ADAPTING THE ROAD SAFETY AUDIT REVIEW FOR LOCAL RURAL ROADS

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ABSTRACT

It is important to improve safety on local rural roads, but many local transportation agencies do not implement a road safety improvement program. This often is due to limitations on funding, expertise, and time. The Road Safety Audit Review (RSAR) process is a viable option for aiding local transportation agencies in addressing safety issues.

This project developed a simple and cost effective local rural RSAR program. The RSAR program was developed to identify critical safety issues and to assess the level of auditor expertise needed. The specific issues of needed safety improvements and the urgency of implementing these improvements have been defined in the audit process. These issues were correlated to a proposed local rural functional classification system, also developed as a component of this research. Pilot audit review groups were composed of experts, county engineers, and local road supervisors. The different auditor groups generally agreed on the level of urgency in correcting the needed improvements. While the control group identified more safety needs on the lower classified roads than the other groups, it should be noted that the differences generally were those on which the control group recommended no action be taken. The importance of this process in meeting the needs of local government is that road supervisors and county engineers from other counties also were effective in identifying safety needs.

Implementing improvements for identified action items with the highest urgency is an approach that will be an effective tool for local rural governmental agencies.

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EXECUTIVE SUMMARY

Improving safety on local rural roads is a tremendous challenge facing local transportation agencies across the United States. Not only has transportation technology undergone many changes, but as our transportation system ages, the uses of many existing roadways have changed as well. Due to limited resources, including funding, expertise, and time, many local transportation agencies have been unable to implement a road safety improvement program.

The purpose of this research was to develop a practical approach to help local transportation agencies address safety issues on local rural roads. While road safety programs have long been a part of the management systems of most state highway agencies, it often is difficult to use the same systems for local jurisdictions. Most local U.S. rural transportation agencies have limited expertise. Most, in fact, have few if any employees with engineering degrees. However, these agencies generally have employees who have developed into knowledgeable professionals through on-the-job learning and training. Improving knowledge and transferring technology to local governments has been the mission of the local technical assistance (LTAP) programs since the mid-1980s. Safety training and identifying the need for roadway improvements have been the focal points of most LTAP programs. Unfortunately, practical applications continue to be needed to aid these agencies.

The goal of this research was to develop a safety process which meets this need, therefore it is important that the process be “easy to learn and easy to use.” Tailoring the road safety audit (RSA) has the potential to fulfill the local government agency safety needs.

According to Austroads,[4] the Australian equivalent to The American Association of State Highway and Transportation Officials (AASHTO), the RSA is "…a formalized examination of an existing or future road or traffic project which interacts with road users, in which an independent, qualified examiner reports on the project's accident potential and safety performance."

Introduced in England in the 1980s, the road safety audit originally was designed to identify traffic safety deficiencies on projects primarily still in the planning or construction stages. Because fewer new roads are being built by rural local U.S. governments, the emphasis has shifted to analyzing safety on existing roads. A road safety audit performed on an existing road is more appropriately termed a road safety audit review (RSAR).[16]

This study examined the minimum level of expertise required to perform a road safety audit review that effectively identifies the nature of safety deficiencies as well as the urgency for repair of those deficiencies. The research also developed a functional local rural road classification system to tailor the RSAR process.

Literature Review

Under the functional classification system, roads and streets are grouped according to the type of service they provide. The arterial system (including the Interstate System) accounts for about 11.1 percent of the nation's total road and street mileage and carries 72.4 percent of total travel.[1] In contrast, the local road system accounts for 68.8 percent of the nation's total road and street mileage and carries 12.7 percent of total travel.[9]

The road classification system developed in this research project is contained in Table 1 and also is included in the attachment, Local Rural Government RSAR Process. This helped

guide the RSAR process and expertise evaluation issues. This was accomplished by conducting RSARs on roadway sections meeting the subclassifications in Table 1. The identification of needed safety improvements and the issue of urgency were correlated to these subclassifications.

Table 1. Functional Local Rural Road Classification

<table>
<tr><th>Rural Major High-Speed</th><th>Rural Minor</th><th>Rural Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 40-65 m.p.h.
♦ Infrequent accesses</td><td rowspan="3">Accumulates traffic from local roads, brings all developed areas within reasonable distances of collector roads, provides service to the remaining smaller communities, and links the locally important traffic generators in their rural region.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 250-400 v.p.d.
♦ Operating speed 40-60 m.p.h.</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 100-250 v.p.d.
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<tr><th>Rural Major Medium-Speed</th><th>Rural Low-volume Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
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♦ Operating speed 30-45m.p.h.
♦ Frequent accesses</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 0-100 v.p.d.
♦ Operating speed variable</td></tr>
</table>

Recalling the definition of an RSAR, the objectives are:[4,15]

- to identify potential safety problems for all road users and others affected by a road project and
- to ensure that measures to eliminate or reduce the problem are considered fully.

Some of the benefits of conducting a road safety audit and review (RSA/RSAR) are the reduction in:[4,14,15]

- the likelihood of crashes on the road network,
- the severity of crashes,
- the need for costly remedial work, and
- the total cost of a project to the community, including accidents, disruption, and trauma.

Audit groups, consisting of a control group, two independent engineers, and a team of superintendents, were used to assess the process developed and issues associated with levels of expertise needed to conduct RSARs. The control group included a University of Wyoming Traffic Engineering Professor, an FHWA Traffic Safety Engineer, and a Wyoming Department of Transportation State Traffic Engineer. Combined, the group had more than 80 years of traffic engineering safety and operational experience. The independent engineers have familiarity with the RSA/RSAR process and are county engineers. One engineer has more than 15 years of experience; the other, 21 years. The team of superintendents consisted of three road supervisors located in other Wyoming counties. This group had no engineering degree credentials, but combined, had more than 50 years of transportation experience. The data collected by the different teams were analyzed using the control group as the basis for comparison.

A trial audit was conducted in County 1 in the southeastern part of the state of Wyoming. The second and final audit was conducted in the northwestern part of the state. The county

engineers audited their own roads and those of the other county engineer. The county engineers were familiar with the classification issues and both also had attended an RSA specialty workshop held in 1998. When all the appropriate data were collected, a comparative analysis was conducted using percentage and weighted percentage of agreement to identify the different effects of auditor skill and urgency of improvement identifications.

Results

The percent of agreement analysis indicated that the combined decisions of the two engineers (hypothetical team) identified the largest number of safety issues that also were identified by the control group. In the first field audit, all groups had a closer agreement for the higher roadway classifications (local rural major and minor subclasses). In the second field audit, the closest results were obtained for the rural major medium-speed and rural minor road classifications. The results were specifically close in the evaluation of roadside features, road surface, and intersections and approaches categories of safety needs. Contained in the Executive Summary attachment is a "Look For" list of the subcategories of safety issues. This attachment also contains the recommended complete RSAR process for rural local governments. The next step is to implement improvements that address the results of the RSAR. To accomplish this objective, a short factual proactive report is a potentially needed tool to secure funding and to help the county transportation agency. A sample of such a report is contained in the Executive Summary attachment. The final step is to learn from these improvements by evaluating their effectiveness over time.

The weighted percent of agreement analysis used only the highest safety severity issues. In the first county, results of the engineers considered as a team were close to matching the

control group. The highest levels of agreement were for the rural secondary and rural local road classifications. The second field audit used the concept of urgency and only those highest urgency issues were used. The best results were obtained for the rural major medium speed and rural minor classifications, again by the hypothetical team. It is important to note that more urgent issues also were identified for these higher roadway classifications.

Overall, the results from these analyses indicate a trend showing that the combination of the engineers compared favorably for the highest severity and urgency levels on the higher local rural road classes. The major differences observed were in the local road auditor's view of correcting drainage needs as a more urgent safety problem and the control group's valuing signing needs as a more urgent priority. These differences probably are reflective of the local "maintenance" smooth road issues compared to the signing value assessment of "traffic engineering." The road supervisors did not identify as many safety issues. They, however, identified urgent issues that also were identified by the other groups. The road supervisor team had a tendency not to identify issues and then recommend "do nothing" to improve the situation. This recommendation surfaced frequently from the other groups, particularly on the lower functional subclassifications. These differences are important as are the statements made by the control group to not fix obviously needed safety improvements on the roads. The issues of user characteristics and resource limitations were important in guiding these decisions.

Conclusions

The finalized local rural road safety audit review approach results in a simple, yet potentially effective, tool to enhance local rural roadway safety. Evaluation of the proposed methodology to aid local rural governments in conducting a RSAR was quite positive.

Valuable safety improvements were identified by all levels of expertise, particularly in the higher local rural classifications.

All levels of expertise demonstrated consistency in their assessment of the issue of urgency, especially in the intermediate to higher urgency levels.

The control group's combined traffic safety expertise clearly was beneficial in identifying potential safety deficiencies. However, considering the issue of recommended urgency, the team of local county engineers identified most higher priority safety needs.

The local county road supervisor team of auditors were less likely to identify low priority issues on lower classified roads, such as rural local and rural low-volume local roads.

Recommendations

The process developed in this study (Local Rural Government RSAR Process) must be transferred to local rural governments, including training and a continuation of evaluating effectiveness of this tool. The Wyoming Association of County Engineers and Road Supervisors must begin to incorporate the RSAR into county practice. Identifying county safety needs by sampling roads using the functional classification system should begin. In a three- to five-year period, all county roads should be assessed using the RSAR process. Combining this with implementing improvements using the urgency concept should provide local rural governments with a practical safety tool. The RSAR is a proactive safety tool.

LOCAL RURAL GOVERNMENT RSAR PROCESS

Instructions for Local Rural Road Safety Audit Review Program

Safety Issues to LOOK FOR

RSAR Form

Functional Local Rural Road Classifications

Sample Letter to County Commissioners

Sample Report of RSAR Findings

“The key to safety is implementing

improvements for safety issues identified as urgent.”

Instructions for Local Rural Road Safety Audit Review Program

When you get to the road section:

1. Remember to evaluate the road section based on its functional rural road classification.

2. Review the "Look For."

3. Remember to consider all road users.

4. Drive slowly through the road section and look for potential safety issues. Focus on these issues in the travel way and to the right, as the initial review will be completed when you return to the starting point.

5. Next, drive through the test section at the posted speed limit or at safe operating speed.

6. Start RSAR by resetting odometer at start point, and drive slowly, with hazard lights activated. Stop and evaluate all potential safety deficiencies, looking at the travel way and to the right. Do one direction at a time.

7. Identify potential safety deficiencies. Use the odometer reading to approximate beginning and ending points or spots of deficiency. Repeat in the opposite direction and remember to reset odometer before you start that direction.

8. Next, check access approaches on the right side of the road. Drive access into the road section noting issues needing to be corrected, sight obstructions, signing, etc. Indicate the access location using the approximate mileage on the road section identified previously. Check for both travel directions.

9. For the road classification of this section, indicate how deficiencies should be corrected:
   a) Leave section as it is, no improvement needed for this road section, i.e. do nothing.
   b) Schedule Routine Maintenance.
   c) Major Reconstruction Required.
   d) Perform Routine Maintenance Immediately.
   e) Spot Improvement(s) Needed.

Have a safe trip!

Safety Issues to LOOK FOR:

Roadside Features

1. Are clear zones free of hazards and non-traversable side slopes without safety barriers?
2. Are the clear zones free of nonconforming and/or dangerous obstructions that are not properly shielded?

Road Surface-Pavement Condition

3. Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?
4. Are changes in surface type (e.g., pavement ends or begins) free of poor transitions?
5. Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?
6. Is the pavement free of areas where ponding or sheet flow of water may occur resulting in safety problems?
7. Is the pavement free of loose aggregate/gravel, which may cause safety problems?

Road Surface-Pavement Markings

8. Is the road free of locations with pavement marking safety deficiencies?
9. Is the road free of pavement markings that are not effective for the conditions present?
10. Is the road free of old pavement markings that affect the safety of the roadway?

Road Surface-Unpaved Roads

11. Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)?
12. Is the road surface free of areas where ponding or sheet flow of water may occur resulting in safety problems?
13. Is the road surface free of loose gravel or fines that may cause safety problems (control, visibility, etc.)?
14. Are changes in surface type (e.g., pavement ends or begins) free of drop-offs or poor transitions?

Signing and Delineation

15. Is the road free of locations where signing is needed to improve safety?
16. Are existing regulatory, warning, and directory signs conspicuous?
17. Is the road free of locations with improper signing, which may cause safety problems?
18. Is the road free of unnecessary signing which may cause safety problems?
19. Are signs effective for existing conditions?
20. Can signs be read at a safe distance?
21. Is the road free of signing that impairs safe sight distances?
22. Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, object markers)?

Intersections and Approaches

23. Are intersections free of sight restrictions that could result in safety problems?
24. Are intersections free of abrupt changes in elevation or surface condition?
25. Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?

Special Road Users, Railroad Crossings, Consistency

26. Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?
27. Are bus stops and mail boxes safely located with adequate clearance and visibility from the traffic lane?
28. Is appropriate advance signing provided for bus stops and refuge areas?
29. Are railroad crossing (crossbucks) signs used on each approach at railroad crossings?
30. Are railroad advance warning signs used at railroad crossing approaches?
31. Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?
32. Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?
33. Is the road section free of inconsistencies that could result in safety problems?

Road Safety Audit Review for Local Rural Roads

Jurisdiction: _____County

Date: _____

Location: _____

Weather: _____

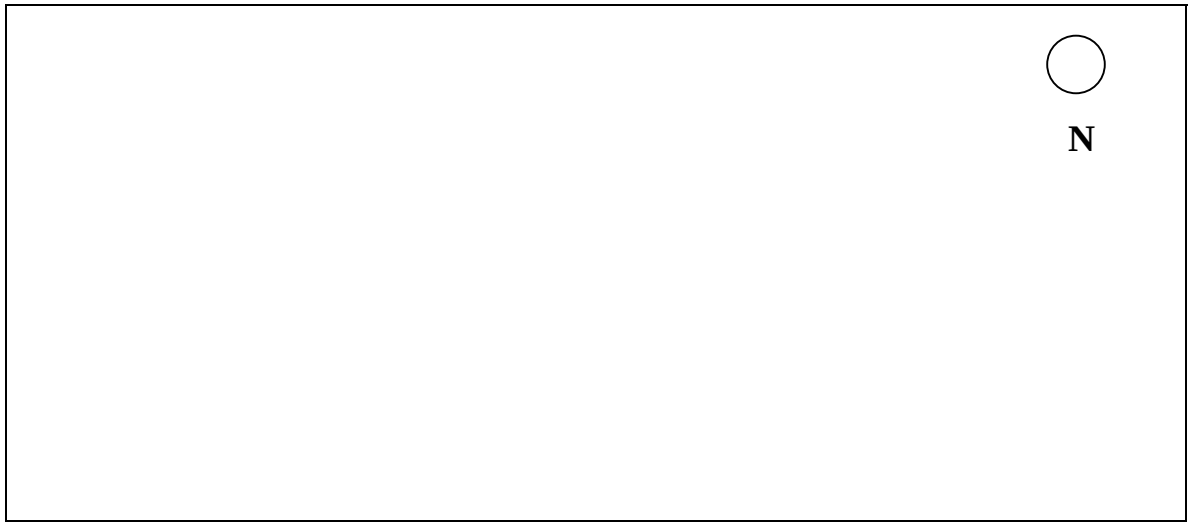
Auditor(s): _____

Road Class: _____

Paved_____ Unpaved_____ Unimproved_____ Speed_____

Sketch of road section:

→ Please include **exact start and end point**, **north arrow**, and other features as appropriate. i.e. cattleguards, etc.



