

# **Evaluation of the Conversion from Two-Way Stop Sign Control to All-Way Stop Sign Control at 53 Locations Statewide**

**Findings of a Report Authored by:**

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**&**

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**March 24, 2010**

**NCDOT Transportation Mobility & Safety Division**

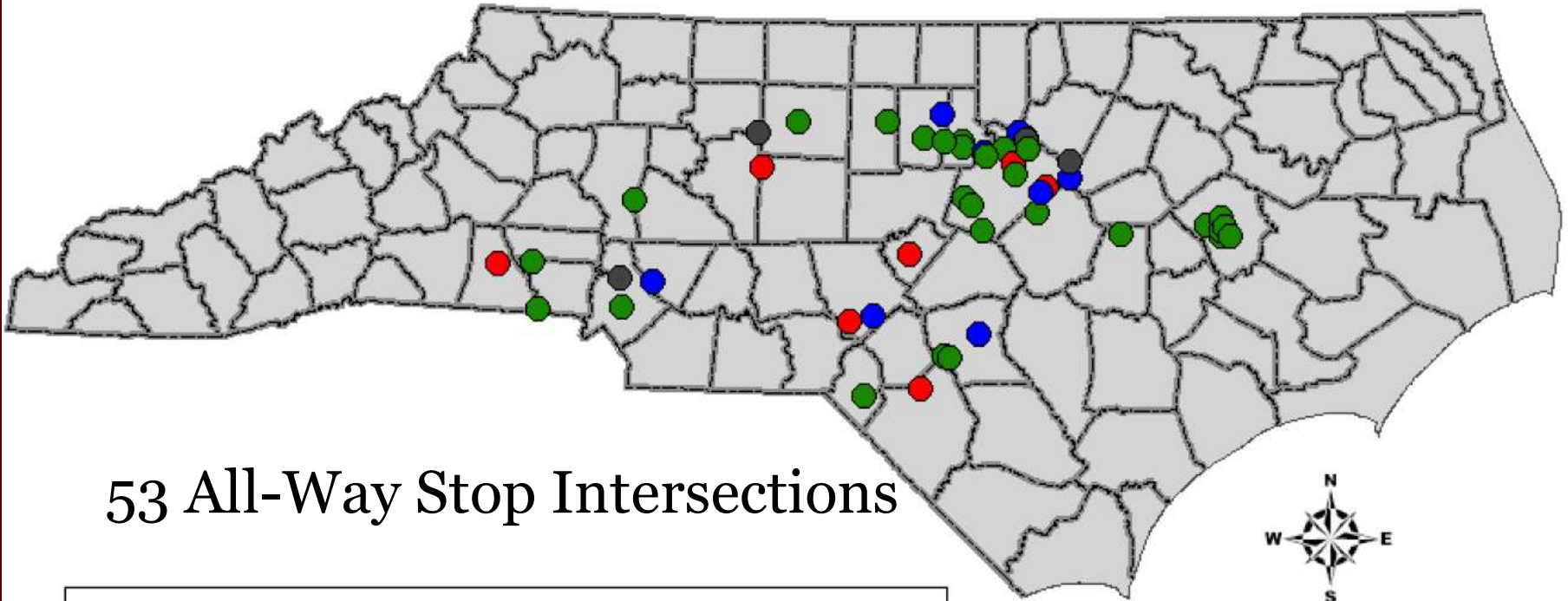
# Introduction

- Growing interest in all-way stop conversion
  - Low cost
  - Quick to implement
  - Treats pattern of high severity frontal impact crashes
- Few current, up-to-date studies quantifying safety benefits
- Goal: Develop crash reduction factors that reflect North Carolina conditions and decision-making

# Evaluation Objectives

1. What is the reduction in total and target crashes at intersections converted to all-way stop control?
2. Is there a difference in crash reductions when all-way stop intersections are equipped with a flashing beacon?
3. What role do intersection volume and approach speed limits play in crash reductions at converted intersections?

# Site Selection



53 All-Way Stop Intersections

## Legend

- Group 1: 33 Sites Without Flashing Beacons
- Group 2: 8 Sites With Flashing Beacons in Before and After Period
- Group 3: 8 Sites With Flashing Beacons Only in After Period
- 4 Additional Sites

# Crash Types Analyzed

Total, Frontal Impact, Injury, & “Ran Stop Sign” Crashes –

- Target: Frontal Impact Crashes occurring in the intersection or related to the intersection.
- Injury crashes include both fatal & non-fatal injury crashes.
- “Ran Stop Sign” crashes defined as a crash in which the officer noted that the vehicle disregarded the stop sign or it could be reasonably inferred from the speeds at impact that the vehicle did not stop at the stop sign.

# Crash Analysis Results

## Recommended CRF's:

**Total: -68%**

**Injury: -77%**

**FI: -75%**

**Ran Stop: -15%**

		Percent Reduction	
<b>Total Crashes</b>			
All Sites	⇒	-68.1%	+/- 2.2%
Group 1		-60.7%	+/- 3.3%
Group 2		-80.2%	+/- 3.9%
Group 3		-81.7%	+/- 3.5%
<b>Injury Crashes</b>			
All Sites	⇒	-77.0%	+/- 2.5%
Group 1		-72.4%	+/- 3.7%
Group 2		-86.5%	+/- 4.8%
Group 3		-86.6%	+/- 4.0%
<b>Frontal Impact Crashes</b>			
All Sites	⇒	-75.3%	+/- 2.0%
Group 1		-70.1%	+/- 3.0%
Group 2		-84.4%	+/- 3.7%
Group 3		-85.7%	+/- 3.3%
<b>"Ran Stop Sign" Crashes</b>			
All Sites	⇒	-14.5%	+/- 11.2%
Group 1		-5.7%	+/- 15.2%
Group 2		-33.3%	+/- 27.5%
Group 3		-39.9%	+/- 20.1%

**Group 1:**  
Without Flashers

**Group 2:**  
With Flashers in Both  
Before & After Periods

**Group 3:**  
Flashers Installed  
With All-Way Stop

“+/-” notation indicates the standard deviation of an estimated value.

