2006-32

Final Report

Review of North Carolina's Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)

Report #2 in the Series: Toward a Multi-State Consensus on Rural Intersection Decision Support

MINNESOTA DEPARTMENT OF TRANSPORTATION

Research

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC-2006-32		

4. Title and Subtitle Review of North Carolina's Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)	5. Report Date August 2006 6.
7. Author(s) Howard Preston, Richard Storm, Max Donath, Craig Shankwitz	8. Performing Organization Report No.
9. Performing Organization Name and Address CH2M HILL 1380 Corporate Center Curve Suite 200 Eagan, MN 55121 ITS Institute University of Minnesota 111 Church Street SE Minneapolis, MN 55455	10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (c) 81655 (wo) 106
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes
http://www.lrrb.org/PDF/200632.pdf
Report #2 in the Series: Toward a Multi-State Consensus on Rural Intersection Decision Support

16. Abstract (Limit: 200 words)

The objective of the Intersection Decision Support (IDS) research project, sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA), is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes. Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. This report documents the crash analysis phase of the pooled fund study for the State of North Carolina, culminating in a recommendation of an intersection for instrumentation. The driver gap acceptance behavior data to be collected at the selected intersection will feed into the Cooperative Intersection Collision Avoidance System (CICAS) Stop Sign Assist Program.

17. Document Analysis/Descriptors		18. Availability Statement
Intersection Decision Support Safety Rural Expressways Thru-STOP intersections	Rural intersections Rural crashes North Carolina	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	56	

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August 2006

Published by:

Minnesota Department of Transportation
Research Services Section
395 John Ireland Boulevard, MS 330
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Acknowledgements

The authors of this report would like to acknowledge and thank the states participating in the IDS Pooled Fund study. With the support of the following listed states, we have been able to further our study and gain a better understanding of crossing-path crashes at rural unsignalized intersections:

- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

We would also like to especially acknowledge several individuals at the North Carolina Department of Transportation (NCDOT) who played key roles in the analysis of North Carolina intersections and development of this report. We would like to thank Carrie Simpson, Traffic Safety Project Engineer with NCDOT, who provided the crash record information, supplied technical direction for the crash reviews, and participated in the intersection field reviews. The research team would also wish to acknowledge Al Grandy, Sandhills Regional Traffic Engineer, who participated in the field reviews and was able to provide additional information and background on each of the intersections reviewed. North Carolina's participation in the pooled fund study reflects the support given by Shawn Troy, North Carolina's Safety Evaluation Engineer and Kevin Lacy, State Traffic Engineer.

Finally, we wish to acknowledge the assistance provided by Ray Starr of the Minnesota Department of Transportation (Mn/DOT) who served as technical manager of the pooled fund project and Jim Klessig of Mn/DOT who served as administrative liaison of the pooled fund.

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Executive Summary

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) whose objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes. Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology under development. Also underway, alternative Driver Infrastructure Interfaces (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. The participating states are:

- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

The first facet of this pooled fund project is a review of intersection crash data from each participating state, applying methods developed in previous IDS research. The crash data will be used to understand rural intersection crashes on a national basis, and to identify candidate intersections for subsequent instrumentation and study. The second facet is a participatory design process to design and refine candidate intersection Driver Infrastructure Interfaces. The third facet is to instrument candidate intersections in participating states, as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. States choosing to instrument intersections will be well positioned to participate in the second phase of the IDS program, a proposed Field Operational Test designed to evaluate the performance of these systems.

Review of North Carolina's Intersections

This report documents the initial phase of the pooled fund study for the State of North Carolina. The crash analysis focused on intersections identified as part of North Carolina's Highway Safety Improvement Program (HSIP) based on the crash data from January 1, 2001 through December 31, 2003. The HSIP program identifies locations that "exceed minimum warranting criteria developed by safety engineers for particular crash types and patterns for further analysis and investigation." In particular, rural, thru-STOP intersections that met criteria I-1 (Frontal

Impact Crashes) and I-5 (Chronic Crash Pattern) were identified. The HSIP intersections were further screened to identify intersections located on rural, divided expressways. This process resulted in a list of twelve intersections which was further screened using the critical crash rate, crash frequency, crash severity, and crash type to identify the following five candidate locations.

- US 74 and SR 2210
- US 74 and SR 1574
- NC 87 and SR 1150
- NC 87 and SR 1700
- US 74 and SR 1152

A field visit revealed that the North Carolina Department of Transportation had deployed two general types of strategies at each intersection. The first type of intersection improvement includes splitter islands with two STOP signs on the stopped approaches, STOP AHEAD signs, STOP AHEAD pavement markings, pavement markings at the STOP bar, street lighting, and/or rumble strips. All of these improvements are relatively low cost, but are designed to help drivers recognize the intersection and do not assist the driver in selecting a safe gap. The second type of strategy was used in the median at four of the intersections to encourage drivers to stop and look again for traffic. These strategies included adding an additional placard under the YIELD sign with the message LOOK AGAIN or LOOK with an arrow along with the pavement marking LOOK RIGHT.

Looking at the crash data, these strategies did prove effective at reducing run-the-STOP crashes since there were few of these crash types. Instead, the crossing path crashes at the five candidate intersections were predominately associated with a driver’s poor gap identification and selection.

Using the crash factors of at-fault driver age, crash severity, driver’s contributing factor along with several other factors, the intersection selected as the best candidate for test deployment of the IDS technology was US 74 and State Route 1574. The US 74 and SR 1574 intersection has one of the worst crash experiences, including a high crash rate, a high percentage of correctable crash types, the highest number of severe injury crashes, a high percentage of farside crashes, and a high percentage of gap related crashes.

1. Project Background

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA). Its objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes (*1*,*2*,*3*). Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology under development. Also underway, alternative Driver Infrastructure Interface (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating on intersection-crash research. The participating states are:

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This report documents the initial phase of the pooled fund study for the State of North Carolina. Following is a description of the crash analysis performed for North Carolina and a recommendation of an intersection for design of an IDS system for possible deployment.

1.1. Typical Countermeasures for Rural Intersections

A typical right-angle crash at a rural unsignalized intersection is most often caused by the driver's (on a minor street approach) inability to recognize the intersection (which consequently results in a run the STOP sign violation) or his/her inability to recognize and select a safe gap in the major street traffic stream.

Traditional safety countermeasures deployed at rural high-crash intersections include:

- Upgrading traffic control devices
  - Larger STOP signs
  - Multiple STOP signs
  - Advance warning signs and pavement markings
- Minor geometric improvements
  - Free right turn islands
  - Center splitter islands
  - Off-set right turn lanes
- Installing supplementary devices
  - Flashing beacons mounted on the STOP signs
  - Overhead flashing beacons
  - Street lighting
  - Transverse rumble strips

All of these countermeasures are relatively low-cost and easy to deploy, but are typically designed to assist drivers with intersection recognition and have not exhibited an ability to address gap recognition problems. Yet, up to 80% of crossing path crashes are related to selection of an insufficient gap (*1*). In addition, a Minnesota study of rural thru-STOP intersections for rural two-lane roadways found only one-quarter of right-angle crashes were caused by the driver on the minor street failing to stop because they did not recognize they were approaching an intersection (*2*). At the same set of intersections, 56% of the right-angle crashes were related to selecting an unsafe gap while 17% were classified as other or unknown.

The concept of gap recognition being a key factor contributing to rural intersection safety appears to be a recent idea. As a result, there are relatively few devices in the traffic engineer's safety toolbox to assist drivers with gap recognition and they mainly consist of a few high cost geometric improvements and a variety of lower cost strategies that are considered to be experimental because they have not been widely used in rural applications. **Figure 1-1** illustrates the range of strategies currently available to address safety deficiencies associated with gap recognition problems, organized in order of the estimated cost to deploy (based on Minnesota conditions and typical implementation costs). The strategies include:

- The use of supplemental devices such as street light poles to mark the threshold between safe and unsafe gaps
- Minor geometric improvements to reduce conflicts at intersection such as inside acceleration lanes, channelized median openings to eliminate certain maneuvers (sometimes referred to as a J-turn), or revising a four-legged intersection to create off-set T's
- Installing a traffic signal to assign right-of-way to the minor street
- Major geometric improvements such as roundabout or grade separated interchanges to eliminate or reduce crossing conflicts. (Refer to *Rural Expressway Intersection Synthesis of Practice and Crash Analysis* for a review of various alternatives [*4*].)

The use of these strategies may not be appropriate, warranted or effective in all situations. Also, the construction cost or right-of-way may prove to be prohibitive at some locations. All of this combined with a recommendation in American Association of State Highway and Transportation Official (AASHTO) Strategic Highway Safety Plan to investigate the use of technology to address rural intersection safety led to the ongoing research to develop a cost-effective Intersection Decision Support (IDS) system, including a new driver interface. The IDS system is intended to be a relatively low cost strategy (similar to the cost of a traffic signal), but at the same time is technologically advanced, using roadside sensors and computers to track vehicles on the major road approaches, computers to process the tracking data and measure available gaps and the driver interface to provide minor road traffic with real-time information.

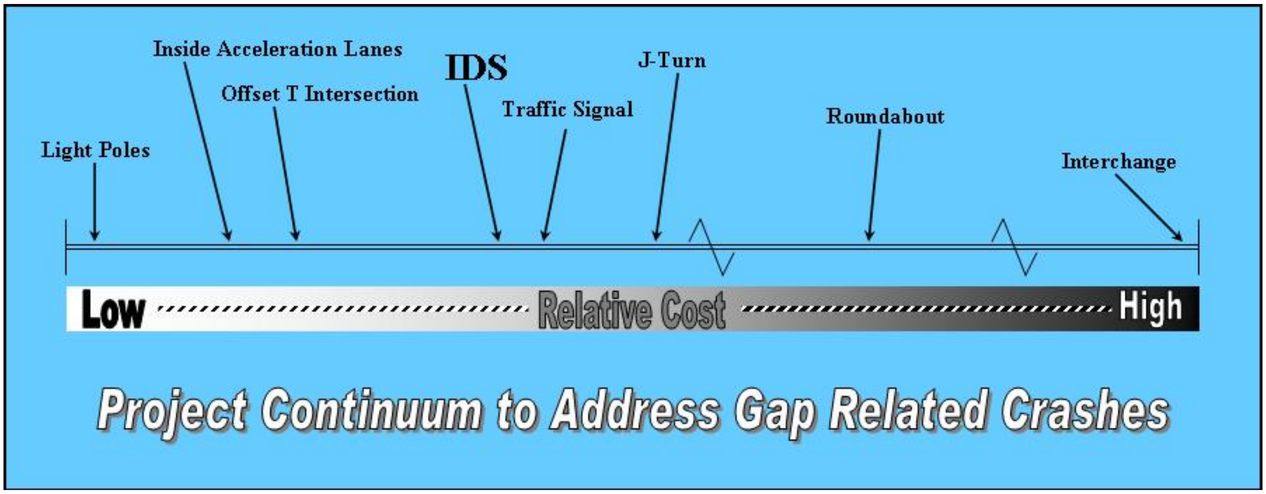


FIGURE 1-1
Gap Selection Related Safety Strategies

2. Crash Analysis Methods for Candidate Intersection Identification

A comprehensive method for intersection identification was developed using Minnesota's crash record system (see **Figure 2-1**). The method was applied to all rural, thru-STOP intersections in Minnesota, as this is the most frequent intersection situation in Minnesota. This intersection type is also the most likely where a driver will have to judge and select a gap at a rural intersection (i.e., stopped vehicle on the minor approach). The approach to identify the intersection selected for a potential field test of the technology used the three screens described in the following:

- **Critical Crash Rate –** The first screen was to identify the rural thru-STOP intersections that have a crash rate greater than the critical crash rate. The critical crash rate is a statistically significant rate higher than the statewide intersection crash rate. Therefore, any intersection with a crash rate equal to or above the critical crash rate can be identified as an intersection with a crash problem due to an existing safety deficiency.
- **Number and Severity of Correctable Crashes –** Once the list of intersections meeting the first criteria was identified, this second screen was performed to identify intersections where a relatively high number and percentage of crashes were potentially correctable by the IDS technologies being developed. In Minnesota's crash record system, right angle crashes were the crash type most often related to poor gap selection. Therefore the ideal candidate intersections had a high number & percentage of right angle collisions and tended to have more severe crashes. This screen was used to identify the top three candidate intersections for the final screen.
- **Crash Conditions and At-Fault Driver Characteristics –** The IDS technology is believed to have the greatest benefit for older drivers. Therefore, the at-fault driver age was reviewed to identify intersections where older drivers were over represented. Other aspects of the crashes that were reviewed include whether the crashes were typically a problem with intersection recognition or gap recognition and the crash location (near lanes or far lanes).

In North Carolina, application of the preferred process was not feasible due to the State DOT's current crash record system. The State has no database of intersection characteristics (i.e., rural versus urban, traffic control device, roadway type, etc.) that is linked to the crash records. Essentially, North Carolina is currently unable to automatically identify and query intersections (including crash records) based on physical characteristics. Therefore, a modification of the approach was needed since it was impracticable to manually search the State for all rural, thru-STOP intersections.

