Yes	No	Comment
Are the roundabout and islands fully visible and recognizable from all approaches?			
Are all signs, markings and lighting correctly in place?			

4. Layout	Yes	No	Comment
Are the lane widths appropriate for all vehicle classes?			
Have upstream and downstream features which may affect safety been checked and addressed (i.e., "visual clutter", angle parking, high volume driveways)?			
Are the appropriate number of lanes (left, through, right) provided and are they of appropriate length?			
Is there advance warning of approaching auxiliary lanes?			
Is sight distance for entering/leaving vehicles adequate?			
Are tapers installed where needed? Are they correctly aligned?			

5.4 Interchanges

1. Interchanges	Yes	No	Comment
Is spacing between interchanges in the network sufficient per AASHTO's A Policy on Geometric Design of Highways and Streets?			
Is the number and length of weaving lanes appropriate to the traffic volume?			
Is the design speed appropriate for site limitations, ramp configurations, and vehicle mix?			
Is there adequate distance between successive entrance and exit gores?			
Is design of the gore and transition area adequate at exit/entrance terminals?			
Is the length of exit ramps adequate for deceleration?			
Is adequate sight and decision sight distance provided?			
Are spiral curves warranted? If so, do spirals begin and end at appropriate			

locations?			
Is the length of entrance ramps appropriate for acceleration and safe and convenient merging with through traffic?			
Is the acceleration lane of sufficient length to accommodate heavy vehicles (i.e., truck, buses, etc.)?			
Is the speed change lane clearly visible at the nose?			
Is visibility unobscured by traffic barriers and other obstructions?			
Has the operation of service road traffic and its impact to traffic flow along the highway been considered and addressed to minimize conflicts?			
Is there sufficient access to/from the service road?			
Is the number of lanes appropriate for safe operations and to accommodate variations in traffic patterns?			
Is there coordination of lane balance and basic lanes?			
Is lane continuity maintained?			
Is there advance warning of approaching auxiliary lanes?			
Is sight distance for entering/leaving vehicles appropriate?			
Are tapers installed where needed? Are they correctly aligned?			
Is the service road being used for its original intent?			

5.5 Special Road Users

1. Adjacent Land Equipment (e.g. tractors)	Yes	No	Comment
Where adjacent land equipment (such as tractors) will access the road does the layout safely accommodate speed differentials, turning radii, and sight distance?			

2. Pedestrians	Yes	No	Comment
Are all pedestrian facilities likely to operate safely regarding: − visibility? − signs? − surfacing? − fencing? − the operation of other hardware, including lighting? − wheel chairs and strollers? − visually impaired people?			

3. Bicyclists	Yes	No	Comment
Are all bicycle ways, lanes, etc. and facilities likely to operate safely regarding: – visibility? – signs? – surfacing? – fencing? – the operation of other hardware, including lighting?			

4. Motorcyclists	Yes	No	Comment
Has the location of devices or objects that might destabilize a motorcycle been avoided on the road surface?			
Is the roadside clear of obstructions where motorcyclists may lean into curves?			
Will warning or delineation be adequate for motorcyclists?			
Has barrier curb been avoided in high-speed areas?			
In areas more likely to have motorcycles run off the road is the roadside forgiving or properly shielded?			
Are all poles, posts and devices necessary? (If so, is shielding an option?)			
Are roadside drains and culverts traversable by motorcycle?			

5. Equestrians	Yes	No	Comment
Are all relevant facilities likely to operate safely regarding: – visibility? – signs? – other special features?			

5.6 Lighting, Signs, Pavement Markings and Delineation

1. Lighting	Yes	No	Comment
Is all lighting operating and is it consistent with the designed lighting level?			
Is the scheme free of glare problems associated with head lights during night time operations?			

2. Signs	Yes	No	Comment

Are the correct signs used and are they correctly placed according to the current MUTCD?			
In daylight and darkness, are signs satisfactory regarding: – conspicuousness? – clarity of message? – readability/legibility at the required distance?			
Is sign retro-reflectivity or illumination satisfactory?			
If variable message signs are present, are they operating satisfactorily?			
Do variable message signs use standard and consistent fonts and phrases?			
Are all signs necessary?			
Can all signs be seen (not hidden or camouflaged by their background or adjacent distractions)?			

3. Pavement Marking and Delineation	**Yes**	**No**	**Comment**
Are all delineation and road marking placed correctly according to the current MUTCD and fully visible in all conditions?			
Are RPMs fully visible with correct spacing, color, etc.?			
Are all other delineation devices correctly installed (especially location, type and size)?			
Are guide posts adequate and properly spaced?			
Are guide post delineators operating adequately at night?			
Are reflectors on safety barrier the correct type, level and spacing and not misleading in alignment?			
Are all road markings clearly visible at all times to motorists and other road users?			
Is there continuity and uniformity of delineation and markings through the scheme and at transitions?			
Are center lines and edge lines clearly visible in day and night time conditions?			
Have old pavement markings been removed?			
Has retro-reflectivity of existing pavement markings been measured and is it sufficient?			
Are raised profile markings necessary?			
Are chevron markers placed correctly?			