Overall Evaluation of Road Section, check one and/or comment:

1. Leave section as it is, no improvement needed at this road section	
2. Schedule Routine Maintenance	
3. Major Reconstruction Required	
4. Perform Routine Maintenance Immediately	
5. Spot Improvement(s) Needed	
6. Comments:	

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☐ **Main Route Safety Evaluation**

☐ **Evaluation of Intersection/Approaches to Main Route**

Direction of travel: **N NW W SW S SE E NE** (please circle appropriate direction)

Approx. Location	**Description of concern or insert a number from the LOOK FOR**	**Urgency**	**Recommended improvement number and/or specify**

Urgency, considering classification of the roadway and cost of improvements	**Recommended improvement, considering classification of the roadway and cost of improvements**
1. Leave as it is 2. No urgency, but should be addressed 3. Schedule improvement in reasonably short time 4. As soon as possible	1. Remove 2. Repair 3. Relocate 4. Replace 5. Delineate 6. Shield 7. Other, please indicate action

Functional Local Rural Road Classification

<table>
<tr><th>Rural Major High-Speed</th><th>Rural Minor</th><th>Rural Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 40-65 m.p.h.
♦ Infrequent accesses</td><td rowspan="2">Accumulates traffic from local roads, brings all developed areas within reasonable distances of collector roads, provides service to the remaining smaller communities, and links the locally important traffic generators within their rural region.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 250-400 v.p.d.
♦ Operating speed 40-60 m.p.h.</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 100-250 v.p.d.
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Typically:
♦ Unpaved surfaces
♦ Traffic volumes 0-100 v.p.d.
♦ Operating speed variable</td></tr>
</table>

Sample Letter to County Commission

The Federal Highway Administration, Wyoming Department of Transportation, and the Wyoming Local Technical Assistance Program were invited to conduct road safety audit reviews on five ____ County roads. The reviews were conducted with two objectives: 1) serve as a pilot in development of a safety review process for local roads, and 2) make recommendations for possible safety improvements on the reviewed Park County roads.

Recommendations from the reviews are attached.

I would like to extend our appreciation to county person for his efforts with initiating the reviews and his assistance in developing a national model for safety reviews at the local level. _____ County should be proud of the progressive approach their personnel approach the safety of the roads.

Mr._____, title
Mr._____, title
Mr._____, title

Roadways reviewed and the recommendations resulting from the reviews are as follows (specifics on exact locations and more details are provided in the review notes):

RURAL MAJOR HIGH-SPEED CLASSIFICATION

Several items were noted that could be improved if the road was ever reconstructed. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are parallel drainage pipe blunt ends, trees, power poles, mailbox supports, and some relatively steep side slopes.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement in a reasonably short time frame:

Westbound:

- relocate curve sign further upstream
- delineate roadside where roadway narrows at horizontal curve and a relatively steep slope exists (two locations)
- replace non-standard speed limit signs

Eastbound:

- replace curve sign with a curve/intersection warning sign
- relocate mailboxes
- relocate curve sign further upstream
- replace curve warning advisory speed plate to be consistent with opposite direction
- add delineation to clearly define edge of roadway cross-section
- install a STOP sign

The following item was thought to be of such a nature that we recommend the improvement be initiated as soon as possible:

- Install delineation where roadway alignment is not consistent with the power pole alignment

The following items were considered to be of such a nature that they would have relatively high safety benefit if corrected, but are of relatively high cost for this classification of roadway. Therefore, it is recommended that they be considered for improvement if major reconstruction occurs on the roadway at or near these locations.

- Driveway approach in poor location
- Westbound view blocked by fence, restricted sight distance

- Driveway approach grades cause restricted sight distance

RURAL MAJOR MEDIUM SPEED CLASSIFICATION

Several items were noted that could be improved if the road was ever reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are low signs, relatively steep ditches, rigid non-breakaway fence, low guardrail, steep slope leading to guardrail, non-standard arrow speed limit sign.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement in a reasonably short time frame:
Westbound:

- relocate 55mph sign
- install winding road sign in lieu of many curve warning signs and replace curve warning sign with turn warning sign at 25mph curve
- delineate relatively steep slopes
- install RR crossing pavement markings

Eastbound:

- delineation inconsistent and in need of maintenance
- repair edge dropoff
- install winding road sign in lieu of many curve warning signs

The following item was thought to be of such a nature that we recommend the improvement be initiated as soon as possible:

- Repair delineation where knocked down and where located on guardrail

RURAL MINOR CLASSICATION

Several items were noted that could be improved if the road ever was reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are vertical and horizontal sight restrictions and culvert blunt ends.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement in a reasonable time frame:

- reshape ditch sections
- delineate roadside near holes
- delineate roadside near steep high slopes

RURAL LOCAL CLASSIFICATION

Many potential safety concerns exist on this roadway. However, due to the classification of the roadway, it is recommended that no improvements be made except to install a STOP sign.

RURAL LOW-VOLUME LOCAL CLASSIFICATION

Several items were noted that could be improved if the road ever was reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are relatively steep slopes and ditches, vertical and horizontal alignment creating sight restrictions, no notification of road ending, and power poles.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:

- pull ditches and remove large rocks

CHAPTER 1. INTRODUCTION

1.1 Background

Providing the safest travel environment is a challenge that the transportation profession continues to face. Over the years, the technology of transportation has changed from many perspectives. These include changes in vehicles, driver demographics and skills, types of other road users, improvements in safety designs, and understanding of the complex interactions needed to provide a safer traveling environment. As the changes have occurred, it has become increasingly more difficult to determine effective techniques to identify and correct safety deficiencies along the millions of existing roadway miles. This has been particularly true in the local rural road arena. Many local road agencies have neither the funding nor the expertise to effectively respond to these issues. Helping to develop a practical approach to address their local rural road safety needs is the purpose of this research.

A nationwide survey indicated that an average of 26 percent of local U.S. road mileage was in need of major repair.[18] Chicoine and Walzer[7] reported that more than 50 percent of that roadway mileage required more than regular road maintenance. When it comes to local rural road safety, the issue for these local road agencies is how to effectively manage the safety of roadway mileage. Wilson[17] has suggested that tailoring road safety audits (RSAs) is one viable option for aiding local road agencies in addressing these issues.

Road safety audits were introduced in England in the 1980s with the publication of the Institution of Highways and Transportation guideline "The Safety Audit of Highways".[4] Later, the road safety audit was adopted by several other countries

including Australia, New Zealand, and Denmark. In recent years, many different guidelines on the topic of road safety audits have been published.[1,2,3,8]

According to Austroads,[4] the Australian equivalent to the American Association of State Highway and Transportation Officials (AASHTO), the RSA is "…a formalized examination of an existing or future road or traffic project which interacts with road users, in which an independent, qualified examiner reports on the project's accident potential and safety performance." The road safety audit was originally designed to identify traffic safety deficiencies on projects that still are in the planning or construction phase or have just been opened. Most agencies, especially federal and state agencies, have had safety programs in place for many years for reviewing new construction. This, coupled with the fact that fewer new roads are being built, has shifted emphasis to analyzing safety on existing roads. Wilson[16] notes that when a road safety audit is used on an existing road, it is more appropriately termed road safety audit review (RSAR). The general purpose of the RSAR is to identify the potential safety hazards that exist. Tailoring the RSAR to fit specialized cases, such as safety audits of bicycle facilities or local rural roads has also been proposed (See Chapter, 2.2.6.).

Although road safety programs have become part of the management systems of most state highway agencies, it often is difficult to use the same systems for local jurisdictions. This is due to the expense of the initial data collection for a complete road system safety needs inventory and the limited budgets that often restrict local transportation agencies.

1.2 Goals and Objectives for Research

The goal of this research is to develop an RSAR tool to help local rural governments develop a practical safety program. Ideally, this program will help to make local rural roads safer. Keys to such a program include the need to be less expensive and less time consuming when compared to earlier road safety programs, which most agencies did not adopt. To meet the research goal, it is important to develop a program that is "easy to learn and easy to use."

To support the goal, this paper includes reviews of existing literature on rural road safety audits and reviews with the objective of modifying and developing an RSAR to match the local rural road needs. This study also examined the minimum level of expertise required to perform a road safety audit review by analyzing results of actual field trials used to develop a road safety audit review process. The final objectives of this research are to create a road safety audit review that effectively identifies the nature of safety deficiencies and urgency for repair of those deficiencies. Meeting the need for this new RSAR to also be less expensive and easier to use was an essential factor.

1.3 Report Organization

Chapter 2 contains a literature review of recent road safety programs. In Chapter 3 the procedures and methodology used to analyze the relationship between level of expertise and safety deficiencies are identified. Chapter 4 presents analysis and results, and Chapter 5 contains the summary, conclusions, and recommendations of this research project.

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

This chapter reviews current literature regarding local rural roads and safety-related programs. Emphasis has been placed on identifying the state of practice for local rural agencies and the use of road safety audits. To identify a framework for local rural roads, functional classification issues are discussed in the following section.

2.1.1 Functional Classification Systems

Under the functional classification system, roads and streets are grouped according to the type of service they provide. The arterial system, including the Interstate System, accounts for about 11.1 percent of the nation's total road and street mileage and carries 72.4 percent of total travel.[1] In contrast, the local road system accounts for 68.8 percent of the nation's total road and street mileage and carries 12.7 percent of total travel.[9]

Local government agencies are responsible for maintaining most of the local public roads in the United States. Funds available for maintaining local roads are, on average, only $11,080 per mile, while state highways receive approximately six times as much maintenance funding.[1]

There is a need to stratify local roads and streets to help guide the improvement decision process. One previous rural local road functional classification system developed at the University of Wyoming indicates the wide range of operating conditions (see Table 1).[1]

Table 1. Classification System for Local Rural Roads[1]

	ROAD CLASSIFICATION	
	A	**B**
FUNCTIONAL SYSTEM	**Rural Primary**	**Rural Secondary**
	Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and towns or with higher systems, and serves the more important intracounty travel corridors Typically paved surface, traffic volumes generally are 400 vehicles per day and above	Accumulates traffic from local roads, brings all developed areas within reasonable distance of collector roads, provides service to the remaining smaller communities, and links the locally important traffic generators with their rural region Typically unpaved surface but may be paved, traffic volumes generally range from 250 to 400 vehicles per day
	ROAD CLASSIFICATION	
	C	**D**
FUNCTIONAL SYSTEM	**Rural Local**	**Rural Low-volume Local**
	Provides access to land adjacent to the collector network and serves travel over relatively short distances Typically unpaved surface, traffic volumes generally range from 100 to 250 vehicles per day	Provides access to land adjacent to the collector network and serves travel over relatively short distances Typically graded surface, traffic volumes generally range from 0 to 100 vehicles per day

*Note: This classification system was modified by this research project.

2.2 Safety Programs

There are a variety of safety programs in use around the world and in the United States. This part of the literature review examines major features of these programs.

2.2.1. Highway Safety Improvement Programs

In 1979, the FHWA required all states to develop and implement a comprehensive Highway Safety Improvement Program (HSIP).[2] The HSIP policy included three standard components to make the program effective: planning, implementation, and evaluation. Each component is a set of defined processes and sub-processes (Table 2). The number in parentheses after each of the sub-processes in Table 2 refers to the number of components suggested to attain completion of that sub-process. The total number of processes and sub-processes recommended for use in the HSIP is 64.

Table 2. Outline of HSIP Structure[1]

I. PLANNING COMPONENT

Process 1: Collect and Maintain Data
Sub-process 1: Define the Highway Location Reference System (5)
Sub-process 2: Collect and Maintain Crash Data (3)
Sub-process 3: Collect and Maintain Traffic Data (3)
Sub-process 4: Collect and Maintain Highway Data (3)
Process 2: Identify Hazardous Locations and Elements (7)
Process 3: Conduct Engineering Studies
Sub-process 1: Collect and Analyze Data at Identified Hazardous Locations (24)
Sub-process 2: Develop Candidate Countermeasures (3)
Sub-process 3: Develop Projects (5)
Process 4: Establish Project Priorities (4)

II. IMPLEMENTATION COMPONENT

Process 1: Schedule and Implement Safety Improvement Projects
Sub-process 1: Schedule Projects (4)
Sub-process 2: Design and Construct Projects
Sub-process 3: Conduct Operational Review

III. EVALUATION COMPONENT

Process 1: Determine the Effect of Highway Safety Improvements
Sub-process 1: Perform Non-Crash-Based Project Evaluation
Sub-process 2: Perform Crash-Based Project Evaluation
Sub-process 3: Perform Program Evaluation
Sub-process 4: Perform Administrative Evaluation

Because many of the HSIP procedures recommended require financing, personnel, and expertise not available at most rural local transportation agencies, few agencies have adopted this safety procedure.

Previous research at the University of Wyoming has focused on tailoring safety improvement programs for rural local transportation agencies. For example, in 1996 Caldwell and Wilson proposed a safety improvement program for rural local roads. This program consisted of a "five step, system-wide prioritization" of roads, identification of safety improvement needs on individual road sections, prioritization of safety improvements, and program evaluation and an updating of processes.[2]

2.2.2. Spot Improvement Approach versus System-Wide Improvement Approach

Highway safety improvements generally are considered as either spot improvements or system wide improvements.[10] The spot improvement approach focuses on hazardous locations or segments of a highway system on which crash frequency or severity is unusually high. Projects that use this approach often include one or more crash prevention measures, such as revising grade and alignment, widening pavement, installing signs or signals, adding pavement markings, flattening fill slopes, removing or installing guardrails, removing trees, and moving utility poles. The program goal is to correct a unique, site-specific safety problem identified from analyzing crash data. This approach then reacts to the identified crash data.