This modification was to look for candidate intersections that were identified as part of North Carolina's Highway Safety Improvement Program (HSIP). The HSIP does not identify the State's most dangerous locations; instead, the program identifies locations that "exceed minimum warranting criteria developed by safety engineers for particular crash types and patterns for further analysis and investigation." In particular, rural, thru-STOP intersections that met criteria I-1 (Frontal Impact Crashes) and I-5 (Chronic Crash Pattern) were identified. The NCDOT also chose to focus on rural expressway; therefore, HSIP intersections were further screened by searching for intersections where the main line is a four-lane divided roadway (i.e., expressway) with a 55 mph speed limit and where no safety improvement projects had recently been implemented. This process resulted in a list of twelve intersections (see **Table 2-1**).

Without the statewide intersection database, NCDOT also could not easily compute a statewide expected crash rate for rural, thru-STOP intersections. This value is important to the process because it is used to calculate the critical crash rate. Therefore, the decision was made to use Minnesota's statewide rate (0.4 crashes per million entering vehicle [MEV]). With this assumption, the process described previously was applied to the twelve intersections.

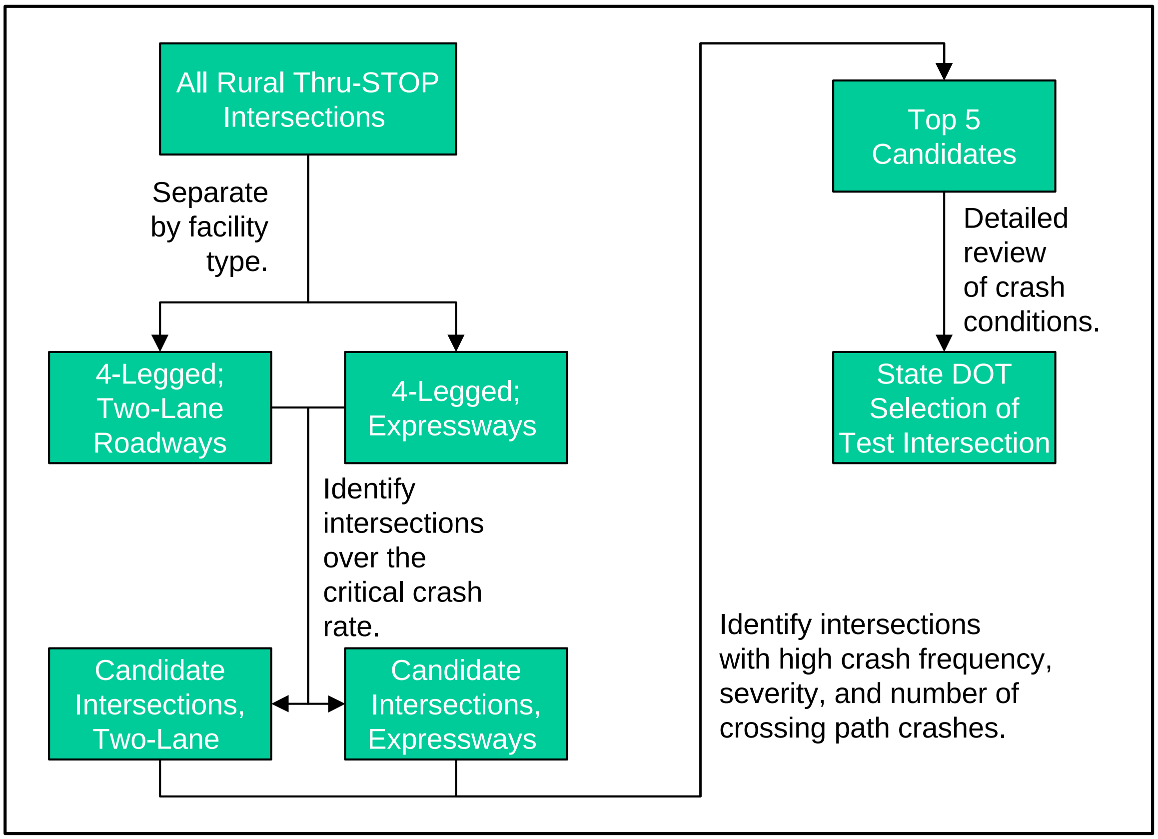


FIGURE 2-1
Preferred Crash Analysis Process

TABLE 2-1
North Carolina Intersection Summary Table

Intersection of	County	Total Crashes	Crashes by Year			Entering ADT	Rate			Severity		
			2001	2002	2003		Crash Rate	Expected Crash	Critical Crash	Fatal	Injury	PDO
							Statewide Distribution			0.6%	37.2%	62.2%
US 74 and SR 2210	Robeson	20	9	7	4	11,150	1.6	0.4	0.7	2 10%	12 60%	6 30%
US 74 and SR 1574	Columbus	21	7	6	8	10,400	1.8	0.4	0.8	0 0%	15 71%	6 29%
NC 87 and SR 1150	Bladen	19	9	5	5	10,000	1.7	0.4	0.8	3 16%	12 63%	4 21%
NC 87 and SR 1700	Bladen	25	8	3	14	8,000	2.9	0.4	0.8	0 0%	21 84%	4 16%
US 70 and SR 1127	Carteret	14	5	3	6	22,310	0.6	0.4	0.6	1 7%	7 50%	6 43%
US 74 and SR 1152	Scotland	28	6	11	11	18,800	1.4	0.4	0.7	1 4%	19 68%	8 29%
US 264 ans SR 1523	Pitt	8	4	1	3	22,000	0.3	0.4	0.6	0 0%	5 63%	3 38%
US 74 and SR 1324	Scotland	10	5	2	3	21,400	0.4	0.4	0.6	0 0%	8 80%	2 20%
NC 11 and SR 1113	Pitt	9	8	0	1	16,000	0.5	0.4	0.7	0 0%	6 67%	3 33%
NC 24 and SR 1230	Onslow	8	2	3	3	9,100	0.8	0.4	0.8	1 13%	2 25%	5 63%
US 70 and SR 1002	Jones	11	2	5	4	13,000	0.8	0.4	0.7	0 0%	8 73%	3 27%
US 19 and SR 1390	Cherokee	8	2	3	3	6,700	1.1	0.4	0.9	0 0%	6 75%	2 25%

TABLE 2-1 (continued)
North Carolina Intersection Summary Table

Intersection of	County	Crash Type: Left Turn	Right Turn	Rear End	Run-Off Road / Overturn	Angle	Sideswipe / Head-On	Other
	Statewide Distribution	10.2%	2.0%	27.6%	22.2%	15.5%	8.7%	13.8%
US 74 and SR 2210	Robeson	1 5%	0%	0%	0%	18 90%	0%	1 5%
US 74 and SR 1574	Columbus	0%	0%	1 5%	0%	18 86%	0%	2 10%
NC 87 and SR 1150	Bladen	1 5%	0%	0%	0%	18 95%	0%	0%
NC 87 and SR 1700	Bladen	0%	0%	0%	0%	22 88%	0%	1 4%
US 70 and SR 1127	Carteret	1 7%	0%	1 7%	0%	11 79%	0%	1 7%
US 74 and SR 1152	Scotland	1 4%	1 4%	4 14%	0%	21 75%	0%	1 4%
US 264 ans SR 1523	Pitt	1 13%	0%	1 13%	0%	4 50%	0%	2 25%
US 74 and SR 1324	Scotland	3 30%	0%	0%	0%	6 60%	0%	1 10%
NC 11 and SR 1113	Pitt	0%	0%	1 11%	0%	7 78%	0%	1 11%
NC 24 and SR 1230	Onslow	1 13%	0%	0%	0%	7 88%	0%	0%
US 70 and SR 1002	Jones	0%	0%	0%	0%	10 91%	1 9%	0%
US 19 and SR 1390	Cherokee	1 13%	0%	0%	0%	7 88%	0%	0%

Source: North Carolina Crash Records; January 1, 2001 to December 31, 2003.

The Statewide Distributions is for all crashes in the State of North Carolina that were reported in the *2002 North Carolina Traffic Crash Facts*. The percentages listed for each intersection are the actual severity and crash type distributions at the individual intersections.

Highlighted rows are intersections where the crash rate was greater than the critical crash rate

3. Identification of Top 5 Candidate Intersections

Review of the 12 intersections began with crash records from January 1, 2001 through December 31, 2003 (3 years), which were provided by the NCDOT. To identify the top five candidate intersections, the first screen was to identify those intersections over the critical crash rate. In Table 3-1, the seven highlighted intersections represent this subset of intersections.

These seven intersections were then reviewed to determine if they have a relative high crash frequency, high crash severity, and a high proportion of angle crashes (the crash type believed to be most often caused by poor gap selection). All seven intersections had a high percentage of fatal and injury crashes (70% and higher compared to 37.8% expected) and a high distribution of angle crashes (75% and higher compared to 15.5% expected). However, two intersections had a crash frequency that was noticeably lower (US 70 & SR 1002 with 11 crashes and US 19 & SR 1390 with 8 crashes). Therefore, these two intersections were not included in the detailed review, and the resulting candidate intersections chosen for further analysis include:

- US 74 and SR 2210
- US 74 and SR 1574
- NC 87 and SR 1150
- NC 87 and SR 1700
- US 74 and SR 1152

The location of these five intersections is shown in **Figure 3-1**.

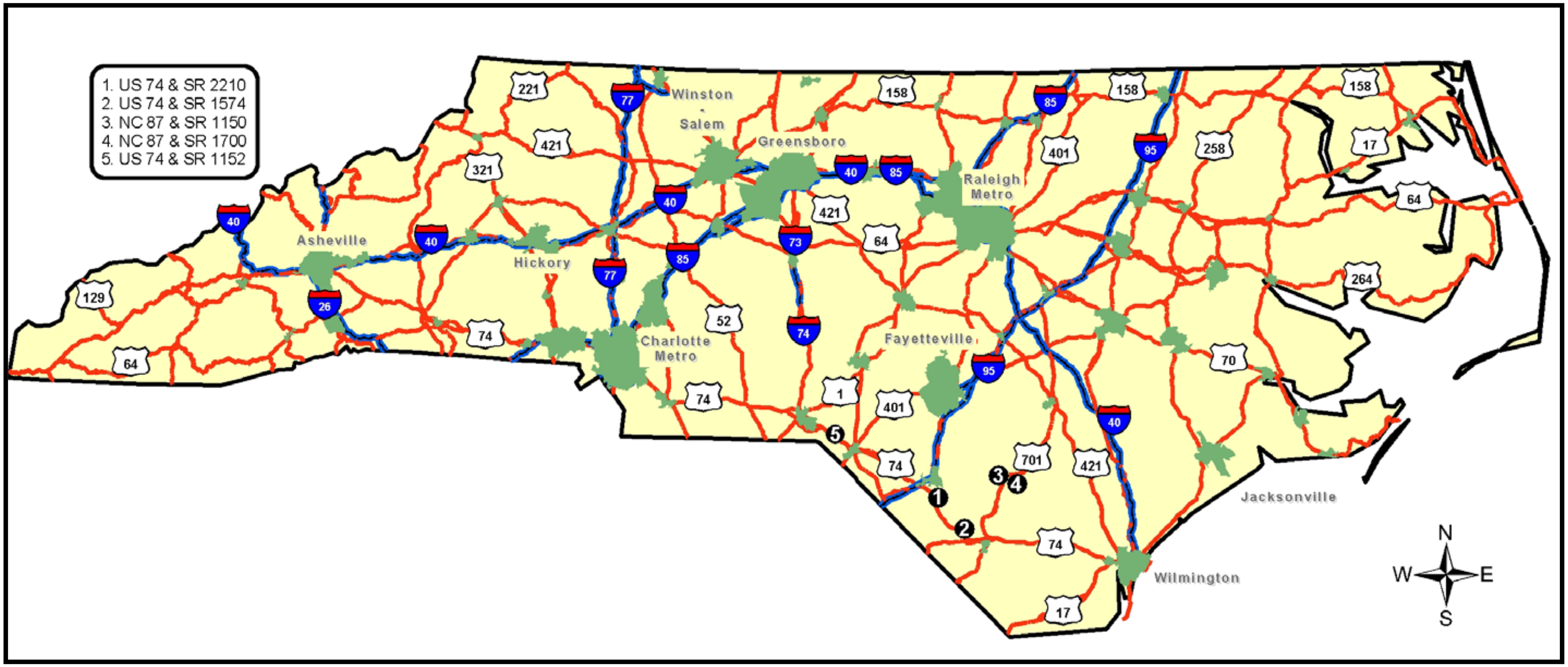


FIGURE 3-1
North Carolina Candidate Intersection Locations

4. Crash Record Review of Candidate Intersections

It was already known that the five candidate intersections had high crash rates, high crash frequencies, and a high number of angle crashes, but the decision was made to investigate each intersection further for specific information pertinent to the IDS technology and also to learn of any unusual circumstances at the intersections. At the candidate intersections, the factors reviewed included at-fault driver age, crash severity, crash location, contributing factors, and the effects of weather. For all of these summaries, the focus is on correctable crossing path crashes only (see following section for definition), which are the crash types that has the greatest potential to be corrected by the IDS device.