Have breakaway or slip-base poles been used?			
Has glare from luminaires on adjacent roads been avoided?			
Are luminaires at interchanges, intersections, etc., placed appropriately?			
Has the effect of adjacent road lighting on driver perception of the road been checked and eliminated as a concern?			
Has lighting for signs been provided where necessary?			
Have bases been installed at the proper height?			
Are all necessary regulatory, warning and guide signs in place and visible?			
Are sign locations correct (i.e., proper height, offset, distance in advance of hazard)?			
Are all signs visible in all typical operating conditions (day, night, rain, fog, snow, etc.)?			
Are breakaway bases provided where it's impossible to locate extruded aluminum sign standards outside clear zone?			
Have any missing/broken signs been replaced?			
Are proper grades of retro-reflective sheeting used?			
Is signage of horizontal alignment adequate where required?			

5.7 Physical Objects

1. Median Barriers	Yes	No	Comment
Are all necessary median barriers in place and properly signed or delineated?			
Are barriers placed so that they do not restrict visibility or form a roadside hazard?			
Is the clear zone free of non-traversable or fixed object hazards?			
Have measures been taken to minimize the risk for vehicles to cross over the median into the path of an opposing vehicle?			
Is the type of median chosen appropriate for the width available?			
Do barriers possess the proper geometrical configuration?			
Are slopes of grass median traversable?			
Are median barriers sufficiently offset from the roadway?			
Are median barrier offsets in the correct range of values?			

Do roadside barriers and bridge barriers meet the appropriate crash test performance level that is consistent with the roadway classification?			
Is there sufficient width for overpass/underpass piers and light standards?			
Is spacing between median crossovers appropriate?			

2. Poles and Other Obstructions	Yes	No	Comment
Are all poles and sign structure bases safely designed and appropriately located?			
Is the project area free of any other poles or obstructions that may have been previously overlooked?			
If present, are obstructions in the clear zone suitably shielded?			
Are unprotected median widths appropriate for lighting poles?			
Are traffic signal and other service poles appropriately positioned?			
Consider the location of services and utilities with respect to the project (i.e. buried and overhead). Is adequate clearance provided for overhead wires?			

3. Guardrails	Yes	No	Comment
Are all guardrails in place and safely located (not a hazard in themselves)?			
Is the length of each guardrail adequate?			
Is the guardrail correctly installed with regard to: – end treatments? – anchorages? – post spacing? – block outs? – post depth? – rail overlap? – stiffening at rigid obstacles?			
Is adequate protection provided where required (i.e., barriers, energy attenuators)?			
Is protection visible in all operating conditions?			
Are end treatments of guiderail properly treated?			
Are dimensions (i.e. length) of protection appropriate?			
Are barrier treatments consistent throughout?			

Is there appropriate transition from one barrier to another?			
Are reflectorized tabs used to delineate guiderail?			

4. Bridges and Culverts	Yes	No	Comment
Is the clear zone free of unprotected objects (temporary or permanent)?			
Is the clear zone of adequate dimension?			
Are culverts at abutting driveways and intersecting roads shielded?			
Are active/passive signing and pavement markings in conformance to the current MUTCD?			
Are sight distances for signing and approaching trains adequate?			

5.8 Operations

1. Operation	Yes	No	Comment
Are all powered devices within the ROW working satisfactorily and can access be gained to them safely?			

2. Traffic Management	Yes	No	Comment
Do all traffic management devices function properly when observed from a moving vehicle?			
If rest areas or picnic sites are present, have appropriate signs been chosen and placed correctly to notify drivers of their access points?			
Can the facility accommodate movements of heavy/public transportation vehicles where required? (clearances, turning radii, shoulder widths, operational capacity?)			
Is there adequate signage of heavy vehicle/public transportation activity?			
Can the facility accommodate movements of road maintenance and emergency vehicles (clearances, turning radii, shoulder widths)?			
Are medians and cross overs visible and in adequate locations for these vehicles?			
Can shoulders accommodate slow-moving vehicles where required? – width? – structural capacity? – continuity?			
Is there appropriate signing of slow-moving vehicles as necessary?			

Is adjacent trail signage, if present, located so as not to confuse road users?			
Check signage and visibility of points where trails cross the highway. Are they handled appropriately?			
Has adequate stopping sight distance been considered where trails cross the highway?			
If ATVs are in use, have precautions been taken to avoid situations where oncoming ATV headlights could confuse motorists?			
Are shoulders wide enough to accommodate cyclists/pedestrians where required?			
Are shoulders/sidewalks provided on bridges?			

3. Temporary Traffic Control/Management	**Yes**	**No**	**Comment**
Have all temporary arrangements, signing, etc. been removed and replaced by final arrangements (for example, signs, signals, lines, construction accesses and temporary barriers)?			
Is temporary work adequately signed?			
Is the temporary work area visible from approaching traffic?			

4. Safety Matters Not Already Covered	**Yes**	**No**	**Comment**
Has the scheme been driven and walked to identify any potential problems not already dealt with?			
Have daytime and night-time inspections been conducted, including inspections of all connecting roads?			
If accident reports are available for the specific facility, have they been reviewed?			
Have the effects of rain, fog, and wind on design features of the project been checked and addresses if issues were noted?			
Have known animal travel/migration routes in surrounding areas been addressed with signage, fences or underpasses where needed?			