The system-wide improvement approach focuses on roadways in a substantial portion of an agency's jurisdiction. An example of a system-wide improvement is to install cross-bucks at all unmarked rail-highway crossings or to fix all deficient guardrail-end terminals in a given jurisdiction.[10] The road safety audit review has features of both

approaches. The RSAR seeks to identify needed safety improvements on road segments and may incorporate analysis of crash data on the roadway segments audit. It is proactive in that it looks at segments of roads not identified by crash data, but it also may incorporate the reactive element of crash data.

2.2.3. Safety Management Systems

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) mandated states to develop, establish, and implement a highway safety management system (SMS).[11] The four processes that SMS focuses on are:[11]

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; and
4. Identifying special safety needs of commercial motor vehicles in the planning, design, construction, and operation of the highway system.

Again, the requirements of an SMS are so extensive that most local agencies do not have the personnel, expertise, and funding to implement an SMS program.

2.2.4. Risk Management Programs

The goals of risk management programs are to identify, quantify, and control exposure to tort liability. Risk management programs include the following activities:[12]

- Recognize and anticipate the degree of legal risk inherent in all of an agency's system responsibilities and programs, procedures, or actions;
- Ensure that available resources are used in a manner that assures maximum reduction of risk and prevention of loss while accomplishing the mission of the agency;
- Prepare a timely, defensive response for actual or threatened legal actions; and
- Manage claims to result in proper resolution while achieving economy and fairness to the agency and therefore the public.

The manner in which a risk management program addresses safety improvement issues is through preventive maintenance. Essential aspects of an effective risk management program are employee training and education, good record keeping, and proper insurance. Other important elements of a successful risk management program are routine inspections, provisions for emergency maintenance, design and operational reviews, and a crash record review.[2, 5, 13]

As with the HSIP and the SMS, risk management programs require resources that often are not available to local government agencies. Therefore, most local government agencies have not adopted comprehensive risk management systems.

2.2.5. Road Safety Audits

The road safety audit (RSA) has been defined as a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner reports on the project's crash potential and safety performance.[1, 2, 4, 6]

The objectives of a road safety audit are:[4, 15]

- to identify potential safety problems for all road users and others affected by a road project; and
- to ensure that measures to eliminate or reduce the problem are considered fully.

Some of the benefits of conducting a road safety audit are the reduction in:[4, 14, 15]

- the likelihood of crashes on the road network;
- the severity of crashes;
- the need for costly remedial work; and
- the total cost of a project to the community, including accidents, disruption and trauma.

Implied in the benefits list is the implementation of needed improvements. It also is a tool to help road designers and traffic engineers give more prominence to road safety. Using the results from an RSA in the design process is a proactive approach to refining roadway design.

RSAs are conducted at any or all stages of a project. It generally is accepted, however, that audits performed in earlier stages have more potential benefits. This is because it is easier to change a line on a plan than to remove the problem by reconstruction once the road is opened. The following five stages of road safety audits are identified by Austroads, the National Association of Road Transport and Traffic Authority for Australia.[4, 15]

Stage 1: The Feasibility Stage

Feasibility stage audits concern route options, layout options, and major design options, such as roundabouts vs. signals. These audits provide an assessment of the relative safety performance of scheme options and identify specific safety needs of various road users. They also may highlight the need to re-design other nearby road or traffic projects to safely accommodate changes in traffic.

Stage 2: The Draft Design Stage

At this stage, issues such as intersections or interchange layout and the chosen design standards are addressed. Where land acquisition is required, the draft design stage audit is undertaken before title boundaries are finalized.

Stage 3: The Detailed Design Stage

At this stage, the geometric design, traffic signing scheme, pavement marking plans, lighting plans, and landscaping plans are available and are looked at in relation to the operation of the road. The purpose is not to selectively evaluate compliance to standards, but to consider how safety enhancements are potentially applied in the design.

Stage 4: The Pre-Opening Stage

Prior to opening, a site inspection is made for all relevant conditions and for all applicable road users to ensure that the construction has addressed earlier audit concerns. This stage, just like all stages in an RSA, focuses entirely on safety issues of all road users.

Stage 5: Existing Roads

Road safety audits also are performed on sections of the existing road networks. Some of the reasons to audit existing roads are changes in road use, changes in adjacent

property use, growth of surrounding landscape, and variances in road features. For local rural governments, their safety needs primarily are in enhancing the existing road safety. Due to the shift from proposed to existing, the concept of a road safety audit review (RSAR) has been used.

When conducting an RSA, the auditor(s) often have available a checklist especially designed for the stage in which the audit is conducted. This is a key tool to aid the audit process. The checklist helps the auditor to consider all factors and provides a reminder of potentially overlooked safety issues.

2.2.6. Road Safety Audit Review

As indicated previously, conducting a safety evaluation of an existing road is more appropriately termed a road safety audit review (RSAR).[16] Several research projects that focused on adopting the road safety audit for existing roadways have been completed at the University of Wyoming. The purposes of these projects were to identify the value of the RSA process and to tailor the RSAR to specific types of projects.

One example of such a project is a bicycle safety audit, which was conducted on the University of Wyoming campus. The bicycle safety audit developed a prototype procedure and checklist for auditing bicycle and pedestrian facilities. The process focused on general facility design, visibility, alignments, travel surface, signing, marking, and issues associated with the multi-use path and other types of bicycle areas.

Another case specific research conducted at the University of Wyoming was a rural local road safety audit review.[1] In this research, checklists tailored to the problems most often encountered on rural local roads were developed.

2.3 Summary of Literature Review

The conventional highway safety improvement, safety management, and risk management programs examined in this literature review require a substantial amount of funding, personnel, and expertise. Due to limited resources, most local government agencies do not implement these programs.

While some tailoring of the road safety audit already has been completed, a safety procedure for road safety audit review on local rural roads is still needed. There also appears to be a lack of research on what level of expertise is needed to perform an RSAR on the local rural roads. This research project assessed the combination of auditor skill needed and how best to classify the safety deficiency in terms of urgency of implementing an improvement. Given the limited resources available to rural local agencies, the feasibility of conducting RSARs by using a team of independent safety specialists also is probably not practical.

CHAPTER 3 - METHODOLOGY

3.1 Overview

The two major issues raised by the literature review are, first, the need to develop a simple yet effective RSAR program for local rural roads, and second, the need to assess the level of expertise needed to perform an RSAR. To address these issues, research began by developing a preliminary road safety audit procedure. This trial procedure was based on the classification, checklists, and approach previously developed by Wilson and Tate;[1] and the road safety audit programs developed in Australia and Denmark.[4,15] Different audit groups applied the trial audit in the field. The focus groups conducted the audit and provided recommendations on the procedure. No training, except for a brief explanation of the proposed RSAR program, was given to different participants in the trial audit in County 1. The control group was familiar with and had conducted audits.

After the trial audit in County 1, and as a result of the recommendations, a new RSAR data collection procedure was developed. One of the recommendations was to add another major rural road classification. The audit classification approach was revised and the same focus groups tested the revised final audit process in County 2. Again the focus groups were encouraged to make comments about the program while performing the audit itself. The final recommended rural local road RSAR process is contained in Appendix A with the revised recommended rural road functional classification system. The purpose of the recommended RSAR is to provide a consistent tool, which is easy-to-use by any auditor.

To answer the second issue of this research, “needed expertise,” the traffic safety deficiency data collected in the audits, and the audit reports written by members of the

audit groups were analyzed. Methods used for the analysis are presented in Section 3.2, Comparative Analysis.

3.1.1. Audit Groups

The audit groups consisted of a control group, two independent engineers, and a team of superintendents. The control group included a University of Wyoming Professor, a FHWA Traffic Safety Engineer, and a Wyoming Department of Transportation State Traffic Engineer. The team of superintendents consisted of three road supervisors located in other Wyoming counties. The data collected by the different teams were analyzed using the control group as the basis for comparison.

3.1.2. Site Identification

The trial audit selected local rural roads, which fit the classifications developed previously (see Table 3).

Table 3. Selected Roads versus Class Requirement

Rural Road Classification	Class Requirement			Road Selected		
	Serves	Surface	ADT	Serves	Surface	ADT
Rural Primary	Town	Paved	400+	Town	Paved	2074
Rural Secondary	Developed Areas	Paved	250-400	Developed Areas	Paved	619
Rural Local	Land Access	Unpaved	00-250	Land Access	Unpaved	424
Rural Low-volume Local	Land Access	Unpaved	0-100	Land Access	Unpaved	no data

The trial audit was conducted in County 1 in the southeastern part of Wyoming. The second and final audit was conducted in the northwestern part of the state. County engineers audited their own roads and those of the other county engineer. Both county engineers were familiar with the classification issues and also had attended an RSA specialty workshop held in 1998. The final audit used five local rural road classifications. In Table 4, the additional classification of a major medium speed local rural road was added.

The major local rural classification was subdivided to reflect the different safety needs that change with operating speed. The difference in access frequency was a major determining characteristic of these two major local rural road classifications.

Table 4. Selected Roads versus Class Requirement for Revised Audit Classification

Rural Road Classification	Class Requirement				Road Selected			
	Serves	Surface	Speed	ADT	Serves	Surface	Speed	ADT
Major Medium Speed	Town	Paved	40-65	400+	Town	Paved	>55	715
Major Medium Speed	Town	Paved	30-45	400+	Town	Paved	<45	2340
Minor	Developed Areas	Paved	40-60	250-400	Developed Areas	Paved	n/a	403
Rural Local	Land Access	Unpaved	30-45	100-250	Land Access	Unpaved	n/a	121
Rural Low-volume Local	Land Access	Unpaved	variable	0-100	Land Access	Unpaved	n/a	59

3.2 Comparative Analysis

When all the appropriate data were collected, a comparative analysis was conducted using percentage and weighted percentage of agreement. Each of the analysis techniques is presented in the following sections.

3.2.1 Percentage

Groups were compared to the control group, whose results were considered the standard. If the team measured had the exact same deficiencies identified, they would score 100 percent. When comparing results using the technique of percentage, it is important that the deficiency found by one group is the exact same deficiency as identified by the control group. Otherwise, the results found by using this analysis technique would not have any meaning.

If the control group identified 28 deficiencies, and one county engineer found 16 of the same deficiencies, the percentage of agreement would be 16 divided by 28, or 57 percent. Even though this is a simple calculation, it is a good measurement of how well the different groups identified the same problems. The results using this analysis technique are presented in Chapter 4.

3.2.2 Weighted Percentage

Another measure used to evaluate results was weighted percentage. This method is similar to percentage, but also takes into account the severity of the deficiencies. When the deficiencies were identified, they also were ranked in the severity or urgency category, depending on the audit in which they were identified. In the first trial audit

(Appendix C) the category was termed severity, with a severity level of 3 classified as a fatal deficiency, level 2 as a serious deficiency, and level 1 as a minor deficiency. Only those deficiencies reported as level 2 or level 3 were used in the weighted percentage of agreement analysis. This decision was made because it is more important to find the deficiencies that are potentially fatal or result in a serious crash compared to those that "only" result in a minor accident.

The final audit developed the concept of urgency. By definition, an urgency level of 4 requires major reconstruction, a level 3 requires intermediate safety improvements, level 2 requires routine maintenance, and level 1 requires no action. Deficiencies of 2, 3, and 4 are analyzed in this study, since it was more important to identify problems that needed to be addressed than problems that could be left as they were. The reason these analyses were conducted was to determine if the audit groups found a higher percentage of deficiencies at these more critical levels.

If the control group identified 23 deficiencies in urgency groups 2 and 3, and the visiting engineer found 14, the weighted percentage of agreement would be 14 divided by 23, or 60 percent. The results of this analysis also are contained in Chapter 4, Analysis and Results.

3.2.3 RSAR Completion Reports

The different groups who participated in this project were asked to write formal reports regarding the audit after they had completed their respective prototype audits. The reports were written and addressed as if the reports were to be sent to county commissioners in each of the two counties.

RSAR reports were analyzed based on engineering judgment. This provided additional insight into evaluating the level of expertise required. These RSAR reports were compared with data the groups had collected in their prototype audits to ensure that conclusions in the reports were the same as conclusions in the findings. Another important aspect of these reports was simply to see if there were any differences in the way the various groups reported. The RSAR reports are contained in Appendices D and E.

3.2.4. Analysis by Local Rural Road Functional Classification

A fourth level of analysis evaluated safety needs stratified by the functional classification of each roadway sector evaluated. The purposes of these evaluations were to assess needs for training and/or the ability of each group to assess safety needs. Considering the safety deficiencies by road type, stratified by the issue of urgency, provided an opportunity to evaluate both expertise and classification issues. These were potential tools to determine if classification issues resulted in differences in identifying and classifying the urgency of improvement.

Ideally all identified "safety needs" would be corrected to the appropriate standard. However, implementing improvements in the real world revolves around how these ideals are tempered with user and cost factors. For example, a vertical fifty-foot drop off adjacent to a roadway is an obvious hazard. However treatment alternatives range from flattening the cross-slope to an acceptable level, providing guardrail, providing delineation, to doing nothing.

An important issue focused on the views of the various groups with respect to urgency. For example, considering the previous drop off issue for a rural local low-volume road classification roadway, groups identifying the issue generally recommended "do nothing." In effect, this decision implies that the cost and user issues do not justify the expense for this road type. On the other hand, the road supervisors often did not even identify this as a safety problem, in effect also "doing nothing."

Contained in Chapter 4 and Appendices B and C are results of the analysis using these methods of evaluation. The analyses provided needed input into developing a practical local rural road safety audit approach, and assessing auditor expertise.

CHAPTER 4 – ANALYSIS AND RESULTS

Refinements made to develop the recommended RSAR process are presented in this chapter. The chapter concludes with an analysis conducted to address auditor expertise and the effect expertise potentially has on audit results. The issues associated with the local rural roadway classification are of particular interest in these evaluations.

4.1 RSAR Program

Development of the proposed RSAR program for local rural roads was undertaken in several steps. The first step was the trial audit, which was developed by reviewing current programs. The second step was to evaluate comments made by various auditors in the initial audit. The third step incorporated the comments by revising proposed local rural road audit classification and redefining the issue of urgency. In step four, the revised audit classification was retested. Comments from this audit classification were then incorporated into the final recommended audit procedure. The results associated with different stages of development of the RSAR program are presented below.