4.1. Correctable Crash Types

The General Estimates System (GES) crash database is a national sample of police-reported crashes used in many safety studies. In the GES, five crossing path crash types have been identified (see **Figure 4-1**), they are:

- Left Turn Across Path – Opposite Direction (LTAP/OD),
- Left Turn Across Path – Lateral Direction (LTAP/LD),
- Left Turn Into Path – Merge (LTIP),
- Right Turn Into Path – Merge (RTIP), and
- Straight Crossing Path (SCP).

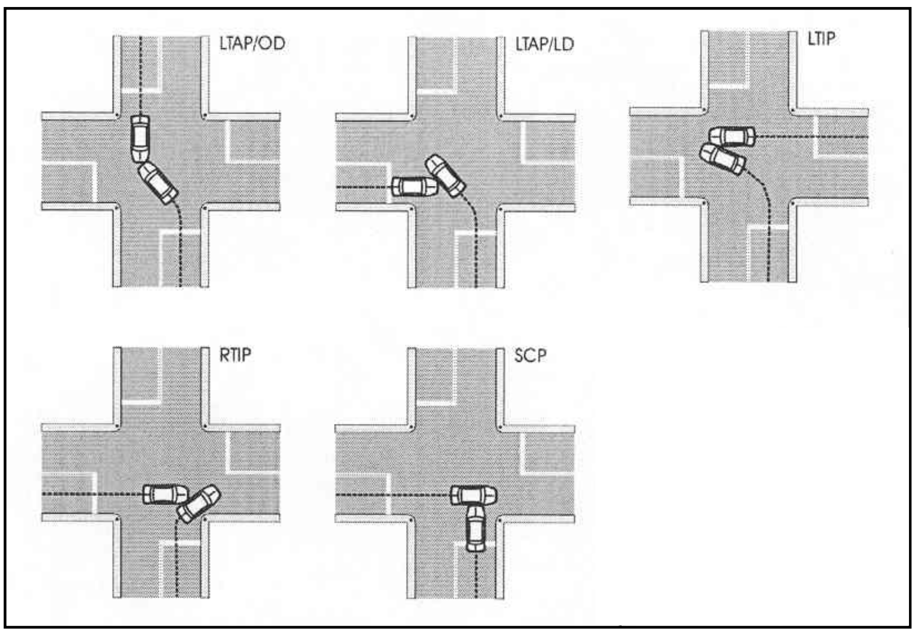


FIGURE 4-1
GES Crossing Path Crash Types

At this time, the IDS system under development is intended to address the crash types involving at least one vehicle from the major and minor street, which includes all five GES crash types except for LTAP/OD. This research has not focused on the LTAP/OD crash type at unsignalized rural intersections because they are expected to be a relatively small problem. However, it is believed the system could be adapted to address LTAO/OD crashes if an intersection had a significant number of these crashes. For example, LTAP/OD crashes involving two vehicles from the major street may be reduced if the DII is placed so that it is visible from the median (NOTE: more research is still needed before conclusions can be drawn about the importance of the placement).

At the candidate intersections, the number and percent of correctable crashes is summarized in **Table 4-1**. As listed in **Table 4-1**, all five intersections have approximately 80% or more of the crashes as a potentially correctable crash type. The intersections of US 74 & SR 1152 and NC 87 & SR 1700 had the most correctable crashes during the study period with 22 crashes each.

TABLE 4-1
Potential Correctable Crashes for IDS Technology at Candidate Intersections

	US 74 and SR 2210	**US 74 and SR 1574**	**NC 87 and SR 1150**	**NC 87 and SR 1700**	**US 74 and SR 1152**
Number of Crashes	20	21	19	25	28
Number of Correctable Crashes	19	18	18	22	22
Percent of Crashes that are Correctable	95%	86%	95%	88%	79%

NOTE: Correctable crashes have been defined as SCP, LTAP/LD, LTIP, and RTIP.

4.2. At-Fault Drivers

For each candidate intersection, all crash reports from January 1, 2001 to December 31, 2003 were reviewed to identify the driver whose action caused the accident, also known as the at-fault driver. The age of the at-fault driver is important since the IDS technology may have its greatest benefit in assisting older drivers in particular (see **Figure 4-2**). From the 2002 North Carolina Traffic Crash Facts, 12.5% of involved drivers were under the age of 20, 79.9% between the age of 20 and 64, and 7.5% over the age of 64. North Carolina Traffic Crash Facts lists involved drivers and not specifically at-fault drivers. Because of the differences between involved drivers and at-fault drivers, comparisons between statewide involvement rates and the at-fault age distributions at the five candidate intersections must be carefully considered.

Based on the statewide age distributions, only the intersection of U.S. 74 & SR 2210 has an older driver involvement rate below the expected value. At US 74 & SR 1574, the percentage of older at-fault drives is only three percentage points above the expected value. Of the three remaining intersections, older at-fault drivers are at least 10 percentage points above the expected rate. For the young drivers, the only intersection where they are noticeably over represented is NC 87 & SR 1150 (approximately 15 percentage points above the expected value).

To assess whether the at-fault drivers are likely to be familiar with the intersection and enter it routinely, the distance from the crash location to their residence was examined (see **Table 4-2**). This can be an important factor if simulation testing reveals that drivers have a difficult time understanding the DII their first time through the intersection. If at-fault drivers are generally local residents, an educational program might be necessary and could be focused on the local population. However, if many of the at-fault drivers were not from the area and also did not have a high understanding of the DII, it is likely the IDS device would not have helped the driver avoid the crash.

A general trend among the at-fault drivers is that they were local to the area (i.e., lived within 30 miles of the crash location). At four of the intersections, nearly half or more of the at-fault drivers lived within 10 miles of the crash location, while only 35% lived within 10 miles at US 74 & SR 1152. At all candidate intersections, 80% or more lived within a 30 mile radius. However, it was common for each intersection (except for NC 87 & SR 1150) to have at-least one or two at-fault drivers that clearly did not live in the local area (i.e., lived more than 50 miles away). Therefore, it is still important for the DII to be easy for a driver to understand the first time they see it.

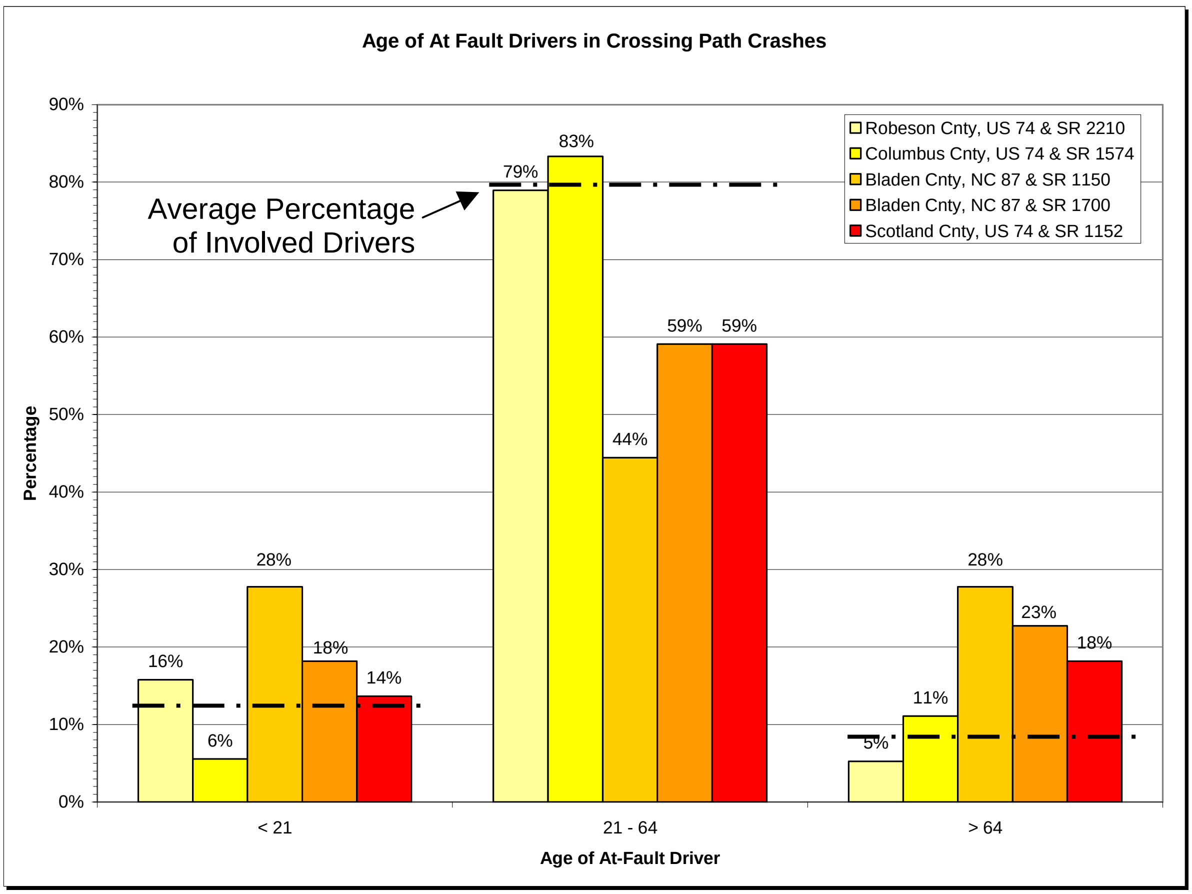


FIGURE 4-2

At-Fault Driver Age of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on involved driver age of all crashes reported in 2002 North Carolina Traffic Crash Facts

TABLE 4-2
Distance from Crash Location to At-Fault Driver's Residence

	US 74 and SR 2210	US 74 and SR 1574	NC 87 and SR 1150	NC 87 and SR 1700	US 74 and SR 1152
Median Distance	8 miles	6 miles	11 miles	10 miles	14 miles
Average Distance	21 miles	16 miles	11 miles	14 miles	24 miles
Minimum Distance	2 miles	3 miles	2 miles	2 miles	1 miles
Maximum Distance	170 miles	132 miles	29 miles	52 miles	118 miles
Percent of Distances ≤ 10 miles	79%	72%	44%	50%	35%
Percent of Distances ≤ 30 miles	89%	94%	100%	91%	80%

4.3. Crash Severity

Another goal of the IDS technology is to address the most serious intersections crashes, especially fatal crashes. Therefore, the best candidate intersection would have a high distribution of fatal and injury crashes. Of North Carolina's 2002 crashes, fatal crashes represented approximately 0.6% of all of crashes, with injury crashes at 37.7% and property damage (PD) crashes representing 62.2 % of all crashes (Source: 2002 North Carolina Traffic Crash Facts). **Figure 4-3** shows that all intersections have a much higher percentage of injury crashes than expected. The intersection of NC 87 & SR 1150 had the highest percentage of fatal crashes, while US 74 & SR 1574 and NC 87 & SR 1700 were the only intersections that had fatal crash percentages less than the expected since they had no fatal crashes. However, these intersections still had the highest percentage of injury crashes.

4.4. Crash Location and Contributing Factors

From the initial review of Minnesota's crash records (*3*), it was observed that crossing path crashes at the candidate intersections were predominately on the far side of the intersection. [NOTE: A farside crash occurs when the stopped vehicle safely negotiates the first two lanes it crosses, but is involved in a crash when leaving the median to either cross or merge into traffic in the second set of lanes.] The primary cause of the high number of farside crashes was not evident from review of the crash records. However, it was speculated that drivers used a one-step process for crossing rather than a two-step process. When a driver enters the median, rather than stopping to reevaluate whether the gap is still safe (a two-step process), it is believed that drivers simply proceed into the far lanes without stopping (a one-step process). At the selected intersection in Minnesota (U.S. 52 and Goodhue County 9), vehicle detection equipment has already been installed along with video cameras. The information recorded at the intersection will be used to quantify how drivers typically cross this and similar intersections. Even though it is still unknown how this may affect the device's final design, the decision was made to still document this crash characteristic. At all five candidate intersections, over 80 percent of the crashes were classified as farside (see **Figure 4-4**), similar to what was observed in Minnesota.