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# Crash Analysis Results

Total Crashes (All Sites)	
Predicted After Period Crashes	977
Actual After Period Crashes	312
Predicted – Actual Crashes	<b>665</b>

Injury Crashes (All Sites)	
Predicted After Period Crashes	481
Actual After Period Crashes	111
Predicted – Actual Crashes	<b>370</b>

Frontal Impact Crashes (All Sites)	
Predicted After Period Crashes	812
Actual After Period Crashes	201
Predicted – Actual Crashes	<b>611</b>

# Crash Analysis Results

## Naïve Before and After Analysis (All Sites):

<b>Rear End Crashes</b>	+6.2% +/- 22.3%
<b>Ran Off Road Crashes</b>	-46.9% +/- 12.2%
<b>Other Crashes</b>	+5.9% +/- 24.1%



# Crash Analysis Results: 2 Months After Installation\*

	Before Period	2 Months After Installation	After Period
Total Crashes/Yr	4.3 (598)	2.3 (12)	1.2 (151)
Injury Crashes/Yr	2.5 (337)	1.2 (6)	0.5 (60)

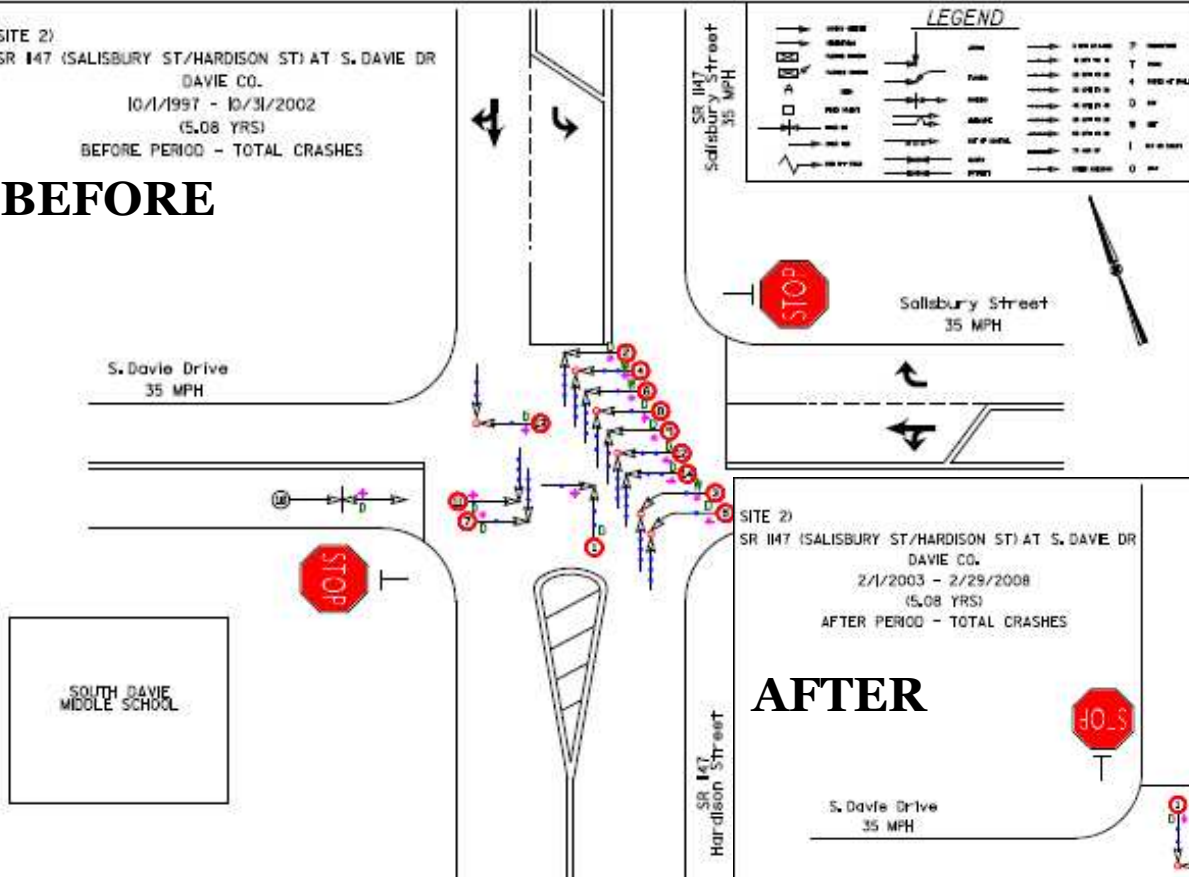
\* Using 31 sites with specific installation dates