4.1.1. Safety Issues to LOOK FOR

The first item developed in the RSAR program was the checklist; this was made after revising the checklist developed by Tate and Wilson[1] (see Appendix A). These checklists were tried in the first field audit. It was determined that a better procedure to conduct an audit was to consider the checklists before, rather than after or during, the

audit. Therefore, the old checklists were more appropriately identified as "Safety Issues to LOOK FOR." (See Table 5.)

Table 5. Safety Issues to LOOK FOR

Roadside Features
Are clear zones free of hazardous, non-traversable side slopes without safety barriers?
Are the clear zones free of nonconforming and/or dangerous obstructions that are not properly shielded?

Road Surface-Pavement Condition
Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?
Are changes in surface type (e.g., pavement ends or begins) free of poor transitions?
Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?
Is the pavement free of areas where ponding or sheet flow of water may occur resulting in safety problems?
Is the pavement free of loose aggregate/gravel that may cause safety problems?

Road Surface-Pavement Markings
Is the road free of locations with pavement marking safety deficiencies?
Is the road free of pavement markings that are not effective for the conditions present?
Is the road free of old pavement markings that affect the safety of the roadway?

Road Surface-Unpaved Roads
Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)?
Is the road surface free of areas where ponding or sheet flow of water occur resulting in safety problems?
Is the road surface free of loose gravel or fines that may cause safety problems (control, visibility, etc.)?
Are changes in surface type (e.g., pavement ends or begins) free of drop-offs or poor transitions?

Signing and Delineation
Is the road free of locations where signing is needed to improve safety?
Are existing regulatory, warning, and directory signs conspicuous?
Is the road free of locations with improper signing, which may cause safety problems?
Is the road free of unnecessary signing, which may cause safety problems?
Are signs effective for existing conditions?
(Table 8. continued)
Can signs be read at a safe distance?
Is the road free of signing that impairs safe sight distances?
Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, object markers)?

Intersections and Approaches
Are intersections free of sight restrictions that could result in safety problems?
Are intersections free of abrupt changes in elevation or surface condition?
Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?

Special Road Users, Railroad Crossings, Consistency
Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?
Are bus stops safely located with adequate clearance and visibility from the traffic lane?
Is appropriate advance signing provided for bus stops and refuge areas?
Are railroad crossing (crossbucks) signs used on each approach at railroad crossings?
Are railroad advance warning signs used at railroad crossing approaches?
Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?
Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?
Is the road section free of inconsistencies that could result in safety problems?

4.1.2. Instructions

Another issue that arose after the first field audit was a need for clear, concise, and simple RSAR instructions. The procedure developed also provided the benefit of comparing results of the different audit groups. The final value, however, is one standardized approach to identify safety needs by different auditors and the potential to repeat audits at a later date.

Contained in Table 6 are the RSAR procedure instructions. An experienced auditor would not need these instructions, however they are useful in identifying locations of safety needs.

Table 6. RSAR Procedure Instructions

When you get to the road section:

1. Remember to evaluate the road section based on its functional rural road classification.
2. Review the "Safety Issues to Look For."
3. Remember to consider all road users. Drive slowly through the road section and look for potential safety issues. Focus on these issues in the travel way and to the right, as the initial review will be completed when you return to the starting point.
4. Next, drive through the test section at the posted speed limit or at safe operating speed. Steps 4 and 5 will probably be combined by experienced auditors.
5. Start RSAR by resetting odometer at start point, and drive slowly, with hazard lights activated. Stop and evaluate all potential safety deficiency, looking at the travel way and to the right. Do one direction at a time.
6. Identify potential safety deficiencies. Use the odometer reading to approximate beginning and ending points or spots of deficiency. Repeat in the opposite direction and remember to reset odometer before you start that direction.
7. Next, check access approaches on the right side of the road. Drive access into the road section noting issues needing to be corrected, sight obstructions, signing, etc. Indicate the access location using the approximate mileage on the road section identified previously. Check for both travel directions.
8. For the road classification of this section, indicate how deficiencies should be corrected. Have a safe trip!

4.1.3. New Classification System

One of the comments made after the first field trial audit was that the current classification system was in need of improvement. The road sections evaluated indicated a need for an additional local major road subclassification. The suggestion was that the range of operating speed and frequency of side road accesses also should be factors for major local roads. Safety issues and operating characteristics differ widely if a road has an operating speed of 65 mph versus 45 mph, even though the rest of the requirements of the road classification are the same. The recommended local rural road functional classification is presented in Table 7.

Table 7. Functional Local Rural Road Classification

<table>
<tr><th>Rural Major High-Speed</th><th>Rural Minor</th><th>Rural Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 40-65 m.p.h.
♦ Infrequent accesses</td><td rowspan="3">Accumulates traffic from local roads, brings all developed areas within reasonable distances of collector roads, provides service to the remaining smaller communities, and links the locally important traffic generators in their rural region.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 250-400 v.p.d.
♦ Operating speed 40-60 m.p.h.</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 100-250 v.p.d.
♦ Operating speed 30-45 m.p.h.</td></tr>
<tr><th>Rural Major Medium-Speed</th><th>Rural Low-Volume Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 30-45m.p.h.
♦ Frequent accesses</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 0-100 v.p.d.
♦ Operating speed variable</td></tr>
</table>

4.1.4. RSAR Program

Members of the audit groups were encouraged to provide comments on the program at all stages of development. Their input simplified the recommended RSAR process developed. (See Appendix A.)

For each evaluated roadway, the RSAR form identified the route, its classification, audit review results, and urgency for each section evaluated. Prior research by Caldwell and Wilson[2] provided guidance in developing an overall county audit program. The forms also were used to assess the audit results and expertise issues. The RSAR forms provide general information about the road. They also provides space for an overall evaluation for the entire road audited. Consideration of the roadway classification is an important aspect of the process. The second page of the RSAR is the actual audit sheet. The audit sheet includes space to record items such as approximate location, description of concern, urgency of the problem, and potential improvement.

4.2 Comparative Analysis

To determine the level of expertise and training needed to perform a rural local road RSAR, it was necessary to measure how groups' results compared with the control group. Discussed in the next section are the results using the percent comparison analysis.

4.2.1. Percent Comparisons

For the percent comparison analysis, an aggregate evaluation considering both engineers also was made. If either the visiting engineer or the resident engineer reported a safety need it was indicated in the hypothetical team report. The analysis was completed on a road-by-road and county-by-county basis. The results are summarized and presented in Table 8, Total Road Deficiencies Identified—Trial Audit and Table 9, Total Road Deficiencies Identified—Final Audit.

Not surprisingly, the hypothetical combination team of engineers achieved the best overall results. Considering all the road classes, the team had an average of 70 percent in the trial audit, and 44 percent in the final audit. One of the reasons for the difference was that there was only one deficiency reported by the control group on the local rural classification roadway and none of the other groups identified this issue.

The other groups did not do as well as the combination of engineers. The visiting engineer alone had an average of 65 percent in the trial audit. The residing engineer identified 35 percent. (This is an interesting result, since the trial audit county is his home county). Only in one road class in one county did the two engineers hypothetical combination result fail to show a better result than every other group.

Table 8. Total Road Deficiencies Identified–Trial Audit

	Control Group	Team of Engineers	Visiting Engineer	Resident Engineer	Team of Superintendents	AVERAGE
Rural Primary	**23**	**15 (65%)**	**14 (61%)**	**4 (17%)**	**3 (13%)**	**9.0 (39%)**
Rural Secondary	**15**	**13 (86%)**	**12 (80%)**	**9 (60%)**	**5 (33%)**	**9.8 (65%)**
Rural Local	**6**	**3 (50%)**	**3 (50%)**	**2 (33%)**	**1 (17%)**	**2.3 (38%)**
Rural Low-Volume Local	**2**	**1 (50%)**	**1 (50%)**	**1 (50%)**	**0**	**.8 (38%)**
Total County 1	**46**	**32 (70%)**	**30 (65%)**	**16 (35%)**	**9 (20%)**	**21.8 (47%)**

Table 9. Total Road Deficiencies Identified–Final Audit

	Control Group	Team of Engineers	Visiting Engineer	Resident Engineer	Team of Superintendents	AVERAGE
Rural Major High-Speed	**23**	**9 (39%)**	**4 (17%)**	**8 (34%)**	**4 (17%)**	**6.3 (27%)**
Rural Major Medium-Speed	**13**	**7 (53%)**	**3 (23%)**	**7 (53%)**	**3 (23%)**	**5.0 (38%)**
Rural Minor	**11**	**7 (64%)**	**4 (36%)**	**5 (45%)**	**4 (36%)**	**4.8 (43%)**
Rural Local	**1**	**0**	**0**	**0**	**0**	**0**
Rural Low-Volume Local	**9**	**2 (22%)**	**1 (11%)**	**1 (11%)**	**3 (33%)**	**1.8 (19%)**
Total County 2	**57**	**25 (44%)**	**12 (21%)**	**21 (37%)**	**14 (25%)**	**18.1 (32%)**

When results are compared by functional classification, it is interesting to note that all groups had a higher agreement on the rural secondary classification for the trial audit. The team of engineers had a percent of agreement with the control group of 86 percent; the visiting engineer's agreement was 80 percent; the resident engineer scored 60 percent; and the team of superintendents had 33 percent agreement on the 15 deficiencies reported.

In the rural primary class the control group reported 23 deficiencies, and the team of engineers and the visiting engineer also had good results with percents of agreement of 65 and 61, respectively. The residing engineer did not do as well (17 percent), while the team of superintendents identified only 13 percent. In the rural local and low-volume local classes, both the team of engineers, and the visiting engineer had a 50 percent agreement. The team of superintendents had 17 and 0 percent of agreement on a total of eight deficiencies reported.

In the final audit, the rural minor class had the highest percent of agreement, and the engineers, when considered as a team, had the best results with 64 percent. The resident engineer reported 45 percent; and the visiting engineer and the team of superintendents, 36. There were 11 deficiencies reported in this class. For rural major medium-speed classification, the engineering team and the resident engineer identified 53 percent; while the visiting engineer and the superintendent team identified only 23 percent.

The rural major high-speed class had 23 reported deficiencies. In this class the team of engineers identified 39 percent, the resident engineer, 34, and the visiting engineer and the superintendents, 17 percent. On the rural local there was only one

identified deficiency, and none of the groups reported that deficiency. The local low-volume class had nine deficiencies, and the engineers identified 22 percent of these. The overall trend was that the team of engineers identified the highest percentage, in all but one road class, when compared to the control group. These groups also identified most of the deficiencies for the higher classified roadways.

The second item that was explored using percent of agreement was how different groups evaluated specific types of deficiencies. The deficiencies were classified in seven different categories (Appendices B & C):

1. Roadside features
2. Pavement condition
3. Pavement markings
4. Unpaved roads
5. Signing and delineation
6. Intersections and approaches, and
7. Special road users, railroad crossings, consistency

Once again, the engineers were compared to the control group, as a team and as individual participants. Overall, on all of the nine field audits, the team of engineers identified 68 percent of the deficiencies reported by the control group in category one, roadside features. The visiting engineer in County I indicated 62 percent, and the resident engineer in County I identified 30 percent. The team of superintendents identified 26 percent. The total number of deficiencies in this category was 50. In the second category the total number of deficiencies was six, and the team of engineers and visiting engineer in County I identified 66 percent of these deficiencies. The resident

engineer in County I and the team of superintendents indicated 50 percent of the deficiencies.

In the signing and delineation category the total number of issues identified by the control group was 19; the team of engineers identified 32 percent of these. Both the engineers indicated 21 percent by themselves, and the superintendent team identified 16 percent.

When it came to the safety issues associated with intersections and approaches, the team of engineers indicated 46 percent of the 13 reported deficiencies. The visiting engineer in County I alone determined that 38 percent were in need of improvement; and the resident engineer in County I and the team of superintendents identified 23 percent. In the category associated with special issues, the team of engineers and visiting engineer in County I identified 33 percent of the six deficiencies; the resident engineer in County I and the team of superintendents indicated 17 percent. The results for all the roads are contained in Appendices B and C.

An interesting observation is that in the pavement condition, signing and delineation, intersection and approaches, special user, and railroad and consistency categories none of the groups identified even half of the issues that were identified by the control group.

It should be noted that the previous discussion has not considered the issue of urgency of the needed safety improvement. This issue is examined in section 4.2.2. A potential for the differences is that although the control group identified a problem as a safety deficiency and the other groups did not identify it, that difference may be attributed to the control group indicating a low priority need for the improvement. The

other groups did not note the deficiency potentially due to low urgency of improvement and roadway classification.

4.2.2. Weighted Percent

The weighted percent analysis was performed in the same manner as the percent analysis: that is, by measuring how well the different groups performed when compared to the control group. The analysis was again conducted on a road-by-road and county-by-county basis. The results are summarized and presented in Table 10, Road Deficiency Urgency—Final Audit, Table 11, Road Deficiency Urgencies 2 and 3—Final Audit, and Appendices B and C.

Measurements of urgency were conducted in the Final Audit as a result of comments received from the trial audit. Urgency replaced the measurement of severity since crash severity was considered too subjective. The analysis below is based on the measurements of an urgency of 4, major reconstruction required, and the combined urgencies of 2 and 3, routine maintenance and intermediate improvements, respectively. More data were identified as urgencies 2 and 3, perhaps reflective of the difficulty in recommending major reconstruction.

As in the percent analysis, the hypothetical combination of the engineers did better than the other groups in identifying deficiencies. The average weighted percent of agreement for the combination of the engineers for the trial audit for the combination of urgencies 2 and 3 was 42 percent; while the visiting engineer identified 21 percent; resident engineer, 38; and the team of superintendents averaged 21 percent (see Table 11). The final audit data were harder to analyze using the weighted percent method; this

was due to the small sample of deficiencies. There were only 12 reported deficiencies with an urgency level of 3 or 4, in the final audit (see Appendix B for summaries). The trial audit in County 1 had 36 deficiencies with a severity level of 2 or 3 reported by the control group. With fewer deficiencies, the weighted percent method produces less reliable analysis.