Checklist 6: Municipal Detailed Checklist

6.1 General Topics

1. Scope	Yes	No	Comment
Have you reviewed all pertinent documentation to gain an understanding of the scope of the project; including project objectives, user characteristics, design vehicles, access, adjacent development, existing network information, and future network expansion?			

2. Traffic Barrier Warrants	Yes	No	Comment
Is the clear zone free of non-traversable or fixed object hazards?			
Is the median of sufficient design so as to minimize the risk for vehicles to cross over the median into the path of an opposing vehicle?			
Have you reviewed the crash history of the area?			

3. Landscaping	Yes	No	Comment
Is landscaping along the road unlikely to present a sight distance obstruction or fixed object hazard?			
Do plantings meet the required clearances and sight distances and are they unlikely to present a future restriction with plant growth?			

4. Temporary Work Area (Maintenance/Construction)	Yes	No	Comment
Observe the interaction between the work area and traffic flow. Does traffic operate in a safe manner and are workers protected from collision?			
Is the temporary work site adequately signed for approaching traffic?			
Does temporary work signage remain even though construction is complete?			
Is the temporary work area visible from approaching traffic?			

5. Glare	Yes	No	Comment
Have measures been taken to reduce the severity of head light glare during night time operations?			
Are there locations where sunlight reduces visibility? If yes, have measures been taken to help motorists see traffic control devices in glare (e.g. signal backplates)?			

6. Traffic Calming	Yes	No	Comment
Are traffic calming measures effective at reducing vehicle speeds?			
Is traffic calming necessary?			

7. Congested Areas	Yes	No	Comment
Have areas of congestion been identified?			
Are areas of regular congestion visible by approaching road users?			

8. Street Network	Yes	No	Comment
Have changes in traffic flow altered the hierarchy of streets? If yes, is the altered traffic pattern appropriately accommodated by the street network?			

9. Schools and Recreation Areas	Yes	No	Comment
Is the posted speed limit appropriate for neighborhood activities?			
Is the speed limit effective at controlling traffic speed?			
Is existing signage sufficient at notifying motorists of upcoming activities?			
Is the visibility of signage from approaching traffic adequate?			
Is the visibility of school and recreational areas by approaching traffic adequate?			
Does on-street parking exist near school? If so, is the visibility of children unobstructed by parked vehicles?			
Do crosswalks exist in the area? If so, are the markings and signage in good condition so as to be highly visible?			
Does approaching traffic adhere to pedestrian rules at crosswalks or are further traffic control measures necessary (e.g. crossing guard, pedestrian corridors, etc.)?			

10. Environmental Considerations	Yes	No	Comment
Have the effects of adverse weather (i.e. rain, snow, fog, etc.) on the facility been observed and have remediation measures been taken to address observed safety concerns?			

6.2 Alignment and Cross Sections

1. Classification	Yes	No	Comment
Is the road classification appropriate for current traffic distribution and volume?			
Are one-way streets clearly marked at intersections and along the street?			

2. Design Speed / Posted Speed	Yes	No	Comment
Is the design speed appropriate for horizontal alignment, vertical alignment and visibility?			
Is the traffic following the posted speed?			

6.3 Cross Sectional Elements

1. Drainage	Yes	No	Comment
Are drainage features sufficient to prevent surface flooding or overflow from surrounding or intersecting drains and water courses?			
Is the drainage channel appropriate for topography and maintenance?			
Is the road free of ponding or debris that might indicate a drainage problem?			
Are the slits of a storm grate oriented perpendicular to traffic flow so as not to present a hazard for cyclists?			

2. Lane Width	Yes	No	Comment
Is the lane width adequate for the road classification and/or traffic volume?			

3. Cross Slopes / Superelevation	Yes	No	Comment
Do crown and cross slopes provide sufficient storm water drainage?			
Are cross slopes along adjacent traffic lanes consistent?			

4. Pavement Widening	Yes	No	Comment
Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected?			

5. Curbs and Gutters	Yes	No	Comment
Are curbs and gutters installed where necessary?			
Are curbs and gutters constructed according to guidelines?			
Are curbs and gutters in good condition?			

6. Sidewalks / Paths / Crosswalks	Yes	No	Comment
Are sidewalks in good condition?			
Is sidewalk width adequate for pedestrian volumes?			
Are the sidewalks free of obstacles that would cause pedestrians to divert to the street?			
Are sidewalks compliant with ADA requirements?			
Are the locations of crosswalks along the road appropriate with regard to: – signage? – sight distance? – spacing?			
Is the visibility of traffic from the crosswalk and the visibility of pedestrians from the traffic flow sufficient?			
Are crosswalk markings in good condition?			

6.4 Alignment

1. Horizontal Alignment	Yes	No	Comment
Is the area free from excessive horizontal curves that could cause sliding in adverse weather conditions?			
Where there is an excessive horizontal alignment, is there warning signage compliant with the current MUTCD?			