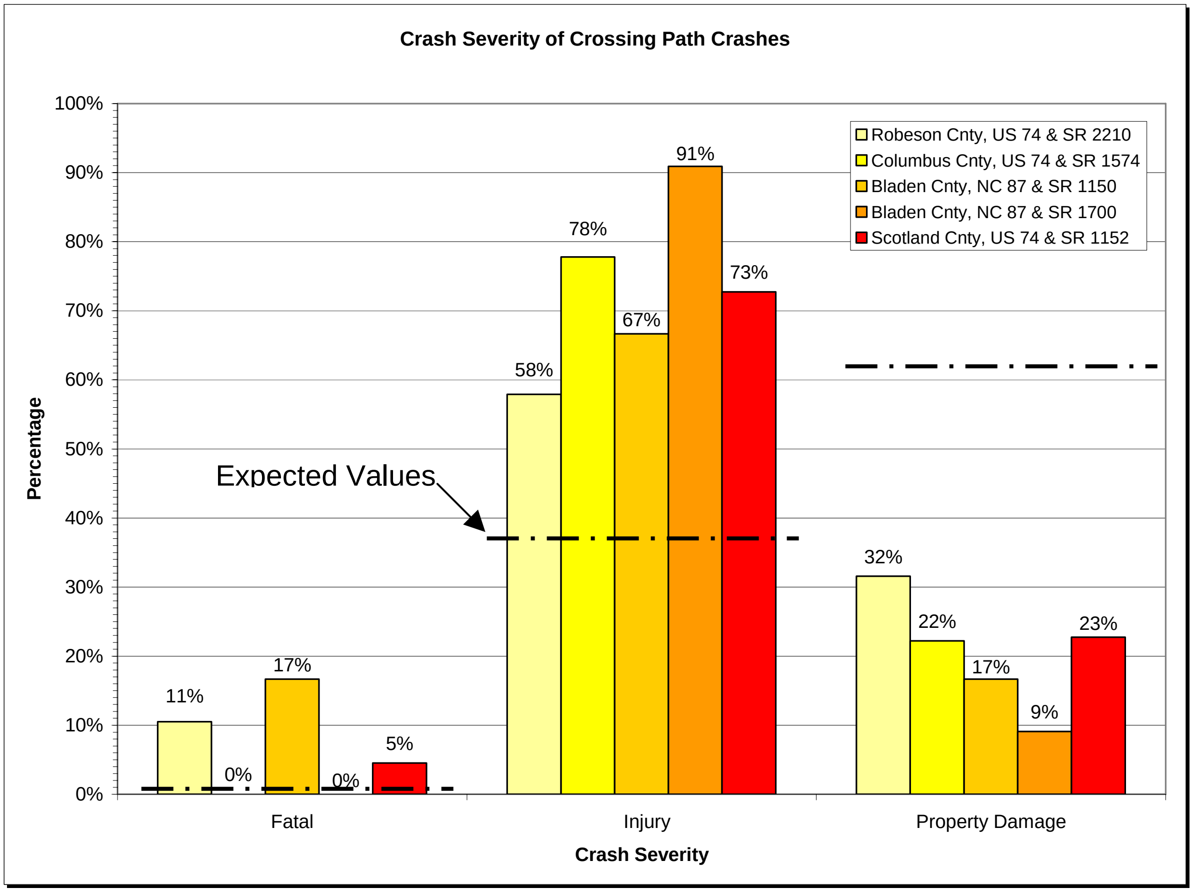


FIGURE 4-3
Crash Severity of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on crash severity of all crashes reported in 2002 North Carolina Traffic Crash Facts

Another important crash characteristic is whether the at-fault driver failed to recognize the intersection (i.e., ran-the-STOP) or failed to select a safe gap (i.e., stopped, pulled out). Since the IDS device is intended to help drivers with selecting safe gaps, crashes where the driver ran the STOP may not be correctable. To classify the crashes as either intersection recognition or gap recognition, the narratives on the officer reports were reviewed. However, some officer reports did not include a narrative. For these crashes, the contributing factor was classified as "unknown." Also, some narratives did not specifically state whether the driver stopped at the STOP sign. However, for most of these situations, the officer's narrative provided enough information to make a determination as to whether or not the driver recognized the intersection. Also, the estimated speed for the vehicle was used as an indicator to determine if the driver stopped. For example, the officer may have reported that the driver slowed for the YIELD sign in the median but did not come to a complete stop. In this example, even though the driver did not come to a complete stop, the driver obviously recognized the intersection but was unable to select a safe gap and the crashes was classified as gap recognition.

A predominate number (68 percent or higher) of the crossing path crashes were drivers selecting gaps that were too small or not seeing the cross traffic before entering the intersection and very few crashes were drivers running the STOP sign (see **Figure 4-5**). The only intersection that had two intersection recognition crashes during the study period was US 74 & SR 2210 (11 percent), otherwise the problem at the candidate intersections was overwhelmingly gap recognition.

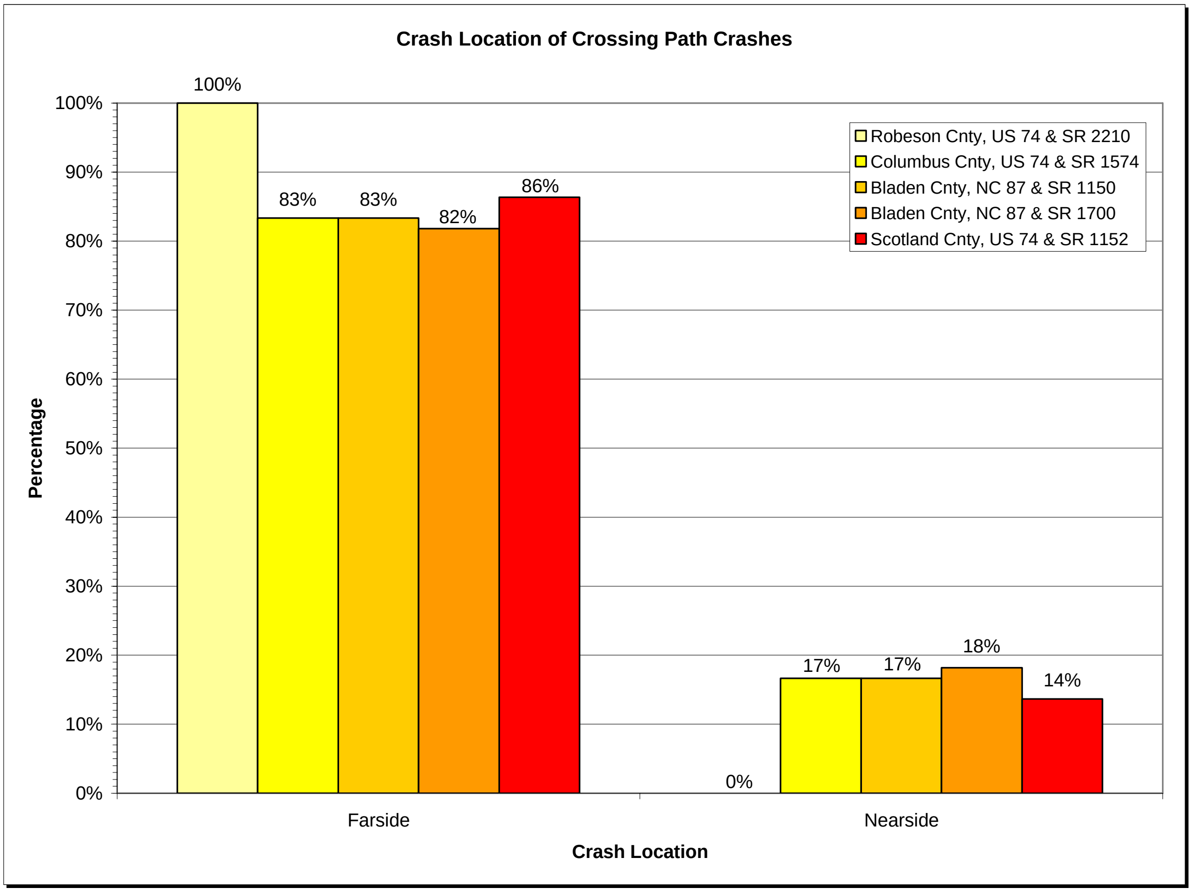


FIGURE 4-4
Crash Location of Correctable Crash Types at Candidate Intersections

4.5. Effect of Weather, Road Condition, and Light Condition

The final factors reviewed for the crossing path crashes at each candidate intersection were the weather, road, and light conditions. If the crashes tended to occur during adverse weather conditions (i.e., snow, rain, dark), then deployment of a new technology may not have a significant benefit unless coordinated with a local RWIS station. In **Tables 4-3** thru **4-5,** all candidate intersections had a higher than expected number of crossing path crashes occurring during clear/cloudy conditions, on dry pavement and during the day. Therefore, weather was determined not to be a significant cause of crossing path crashes at any of the five intersections.

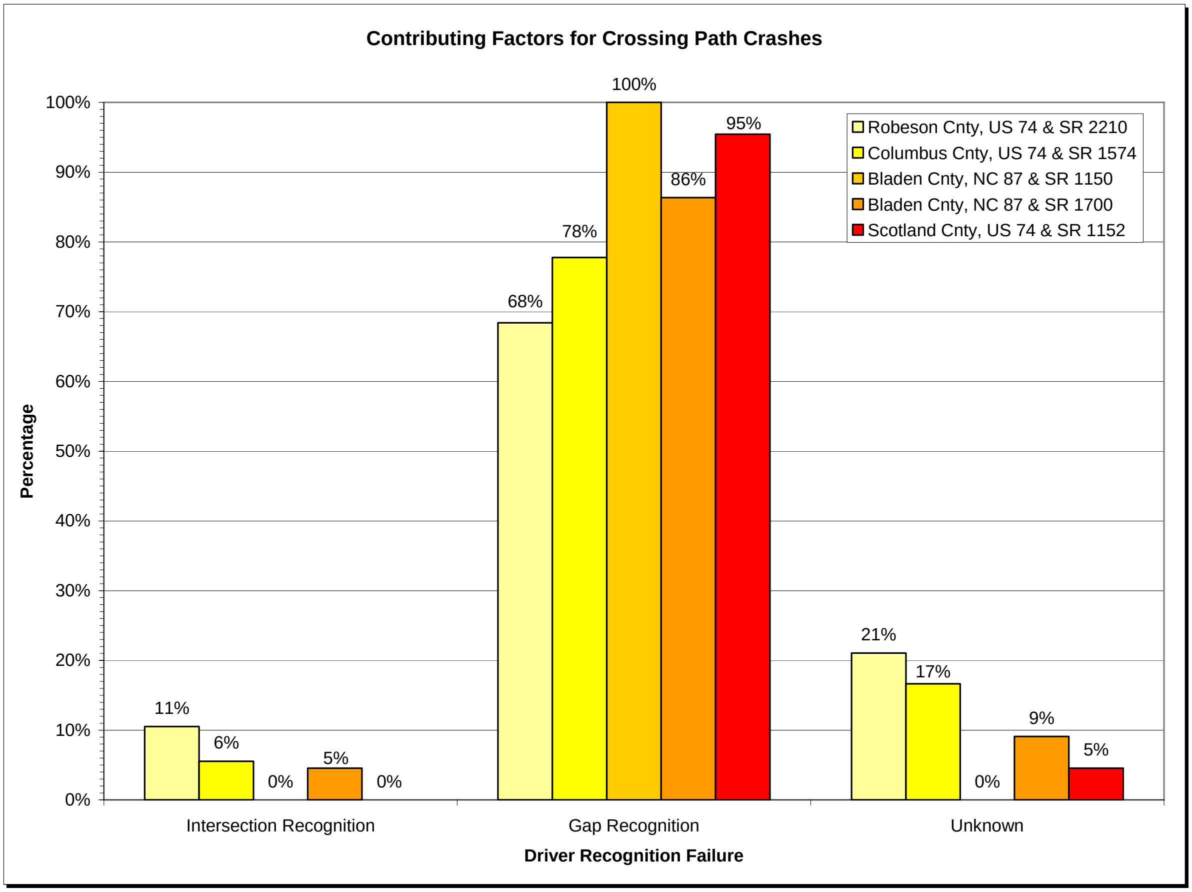


FIGURE 4-5
Contributing Factors of Correctable Crash Types at Candidate Intersections

TABLE 4-3
Weather Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	**US 74 and SR 2210**	**US 74 and SR 1574**	**NC 87 and SR 1150**	**NC 87 and SR 1700**	**US 74 and SR 1152**
Clear or Cloudy	88%	100%	100%	100%	95%	91%
Rain	10%	0%	0%	0%	5%	9%
Snow or Sleet	< 2%	0%	0%	0%	0%	0%
Unknown	< 1%	0%	0%	0%	0%	0%

NOTE: Expected values based on all crashes reported in 2002 North Carolina Traffic Crash Facts

TABLE 4-4
Roadway Surface Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	**US 74 and SR 2210**	**US 74 and SR 1574**	**NC 87 and SR 1150**	**NC 87 and SR 1700**	**US 74 and SR 1152**
Dry	77%	95%	94%	100%	77%	86%
Wet	19%	5%	6%	0%	23%	14%
Snow or Ice	3%	0%	0%	0%	0%	0%
Unknown	< 1%	0%	0%	0%	0%	0%

NOTE: Expected values based on all crashes reported in 2002 North Carolina Traffic Crash Facts

TABLE 4-5
Light Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	**US 74 and SR 2210**	**US 74 and SR 1574**	**NC 87 and SR 1150**	**NC 87 and SR 1700**	**US 74 and SR 1152**
Daylight	68%	100%	89%	89%	95%	91%
Dawn or Dusk	4%	0%	6%	0%	0%	0%
Dark	27%	0%	6%	11%	5%	9%

NOTE: Expected values based on all crashes reported in 2002 North Carolina Traffic Crash Facts

5. Field Review

On January 14, 2005, a field review of the five candidate intersections was performed. Some of the general observations made during the field review include:

- The typical minor street approach (stopped approach) included a splitter island with two STOP signs (see **Figure 5-1**). Often a STOP AHEAD sign, STOP AHEAD pavement marking, street lighting, and/or rumble strips were also included on the minor street approaches to alert drivers they were approaching an intersection. Some intersections also included the pavement marking STOP at the stop bar (shown in **Figure 5-1**). All of these improvements are relatively low cost, but are designed to help drivers recognize the intersection and do not assist the driver in selecting a safe gap, which was found as the major contributing factor at the candidate intersections (see **Figure 4-5**).
- Additional low cost strategies were used in the median at four of the intersections to encourage drivers to stop and look again for traffic. These strategies included adding an additional placard under the YIELD sign with the message LOOK AGAIN or LOOK with an arrow (see **Figure 5-2** for an example). The pavement marking LOOK RIGHT was also added in the median to reminded drivers to look for traffic approaching from the right.
- Power is readily available at all intersections to operate an IDS system.
- Some intersections are located on or near a horizontal or vertical curve. Yet, at these intersections, at least 10 or more seconds of sight distance is available for a stopped vehicle. In contrast, several of the intersections were along stretches of highway that were straight and very flat for nearly a mile in each direction.
- All medians are wide enough to store one or two passenger vehicles. None of the medians were able to store a large truck, such as a bus or semi-trailer.