Table 10. Road Deficiency Urgency 4 Only–Final Audit

	Control Group	Team of Engineers	Visiting Engineer	Resident Engineer	Team of Superintendents	AVERAGE
Rural Major High-Speed	3	2 (67%)	1 (33%)	1 (33%)	0	**1.0 (33%)**
Rural Major Medium-Speed	0	0	0	0	0	**0**
Rural Minor	4	3 (75%)	1 (25%)	3	1 (25%)	**2.0 (50%)**
Rural Local	0	0	0	0	0	**0**
Rural Low-Volume Local	0	0	0	0	0	**0**
Total County 2	**7**	**5 (71%)**	**2 (29%)**	**4 (57%)**	**1 (14%)**	**3.0 (43%)**

Note:

1) Road Deficiency Urgency is measured in terms of the repair required to prevent a crash based on judgement of the potential for a crash. Urgency is measured as: 1 – leave as is, 2- routine maintenance immediately, 3- apply intermediate safety improvements, and 4- major reconstruction to standard required. This differs from the measure used in Table 10 (Trial Audit). Only deficiencies identified by the control group as urgency 4 appear in this table.
2) The use of Severity in the Trial Audit was considered too subjective and was changed to Urgency in the Final Audit.

Table 11. Road Deficiency Urgencies 2 & 3 – Final Audit

	Control Group	Team of Engineers	Visiting Engineer	Resident Engineer	Team of Superintendents	AVERAGE
Rural Major High-Speed	15	5 (33%)	2 (13%)	5 (33%)	2 (13%)	**3.5 (23%)**
Rural Major Medium-Speed	6	4 (67%)	2 (33%)	4 (66%)	2 (33%)	**3.0 (50%)**
Rural Minor	2	1 (50%)	1 (50%)	0	1 (50%)	**.8 (38%)**
Rural Local	0	0	0	0	0	**0**
Rural Low-Volume Local	1	0	0	0	0	**0**
Total County 2	**24**	**10 (42%)**	**5 (21%)**	**9 (38%)**	**5 (21%)**	**7.3 (30%)**

Note:

1) Road Deficiency Urgency is measured in terms of the repair required to prevent a crash based on judgement of the potential for a crash. Urgency is measured as: 1 – leave as is, 2- routine maintenance immediately, 3- apply intermediate safety improvements, and 4- major reconstruction to standard required. This differs from the measure used in Table 10 (Trial Audit). Only deficiencies identified by the control group as urgency 2 or 3 appear in this table.
2) The use of Severity in the Trial Audit was considered too subjective and was changed to Urgency in the Final Audit.

When the roads were compared by functional classification using the weighted percent of agreement, the rural secondary category for the trial audit in County 1 (Appendix C) also indicated the best agreement with safety problems identified by the control group. The hypothetical combination of engineers identified 79 percent of deficiencies in need of improvement reported by the control group in the trial audit, whereas the visiting engineer, identified 71 percent, and the residing engineer indicated 50 percent. All the reported deficiencies in this road classification were identified as an urgency of 2 or 3.

Of the 16 reported deficiencies in the rural primary class, the engineers identified 81 percent; the visiting engineer, 75; resident engineer, 25; and the superintendents 13 percent. In the two lowest local rural road classes the engineers and the visiting engineer identified 75 percent in the local class and 50 percent in the low-volume class. The resident engineer reported 50 percent in both classes, and the superintendents reported no issues for low-volume class.

In the final audit (measuring urgencies 2 and 3; Table 11, Road Deficiency Urgencies 2 and 3—Final Audit), the trend was similar but there were fewer deficiencies reported by the control group. For the rural minor roadway the engineers combined, the visiting engineer, and the team of superintendents identified 50 percent. Of the 15 reported deficiencies in the major high-speed class, the combined engineers indicated 33 percent, visiting engineer 13 percent, resident engineer 33 percent, and superintendents 13 percent. In the low-volume local class, only one deficiency was reported. The rural local class had no deficiencies reported by the control group. Once again, the results of the weighted percent indicated that the hypothetical team of engineers produced the best results.

4.2.3. RSAR Completion Reports

The different groups who participated in this project were asked to write a formal report regarding audit results. It was requested that these reports be written as if they were to be sent to the county commissioners in each of the two counties.

Reports from the control group were clear and precise. They gave comments on the various deficiencies and also technical suggestions for improvements. Their conclusions were in agreement with their field data.

The reports from the engineers also were very good. They gave recommendations for improvements, and their reports were clear and understandable.

The report from the superintendent team was brief and less precise. This group barely touched on main problems in the county, and only one of the members of this group mentioned any recommendations for improvement for each of the local rural roads in the county audited. These reports are contained in Appendices D and E.

4.3 Summary of Results

In terms of identifying safety deficiencies, results presented in this chapter indicate that a hypothetical group combining several county engineers resulted in the best agreement with the control group. Results of the engineering combination are based on the concept that they performed the field audits separately and not as a team. These results only indicate that the two separate engineers' combined results were better than the results of either engineer individually.

Considering the classification system the highest level of agreement occurred in the higher rural roadway classifications. This also is where the control group reported the

highest number of deficiencies. These classes both have the highest average daily traffic and the highest operating speed levels. It is well documented that the severity of accidents increases with speed. Roadside features, pavement markings, and unpaved roads safety "look for issues" were more consistently identified by all comparison groups. Few deficiencies were identified as needing improvement by any groups for the rural local and the rural low-volume local, which were unpaved roads.

In the final audit, deficiencies when identified with urgency resulted again in the combination of the engineers agreeing the closest to the control group. These results were best for the higher local rural road classes, and higher urgencies. Results were closest to the control group in the rural major high-speed, rural major medium-speed, and rural minor roads audited. It is quite possible that the team of superintendents detected more problems in these roads than they reported. They may have not reported the problem since the severity/urgency was not high enough to be corrected on that particular road. An example of this is the obvious problem with the steep side slope next to the low-volume road in County II; this deficiency was reported by the control group and was given an urgency of 1 (do nothing). This deficiency was not reported by any of the local auditors. The agreement was not as good on the rural local and the rural low-volume local roads audited. The major differences were in the local road auditors' view to correct drainage needs as a more urgent safety problem and the control groups valuing signing needs as a more urgent priority.

The following chapter presents a summary of the findings associated with the project. Also included are conclusions made based on the analysis of research findings. Specific recommendations for further study also are contained in Chapter 5.

CHAPTER 5 – SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

This research project addressed benefits of a local rural road safety audit review program, and explored the level of expertise necessary to conduct such a program. The goal of this research was to develop a tool to help make local rural roads safer.

The conventional highway safety improvement, safety management, and risk management programs examined in the literature review require substantial amounts of funding, personnel, and expertise. Due to limited resources at the local level, most local transportation agencies do not implement such safety programs. Instead, they rely on input from law enforcement, analysis of accident records, routine maintenance inspection, and/or input from the public, public officials, and employees for identifying safety improvement needs. While these methods are somewhat beneficial, the current high crash rates indicate a need for further attention to safety issues on local rural roads. The literature review revealed a lack of research regarding the level of expertise needed to perform a rural local RSAR, and also pointed to the need for a simple, yet effective, rural local RSAR program.

Research began by developing a preliminary road safety audit program; the program then was given to the focus group for a prototype audit in the field. Focus groups were encouraged to not only perform an audit, but also to comment on the process. The focus groups completed a second series of audits, which led to the final recommended rural local RSAR.

To explore the level of expertise needed to perform a rural local RSAR, comparative analysis was used in combination with engineering judgment. The data collected in prototype audits were used as background information for the comparative analysis. Three methods were used in the analysis: percent of agreement, weighted percent of agreement, and analysis by local rural functional classification.

The focus groups for this research consisted of a control group, two county engineers and a team of superintendents. The control group was composed of a WyDOT traffic engineer, a FHWA safety engineer and a University of Wyoming traffic engineering professor. In these analyses, results from the different groups were compared with the results of the control group.

The percent of agreement analysis indicated that the combined decisions of the two engineers identified the largest number of safety issues identified by the control group. In the first field audit, all groups had a closer agreement for the higher roadway classifications. In the second field audit the closest results were obtained for the rural major medium-speed, and rural minor road classifications. The results were specifically close in the evaluation of roadside features, road surface, and intersections and approaches categories.

The weighted percent of agreement analysis used only the highest safety severity issues. In the first county the results of the engineers considered as a team identified close to the control group. The highest levels of agreement were for the rural secondary and rural local road classifications. The second field audit used the concept of urgency and only those highest urgency issues. The best results were obtained for the rural major medium speed and rural minor classifications. However, it is important to note that more urgent issues were identified for the higher roadway classifications.

Overall, results from these analyses indicate a trend showing that the combination of the engineers compared favorably for the highest severity and urgency levels on the higher local rural road classes. The major differences were in the local road auditor's view of correcting drainage needs as a more urgent safety problem and the control group's valuing signing needs as a more urgent priority.

The different groups who participated in this project were asked to write a formal report regarding the audit after they had completed their prototype audits. These RSAR reports were analyzed based on engineering judgment. The results from the comparisons of these reports indicated the value of engineering expertise. Reports from the engineers were more specific and professionally developed.

5.2 Conclusions

In this section, the conclusions reached from the local rural road safety audit review research are presented:

1. The local rural road functional classification system was improved by reflecting different operating speed conditions for the major rural roads. These functional classifications were stratified into major rural high-speed and major rural medium-speed classes.
2. The finalized local rural road safety audit review approach results in a simple, yet potentially effective, tool to enhance local rural roadway safety. The evaluation of the proposed methodology to aid local rural governments in conducting an RSAR was positive.
3. Valuable safety improvements were identified by all levels of expertise, particularly in the higher local rural classifications.

4. All levels of expertise demonstrated consistency in their assessment of the issue of urgency, especially in the intermediate to higher urgency levels.
5. The control groups' combined traffic safety expertise clearly was beneficial in identifying potential safety deficiencies. However, considering the issue of recommended urgency, the team of local county engineers identified mainly the higher priority safety needs.
6. The local county road auditors were less likely to identify low priority issues on lower classified roads, such as rural local and rural low-volume local roads.

5.3 Recommendations

In this section, recommendations for additional research concerning local rural road safety audit reviews are presented:

1. Additional field studies of the finalized RSAR program should be conducted to test the program's reliability.
2. A larger sample size is needed to validate results from this study and to more precisely determine the appropriate level of expertise needed to perform an RSAR.
3. In this study the engineers went out separately, but their combined observations were used to identify deficiencies at their level of expertise. Additional research should be conducted to explore the value of engineers working as a team, rather than individually.
4. For further development of the finalized RSAR program, it should be disseminated to the Wyoming Association of County Engineers and Road Supervisors (WACERS).
5. An appropriate training program for the auditors of local rural RSARs should be developed.

6. The value of using global positioning system technology in rural road safety audit reviews should be investigated.

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APPENDIX A – Audit Review Program

Instructions for Local Rural Road Safety Audit Review Program

When you get to the road section:

10. Remember to evaluate the road section based on its functional rural road classification.

11. Review the "Look For."

12. Remember to consider all road users.

13. Drive slowly through the road section and look for potential safety issues. Focus on these issues in the travel way and to the right, as the initial review will be completed when you return to the starting point.

14. Next, drive through the test section at the posted speed limit or at safe operating speed.

15. Start RSAR by resetting odometer at start point, and drive slowly, with hazard lights activated. Stop and evaluate all potential safety deficiencies, looking at the travel way and to the right. Do one direction at a time.

16. Identify potential safety deficiencies. Use the odometer reading to approximate beginning and ending points or spots of deficiency. Repeat in the opposite direction and remember to reset odometer before you start that direction.

17. Next, check access approaches on the right side of the road. Drive access into the road section noting issues needing to be corrected, sight obstructions, signing, etc. Indicate the access location using the approximate mileage on the road section identified previously. Check for both travel directions.

18. For the road classification of this section, indicate how deficiencies should be corrected:
    f) Leave section as it is, no improvement needed for this road section, i.e. do nothing.
    g) Schedule Routine Maintenance.
    h) Major Reconstruction Required.
    i) Perform Routine Maintenance Immediately.
    j) Spot Improvement(s) Needed.

Have a safe trip!

Functional Local Rural Road Classification

<table>
<tr><th>Rural Major High-Speed</th><th>Rural Minor</th><th>Rural Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 40-65 m.p.h.
♦ Infrequent accesses</td><td rowspan="2">Accumulates traffic from local roads, brings all developed areas within reasonable distances of collector roads, provides service to the remaining smaller communities, and links the locally important traffic generators within their rural region.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 250-400 v.p.d.
♦ Operating speed 40-60 m.p.h.</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 100-250 v.p.d.
♦ Operating speed 30-45 m.p.h.</td></tr>
<tr><th>Rural Major Medium-Speed</th><th>Rural Low-volume Local</th></tr>
<tr><td>Serves larger towns and other traffic generators not served by higher systems, links these places with nearby cities and larger towns or with higher systems, and serves more important intracounty travel corridors.

Typically:
♦ Paved surfaces
♦ Traffic volumes 400 v.p.d.
♦ Operating speed 30-45m.p.h.
♦ Frequent accesses</td><td>Provides access to land adjacent to the collector network and serves travel over relatively short distances.

Typically:
♦ Unpaved surfaces
♦ Traffic volumes 0-100 v.p.d.
♦ Operating speed variable</td></tr>
</table>

Safety Issues to LOOK FOR:

Roadside Features

34. Are clear zones free of hazards and non-traversable side slopes without safety barriers?
35. Are the clear zones free of nonconforming and/or dangerous obstructions that are not properly shielded?

Road Surface-Pavement Condition

36. Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?
37. Are changes in surface type (e.g., pavement ends or begins) free of poor transitions?
38. Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?
39. Is the pavement free of areas where ponding or sheet flow of water may occur resulting in safety problems?
40. Is the pavement free of loose aggregate/gravel, which may cause safety problems?

Road Surface-Pavement Markings

41. Is the road free of locations with pavement marking safety deficiencies?
42. Is the road free of pavement markings that are not effective for the conditions present?
43. Is the road free of old pavement markings that affect the safety of the roadway?

Road Surface-Unpaved Roads

44. Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)?
45. Is the road surface free of areas where ponding or sheet flow of water may occur resulting in safety problems?
46. Is the road surface free of loose gravel or fines that may cause safety problems (control, visibility, etc.)?
47. Are changes in surface type (e.g., pavement ends or begins) free of drop-offs or poor transitions?

Signing and Delineation

48. Is the road free of locations where signing is needed to improve safety?
49. Are existing regulatory, warning, and directory signs conspicuous?
50. Is the road free of locations with improper signing which may cause safety problems?
51. Is the road free of unnecessary signing which may cause safety problems?
52. Are signs effective for existing conditions?
53. Can signs be read at a safe distance?
54. Is the road free of signing that impairs safe sight distances?
55. Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, object markers)?

Intersections and Approaches

56. Are intersections free of sight restrictions that could result in safety problems?
57. Are intersections free of abrupt changes in elevation or surface condition?
58. Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?