2. Vertical Alignment	Yes	No	Comment
Is the area free from excessive grades that could be unsafe in adverse weather conditions?			
Where there is an excessive grade, is there warning signage compliant with the current MUTCD?			

3. Combined Horizontal and Vertical Alignment	Yes	No	Comment

Have the interaction of horizontal and vertical alignments (i.e. roller coaster alignments, sequencing of horizontal/vertical curves, etc.) in the road been checked for safety impacts?			

4. Sight Distance	Yes	No	Comment
Is the route free from obstructions that could interfere with sight distance along the travel way?			
Is adequate stopping sight distance provided?			

5. Readability by Drivers	Yes	No	Comment
Is the roadway free of potentially confusing alignment problems: – old pavement markings not properly removed? – streetlight/tree lines that don't follow road alignment?			

6. Bridge Structures	Yes	No	Comment
Is vertical clearance for underpasses sufficient? If not, are height restrictions properly signed?			
Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?			
Are bridge abutments situated so as not to obstruct sight distance?			
Is signing required for delineation, weight restriction, or warning of freezing deck? Is it properly installed?			
Are drainage grates located so they do not interfere with cyclists?			
Are provisions made for pedestrians and cyclists crossing bridge?			
If shoulder widths are reduced across structure, have warning signs been included?			

6.5 Intersections

1. Type	Yes	No	Comment
Are the types of intersections appropriate for current and future traffic volumes as it relates to safety?			
Can intersection designs accommodate all design vehicle classifications?			

2. Visibility / Conspicuity on Approach	Yes	No	Comment

Does the horizontal and vertical alignment provide adequate visibility of the intersection?			
Are sight lines to the intersection unobstructed by buildings, trees, etc.?			

3. Layout	**Yes**	**No**	**Comment**
Is the layout of the intersection appropriate for the road function?			
Are the lane widths adequate for all vehicle classes?			
Have any upstream and downstream features which may affect safety (i.e., “visual clutter”, angle parking, high volume driveways) been checked and addressed?			
Are intersections and access driveways adequate for all vehicle movements?			

4. Vehicle Turns	**Yes**	**No**	**Comment**
Has consideration been given to eliminating or limiting problematic traffic movements with the use of channelizing islands, one-way streets, cul-de-sacs, chokers or medians?			

5. Channelization	**Yes**	**No**	**Comment**
Are channelizing features effective?			
Has consideration been given to installing channelization to better manage turn movements at areas with uncontrolled pavement?			

6. Islands	**Yes**	**No**	**Comment**
Are islands free from visual clutter that might affect sight distance?			
Are islands provided where needed to channel vehicle traffic?			
Are the dimensions of the island adequate for the intersection (width, length, turning radius)?			
Is the existing island clearly visible to drivers?			

7. Sight Distance at Intersections	**Yes**	**No**	**Comment**
Are all sight distances adequate for all movements and road users?			
Are sight lines unobstructed by signs, bridge abutments, buildings, or landscaping?			
Will sight lines continue to be unobstructed by temporarily parked vehicles, seasonal foliage, etc.?			

6.6 Controls

1. Markings	Yes	No	Comment
Are pavement markings clearly visible in day and night time conditions?			
Have pavement markings been checked for acceptable retro-reflectivity?			
Are all necessary pavement markings present?			

2. Signs	Yes	No	Comment
Are signs visible and readable to approaching users?			
Have any missing, redundant, or broken signs been replaced, removed, or repaired?			
Is adequate warning provided for signals not visible from an appropriate sight distance?			

3. Signals	Yes	No	Comment
Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?			
Check location and number of signals. Are signals visible?			
Is traffic signal head placement consistent with the current MUTCD?			

4. Signal Phasing	Yes	No	Comment
Are minimal green and clearance phases provided?			
Is dedicated left turn signal phasing provided where necessary?			
Is the signal phasing plan consistent with adjacent intersections?			

5. Landscaping	Yes	No	Comment
Will required clearances, traffic flow devices, or sight distances be maintained with current plantings and future plant growth?			

6.7 Road Surface

1. Skid Resistance	Yes	No	Comment
Does adequate skid resistance exist along curves, intersection approaches and steep grades?			
Has skid resistance testing been carried out?			

2. Pavement Distress	Yes	No	Comment
Is the pavement free of distress (i.e., potholes, rutting, etc.)?			

3. Surface Texture	Yes	No	Comment
Is clear visibility of the roadway edge and pavement markings maintained in wet conditions?			
Is clear visibility of the pavement markings maintained in bright sunlight conditions?			

4. Ponding	Yes	No	Comment
Is the pavement free of depression areas where ponding can occur?			

5. Pavement Edge Rounding	Yes	No	Comment
Is pavement edge rounding adequate?			

6.8 Visual Aides

1. Pavement Markings and Delineation	Yes	No	Comment
Are center lines clearly visible at all times?			
Have old pavement markings been removed?			
Has the retro-reflectivity of existing markings been checked and is it acceptable?			
Have old pavement markings been obliterated well enough to avoid causing driver confusion?			
Is delineation adequate and effective in all conditions?			
Are retro-reflective devices intended for heavy vehicle operators installed at their eye height?			
Are chevron markers placed correctly?			