# Before and After Crash Diagrams

Salisbury St at  
Hardison St/Davie St  
Davie County  
Division 9

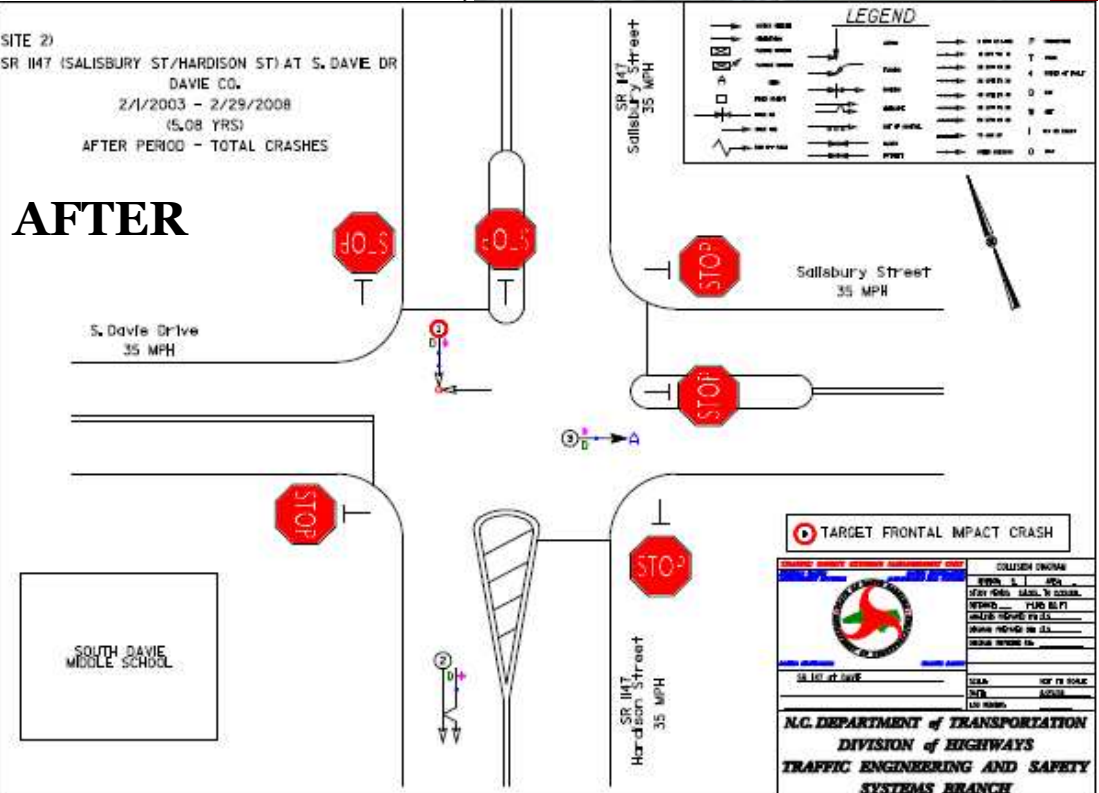
SITE 2)  
SR 147 (SALISBURY ST/HARDISON ST) AT S. DAVIE DR  
DAVIE CO.  
10/1/1997 - 10/31/2002  
(5.08 YRS)  
BEFORE PERIOD - TOTAL CRASHES

## BEFORE



SITE 2)  
SR 147 (SALISBURY ST/HARDISON ST) AT S. DAVIE DR  
DAVIE CO.  
2/1/2003 - 2/29/2008  
(5.08 YRS)  
AFTER PERIOD - TOTAL CRASHES

## AFTER



Approach Speeds: 35  
Entering AADT: 8500  
Volume Split: 56%/44%  
Non-Flasher

**TARGET FRONTAL IMPACT CRASH**

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**DIVISION of HIGHWAYS**  
**TRAFFIC ENGINEERING AND SAFETY**  
**SYSTEMS BRANCH**

# Before and After Crash Diagrams

Courtland Rd at Harkey Rd

Lee County

Division 8

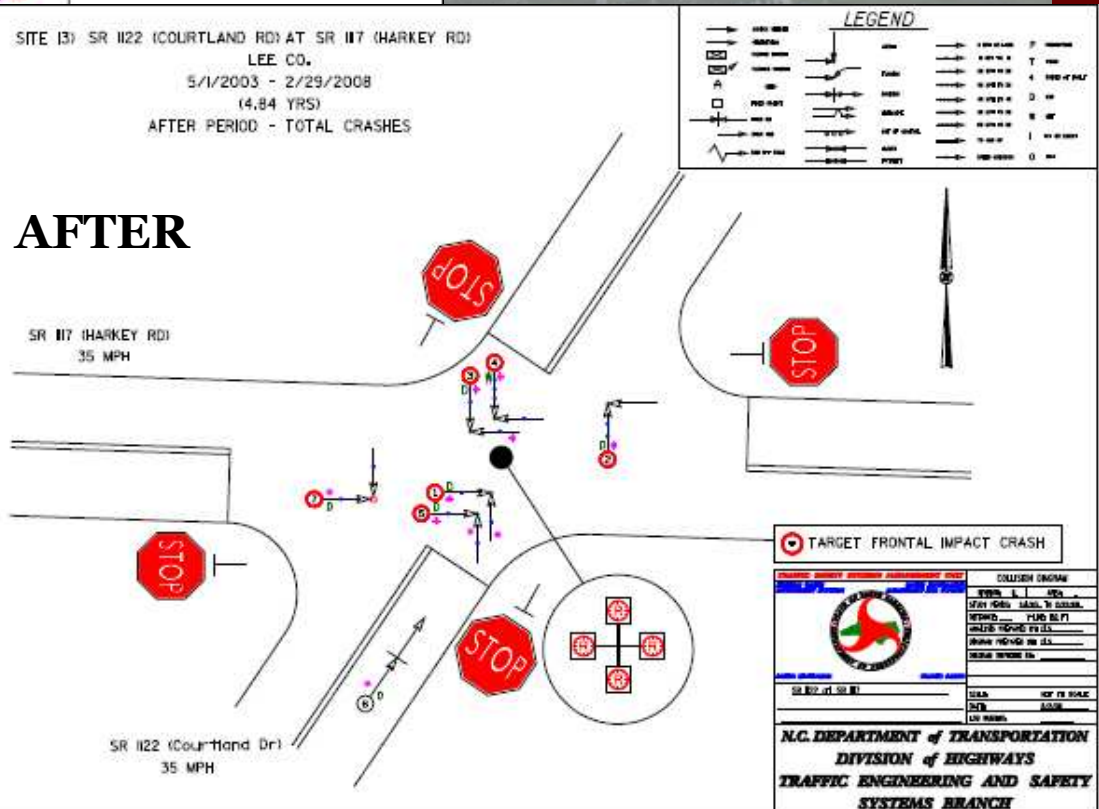
SITE 13) SR 1122 (COURTLAND RD) AT SR 117 (HARKEY RD)  
LEE CO.  
4/1/1998 - 1/31/2003  
(4.84 YRS)  
BEFORE PERIOD - TOTAL CRASHES

**BEFORE**



SITE 13) SR 1122 (COURTLAND RD) AT SR 117 (HARKEY RD)  
LEE CO.  
5/1/2003 - 2/29/2008  
(4.84 YRS)  
AFTER PERIOD - TOTAL CRASHES