Special Road Users, Railroad Crossings, Consistency

59. Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?
60. Are bus stops and mail boxes safely located with adequate clearance and visibility from the traffic lane?
61. Is appropriate advance signing provided for bus stops and refuge areas?
62. Are railroad crossing (crossbucks) signs used on each approach at railroad crossings?
63. Are railroad advance warning signs used at railroad crossing approaches?
64. Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?
65. Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?
66. Is the road section free of inconsistencies that could result in safety problems?

Road Safety Audit Review for Local Rural Roads

Jurisdiction: _____County

Date: _____

Location: _____

Weather: _____

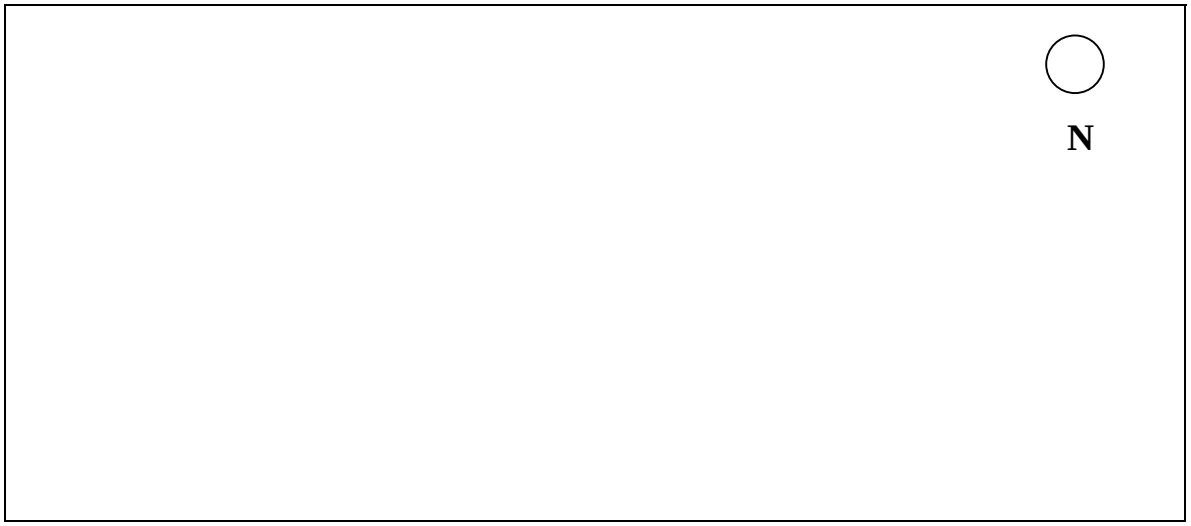
Auditor(s): _____

Road Class: _____

Paved_____ Unpaved_____ Unimproved_____ Speed_____

Sketch of road section:

→ Please include **exact start and end point**, **north arrow**, and other features as appropriate. i.e. cattleguards, etc.



Overall Evaluation of Road Section, check one and/or comment:

1. Leave section as it is, no improvement needed at this road section	
2. Schedule Routine Maintenance	
3. Major Reconstruction Required	
4. Perform Routine Maintenance Immediately	
5. Spot Improvement(s) Needed	
6. Comments:	

Page____ of ____

☐ **Main Route Safety Evaluation**

☐ **Evaluation of Intersection/Approaches to Main Route**

Direction of travel: **N NW W SW S SE E NE** (please circle appropriate direction)

Approx. Location	**Description of concern or insert a number from the LOOK FOR**	**Urgency**	**Recommended Improvement number and/or specify**

Urgency, considering classification of the roadway and cost of improvements	**Recommended improvement, considering classification of the roadway and cost of improvements**

1. Leave as it is 2. No urgency, but should be addressed 3. Schedule improvement in reasonably short time 4. As soon as possible	2. Remove 2. Repair 3. Relocate 8. Replace 9. Delineate 10. Shield 11. Other, please indicate action

APPENDIX B – County 2 - Final Audit Results

Road Deficiency Urgency –Final Audit

Rural Major High Speed

DN	#	Deficiency Type	Rec Imp				Urgency				Urgency of 3 & 4					Urgency of 2 & 3					Urgency 4 Only				
			CG	RE	VE	RS	CG	RE	VE	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS
17	1	Edge Definition	5				2	3								1	1		1						
19	1	Edge Definition	5				2									1									
3	1	Steep Side Slope	5	2	1		2	2	2							1	1	1	1						
16	1	Steep Side Slope	5	2		5	2	2		2						1	1		1	1					
25	2	Ditch Erroding Into Shoulder		2	1	2		3	3	3															
4	2	Drainage Pipe End Blunt		4	1	4	1	3	3	3															
11	2	Mailbox Support					1																		
18	2	Mailbox Treatment	1	1			1	3																	
9	2	Mailboxes Location	3				3				1					1									
14	2	Mailboxes Location	3				3				1					1									
10	2	Power Poles					1																		
6	2	Trees																							
20	15	Stop Sign Missing	4				2									1									
1	17	Curve Sign Close	3				2									1									
13	17	Curve Sign Close	3	2			2									1									
8	23	Blind Intersection	4			2	2			3						1				1					
22	23	Blocked By Fence	1		2		4		3		1		1	1							1		1	1	
23	24	Driveway Poorly Design					4	2			1	1		1							1	1		1	
12	33	Alignment PP vs RW	4	2			3				1					1									
15	33	Curve Speed Signs	4				2									1									
21	33	Driveway Poorly Located					4				1										1				
24	33	Field Access Approaches		2		3		3		3															
7	33	Non-Std. Speed Sign	4				3				1					1									
2	33	Road Narrows	5	5	5		2	2	2							1	1	1	1						
5	33	Road X-Section	5				2	1								1	1		1						
		Total Identified Urgencies					22	10	5	5	7	1	1	2		15	5	2	5	2	3	1	1	2	
		Total Recommended Improvements	17	9	5	5																			

Notes: CG - Control Group; RE - Resident Engineer; VE - Visiting Engineer; RV - Combined results of RE & VE; RS - Team of Superintendents
Recommended Improvements: 6 - Other; 5 - Shield; 4 - Delineate; 3 - Relocate; 2 - Repair; 1 - Remove
Urgency: 4 - Major Reconstruction; 3 - Intermediate Improvements; 2 - Routine Maintenance; 1 - Leave as is

	Urgency of Deficiency																			
	Major Reconstruction					Intermediate Safety Improvements					Routine Maintenance					Leave deficiency as it is				
Rural Major High-speed	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**
Roadside Features	0	0	0	0	0	2	3	3	1	1	4	2	2	1	1	5	0	0	0	0
Pavement Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavement Marking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unpaved Roads	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Signing & Delineation	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Intersections & Approaches	2	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0
Special Users, RR & Cons.	1	0	0	0	0	2	0	0	0	0	3	1	1	1	0	0	1	1	0	0

Road Deficiency Urgency – Final Audit

Rural Major Medium Speed

DN	#	Deficiency Type	Rec Imp				Urgency				Urgency of 3 & 4					Urgency of 2 & 3					Urgency 4 Only				
			CG	RE	VE	RS	CG	RE	VE	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS
11	1	Erosion On Edge	2	2	2	2	2	3	3	2						1	1	1	1	1					
10	1	Guard Rail Short	2	6			1	3																	
13	1	Guard Rail Short	2	6			1	3																	
4	1	Steep Sideslope		2	2			3	3																
8	1	Steep Sideslope	3	2			2	3								1	1		1						
16	1	Steep Sideslope	4	2			2	3								1	1		1						
17	2	Drainage Short		2	2			3	3																
7	2	Utility Near Shoulder				3				3															
3	8	No Sideline - Road Narrows			4	4			3	2															
20	8	RR Marking																							
9	15	Curve Sign		4				3																	
12	15	General Winding Road Sign	4				2									1									
15	15	No Stop Sign				4				4															
6	16	Speed Limit Sign Low																							
18	17	Non-Std. Spd. Limit Sign					1																		
21	17	RR Sign Low																							
14	17	Speed Limit Wrong	3				2									1									
2	17	Yield Sign				4				4															
5	22	Delineators Down	2	5	1	5	3	2	3	2	1	1	1	1	1	1	1	1	1	1					
19	24	Access Road		2				3																	
1	32	Rough Crossing		1				3																	
		Total Identified Urgencies					9	11	5	6	1	1	1	1	1	6	4	2	4	2					
		Total Recommended Improvements	8	11	5	6																			

Notes: CG - Control Group; RE - Resident Engineer; VE - Visiting Engineer; RV - Combined results of RE & VE; RS - Team of Superintendents
Recommended Improvements: 6 - Other; 5 - Shield; 4 - Delineate; 3 - Relocate; 2 - Repair; 1 - Remove
Urgency: 4 - Major Reconstruction; 3 - Intermediate Improvements; 2 - Routine Maintenance; 1 - Leave as is

	Urgency of Deficiency																			
	Major Reconstruction					Intermediate Safety Improvements					Routine Maintenance					Leave deficiency as it is				
Rural Major Med.-speed	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**
Roadside Features	0	0	0	0	0	0	6	6	2	0	3	0	0	0	1	3	0	0	0	1
Pavement Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavement Marking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unpaved Roads	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Signing & Delineation	0	0	0	0	0	1	1	0	1	0	2	0	1	0	1	3	0	0	0	0
Intersections & Approaches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Road Deficiency Urgency – Final Audit

Rural Minor

DN	#	Deficiency Type	Rec Imp				Urgency				Urgency of 3 & 4					Urgency of 2 & 3					Urgency 4 Only				
			CG	RE	VE	RS	CG	RE	VE	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS
8	2	Culvert Blunt End		5			1	3																	
9	2	Culvert Blunt End		5			1	3																	
10	2	Culvert Blunt End					1																		
3	2	Ditch X-Section	2		2		2		2	2						1		1	1	1					
7	2	Ditch X-Section	2				2									1									
6	2	Hole On Side Of Road	5				4				1										1				
13	2	Hole On Side Of Road	5	2			4	4			1	1		1							1	1		1	
15	2	Steep/Deep Gravel Pit	5	6	1		4	1	4		1	1	1	1							1	1	1	1	
12	2	Steep/Deep Side Slope	5	5		2	4	3		3	1	1		1	1						1	1		1	1
2	11	Washboard			1				4																
11	17	Unmarked Intersection			2	4			3	2															
1	23	Gravel Pit I.S. Narrow		2				3																	
5	23	Sight Restriction			1				2																
14	23	Sight Restriction					1																		
		Total Identified Urgencies					10	6	5	3	4	3	1	3	1	2		1	1	1	4	3	1	3	1
		Total Recommended Improvements	6	6	5	2																			

Notes: CG - Control Group; RE - Resident Engineer; VE - Visiting Engineer; RV - Combined results of RE & VE; RS - Team of Superintendents
Recommended Improvements: 6 - Other; 5 - Shield; 4 - Delineate; 3 - Relocate; 2 - Repair; 1 - Remove
Urgency: 4 - Major Reconstruction; 3 - Intermediate Improvements; 2 - Routine Maintenance; 1 - Leave as is

	Urgency of Deficiency																			
	Major Re-construction					Intermediate Safety Improvements					Routine Maintenance					Leave deficiency as it is				
Rural Minor	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**
Roadside Features	4	2	1	1	0	0	3	3	0	1	2	1	0	1	1	4	1	1	0	0
Pavement Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavement Marking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unpaved Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signing & Delineation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intersections & Approaches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	1
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Road Deficiency Urgency – Final Audit

Rural Local

DN	#	Deficiency Type	Rec Imp				Urgency				Urgency of 3 & 4					Urgency of 2 & 3					Urgency 4 Only				
			CG	RE	VE	RS	CG	RE	VE	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS
2	1	Steep Drop Off						1																	
7	2	Support Pole				3																			
8	2	Utility Pole				3																			
1	11	Washboard			2				3																
10	12	Build Up Road				2				2															
11	15	End of County Road			4				3																
9	15	Missing Stop Sign																							
3	33	Irrigation Crossing Narrow		4		3		3		4															
6	33	Irrigation Crossing Narrow		4		3		3		4															
5	33	Narrow Section		4	1			3	3																
		Total Identified Urgencies						4	3	3															
		Total Recommended Improvements		3	3	5																			

Notes: CG - Control Group; RE - Resident Engineer; VE - Visiting Engineer; RV - Combined results of RE & VE; RS - Team of Superintendents
Recommended Improvements: 6 - Other; 5 - Shield; 4 - Delineate; 3 - Relocate; 2 - Repair; 1 - Remove
Urgency: 4 - Major Reconstruction; 3 - Intermediate Improvements; 2 - Routine Maintenance; 1 - Leave as is

Road Deficiency Urgency –Final Audit

Rural Low-Volume

DN	#	Deficiency Type	Rec Imp				Urgency				Urgency of 3 & 4					Urgency of 2 & 3					Urgency 4 Only				
			CG	RE	VE	RS	CG	RE	VE	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS	CG	RE	VE	RV	RS
1	1	Deep Ditch					1																		
6	1	Steep Side Slope		1			1	1																	
8	1	Steep Side Slope					1																		
7	2	Power Poles					1																		
4	2	Rocks	1				2									1									
5	2	Sight Restriction					1																		
3	15	No End Of Road Sign			4		1		3																
2	23	Vert/Hor Alignment					1																		
9	24	Steep Approach Side Slope					1																		
		Total Identified Urgencies					9	1	1							1									
		Total Recommended Improvements	1	1	1																				

Notes: CG - Control Group; RE - Resident Engineer; VE - Visiting Engineer; RV - Combined results of RE & VE; RS - Team of Superintendents
Recommended Improvements: 6 - Other; 5 - Shield; 4 - Delineate; 3 - Relocate; 2 - Repair; 1 - Remove
Urgency: 4 - Major Reconstruction; 3 - Intermediate Improvements; 2 - Routine Maintenance; 1 - Leave as is

	Urgency of Deficiency																			
	Major Reconstruction					Intermediate Safety Improvements					Routine Maintenance					Leave deficiency as it is				
Rural Low-volume Local	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**	**ET**	**TE**	**RE**	**VE**	**RS**
Roadside Features	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5	1	1	0	3
Pavement Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavement Marking	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unpaved Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Signing & Delineation	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Intersections & Approaches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX C – Trial Audit Results

Road Deficiency Severities 2 & 3 Summary– Trial Audit

	Control Group	Team of Engineers	Visiting Engineer	Resident Engineer	Team of Superintendents	AVERAGE
Rural Primary	16	13 (81%)	12 (75%)	4 (25%)	2 (13%)	**7.8 (48%)**
Rural Secondary	14	11 (79%)	10 (71%)	7 (50%)	0	**7.0 (50%)**
Rural Local	4	3 (75%)	3 (75%)	2 (50%)	0	**2.0 (50%)**
Rural Low-Volume Local	2	1 (50%)	1 (50%)	1 (50%)	0	**.8 (38%)**
Total County 1	**36**	**28 (78%)**	**26 (72%)**	**14 (39%)**	**2 (6%)**	**17.5 (49%)**

Notes:

1). Road Deficiency Severity is measured in terms of the presumed consequences of a crash as a result of the deficiency. Severity is measured as: 1 – minor accident, 2- serious accident, 3- fatal accident. Only deficiencies identified by the control group as severity 2 or 3 appear in this table.