2. Lighting	Yes	No	Comment
Are luminaires adjusted so as not to create glare for road users on adjacent roads?			
Are luminaires at interchanges, intersections or along the route, properly located outside the clear zone, shielded or breakaway?			
Is lighting controlled so as not to interfere with traffic signals or signs?			
Has lighting for signs been provided where necessary?			

3. Signs	Yes	No	Comment
Are all current signs visible?			
If conditions exist which require additional signs, have they been installed?			
Are signs correctly located (i.e., proper height, offset, distance in advance of hazard) in conformance with the current MUTCD?			
Is sight distance for road users unobstructed by signs?			
Are signs readable and visible in all operating conditions (day, night, rain, fog, snow, etc.)?			
Have any redundant, missing or broken signs been removed, replaced or repaired?			
Have signs been checked to avoid contradictory messages?			
Are signs and supporting structures in good condition?			
Have signs that are no longer applicable been removed?			
Are proper grades of retro-reflective sheeting used?			

6.9 Physical Objects

1. Medians	Yes	No	Comment
Is the type of median chosen appropriate for width available?			
Are slopes of grass median adequate?			
Are median barriers sufficiently offset from the roadway?			
Is there sufficient width for overpass/underpass piers and light standards?			

Is the spacing between median crossovers appropriate and consistent with the Alabama Access Management Manual?			

2. Hazardous Object Protection	**Yes**	**No**	**Comment**
Is adequate protection of hazards (i.e., barriers, energy attenuators) provided where required?			
Are end treatments sufficiently anchored?			
If there has been pavement buildup, are roadside guardrails/barriers still at the appropriate height to be effective?			
Are dimensions (i.e., length) of protection appropriate?			
Is there appropriate transition from one barrier to another?			
Are reflectorized tabs used where necessary?			

3. Clear Zone	**Yes**	**No**	**Comment**
Is the clear zone free of fixed objects (temporary or permanent)? If not, are they properly shielded or breakaway?			
Is the clear zone of adequate dimensions?			

4. Culverts	**Yes**	**No**	**Comment**
Are culverts adequately protected at abutting driveways and intersecting roads?			

5. Poles and Other Obstructions	**Yes**	**No**	**Comment**
Are poles and other obstructions adequately protected?			
Are unprotected median widths appropriate for lighting poles?			
Do overhead wires have adequate clearance?			
Have breakaway or slip-base poles been used?			
Are traffic signal and other service poles appropriately placed?			

6. Railroad Crossings	**Yes**	**No**	**Comment**
Are active/passive signing and pavement markings in conformance to the MUTCD?			
Are sight distances for signing and approaching trains adequate?			

Are gates of adequate width to prevent motorists from driving around them?			
Are at-grade crossings approximately level with the traveled roadway?			

7. Manholes	Yes	No	Comment
Are manholes too high or too low?			

8. Barriers and Fencing	Yes	No	Comment
Is there adequate fencing to guide pedestrians and cyclists to crossings/overpasses?			
Are barriers or fences visible at night?			
Is the fence free of solid horizontal rails that might present a crash hazard?			

6.10 Road Users

1. Heavy Vehicles / Public Transportation	Yes	No	Comment
Can the facility accommodate movements of heavy/public transportation vehicles (i.e., clearances, turning radii, shoulder widths, and operational capacity)?			
Is there adequate signage of heavy vehicle/public transportation activity?			
Are bus stops located with sufficient clearance from the traffic lane?			
Are bus stops clearly visible by approaching traffic?			
If bus bays/lanes are needed, have they been provided?			

2. Emergency Vehicles	Yes	No	Comment
Can the facility accommodate movements of road maintenance and emergency vehicles (i.e., clearances, turning radii, and shoulder widths)?			
Are medians and cross overs visible and in adequate locations for these vehicles?			
Are median cross overs properly signed?			

3. Cyclists	Yes	No	Comment
Is there adequate width along the shoulder for cyclists sharing the street with motorists?			

Are shoulders properly maintained for cyclist traffic?			
Are alignment and cross section for bicycle facilities appropriate?			
If a bike route exists, are adequate markings and signage provided?			
If bike lanes are necessary, are they provided?			

4. Pedestrians	Yes	No	Comment
Are hand rails provided (on bridges, ramps)?			
Is signal timing (cycle length, pedestrian clearance time) appropriate for safe crossings by pedestrians?			
Is there adequate signage for pedestrian paths?			
Are sight lines for pedestrians clear? (i.e., around parked cars)			

5. Elderly and Disabled	Yes	No	Comment
Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages with regard to: − curb and median crossings? − ramps? − raised crosswalks? − curb cuts?			
Does tactile paving exist at street crossing points and is it applied properly per ADA standards?			

6.11 Access and Adjacent Development

1. Right-of-Way	Yes	No	Comment
Is driver perception of the road unaffected by traffic signals and lighting on adjacent roads?			
Is the area beyond the ROW free of “visual clutter” (excessive commercial signing or lighting) that could distract drivers?			