**AFTER**



Approach Speeds: 35

Entering AADT: 6900

Volume Split: 64%/36%

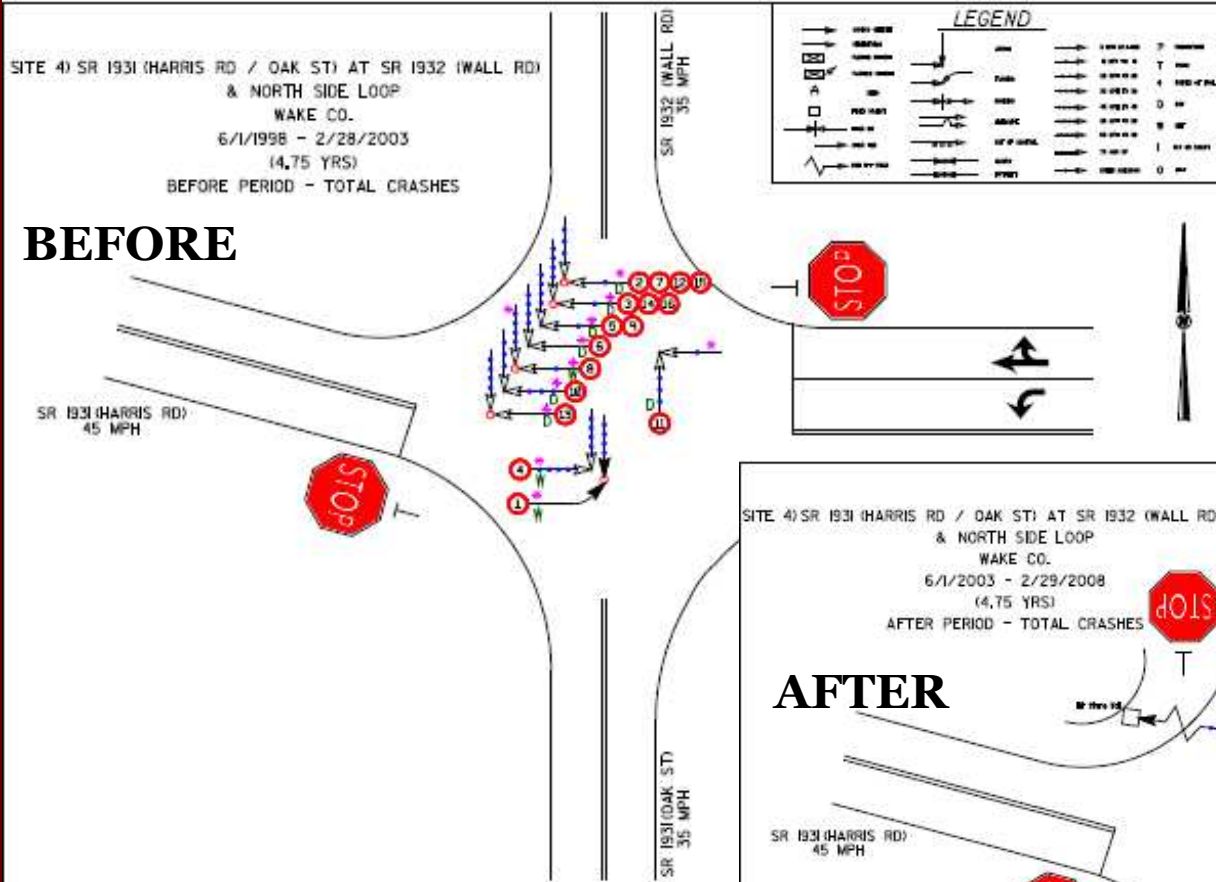
Flasher

# Before and After Crash Diagrams

Harris Rd/Oak St at Wall Rd

Wake County

Division 5



**Approach Speeds: 35/45**

**Entering AADT: 4800**

**Volume Split: 56%/44%**

**Non-Flasher**

**TARGET FRONTAL IMPACT CRASH**

		<b>CRASH REPORT</b> DATE: _____ TIME: _____ COUNTY: _____ DISTRICT: _____ ROAD: _____ MILE: _____ CRASH TYPE: _____ CRASH SEVERITY: _____ CRASH REASON: _____ CRASH REPORT TO: _____	
STATE: _____ COUNTY: _____ DISTRICT: _____ ROAD: _____ MILE: _____	COUNTY: _____ DISTRICT: _____ ROAD: _____ MILE: _____	COUNTY: _____ DISTRICT: _____ ROAD: _____ MILE: _____	COUNTY: _____ DISTRICT: _____ ROAD: _____ MILE: _____

**N.C. DEPARTMENT of TRANSPORTATION**  
**DIVISION of HIGHWAYS**  
**TRAFFIC ENGINEERING AND SAFETY**  
**SYSTEMS BRANCH**