2). Severity, as used in this table (Trial Audit), was considered very subjective and was modified to measure urgency in the Final Audit. Comparative analyses using urgency are presented later in this chapter.

Summary of Results from Field RSAR in County I for the Rural Primary Roadway Classification

Jurisdiction: County I **Road Class: Rural Primary**	**Included in this table are the results from the control group and all the deficiencies identified by all participants of this study. The deficiencies identified by the other groups, but not by the control group, are not included in the analysis for this research.**
CG = Control Group	
VE = Visiting Engineer	
RE = Resident Engineer	
RS = Team of Superintendents	

Under Deficiencies Identified by:
1 means identified, 0 means not identified
Under Severity:
1 means minor accident, 2 means serious accident, 3 means fatal accident,
* means no data
Under Recommended Improvements:
1 means remove, 2 means repair, 3 means relocate, 4 means delineate, 5 means shield, 6 means other, * means no data

Def. #	Deficiency Type	Deficiency Identified by:				Severity				Recommended Improvements			
		CG	VE	RE	RS	CG	VE	RE	RS	CG	VE	RE	RS
1	1-side slope	1	1	1	1	2	1	2	2	*	2	*	2
2	25 constr.area	1	1	0	0	2	1	*	*	3	5	*	*
3	2-rocks	1	1	0	0	1	1	*	*	1	1	*	*
4*	25-access	0	1	0	0	*	1	*	*	*	7	*	*
6	24-non transv.	1	0	0	0	2	*	*	*	*	*	*	*
7	9-lack of p.mark.	1	1	1	0	2	2	2	*	4	4	1	*
8	1-fence down	1	0	0	0	2	*	*	*	2	*	*	*
9	22-bad delin.brid	1	0	0	0	1	*	*	*	4	*	*	*
10	2-guardrail end	1	1	0	0	2	2	*	*	*	4	*	*
11	2-bridgerail	1	1	0	0	2	2	*	*	*	4	*	*
12	2-guardrail/bridge	1	1	0	0	2	2	*	*	*	4	*	*
13	2-guardrail low	1	1	0	0	2	2	*	*	*	4	*	*
14	23-bad sight dist.	1	1	0	1	2	2	*	2	*	1	*	1
15	4- pavement end	1	1	0	0	1	1	*	*	2	2	*	*
16*	19-roadname sign	0	1	0	0	*	1	*	*	*	4	*	*
17	19-speedsign high	1	0	0	0	1	*	*	*	*	*	*	*
18	2-mailboxes	1	1	1	0	2	2	1	*	3	3	*	*
19	22-poor conditions	1	1	0	0	2	2	*	*	2	2	*	*
20	2-mailboxes	1	1	0	0	2	2	*	*	3	3	*	*

Summary of Results from Field RSAR in County I for the Rural Primary Roadway Classification (Cont.)

21	23-vegetation	1	1	0	0	2	2	*	*	1	1	*	*
22	3-workz. utility-cut	1	0	0	1	1	*	*	*	2	*	*	2
23	2-rocks in c.z.	1	0	1	0	*2	*	2	*	1	*	6	*
24*	2-utility platform	0	1	0	0	*	3	*	*	*	6	*	*
25	23-visiability n.b.	1	0	0	0	2	*	*	*	5	*	*	*
26	2-non-br.away lam.	1	0	0	0	1	*	*	*	4	*	*	*
27	1-unnec.fence post	1	0	0	0	1	*	*	*	1	*	*	*

Summary Data	**CG**	**VE**	**RE**	**RS**
Found Deficiencies =	23	17	4	3

*****These deficiencies were identified by the groups and not identified by the control group as needed safety improvements. Considering the severity issues most of these deficiencies were identified by the other groups as minor accident.

	Severity of Deficiency														
	3--Fatality likely					2--Serious injury					1--Minor damage				
Rural Primary	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**
Roadside Features	0	0	0	0	0	9	8	6	2	1	3	1	2	1	0
Pavement Condition	0	0	0	0	0	0	0	0	0	0	2	1	1	0	1
Pavement Marking	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Unpaved Roads	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Signing & Delineation	0	0	0	0	0	1	1	1	0	0	2	0	0	0	0
Intersections & Approaches	0	0	0	0	0	5	2	2	0	1	0	1	1	0	0
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary of Results from Field RSAR in County I for the Rural Secondary Roadway Classification

Jurisdiction: County I **Road Class: Rural Secondary**	**Included in this table are the results from the control group and all the deficiencies identified by all participants of this study. The deficiencies identified by the other groups, but not by the control group, are not included in the analysis for this research.**
CG = Control Group	
VE = Visiting Engineer	
RE = Resident Engineer	
RS = Team of Superintendents	

Under Deficiencies Identified by:
1 means identified, 0 means not identified
Under Severity:
1 means minor accident, 2 means serious accident, 3 means fatal accident,
* means no data
Under Recommended Improvements:
1 means remove, 2 means repair, 3 means relocate, 4 means delineate, 5 means shield, 6 means other, * means no data

Deficiency #	Deficiency Type	Deficiency Identified by:				Severity				Recommended Improvements if any			
		CG	VE	RE	RS	CG	VE	RE	RS	CG	VE	RE	RS
1*	33-road narrow	0	1	1	0	*	1	1	*	*	*	4	*
2	17-bike sign	1	0	0	0	3	*	*	*	*	*	*	*
3	1-side slope	1	1	1	1	*	2	2	*	*	*	2	2
4	8-pm poor	1	1	1	1	3	2	*	*	2	2	2	2
5*	2-tresp.sign	0	0	0	0	*	*	*	*	*	*	*	*
6	24-slope/pipe	1	1	1	0	3	1	2	*	*	*	2	*
7*	2-ditch erosion	0	0	1	1	*	*	2	*	*	*	2	2
8	2-blind curve	1	1	0	0	3	3	*	*	5	*	*	*
9*	2-construction	0	1	0	0	*	1	*	*	*	*	*	*
10	2-ditch/cr.sec	1	1	1	0	3	1	2	*	*	*	4	*
11	16-curve sign	1	0	1	1	3	*	2	*	4	*	4	4
12	1-curve delin	1	1	1	1	3	2	1	*	5	5	5	5
13	2-x.section	1	1	0	0	2	1	*	*	*	*	*	*
14	15-haz.marking	1	0	0	0	2	*	*	*	*	*	*	*

Summary of Results from Field RSAR in County I for the Rural Secondary Roadway Classification (Cont.)

15	2-steep ravine	1	1	0	0	3	1	*	*	*	*	*	*
16	2-x.sect.access	1	1	1	0	3	1	1	*	*	2	2	*
17	2-steep side sl.	1	1	1	1	3	1	2	*	*	*	2	2
18	2-culvert end	1	1	0	0	3	*	*	*	*	2	*	*
19	22-curve design	1	1	1	0	3	3	2	*	5	5	5	*
20*	16-no speedl.sb	0	0	0	1	*	*	*	*	*	*	*	4

Summary Data	**CG**	**VE**	**RE**	**RS**
Found Deficiencies =	15	14	11	7

*****These deficiencies were identified by the groups and not identified by the control group as needed safety improvements. Considering the severity issues most of these deficiencies were identified by the other groups as minor accident or without severity.

	Severity of Deficiency														
	3--Fatality likely					2--Serious injury					1--Minor damage				
Rural Secondary	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**
Roadside Features	7	1	1	0	0	1	4	2	3	0	1	3	5	2	0
Pavement Condition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavement Marking	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Unpaved Roads	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Signing & Delineation	3	1	1	0	0	1	1	0	1	0	0	0	0	0	0
Intersections & Approaches	1	0	0	0	0	0	1	0	1	0	0	1	1	0	0
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary of Results from Field RSAR in County I for the Rural Local Roadway Classification

Jurisdiction: County I **Road Class: Rural Local**	**Included in this table are the results from the control group and all the deficiencies identified by all participants of this study. The deficiencies identified by the other groups, but not by the control group, are not included in the analysis for this research.**
CG = Control Group	
VE = Visiting Engineer	
RE = Resident Engineer	
RS = Team of Superintendents	

Under Deficiencies Identified by: 1 means identified, 0 means not identified
Under Severity: 1 means minor accident, 2 means serious accident, 3 means fatal accident, * means no data
Under Recommended Improvements: 1 means remove, 2 means repair, 3 means relocate, 4 means delineate, 5 means shield, 6 means other, * means no data

Deficiency #	Deficiency Type	Deficiency Identified by:				Severity				Recommended Improvements			
		CG	VE	RE	RS	CG	VE	RE	RS	CG	VE	RE	RS
1	11-washboard	1	1	1	1	2	1	2	*	1	*	1	1
2	2-utility nb	1	0	0	0	1	*	*	*	3	*	*	*
3	2-ditch	1	1	1	0	2	2	2	*	6	4	4	*
4	17-stop sign	1	1	0	0	2	3	*	*	4	4	*	*
5	33- expect.	1	0	0	0	2	*	*	*	4	*	*	*
6	2-street sign	1	0	0	0	1	*	*	*	2	*	*	*
7*	13-soft spots	0	0	1	0	*	*	2	*	2	*	*	*
Summary Data		**CG**	**VE**	**RE**	**RS**								
Found Deficiencies =		6	3	3	1								

*****This deficiency was identified by the resident engineer and not identified by the control group as a needed safety improvement. Considering the severity issues this deficiency was identified by the engineer as serious accident.

	Severity of Deficiency														
	3--Fatality likely					2--Serious injury					1--Minor damage				
Rural Local	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**	**ET**	**TE**	**VE**	**RE**	**RS**
Roadside Features	0	0	0	0	0	1	1	1	1	0	2	0	0	0	0
Pavement Condition	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pavement Marking	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Unpaved Roads	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0
Signing & Delineation	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Intersections & Approaches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Special Users, RR & Cons.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Summary of Results from Field RSAR in County I for the

Rural Low-volume Local Roadway Classification

Jurisdiction: County I **Road Class: Rural Low-volume Local**	**Included in this table are the results from the control group and all the deficiencies identified by all participants of this study. The deficiencies identified by the other groups, but not by the control group, are not included in the analysis for this research.**
CG = Control Group	
VE = Visiting Engineer	
RE = Resident Engineer	
RS = Team of Superintendents	

Under Deficiencies Identified by:
1 means identified, 0 means not identified
Under Severity:
1 means minor accident, 2 means serious accident, 3 means fatal accident, * means no data
Under Recommended Improvements:
1 means remove, 2 means repair, 3 means relocate, 4 means delineate, 5 means shield, 6 means other, * means no data

Deficiency #	Deficiency Type	Deficiency Identified by:				Severity				Recommended Improvements			
		CG	VE	RE	RS	CG	VE	RE	RS	CG	VE	RE	RS
1	1-drainage	1	1	1	0	2	2	2	*	*	3	2	*
2	2-narrow cattle guard	1	0	0	0	2	*	*	*	*	*	*	*
3*	17- road end	0	1	0	0	*	1	*	*	*	4	*	*
4*	1-steep slope	0	1	1	1	*	1	1	*	*	*	3	*
Summary Data		**CG**	**VE**	**RE**	**RS**								
Found Deficiencies =		2	3	2	1								

*****These deficiencies were identified by the groups and not identified by the control group as needed safety improvements. Considering the severity issues most of these deficiencies were identified by the other groups as minor accident.

APPENDIX D – Control Group Audit Reports

Final Audit – County 2 Control Group Report

Letter to [redacted] County Commission

The Federal Highway Administration, Wyoming Department of Transportation, and the Wyoming Local Technical Assistance Program were invited to conduct road safety audit reviews on five [redacted] County roads. The reviews were conducted with two objectives; 1. serve as a pilot in development of a safety review process for local roads, and 2. make recommendations for possible safety improvements on the reviewed [redacted] County roads.

Recommendations from the reviews are attached.

I would like to extend our appreciation to Mr. [redacted] for his efforts with initiating the reviews and his assistance in developing a national model for safety reviews at the local level.

[redacted] County should be proud of the progressive approach their personnel approach the safety of the roads.

[redacted]

[redacted] County Road Safety Audit Reviews
November 2, 1999

[redacted]

Roadways reviewed and the recommendations resulting from the reviews are as follows (specifics on exact locations and more details are provided in the review notes):

Road 6-[redacted]

Several items were noted that could be improved if the road was ever reconstructed. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are parallel drainage pipe blunt ends, trees, power poles, mailbox supports, and some relatively steep side slopes.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:
Westbound:

- relocate curve sign further upstream
- delineate roadside where roadway narrows at horizontal curve and a relatively steep slope exists (2 locations)
- replace non-standard speed limit signs

Eastbound:

- replace curve sign with a curve/intersection warning sign
- relocate mailboxes
- relocate curve sign further upstream
- replace curve warning advisory speed plate to be consistent with opposite direction
- add delineation to clearly define edge of roadway cross-section
- install a STOP sign

The following item was thought to be of such a nature that we recommend the improvement be initiated as soon as possible:

- Install delineation where roadway alignment is not consistent with the power pole alignment

The following items were considered to be of such a nature that they would have relatively high safety benefit if corrected, but are of relatively high cost for this classification of roadway. Therefore, it is recommended that they be considered for improvement if major reconstruction occurs on the roadway at or near these locations.

- Driveway approach in poor location
- Westbound view blocked by fence, restricted sight distance
- Driveway approach grades cause restricted sight distance

Road 2-[redacted]

Several items were noted that could be improved if the road was ever reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are low signs, relatively steep ditches, rigid non-breakaway fence, low guardrail, steep slope leading to guardrail, non-standard arrow speed limit sign, .