2. Driveways / Approaches	Yes	No	Comment
Is there adequate sight distance to and from driveways?			
Is there adequate space between driveways/approaches on same side of street to avoid conflicts between turning vehicles?			
Are turn lanes provided to driveways where needed per the Alabama Access Management Manual?			

3. Building Setbacks	Yes	No	Comment
Is sight distance around buildings from the edge of the traveled roadway adequate?			

4. Loading / Unloading Areas	Yes	No	Comment
Is there adequate separation or delineation of the loading area to prevent it from negatively impacting traffic flow?			
Are loading areas clearly visible to oncoming traffic?			
Are loading/unloading areas situated in such a way that prevents heavy vehicles from blocking visibility to signs and signals?			
Is the loading area adequately signed?			

6.12 Parking

1. Parking Lot Entrance / Exit Visibility	Yes	No	Comment
Are vehicles entering and exiting parking facilities clearly visible?			
Are parking lot facilities clearly signed?			
Are pedestrians on sidewalks near parking lot entrance/exits visible to motorists?			

2. On-Street Parking	Yes	No	Comment
Is parking orientation (parallel, angled) along the route appropriate for traffic flow and operation?			
Can vehicles be parked without obstructing sight distances?			
Are parking space dimensions adequate to facilitate easy parking and unparking maneuvers?			
Are the parking facilities along a route appropriate for the classification of the route?			
Are parking restrictions near intersections sufficient?			
Are pedestrians clearly visible as they circulate around parked vehicles?			

Appendix H

Prompt Lists for Special Conditions

Checklist for Bicycle Facilities

1. Design and Placement	Yes	No	Comment
Do design features support safe usage of the facility by cyclists?			
Do accommodations for cyclists conform to the state of practice, guidelines, and relevant standards?			
Are there adequate cycling provisions on both sides/directions of the roadway?			
Does the design consider prevailing speeds of cyclists and comfort with regard to steep downgrades and horizontal curves without superelevation?			
Are cross-slopes adequate for prevailing speeds by cyclists?			
Where bicycle lanes or separated facilities are provided, is there adequate separation between vehicular and bicycle traffic?			
Do traffic calming measures and traffic management practices allow for safe and efficient cycling operations?			
Where rumble strips are present, does the shoulder width provide enough usable width for cyclists and are there regularly-spaced breaks for cyclists to traverse the rumble strip?			
Are bridges/tunnels designed with adequate bicycle accommodations on both sides?			
Are intersection/interchange accommodations designed to reduce conflicting movements and communicate proper bicycle positioning through the crossing?			
Are transition areas designed to avoid sudden and difficult merges for bicyclists, midblock crossings, or behaviors such as wrong-way riding?			
Where there is parallel on-street parking and an adjacent bicycle lane, is the lane wide enough for cyclists to keep out of the door zone of parked vehicles without leaving the lane?			
Has consideration been given to reversing pull in/angle parking to back-in/head-out parking to improve visibility of approaching cyclists?			
Do at-grade railroad crossings safely accommodate bicyclists?			
Are transit facilities designed and placed to minimize conflicts with bicyclists?			

2. Operations	**Yes**	**No**	**Comment**
Are there suitable provisions for cyclists given the characteristics of the roadway or path with regard to: – speed? – volume? – vehicle mix (i.e. percent of heavy vehicles)? – functional classification?			
Are cyclists appropriately accommodated during all times of day, including during peak periods?			
Are there sufficient gaps in traffic or gaps created by geometry or traffic controls for bicycle crossings at intersecting streets?			

3. Quality and Conditions	**Yes**	**No**	**Comment**
Is the riding surface smooth, stable, and free of debris accumulation?			
Is drainage adequate to prevent ponding of water in the cyclists' path of travel?			
Are drainage grates oriented perpendicular to the travel path of cyclists so as not to trap wheels or are bicycle compatible drainage grates used?			
Are manhole covers even with the pavement surface so bicyclists can easily traverse them?			
Where practical, have surface objects (e.g. manhole covers and drainage grates) been placed outside turning radii, where a cyclist is less balanced?			
Is the road surface or bridge structure free of longitudinal or transverse joints that may trap a cyclist's wheel?			

4. Obstructions and Roadside Clear Zone	**Yes**	**No**	**Comment**
Where there are horizontal or vertical obstructions (temporary or permanent) along the cycling facility, is adequate clearance provided?			
If bollards or other physical terminal devices are used, is the risk of occasional motorized vehicles greater than the risk of a fixed object within the travel way?			
Are sign faces, including temporary construction or detour signs, mounted away from the cyclists' operating space?			
Is the cycling operating space free of encroachment by vegetation?			
Is the clear zone free of signs, fences, non-traversable landscaping, steep slopes, drop-offs, and loose material that act as fixed objects or that can destabilize a cyclist?			

Are railings, guardrail, parapets and other structures installed at an appropriate height and shy distance (i.e. distance between vehicles and cyclists)?			

5. Continuity and Connectivity	Yes	No	Comment
Are bicycle accommodations continuous (especially without abrupt ending points at bridges, tunnels, intersections, interchanges)?			
Do bicycle accommodations provide adequate connectivity to major destinations?			
Is there a safe way for cyclists from both directions to access connections or continue to other destinations along the street network?			