FIGURE 5-1
Typical Intersection Approach for Candidate Intersections

FIGURE 5-2
Typical Intersection Median for Candidate Intersections

Following is a brief description of each of the intersections. For each intersection, crash diagrams are included in **Appendix A** and aerial photos are in **Appendix B**.

5.1.   US 74 and SR 2210

The intersection of US 74 and SR2210 is located miles from any urban or suburban areas, making the area truly rural. The area around the intersection also has excellent sight distance since there are no vertical or horizontal curves within close proximity of the intersection (see **Figure 5-3**). From the aerial photo (**Appendix B**), it is visible that the intersection does have a skew angle of approximately 10 degrees. The intersection median includes both the additional placard and pavement marking shown in **Figure 5-2**. Finally, during the field review, one issue noticed is that the flat terrain and continuous stand of trees gives the intersection little conspicuity while on US 74, in other words, it is difficult for a driver on US 74 to recognize they are approaching the intersection (see **Figure 5-4**).

5.2.   US 74 and SR 1574

The intersections of SR 1574 and SR 2210 are located along the same portion of the US 74. The intersection of US 74 and SR 1574 is also located miles from any urban or suburban area and has excellent sight distance since there are no vertical or horizontal curves within close proximity of the intersection (see **Figure 5-5**). Like the SR 2210 intersection, the intersection skewed is visible from the aerial photo in **Appendix B**; however, the skew angle is approaching 30 degrees. The intersection median also includes the additional placard and pavement marking shown in **Figure 5-2**. Similar to the SR 2210 intersection, this intersection has low conspicuity due to the flat terrain, continuous stand of trees, and lack of advance guide signs gives the intersection.

FIGURE 5-3
Typical Terrain at US 74 and SR 2210 (looking north from east approach)

FIGURE 5-4
Low Intersection Conspicuity for Vehicles on US 74 (looking south at intersection)

FIGURE 5-5
Typical Terrain at US 74 and SR 1574 (looking west from north approach)

5.3. Intersections of NC 87 with SR 1150 and SR 1700

A bypass for NC 87 has been constructed around Elizabethtown, NC. The bypass has a traditional rural expressway with four lanes, depressed grass median, and at-grade intersections. Most intersections along the bypass are thru-STOP; however, some signals have been constructed at key intersections that provide access to Elizabethtown. The distance between the candidate intersections and the signalized intersections is typically between one and two miles.

These two candidate intersections have acceptable sight distance for the stopped vehicles (10 seconds or more); despite general rolling terrain (see **Figures 5-6** and **5-7**). In the median at both intersections, additional improvements have been implemented to encourage drivers to look for safe gaps in traffic, including a LOOK AGAIN sign and LOOK RIGHT pavement markings (see **Figure 5-8**).

Along the NC 87 bypass, additional warning signs have been placed on the mainline (see **Figure 5-9**). These warning signs have the text VEHICLES ENTERING along with flashers. The flashers are turned on when a vehicle is detected by loops placed along the minor street. Finally, the Area Resident engineer mentioned that the possibility of constructing a J-Turn at SR 1150 is being evaluated. Constructing a similar treatment at SR 1700 would be considered if the project proved successful at SR 1150.

FIGURE 5-6
Looking North and South from East Approach at SR 1150
Note: Vertical curve to south still provides 10 seconds or more of sight distance.

FIGURE 5-7
Looking East and West from North Approach at SR 1700
Note: Vertical curves still provide 10 seconds or more of sight distance.

5.4. US 74 and SR 1152

The field review revealed that the intersection of SR 1152 and US 74 is not an isolated rural intersection because it is located just outside of Laurel Hill, NC and is only ½ mile away from a signalized intersection in Laurel Hill. Still, vehicles stopped at the minor street approaches generally have at least 10 seconds of sight distance despite a significant skew and separated vertical grades along US 74 (see **Figure 5-10**). One factor that does slightly reduce the sight distance for vehicles stopped on the south approach is landscaping placed in the median approximately 800 feet east of the intersection (see **Figure 5-11**).

Another complicating issue at this intersection is the proximity of a railroad line. Along this portion of US 74, a parallel railroad line is located about 50 to 100 feet north of US 74 (see **Figure 5-12**)

FIGURE 5-8
Median at Intersection of NC 87 and SR 1700
Note: Typical of Median at NC 87 and SR 1150

FIGURE 5-9
Advance Warning at Intersection of NC 87 and SR 1150
Note: Typical of Advance Warning at NC 87 and SR 1700

FIGURE 5-10
Grade Separation to the West of US 74 and SR 1152 Intersection (looking west from north approach)

FIGURE 5-11
Median Landscaping Along US 74 (looking east from south approach)

FIGURE 5-12
Location of Railroad Line (looking south at intersection)

6. Summary and Intersection Recommendation

A summary of the pertinent crash statistics has been summarized in **Table 6-1** for the five candidate intersections. Following is a set of general observations from the analysis of the North Carolina candidate intersections.

TABLE 6-1
Candidate Intersection Summary

Performance Measure	US 74 and SR 2210	US 74 and SR 1574	NC 87 and SR 1150 (123)	NC 87 and SR 1700 (131)	US 74 and SR 1152
Crash Frequency	20	21	19	25	28
Crash Severity					
Fatal	2 (10%)	0 (0%)	3 (16%)	0 (0%)	1 (4%)
"A" Inj	0 (0%)	2 (10%)	0 (0%)	1 (4%)	2 (7%)
"B" Inj	7 (35%)	7 (33%)	6 (32%)	8 (32%)	10 (36%)
"C" Inj	5 (25%)	6 (29%)	6 (32%)	12 (48%)	7 (25%)
PD	6 (30%)	6 (29%)	4 (21%)	4 (16%)	8 (29%)
Entering ADT	11,150	10,400	10,000	8,000	18,800
Crash Rate	1.6	1.8	1.7	2.9	1.4
Expected Rate	0.4 (MN)	0.4 (MN)	0.4 (MN)	0.4 (MN)	0.4 (MN)
Critical Crash Rate	0.7	0.8	0.8	0.8	0.7
Correctable Crash Type	19 (95%)	18 (86%)	18 (95%)	22 (88%)	22 (79%)
Crash Severity					
Fatal	2 (11%)	0 (0%)	3 (17%)	0 (0%)	1 (5%)
"A" Inj	0 (0%)	2 (11%)	0 (0%)	1 (5%)	1 (5%)
"B" Inj	7 (37%)	6 (33%)	6 (33%)	8 (36%)	9 (41%)
"C" Inj	4 (21%)	6 (33%)	6 (33%)	11 (50%)	6 (27%)
PD	6 (32%)	4 (22%)	3 (17%)	2 (9%)	5 (23%)
At-Fault Driver					
< 21	3 (16%)	1 (6%)	5 (28%)	4 (18%)	3 (14%)
21 – 64	15 (79%)	15 (83%)	8 (44%)	13 (59%)	13 (59%)
> 64	1 (5%)	2 (11%)	5 (28%)	5 (23%)	4 (18%)
Crash Location					
Farside	19 (100%)	15 (83%)	15 (83%)	18 (82%)	19 (86%)
Nearside	0 (0%)	3 (17%)	3 (17%)	4 (18%)	3 (14%)
Contrb. Factors					
Int Recg	2 (11%)	1 (6%)	0 (0%)	1 (5%)	0 (0%)
Gap Recg	13 (68%)	14 (78%)	18 (100%)	19 (86%)	21 (95%)
Unknown	4 (21%)	3 (17%)	0 (0%)	2 (9%)	1 (5%)

- NCDOT has applied many strategies in the traffic safety toolbox at each of these intersections. Generally, these strategies (minor street improvements such as STOP AHEAD sign, rumble strips, splitter island, second STOP sign placed in splitter island, and street lights) have been very effective at reducing intersection recognition crashes, but have not been effective at addressing gap related crashes – a crash type which is over represented at the highest crash frequency intersections in the State.
- Placing LOOK AGAIN signs and LOOK RIGHT pavement markings in the median have also not addressed the gap related crashes. Attempts to warn mainline drivers of entering vehicles also seem to have no noticeable impact on the number of crashes.
- The crash characteristics for the subset of high crash frequency intersections examined are very similar to the data for comparable intersections in Minnesota. The intersections have a crash rate greater than the critical crash rate (statistically significantly different than the expected value), the distribution of crash types skewed to angle crashes (predominately on the farside of the intersection), gap related, more severe than expected, and typically not caused by weather and/or light conditions.
- The subset of intersections with crash rates over the critical rate is different than a "typical" intersection, but not just from the perspective of more crashes. The distribution of severity is higher and the distribution of crash type is skewed towards right angle crashes (the fraction of right angle crashes is more than twice the expected value at a "typical" intersection).
- There is a complicating geometric or traffic pattern at each of the intersections – vertical curve, horizontal curve, intersection skew, etc. However, the actual intersection sight distance at each intersection is consistent with AASHTO guidelines.
- Overall, many of the at-fault drivers are local to the area (live within 30 miles of crash location).

6.1. Recommended Intersection for Deployment

For the five candidate intersections, the pros and cons of each is summarized in **Table 6-2**. Because of the close proximity to small urban areas and signalized intersections, the intersections of NC 87 & SR 1150, NC 87 & SR 1700, and US 74 & SR 1152 are not isolated rural intersections. Deploying at one of these intersections would allow for data collection at a site that is different than the intersection instrumented in Minnesota. However, NCDOT has already considered constructing a J-Turn at the two intersections on NC 87. Of the remaining two intersections (US 74 & SR 2210 and US 74 & SR 1574), both are located on a portion of US 74 where the plan is to upgrade the highway to a freeway design, but not in the near future. Because of the rural location, installing a traffic signal to address the crash problems could significantly increase the delay at the intersection. Testing the IDS technology at either of these intersections may address the crash problem while at the same time preserving travel speeds on US 74. The intersection of US 74 and SR 2210 had two fatal crashes during the study period. The SR 1574 intersection had no fatal crashes, but two severe injury crashes. The number of correctable crashes, at-fault older drivers, farside crashes, and gap recognition crashes were relatively similar. However, the US 74 SR 1574 intersection had one more at-fault older driver crash and one more gap recognition crash than at US 74 and SR 2210. Because the IDS technology is focused on reducing the number of at-fault older drivers and gap recognition crashes, the intersection recommended for data collection and potential deployment of the IDS technology is US 74 & SR 1574.

TABLE 6-2
Pros and Cons of Candidate Intersections

Candidate Intersection	Pros	Cons
US 74 - SR 2210	Tied with NC 87 & SR 1150 for the highest percentage of correctable crash types. Relative high number of fatal crashes. Highest percentage of farside crashes. High percentage of gap related crashes.	The percentage of older drivers (target group) is below expected value.
US 74 - SR 1574	High percentage of correctable crash types. Highest number of severe injury crashes. High percentage of farside crashes. High percentage of gap related crashes.	The frequency and percentage of correctable crashes was low compared to the other four intersections, however, still higher than expected.
NC 87 - SR 1150	Tied with US 74 & SR 2210 for the highest percentage of correctable crash types. Has the highest number of fatal crashes. Has the highest involvement of older drivers. High percentage of farside crashes. Has the highest percentage of gap related crashes.	NCDOT is considering intersection a candidate for constructing a J-Turn. Close to signal and urban area.
NC 87 - SR 1700	Has the highest intersection crash rate. Tied with US 74 & SR 1152 for the greatest number of correctable crash types. High involvement of older drivers. High percentage of farside crashes. High percentage of gap related crashes.	NCDOT may construct a J-Turn if strategy proves successful at NC 87 & SR 1150. Close to signal and urban area.
US 74 - SR 1152	Tied with NC 87 & SR 1700 for the greatest number of correctable crash types. Relative high number of fatal and severe injury crashes. High involvement of older drivers. High percentage of farside crashes. Has the highest number of gap related crashes.	Railroad located approximately 50 to 100 feet from intersection. Close to signal and urban area. NCDOT suspects landscaping in median may be proximate cause for some of the crashes.

Note: "Correctable crash type" implies that the crash was potentially correctable by the IDS technology.

6.2. Other Recommendations

The University of Minnesota could design an IDS system for any of the remaining candidate intersections if NCDOT wished to implement additional intersections. If so, the second recommended intersection is NC 87 & SR 1150 because this would allow the technology to be implemented and tested on the fringe of a small urban area. If the NCDOT does proceed with constructing a J-Turn at NC 87 & SR 1150, then a comparison study could be conducted on the effectiveness of the two strategies on North Carolina highways.