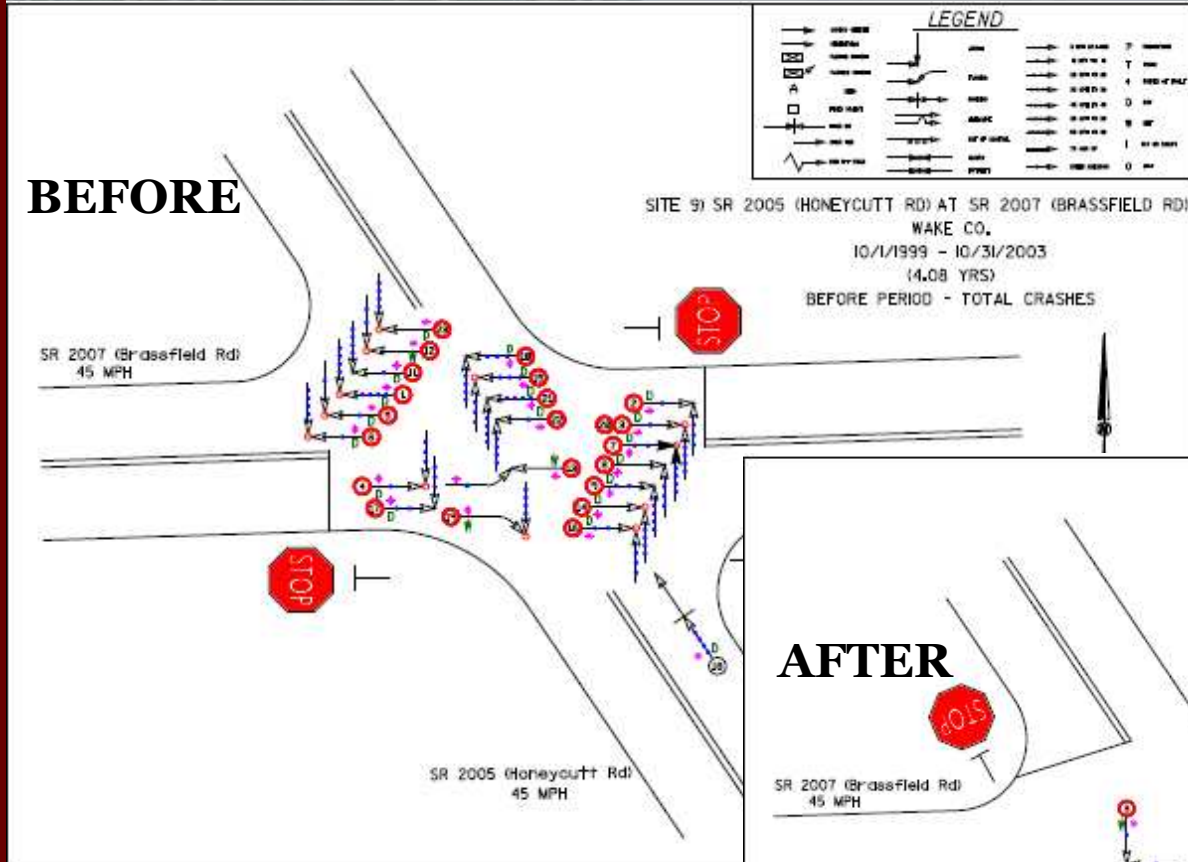
# Before and After Crash Diagrams

Honeycutt Rd at Brassfield Rd

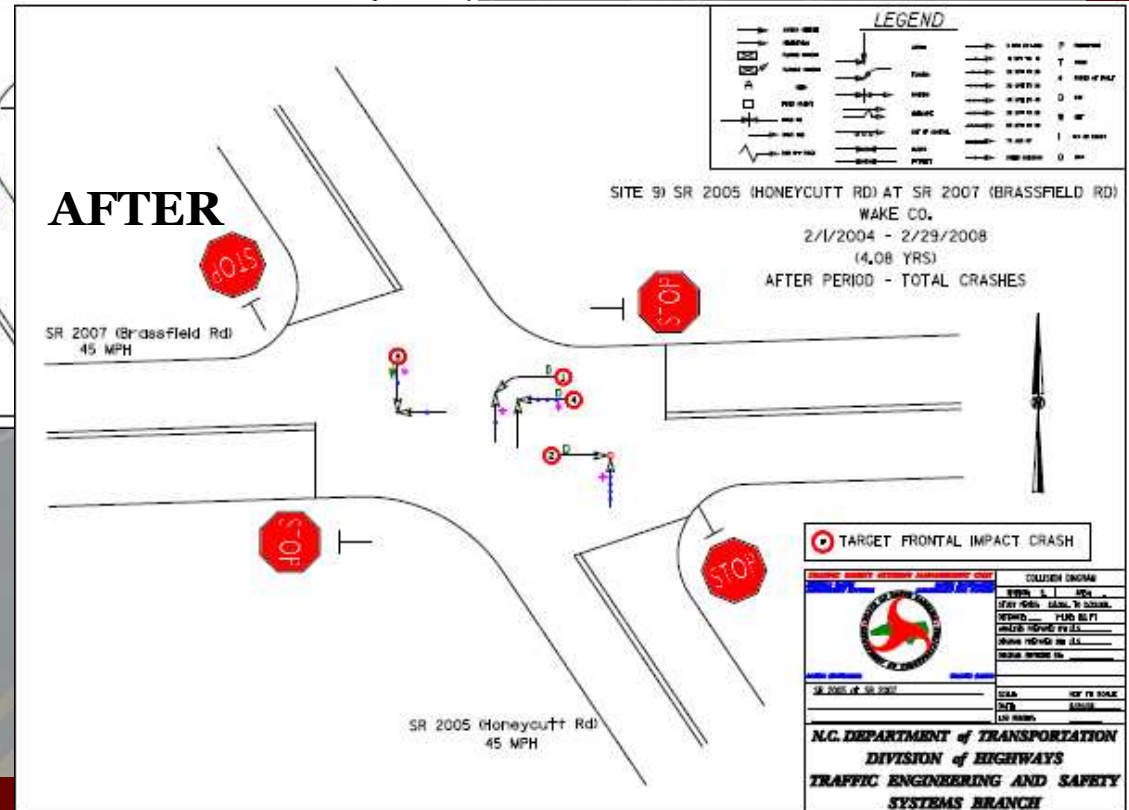
Wake County

Division 5