6. Lighting and Visibility	Yes	No	Comment
Is the riding surface adequately lit?			
Are bridges and tunnels adequately lit?			
Are the intersections and other crossing points or transition points adequately lit?			
Is the visibility of cyclists using the facility adequate from the perspective of all road users?			
Can cyclists see approaching vehicles/pedestrians at all legs of an intersection, crossing, or transition and vice versa?			
Is sight distance for cyclists adequate with regard to: – trees, shrubs, and landscaping? – sharp horizontal curves? – crests on steep hills? – fences and walls? – structures and buildings?			

7. Signs and Pavement Markings	Yes	No	Comment
Are signs and markings along the riding surface visible, well-maintained, easily understood, and adequate?			
Are adequate warning signs posted at bridge or tunnel entrances?			
Do signs and markings along the cycling facility clearly indicate the cyclist path and right-of-way at intersections?			
Are signs and markings at transition areas appropriate?			
Have signs and markings for cyclists been situated so they do not create confusion for other road users?			

8. Signals	Yes	No	Comment
If bicycle traffic signalization and detection are present, are they properly positioned, functioning, and effective?			
Does the traffic signal design accommodate all users?			
Do traffic signal clearance intervals safely accommodate cyclists?			

Checklist for Pedestrian Facilities

1. Presence, Design and Placement	Yes	No	Comment
Are sidewalks provided along the street?			
If no sidewalk is present, is there a walkable shoulder (e.g. wide enough to accommodate cyclists/pedestrians) on the road or other pathway/trail nearby?			
Are shoulders/sidewalks provided on both sides of bridges?			
Is the sidewalk width adequate for pedestrian volumes?			
Is there adequate separation distance between vehicular traffic and pedestrians?			
Are sidewalk/street boundaries discernible to people with visual impairments?			
Are ramps provided as an alternative to stairs?			
Where feasible and appropriate, have curb radii been minimized to keep pedestrian crossing distances reasonable and discourage high-speed right turns?			
Are channelized right turn lanes designed or constructed so as to minimize conflicts with pedestrians?			
Have raised medians been designed to provide a safe waiting area (refuge) for pedestrians?			
Are supervised crossings adequately staffed by qualified crossing guards?			
Are marked crosswalks wide enough?			
Do at-grade railroad crossings accommodate pedestrians safely?			
Are crosswalks sited where pedestrians desire to cross and are these locations clearly visible to approaching vehicles?			
Are corners and curb ramps appropriately planned and designed at each approach to a crossing? Are they ADA compliant?			
Are there adequate waiting areas at corners, curb ramps and marked crosswalks?			
Do sidewalks/paths connect the street and adjacent land uses? Are the sidewalks/paths designed appropriately and are they ADA compliant?			
Are building entrances located and designed to be obvious and easily accessible to pedestrians?			

Where access driveways are present, are travel paths for pedestrians clearly delineated at driveway openings?			
Where there are transit or school bus stops, are safe crossings provided for bus users to cross the road?			
Are bus stops sited properly (e.g. with adequate sight distance, waiting area, accessibility)?			

2. Quality, Conditions and Obstructions	Yes	No	Comment
Is the path clear from both temporary and permanent obstructions?			
Is the walking surface adequately smooth and well-maintained?			
If the walking path is steep, have landing areas been provided per ADA standards?			
If crossing pavement is of a material that is different from the street pavement, is the crossing pavement adequate and well-maintained? Is it flush with the roadway surface?			
Are pedestrian paths free from obstruction by parked vehicles?			
At transit/bus stops, is sufficient landing area provided to accommodate waiting passengers, boarding/alighting passengers, and through/bypassing pedestrian traffic at peak times?			
At transit stops is the landing area paved and free of problems such as uneven surfaces, standing water, or steep slopes?			
Is the sidewalk free of temporary/permanent obstructions that constrict its width or block access to the bus stop?			

3. Continuity and Connectivity	Yes	No	Comment
Are sidewalks/walkable shoulders continuous and on both sides of the street?			
If measures are needed to direct pedestrians to safe crossing points and pedestrian access ways, are they provided?			

4. Lighting and Visibility	Yes	No	Comment
Is the sidewalk adequately lit?			
Is the pedestrian crossing adequately lit?			
If street lighting is needed to improve pedestrian visibility at night, is it provided?			
Are access ways to transit facilities well-lit to accommodate early-morning, late-afternoon, and evening lighting conditions?			

Is the visibility of pedestrians walking along the sidewalk/shoulder adequate: – from the parallel roadway? – from crossing driveways? – from intersecting streets?			
Can pedestrians see approaching vehicles at all legs of the intersection/crossing and vice versa?			
Is the distance from the stop (or yield) line to a crosswalk sufficient for drivers to see pedestrians?			
Are open sight lines maintained between approaching buses and passenger waiting and loading areas?			

5. Operations	**Yes**	**No**	**Comment**
Are there sufficient gaps in traffic to allow pedestrians to cross the road?			
Is the pedestrian travel path adequately separated from adjacent vehicle paths to provide comfortable walking conditions in areas with high-speed traffic or moderate to large amounts of heavy vehicle traffic?			
Are pedestrians entering and leaving buses able to do so without conflicting with cars, bicycles or other pedestrians?			