If the IDS system is only deployed at US 74 & SR 1574, the remaining four candidate intersections still could benefit from traditional mitigation strategies to address the high number of crossing path crashes (especially those related to gap recognition). The following recommendations are presented for NCDOT's consideration. However, further investigation is required to determine if these recommendations are feasible solutions or if another strategy may be optimal.

- US 74 & SR 2210 – Close the median and construct a J-Turn to accommodate left turn and crossing maneuvers. As an alternative to closing the median, an island could be constructed in the median so that a left turn from the mainline onto the minor street would still be permitted, but vehicles on the minor street would have to use the J-Turn. Also because of the low intersection conspicuity for the mainline, advanced and larger guide signing could be placed to increase the drivers' awareness of the upcoming intersection.
- NC 87 with SR 1550 and SR 1700 – NCDOT has mentioned the possibility of constructing J-Turns at these intersections.
- US 74 & SR 1152 – Consideration should be given to closing the north leg (approach with at-grade railroad crossing) to create a T intersection. Access to US 74 from the north would still be provided at the signalized intersection located less than one mile to the west. If the north leg can not be closed, then creating two right-in/right-out intersections by closing the median would be a second option. The NCDOT also should investigate if the landscaping in the median does significantly restrict sight distance and consider removing if it does.

References

1. W.J. Najm, J.A. Koopmann and D.L. Smith. "Analysis of Crossing Path Crash Countermeasure Systems." Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam, The Netherlands. June 2001.

2. K.A. Harder, J. Bloomfield, B.J. Chihak. *Crashes at Controlled Rural Intersection*. Report MN/RC-2003-15. Local Road Research Board, Minnesota Department of Transportation. July 2003.

3. H.R. Preston, R. Storm, M. Donath, C. Shankwitz. *Review of Minnesota's Rural Intersection Crashes: Methodology for Identifying Intersections for Intersection Decision Support*. Report MN/RC-2004-31. Minnesota Department of Transportation. May 2004.

4. T. Maze, N. Hawkins, and G. Burchett. *Rural Expressway Intersection Synthesis of Practice and Crash Analysis*. CTRE Project 03-157. Iowa Department of Transportation. October 2004.

Appendix A

Intersection Crash Diagrams

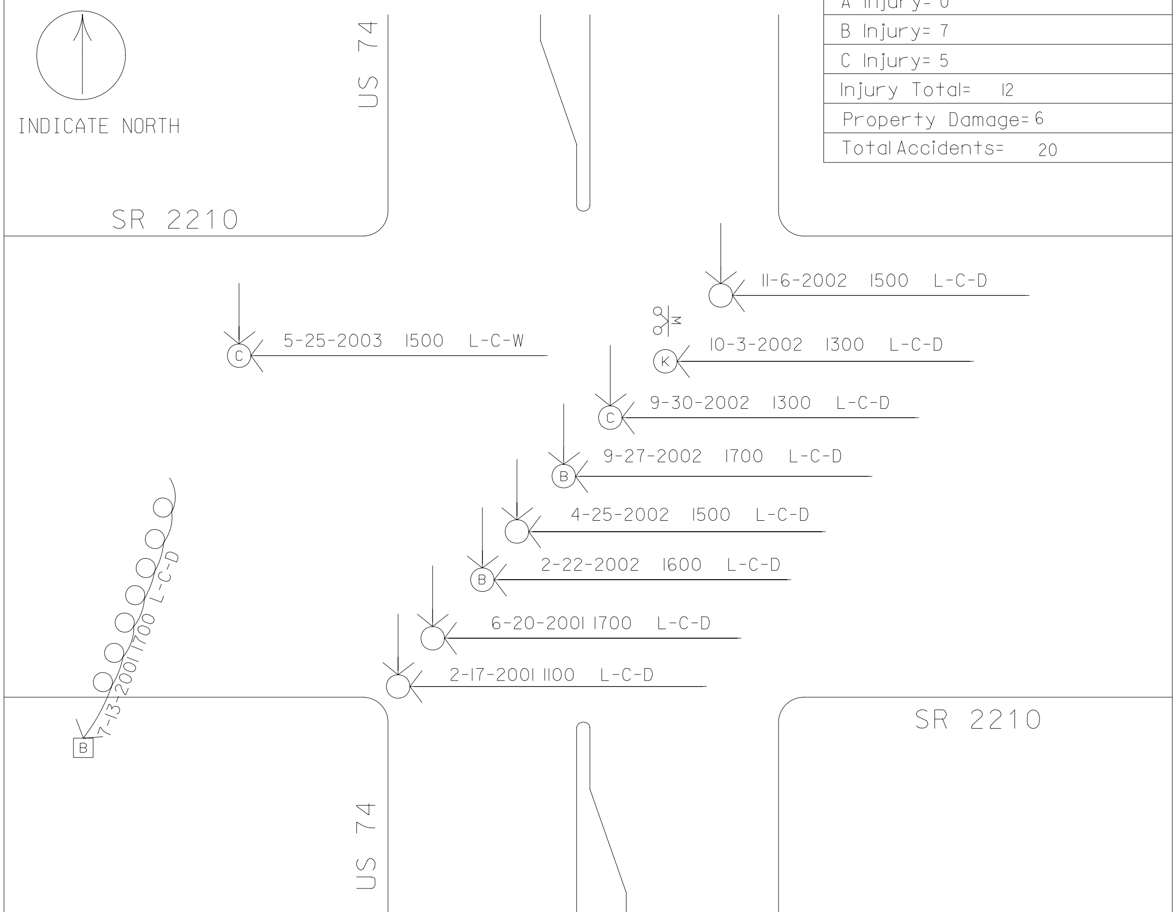
COLLISION DIAGRAM

LOCATION: US 74 & SECONDARY ROAD 2210 (ROBESON COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

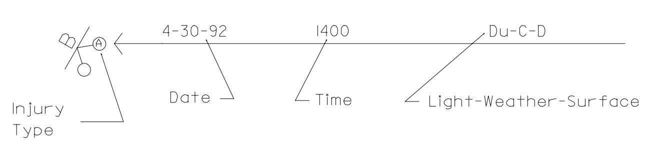
No. of Accidents
Fatal= 2
A Injury= 0
B Injury= 7
C Injury= 5
Injury Total= 12
Property Damage= 6
Total Accidents= 20



- Motor Vehicle Ahead
- Motor Vehicle Backing Up
- Motor Vehicle Out of Control
- Pedestrian
- Bicycle/Moped
- Motorcycle
- Fixed Object
- Fatal Acc.
- A Injury Acc.
- B Injury Acc.
- C Injury Acc.
- * Location/Details Unclear
- Property Damage Acc.
- Rear End Property Damage
- Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



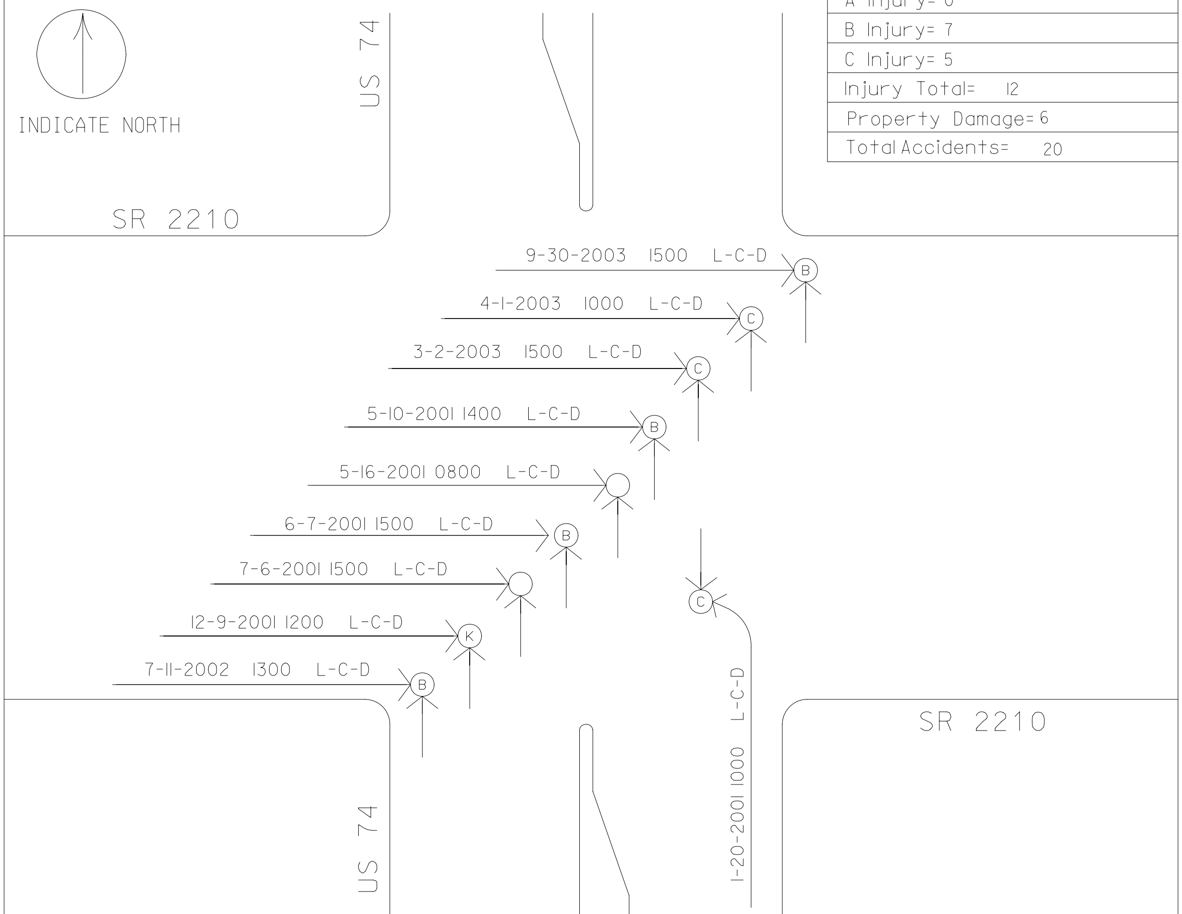
COLLISION DIAGRAM

LOCATION: US 74 & SECONDARY ROAD 2210 (ROBESON COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents
Fatal= 2
A Injury= 0
B Injury= 7
C Injury= 5
Injury Total= 12
Property Damage= 6
Total Accidents= 20



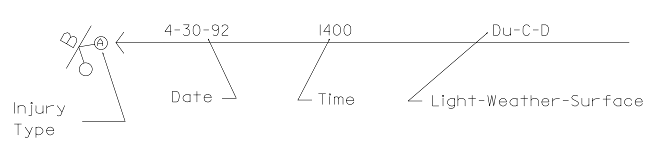
Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:



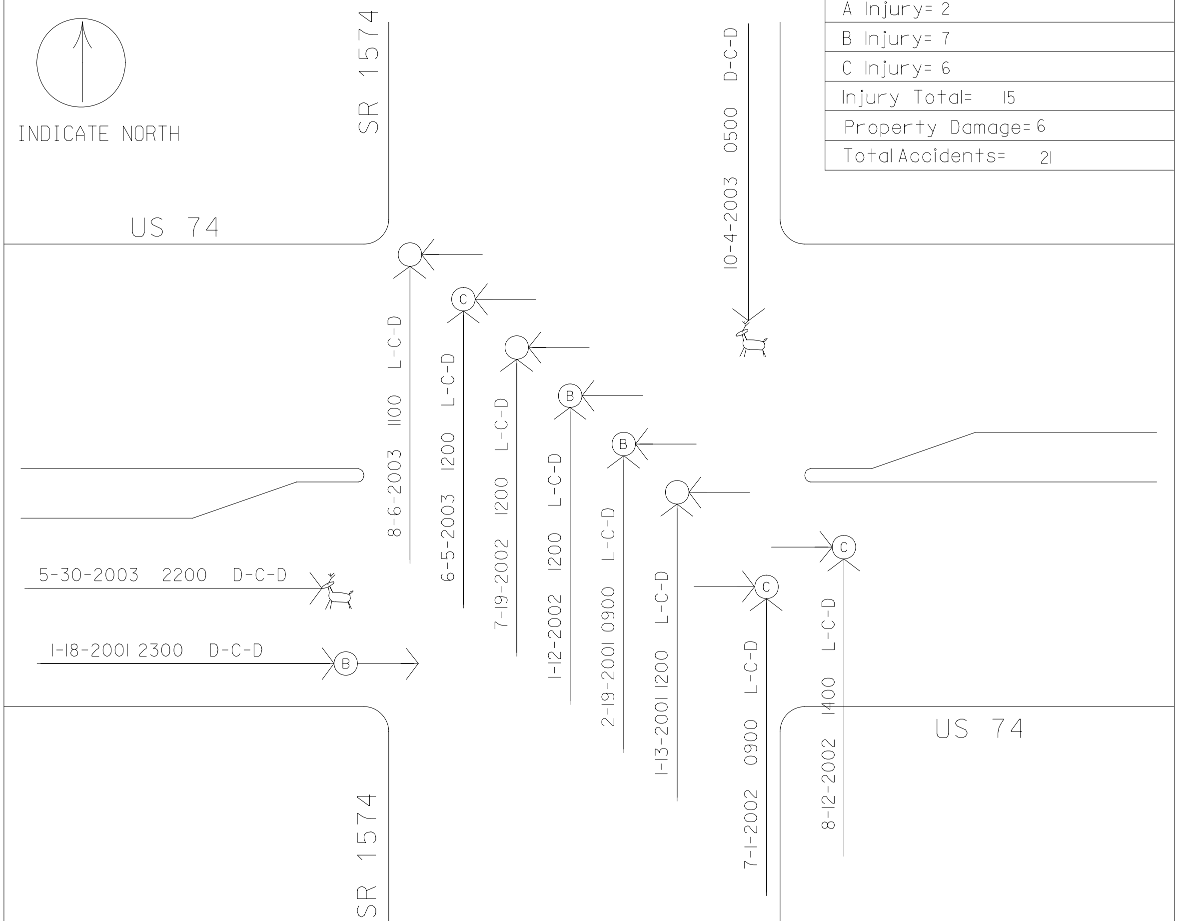
COLLISION DIAGRAM

LOCATION: US 74 & SECONDARY ROAD 1574 (COLUMBUS COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents
Fatal= 0
A Injury= 2
B Injury= 7
C Injury= 6
Injury Total= 15
Property Damage= 6
Total Accidents= 21