**BEFORE**



**AFTER**



**Approach Speeds: 45**

**Entering AADT: 5300**

**Volume Split: 62%/38%**

**Non-Flasher**

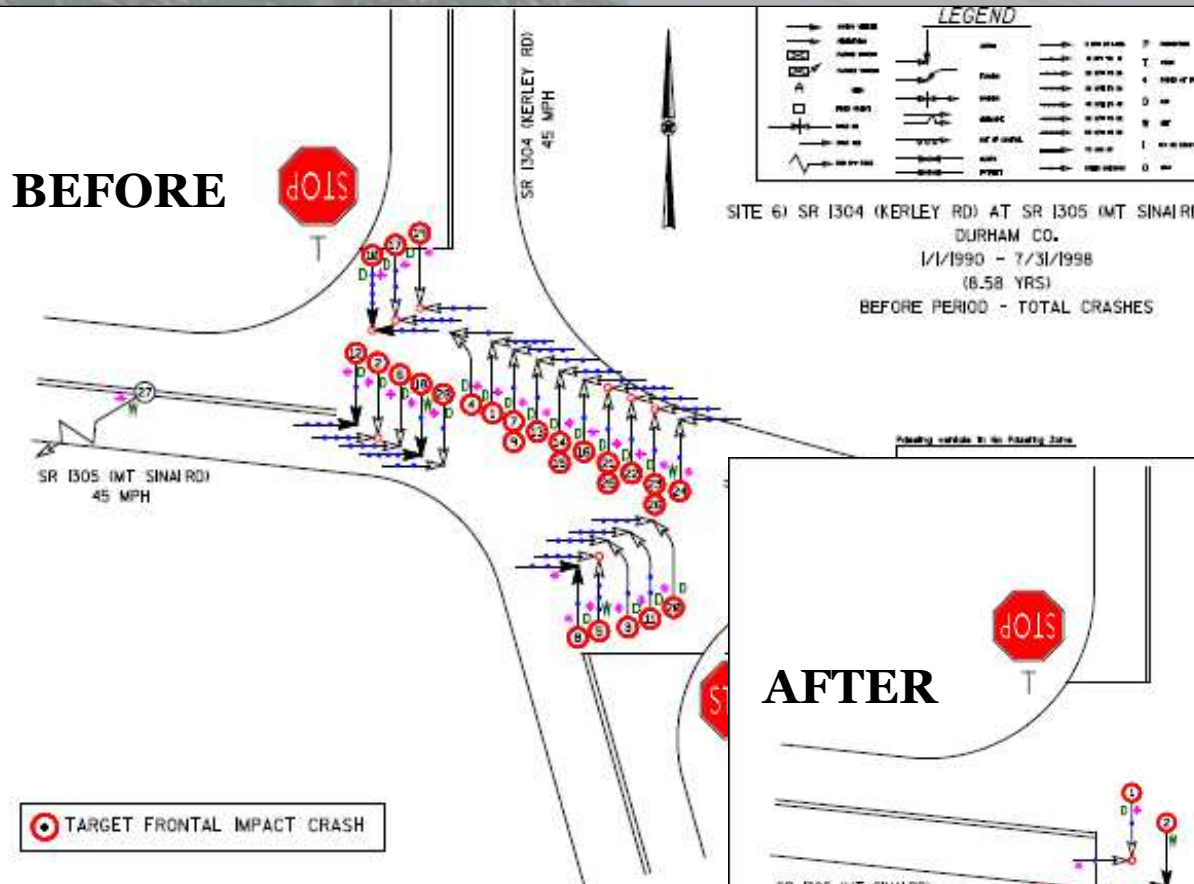
# Before and After Crash Diagrams

**Kerley Rd at Mt Sinai Rd**