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:
Westbound:

- relocate 55mph sign
- install winding road sign in lieu of many curve warning signs and replace curve warning sign with turn warning sign at 25mph curve
- delineate relatively steep slopes
- install RR crossing pavement markings

Eastbound:

- delineation inconsistent and in need of maintenance
- repair edge dropoff
- install winding road sign in lieu of many curve warning signs

The following item was thought to be of such a nature that we recommend the improvement be initiated as soon as possible:

- Repair delineation where knocked down and where located on guardrail

Road 2-[redacted]

Several items were noted that could be improved if the road was ever reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are vertical and horizontal sight restrictions and culvert blunt ends.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonable time frame:

- reshape ditch sections
- delineate roadside near holes
- delineate roadside near steep high slopes

Road 2-[redacted]

Numerous potential safety concerns exist on this roadway. However, due to the classification of the roadway, it is recommended that no improvements be made except to install a STOP sign.

Road 6-[redacted]

Several items were noted that could be improved if the road was ever reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are relatively steep slopes and ditches, vertical and horizontal alignment creating sight restrictions, no notification of road ending, and power poles .

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:

- pull ditches and remove large rocks

MEMO

DATE: March 30

TO: To Whom It May Concern
FROM: [redacted]

SUBJECT: Improvements to the County Road System

On October 7, 1999, I participated in a road safety audit on several road sections in [redacted] County. This memo is a recap of the deficiencies noted and the recommended actions for the county to take.

Functional Classification: Rural Primary - [redacted]
This road is an asphalt highway that carries just over 2000 vehicles per day.

There were 23 deficiencies noted, but only four will be addressed in this report. The four listed below are considered serious enough to require immediate attention. The remaining problems should be addressed as part of on going maintenance.

Item #1. [redacted] Access
The access for [redacted] on [redacted] Drive is too close to the intersection of [redacted] Drive and [redacted] Avenue. Any north bound [redacted] Drive traffic stopped at the [redacted] Avenue STOP sign will block the [redacted] access. This approach should be relocated approximately 150 to the south. This should be corrected by [redacted] while the building is under construction.

Item #2. Intersection of [redacted] Drive with [redacted]

Avenue
Because of the skewed intersection angle, [redacted] Drive is "button hooked" to create an intersection close to 90 degrees with [redacted] Avenue. This causes a sight restriction for motorists approaching the intersection north bound. The geometrics of the intersection and the STOP sign are not visible to the north bound motorist approaching the intersection. This is more of a problem at night. Pavement markings are non-existent, and they should be replaced. This work needs to be put out to contract. The outside of the "button hook" should be delineated with chevron warning signs, and the STOP sign should be replace with a better grade of sheeting to increase angular retroreflectivity. This work can be done as special project with county personnel.

Item #3. Intersection of [redacted] Drive with [redacted] Avenue
The state installed luminaires at the [redacted] Drive and [redacted] Avenue intersection are within the clear zone for both [redacted] Drive and [redacted] Avenue. They were not installed with breakaway features. The Wyoming Department of Transportation own these luminaires, and they should be notified immediately of this deficiency.

Item #4. This problem is along the entire length of [redacted] Drive.
All the mail boxes are installed adjacent to the pavement, and they are installed on non-breakaway posts. They should be clustered at a single location, an installation pad constructed, and all old mailboxes removed. This work should be coordinated with the Post Office, and if they agree, a cluster box installed outside the clear zone. This work could be done as a special project with county personnel.

All of the rest of the deficiencies can be corrected with county personal during normal

maintenance.

Functional Classification: Rural Secondary - [redacted] Street

This rural, high speed highway which is paved and carries little over 600 vehicles per day. It has a history of fatal and injury accidents.

A total of 15 deficiencies were noted of which four should be corrected immediately.

The pavement markings have deteriorated to a point that they are almost non-existent over the entire road. A contract should be initiated as soon as practicable to re-stripe the pavement markings. This work will have to be done by contract since the county does not have striping equipment.

The curve at milepost 5.1 is sharp with slopes that are steep and have been eroded. It is apparent that several vehicles have driven off the highway at this location. The sideslopes should be flattened to improve the ride-out characteristics of the sideslopes, and chevron signs should be installed to improve visibility of the curve. This work can be accomplished with county personnel, however special funding will have to be set up to flatten the slopes.

Delineation for the entire length of the road section is marginal. It has deteriorated over time with missing installations and poor reflectivity. The entire road should have new delineators installed. This can be done with county personnel, but special funding should be set up.

There are several curves that should have curve warning signs installed. They ball bank in an area were the signs would not have to be installed, but because of the high speeds and accident experience on this road, they should be

installed. This work can be accomplished with county personnel with existing budgets.

It was noted during the safety audit that most of the approaches have been constructed in such a manner that blunt ends of culvert pipe are in the clear zone and the side slopes of the approaches are excessive. The road is narrow, and ditch sections are sub standard. These items are outside the realm of minor improvements. Consideration should be given to a major reconstruction project that would correct these as well as other problems. This will be a major expense, and it will have to be considered with the overall county budget.

Other items noted were minor and will be corrected as part of routine maintenance.

Functional Classification: Rural Local - [redacted] Street West of [redacted]

This is a gravel road with an ADT of 424.

There were two deficiencies noted, but they were considered minor, and no immediate corrective action needs to be taken. They will be corrected as part of routine maintenance.

Functional Classification: Rural Local - [redacted] Lane

This is a gravel road which connects [redacted] with WYO [redacted]

There were four deficiencies notes, but only one needs to be covered in this report.

The road is rough and needs to be bladed. This will be accomplished as part of routine maintenance.

Functional Classification: Rural Low-Volume Local

- [redacted] County Road Number [redacted]

This is a gravel, rural county road that serves two residences. Traffic volume is very low.

Two deficiencies were noted. However, they are minor, and no corrective action needs to be taken at this time. They will be corrected as part of routine maintenance.

APPENDIX E – Engineer and Superintendent Audit Reports

Engineer Audit Reports

County I, Rural Primary
(This is only the part of the report which reflect the Rural Primary Classification)

At the request of …….. Road & bridge Supervisor, and ……. I completed a Safety Audit Review (SAR) on October 6, 1999 of several of …….. County's roads. The following is a summary and recommended improvements to be made based on this review.

First, it should be noted that this review is only of a few select ……. County Roads and is not indicative of all of …….. County Roads. The roads where selected based on the Functional classification of the road, as described in the attached table:

…….. Drive, from …….. Avenue to end of County Road past ……. Drive

……. Drive from ……Avenue to end of County Road past …… Drive

Recommended Improvements:

1. Construction area signage and control
2. Improve side slopes and drainage.
3. Remove bushes, mailboxes, fences, power poles and other obstructions from R.O.W.
4. Striping – either remove or eliminate centerline striping.

County I, Rural Secondary
(This is only the part of the report which reflect the Rural Secondary Classification)

Ninth Street, from north City limits, at the cattleguard, north six miles to MP 8.

Recommended Improvements

1. Curve at MP 4.8 to MP 5.1 – There have been several accidents with injuries at this location..
   - Improve the side slopes to allow for recovery if a vehicle misses the curve.
   - Install chevrons and advance warning signs to warn drivers of hazard.

2. Improve side slopes and drainage. Improve drainage and repair erosion damage.
3. Striping – either remove or eliminate centerline striping.
4. Improve access control – side slopes, radii and culverts

County I, Rural Local

(This is only the part of the report which reflect the Rural Local Classification)

Functional Classification: Rural Local Street

This is a gravel road with an ADT of 424.
There were two deficiencies noted, but they were considered minor, and no immediate corrective action needs to be taken. They will be corrected as part of routine maintenance.

Functional Classification: Rural Local

This is a gravel road which connects …… with …….. There were four deficiencies noted, but only one needs to be covered in this report. The road is rough and needs to be bladed. This will be accomplished as part of routine maintenance.
The full report from the Team of Superintendents is contained in Appendix B-1-b

County I, Rural Low-volume Local
(This is only the part of the report which reflect the Rural Low-volume Local Classification)

County Road from …….. South 1.1 miles to the end of County Maintenance.

Recommended Improvements:

1. Extend culverts for irrigation crossings from the edge of R.O.W. to the edge of the R.O.W.
2. Mark end of county road.

County II, Rural Major High-speed
(This is only the part of the report which reflect the Rural Major High-speed Classification)

Rural Major High Speed	End of new construction. Road Narrows without warning. Steep in slopes on new construction. Irrigation ditches extend into clear zone.	Install Narrow Toad sign as soon as possible. Improve side slope as time and money allow. Extend pipe to the edge of the right of way.

County II, Rural Major Medium-speed
(This is only the part of the report which reflect the Rural Major Medium-speed Classification)

Rural Major Medium Speed	Road narrows about half way through the section. Delineators missing or not up to standards. Holes in shoulders.	Install sign to warn motorist about narrow roadway as soon as possible. Bring delineators up to standard or eliminate. Blade shoulders to insure smooth pavement transition from shoulder.

County II, Rural Minor
(This is only the part of the report which reflect the Rural Minor Classification)

Rural Minor	Washboard surface. Steep in slopes. No sign at T junction on North end of road. Bad new approach. Insufficient sight distance on corner. Gravel pit next to road.	Blade road immediately. Lessen in slopes with maintainer when time and money allow. Install stop sign as soon as possible. Make approach installer, Lessen side slopes and make better ratios. Daylight corner or sign when time and money allow. Work with landowner to keep any further excavation away from clear zone.

County II, Rural Local
(This is only the part of the report which reflect the Rural Local Classification)

Rural Local	Wash board surface. Horizontal and vertical site distance very limited. End or road.	Blade road immediately. Install a "Narrow Winding Road with Limited Site Distance" sign. Due to the local nature of the road and the high cost to improve, install a sign.

Rural Low-volume Local
(This is only the part of the report which reflect the Rural Low-volume Local Classification)

Rural Low-Volume local	Excellent local, low volume road.	I wish we had some like this in our County.

Superintendents Audit Reports

(The reports from the superintendents are in general not classification specific so the entire report from all the participants will follow.)

Superintendent I

Dear ……..

First of all I would like to thank you for asking me to be a part of the Safety Audit Team.

It gave me a chance to view roads in there counties with a team of professionals not only to look at safety concerns, but also to compare roads in …… County to other county roads. Also, I was able to visit with my counterparts and discuss our concerns.

When we upgrade a road I feel it would be very beneficial to have a professional team conduct a safety audit to assist me with setting priorities and prepare plans for the Board of Commissioners.

County II:

County has similar problems as we do in …… County. The main item is with utilities in the right of way along with private fences, irrigation ditches and large trees. Some approaches on various properties were established before standards were set in the county. They have done a very good job on the newly constructed and road upgrades and they should be proud of their accomplishments.

County I:

Again, the same situation as ……. County II, utilities and privates fences are within the right of way. Additionally, some industries have built on or near the edge of the right of way. Also, it appears that an upgrade on signing and delineation needs to be done in some areas. This is something that needs to be looked at closely because it is very expensive and very expensive to maintain. Overall, their roads are well maintained.

If the County's decide that Road Safety Audits should continue, I would appreciate a chance to participate.

Thanks again.

Sincerely,
Road supervisor.

Superintendent II

TO WHOM IT MAY CONVERN - COUNTY II

UPON COMPLETION OF OUR ROAD SAFETY AUDIT IN YOUR COUNTY, WE HAVE LISTED SOME OF THE FOLLOWING CONCERNS WE HAVE ENCOUNTERED. WE UNDERSTAND THAT DUE TO BUDGET RESTRAINTS AND MANPOWER, SOME OF THE ISSUES MAY NOT BE ABLE TO BE ADRESSED UTINL FUTURE DATE.

RURAL LOCAL ON COUNTY ROAD: WE FOUND THAT THE ROW WAS LIMITED DUE TO THE IMPROPER INSTALLATION AND LOCATION OF THE UTILITIES AND ALSO THE LOCATION OF THE IRRIGATION DITCH. WE DO FEEL THAT THERE MAY BE AN AREA ON THE SOUTH SIDE OF THE ROAD THAT COULD BE USED TO RAISE THE ELEVATION OF THE ROAD AND REPAIR SOME OF THE SLOPES. THE BERMS ALONG SIDE THE ROAD COULD ALSO BE USED AS FILL.

RURAL MAJOR H.S ON THE …… WE FOUND SOME AREAS THAT MAY NEED MORE IMMEDIATE ATTENTION. THE REASON WE FEEL THIS IS THAT THIS ROAD HAS A LOT HIGHER VOLUME OF TRAFFIC. THE MOST APPARENT BEING THE OBSTRUCTIONS IN THE IRRIGATION DITCHES THAT ARE WITHIN THE RIGHT OR WAY. ALSO CONSIDER LIMITING SOME OF THE FIELD APPROACHES.

WE THOUGHT THAT THE BEGINNING OF THE ROAD WAS IN VERY GOOD CONDITION AND THE IMPROVEMENTS THAT WERE MADE TO THAT SECTION WERE VERY WELL DONE. IT WAS CLEAR THAT SAFETY WAS CONSIDERED IN THAT NEW CONSTRUCTION.

OVERALL, WE FELT THAT THE COUNTY ROAD SYSTEM IN ….. COUNTY ii WAS IN GOOD SHAPE. WITH ROUTINE MAINTENANCE, WE FEEL THAT A LOT OF THE COMMENTS IN THIS REPORT WOULD BE TAKEN CARE OF.

RSA TEAM
SUPERINTENDANT

Superintendent III

Road Safety Audit

I would like to applaud you on your efforts to make our county roads safer. It will be interesting to see the comparisons between the different observers on tis project.

It would be wrong for me to say that our County roads are totally safe, as I don't believe any county's roads are. This RSA can be a very good tool for identifying safety problems, and hopefully correcting them as budgets allow.

As we observed these roads, as County Road Supervisors, we were finding problems that we may have already corrected in our counties: such as inslopes, back slopes or crowning the centerline, etc. But on the other hand I don't believe we scrutinized some areas as intensely as some of the other observers may have: such as gravel or other surface types, as I see these as cosmetic problems that are solved with routine maintenance.

We found a few signing problems such as changing a yield to stop sign, or something that directly impacted an intersection. I am sure there will be some conflicting reports on signing with this report. I really feel we need to consider ADT's and user types when we address the signing issue.

I will end by suggesting that in the future when we do an RSA that the observer know who will be reviewing the RSA because that will dictate one or two things. First, if it is reviewed by Road & Bridge personnel, who will be constructing and or maintaining the problem, then it will be looked on as positive constructive criticism. Second if it is reviewed by County commissioners, who may not have an understanding of road constructions or if it is reviewed in a public forum; it could be potentially detrimental to road & bridge programs, as well as counties in general. In either case, you will get a different report. The first being more productive.

Thank you for the opportunity to participate in this worthwhile project.

County Road & Bridge.