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

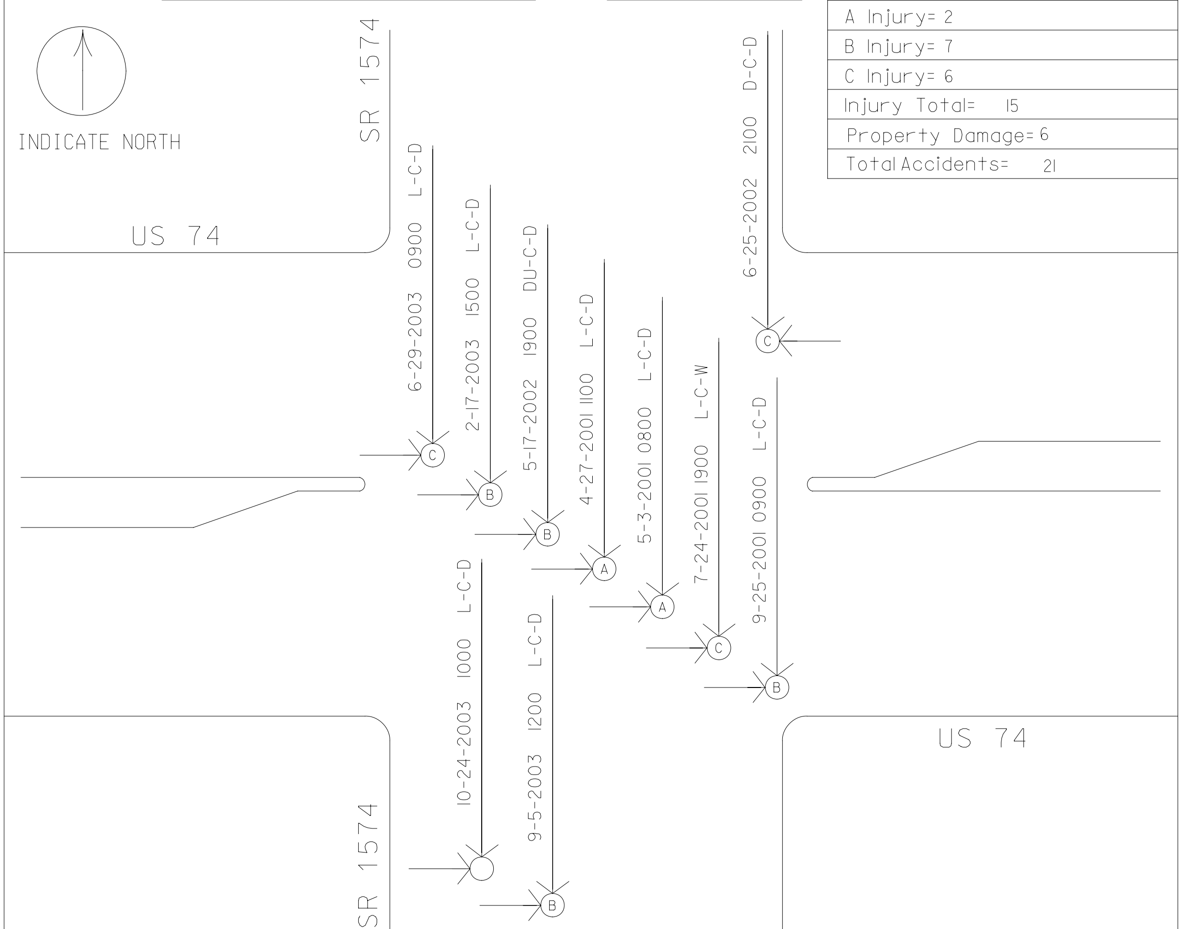
COLLISION DIAGRAM

LOCATION: US 74 & SECONDARY ROAD 1574 (COLUMBUS COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

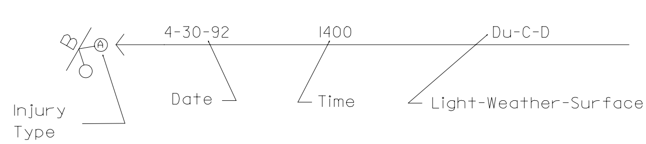
No. of Accidents
Fatal= 0
A Injury= 2
B Injury= 7
C Injury= 6
Injury Total= 15
Property Damage= 6
Total Accidents= 21



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

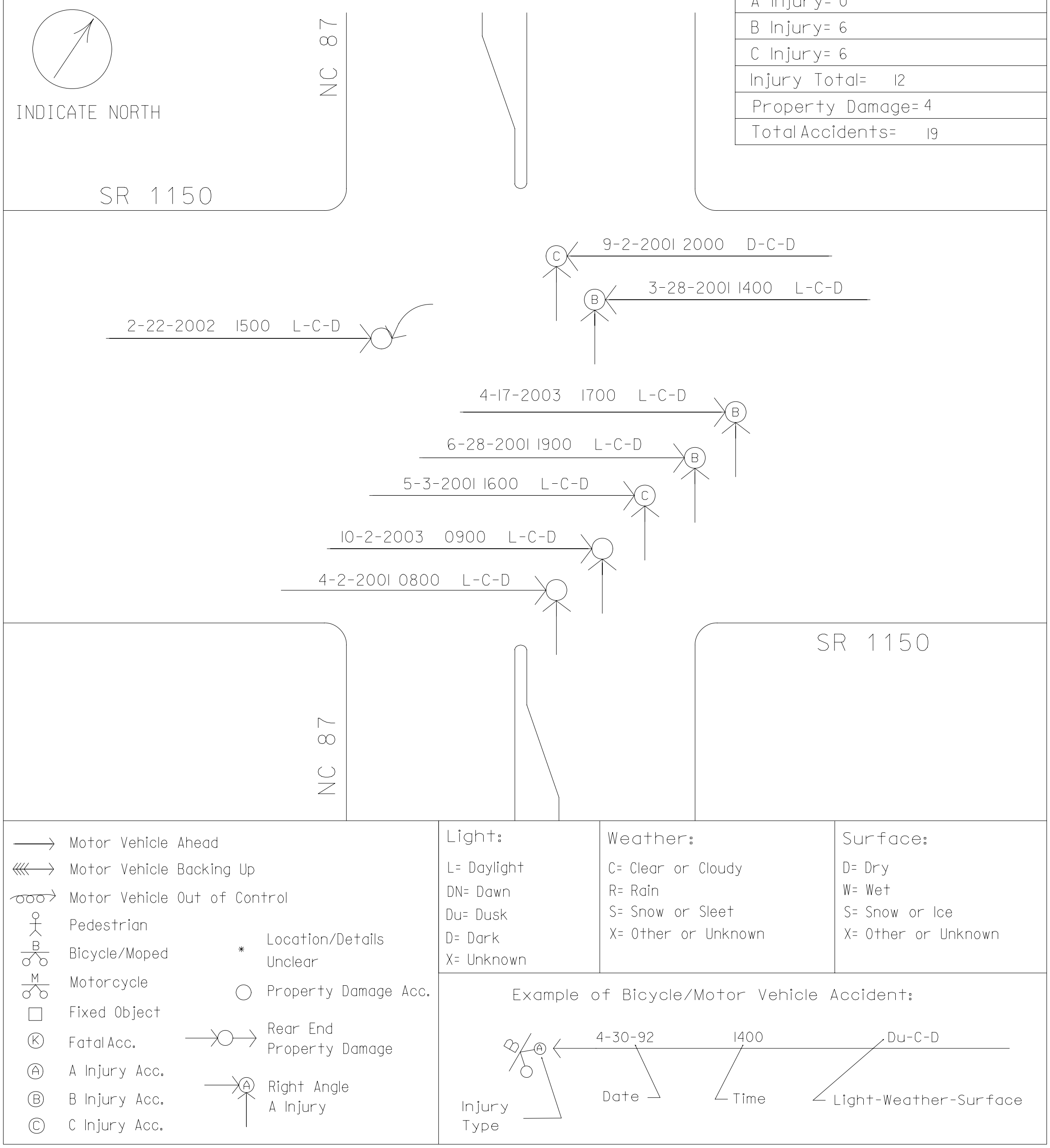
LOCATION: NC 87 & SECONDARY ROAD 1150 (BLADEN COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents

Fatal=	3
A Injury=	0
B Injury=	6
C Injury=	6
Injury Total=	12
Property Damage=	4
Total Accidents=	19



COLLISION DIAGRAM

LOCATION: NC 87 & SECONDARY ROAD 1150 (BLADEN COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents

Fatal=	3
A Injury=	0
B Injury=	6
C Injury=	6
Injury Total=	12
Property Damage=	4
Total Accidents=	19

Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type Date Time Light-Weather-Surface

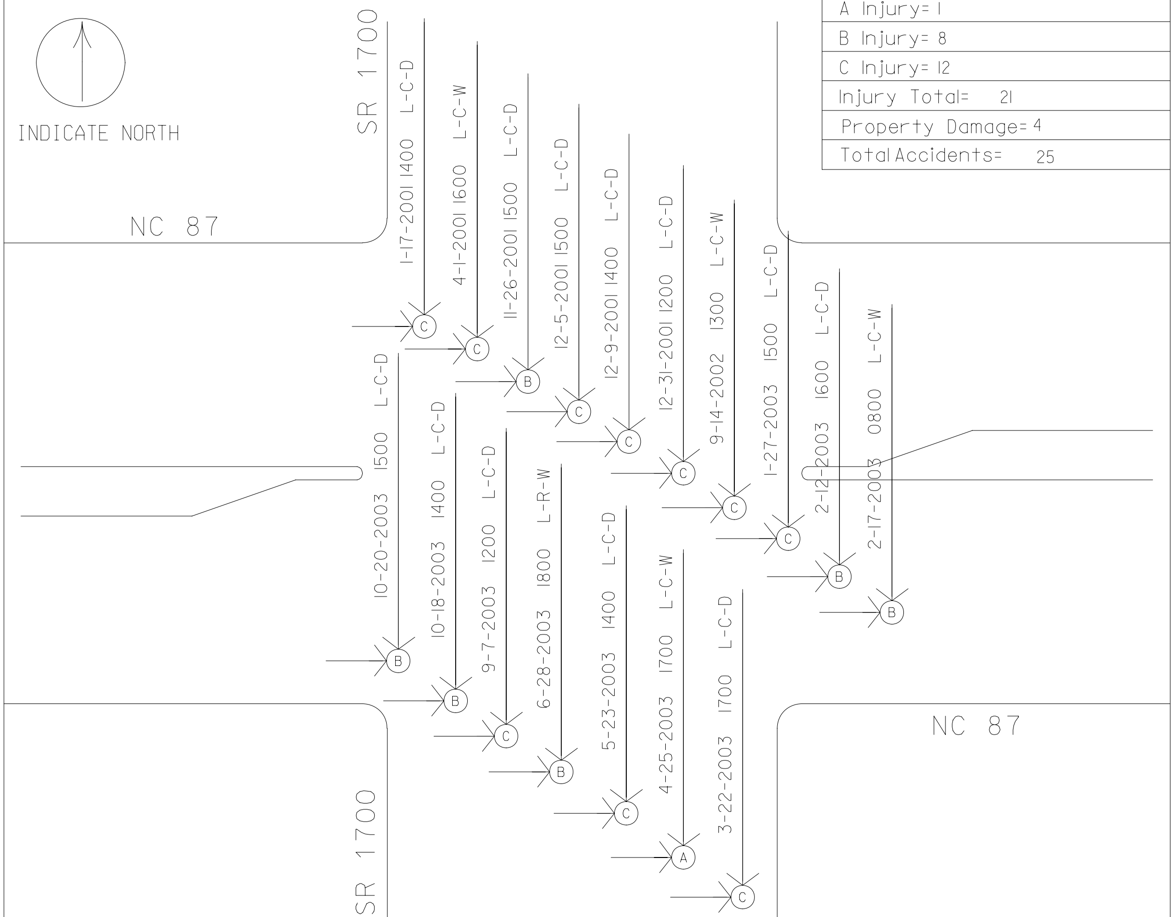
COLLISION DIAGRAM

LOCATION: NC 87 & SECONDARY ROAD 1700 (BLADEN COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents
Fatal= 0
A Injury= 1
B Injury= 8
C Injury= 12
Injury Total= 21
Property Damage= 4
Total Accidents= 25