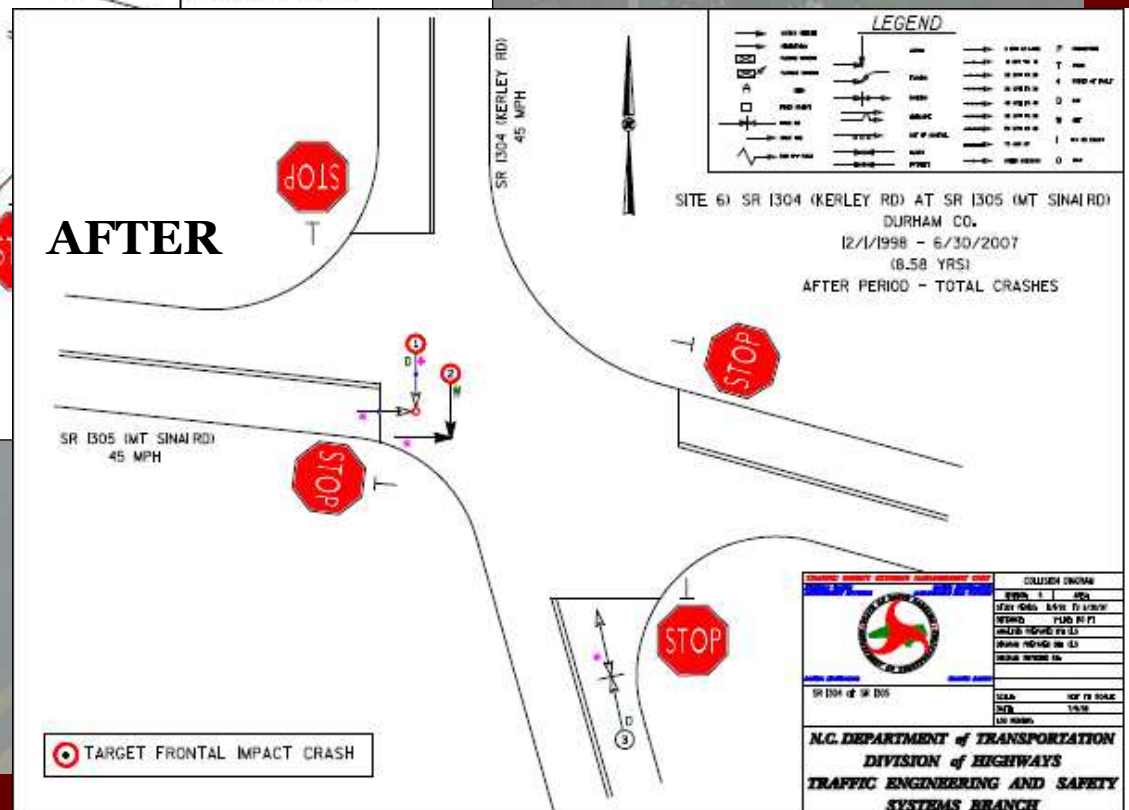
**Durham County**

**Division 5**

**BEFORE**



**AFTER**



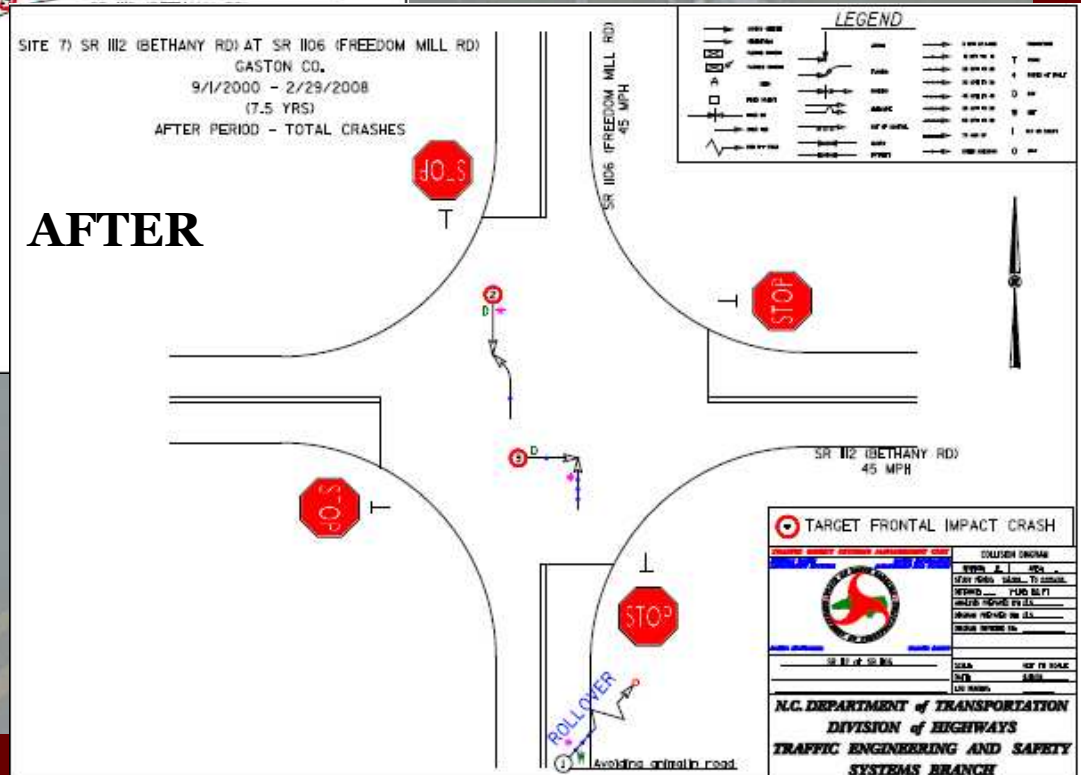
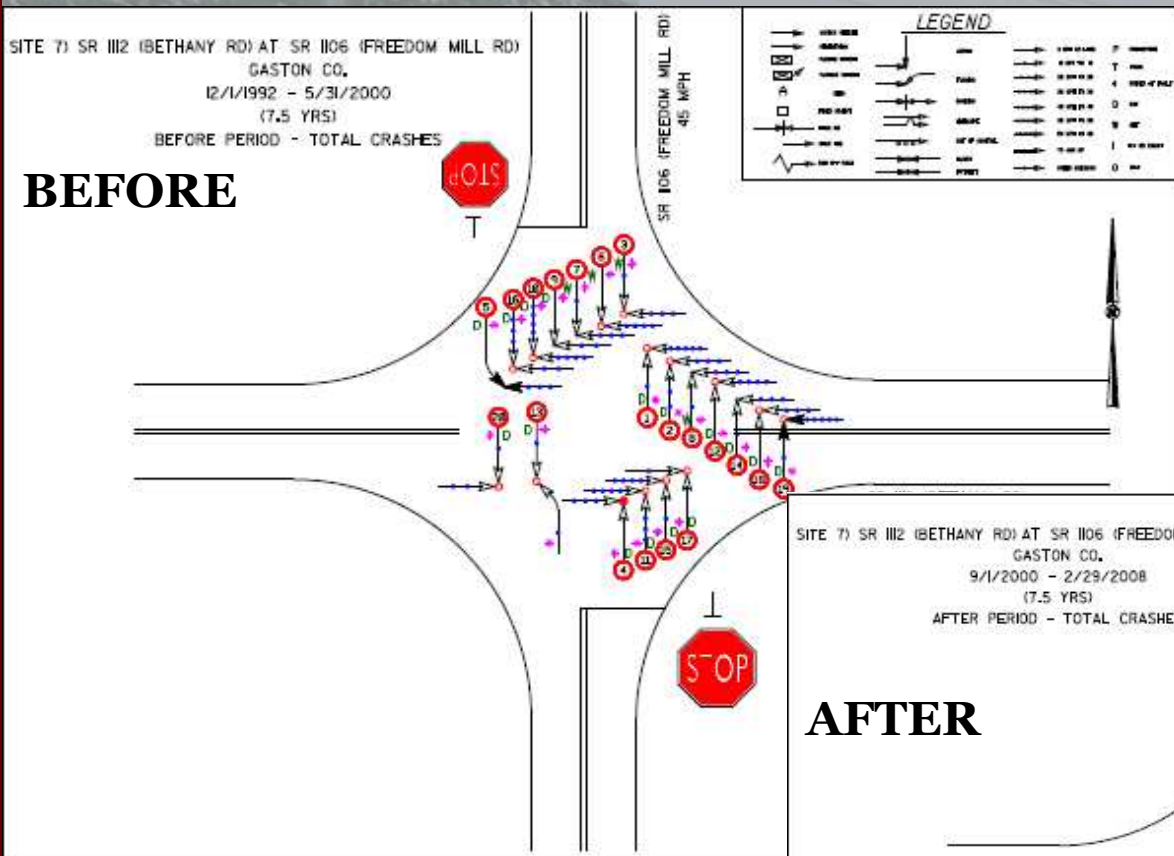
**Approach Speeds: 45**