6. Signs and Pavement Markings	**Yes**	**No**	**Comment**
Are pedestrian travel zones clearly delineated from other modes of traffic through the use of striping, colored and/or textured pavement, signing, and other methods?			
Is the visibility of signs and pavement markings adequate during the day and night?			
Are crossing points for pedestrians properly signed and/or marked?			
Are all markings and signs clearly visible and free from damage or wear?			
Are appropriate signs and pavement markings provided for school bus and transit stops?			

7. Signals	**Yes**	**No**	**Comment**
Are pedestrian signal heads provided and adequate?			
Are traffic and pedestrian signals timed so that wait times and crossing times are reasonable?			
Is there consistency in pedestrian actuation (or detection) types between adjacent intersections?			
Are all pedestrian signals and push buttons functioning correctly and safely?			
Are ADA accessible push buttons provided and properly located?			

Checklist for Wrong Way Driving

1.1 Factors Consistent with the Probability of Wrong Way Driving

1. Function, Traffic Mix, Road Users, Geometry, Temporary Conditions	Yes	No	Comment
Is there reasonable expectation of older (over the age of 70) or younger (under the age of 25) drivers in the study area?			
Is the study area located in proximity to or along a corridor with drinking establishments?			
Is there a significant population of drivers who may be unfamiliar with the facility, particularly during nighttime conditions?			
Are there notable differences in traffic activity during nighttime conditions, as compared to daytime conditions?			
Are any exit ramps located adjacent to entrance ramps (i.e., a partial cloverleaf design)?			
Do local roadways or driveways intersect near interchange ramps?			
Could the layout and/or number of lanes on exit ramps contribute to potential driver confusion when approaching from the mainline roadway?			
Is the paved width (total of lanes and shoulders) of the ramps adequate for turning movements of design vehicles, but to the point of creating potential wrong way confusion?			
Do any paved shoulders along the ramps detract from lane channelization?			
Does horizontal or vertical curvature affect visibility of interchange ramps or signs?			
Does sun glare at certain hours of the day affect driver visibility of exit ramp signs or markings from any approach?			
Do area traffic generators experience unique volume peaks at unusual hours or days?			
Does crash data suggest any trends that may indicate seasonal contributing factors?			
Does inclement weather affect the visibility of signs or geometric conditions at or approaching interchange ramps?			
Has freeway construction or other temporary conditions impacted the visibility or retention of adequate signs at exit ramps?			

1.2 Factors to Discourage Wrong Way Driving

1. Design	Yes	No	Comment
Does ramp alignment reinforce appropriate access to ramps to deter WWD?			
Is the spacing between ramps and/or intersections adequate to allow drivers to clearly identify the correct direction of travel?			
Are entrance and exit ramps separated by pavement markings, median, or other physical separation? Is the median or other physical separation conspicuous?			
Do medians, channelization, or other physical barriers prohibit or deter wrong way access to the freeway ramps?			
Is guardrail or any other traffic barriers along or between ramps located so as not to obstruct visibility of the respective ramps?			
Is vehicle queuing between ramps or intersections managed so as not to affect sign visibility or driver behavior?			
Is the corner radius at an exit ramp designed to deter wrong way entry by turning vehicles?			
Are sight lines on ramps and at ramp termini appropriate for the location, traffic, and vehicle speeds?			
Are traffic signals or other traffic control devices configured to reinforce the proper travel directions for ramps?			

2. Signs and Markings	Yes	No	Comment
Are signs at both entrance and exit ramps positioned to be conspicuous to drivers approaching from all directions?			
Is visibility of regulatory signs, warning signs, or geometric conditions at entrance and exit ramps maintained with respect to: − parked vehicles? − pedestrian activity? − vegetation? − other signs? − roadside objects?			
Are DO NOT ENTER, WRONG WAY, and ONE WAY signs provided on freeway exit ramps in conformance with the MUTCD? Are the signs double-posted and in adequate condition?			
Are supplemental signs provided on the approaching roadways (i.e. warning or regulatory signs to deter left and right turns from a roadway onto an exit ramp)?			
Are appropriate wayfinding or guide signs provided at freeway entrance ramps?			
Are dynamic warning systems (such as actuated Wrong Way signs) provided on any exit ramps?			

Are signs or other visual cues to deter WWD provided along the length of the exit ramp and at the junction of the exit ramp and freeway?			
Are any directional arrows or other pavement markings provided on exit ramps?			
Are dashed markings (i.e. skip markings) or reflective pavement markers provided to guide left-turn movements at the proper locations?			

3. Lighting and Visibility	**Yes**	**No**	**Comment**
Is lighting provided at exit ramp locations? Is lighting functional?			
Are signs and markings that are clearly visible at night (i.e. illuminated or sufficiently retroreflective) provided at ramps?			
Are signs mounted at heights and positions consistent with where drivers will be looking?			
Is the driver's visual field free from sign clutter (e.g. non-warning or non-regulatory signs) that can cause driver confusion?			