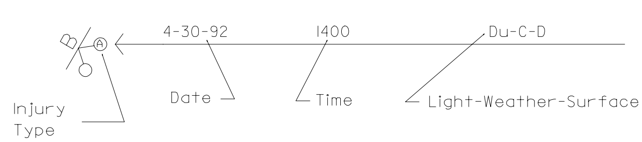
Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:



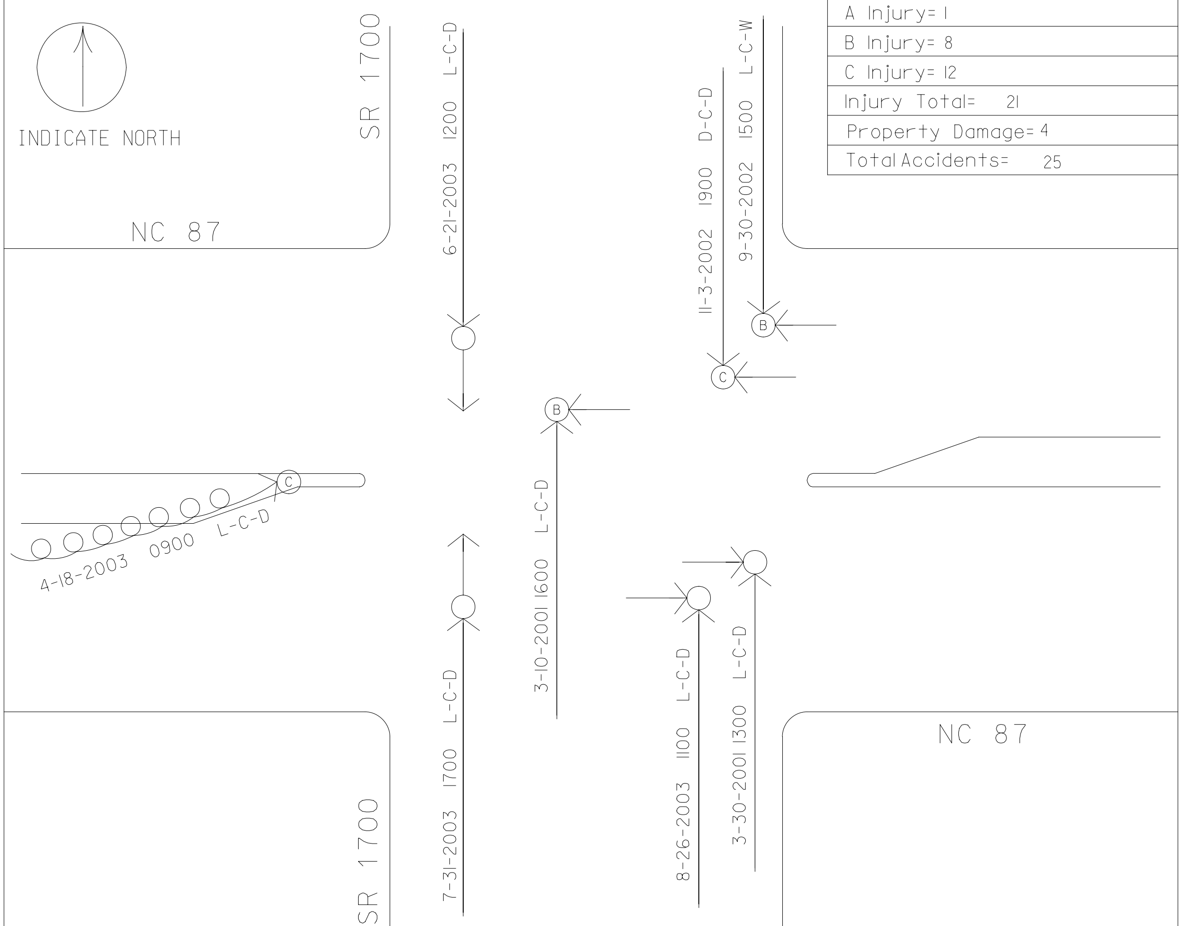
COLLISION DIAGRAM

LOCATION: NC 87 & SECONDARY ROAD 1700 (BLADEN COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents	
Fatal=	0
A Injury=	1
B Injury=	8
C Injury=	12
Injury Total=	21
Property Damage=	4
Total Accidents=	25



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

COLLISION DIAGRAM

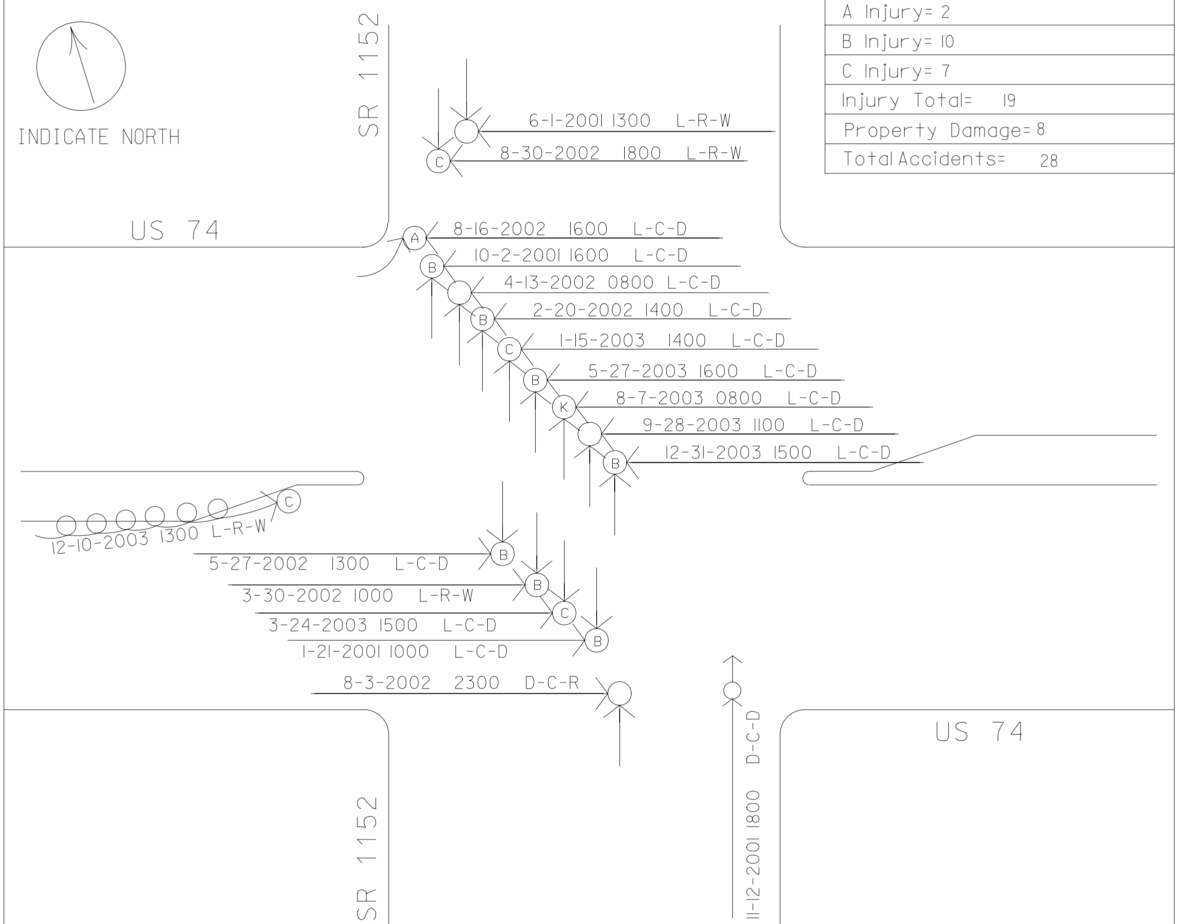
LOCATION: US 74 & SECONDARY ROAD 1152 (SCOTLAND COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents

Fatal=	1
A Injury=	2
B Injury=	10
C Injury=	7
Injury Total=	19
Property Damage=	8
Total Accidents=	28



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

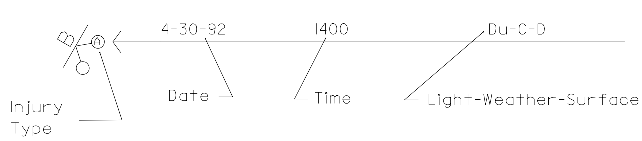
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

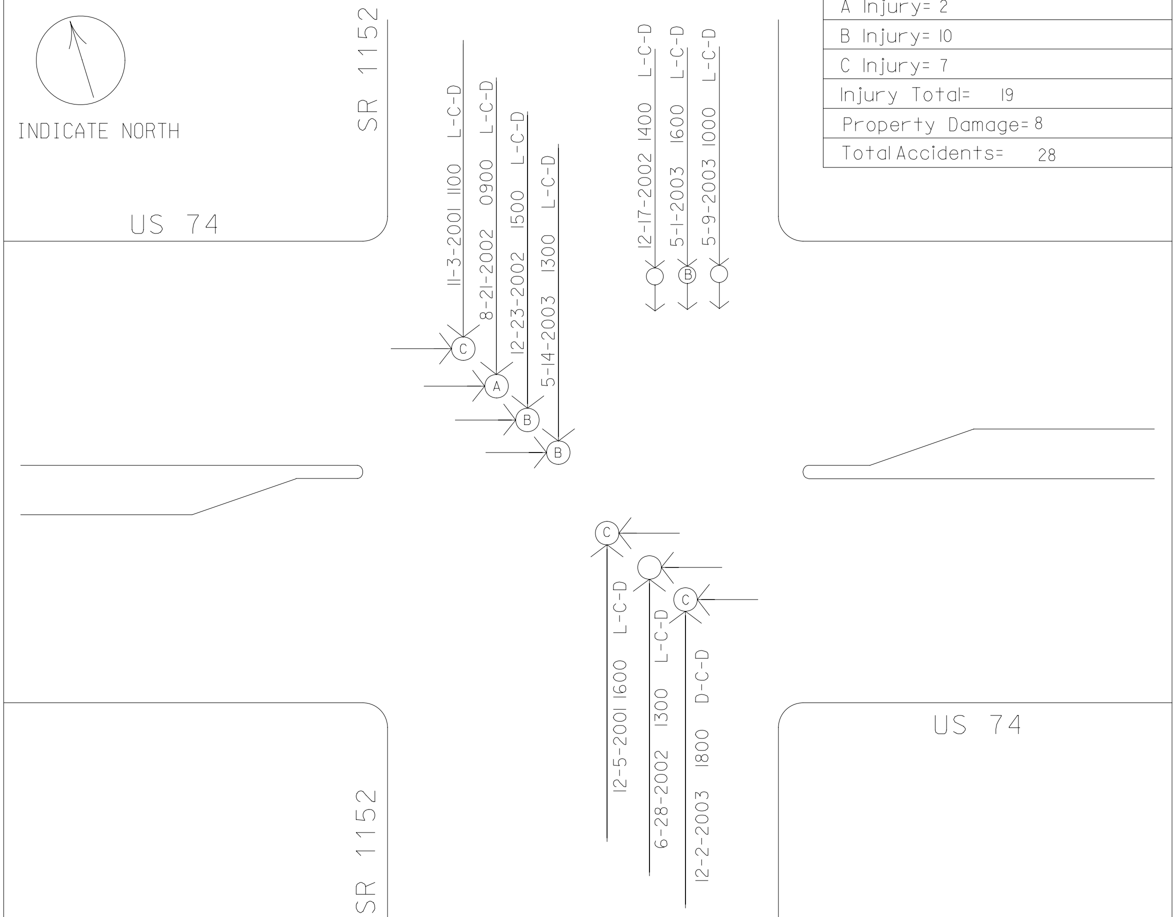
LOCATION: US 74 & SECONDARY ROAD 1152 (SCOTLAND COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 12-03-2004

No. of Accidents

Fatal=	1
A Injury=	2
B Injury=	10
C Injury=	7
Injury Total=	19
Property Damage=	8
Total Accidents=	28



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

Appendix B

Aerial Photographs

FIGURE B-1
Aerial Photo of US 74 and SR 2210
Source: North Carolina Department of Transportation

FIGURE B-2
Aerial Photo of US 74 and SR 1574
Source: North Carolina Department of Transportation

FIGURE B-3
Aerial Photo of NC 87 and SR 1150
Source: North Carolina Department of Transportation

FIGURE B-4
Aerial Photo of NC 87 and SR 1700
Source: North Carolina Department of Transportation

FIGURE B-5
Aerial Photo of US 74 and SR 1152

Source: North Carolina Department of Transportation