**Entering AADT: 4200**

**Volume Split: 59%/41%**

**Non-Flasher**

# Before and After Crash Diagrams



**Bethany Rd at  
 Freedom Mill Rd**  
**Gaston County**  
**Division 12**

**Approach Speeds: 45**  
**Entering AADT: 5100**  
**Volume Split: 55%/45%**  
**Non-Flasher**

# Before and After Crash Diagrams

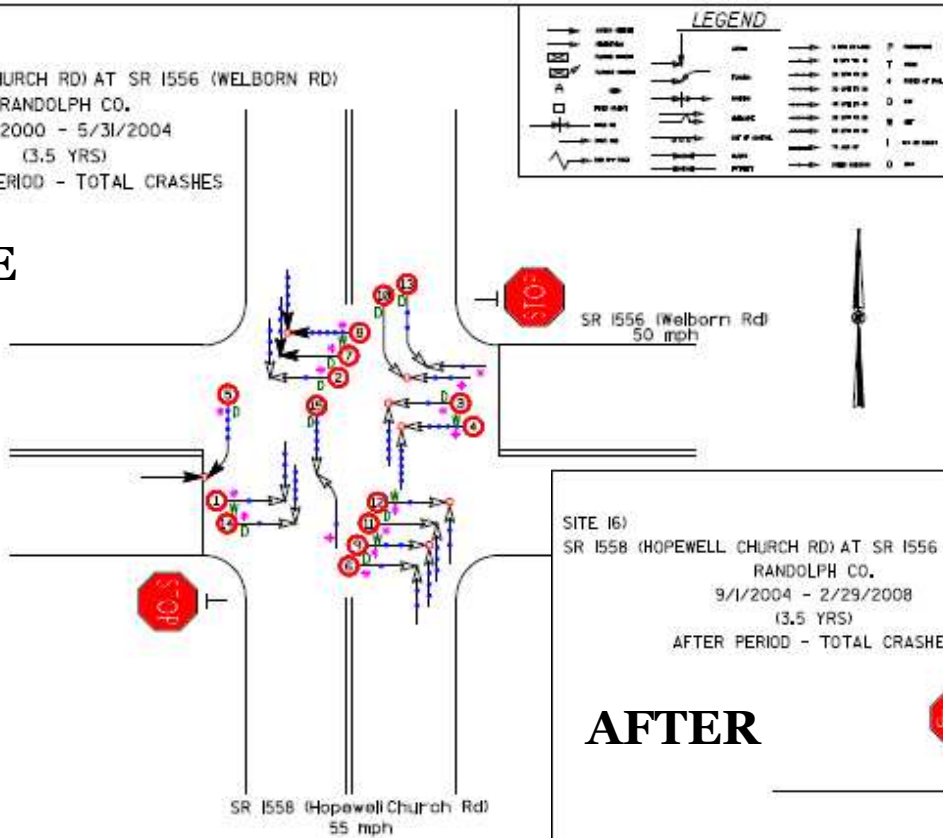
Hopewell Church Rd  
at Welborn Rd

Randolph County

Division 8

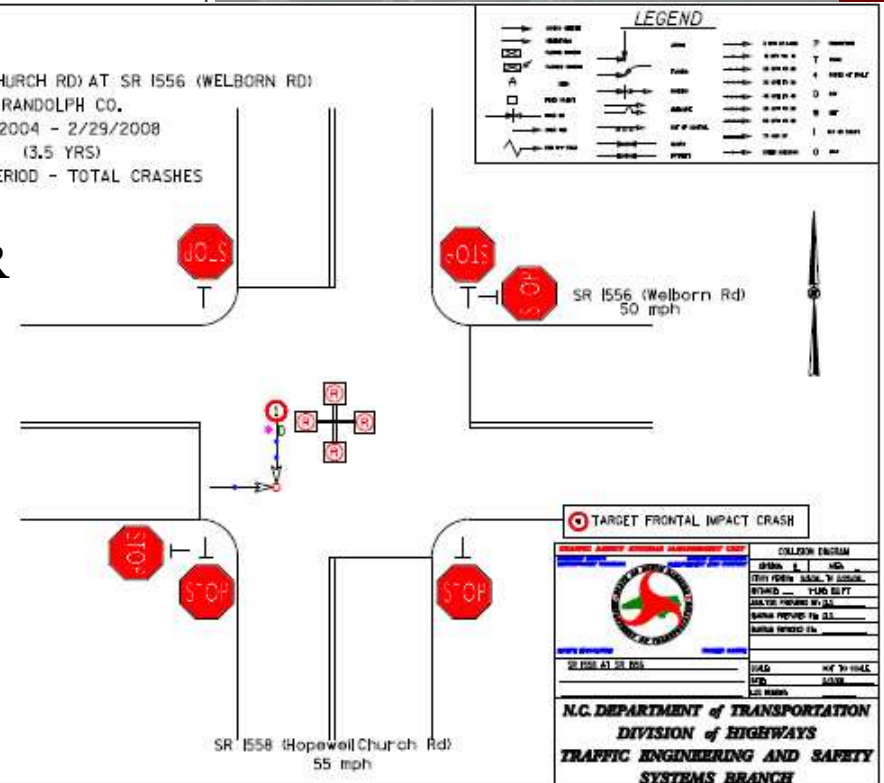
SITE 16)  
SR 1558 (HOPEWELL CHURCH RD) AT SR 1556 (WELBORN RD)  
RANDOLPH CO.  
12/1/2000 - 5/31/2004  
(3.5 YRS)  
BEFORE PERIOD - TOTAL CRASHES

**BEFORE**



SITE 16)  
SR 1558 (HOPEWELL CHURCH RD) AT SR 1556 (WELBORN RD)  
RANDOLPH CO.  
9/1/2004 - 2/29/2008  
(3.5 YRS)  
AFTER PERIOD - TOTAL CRASHES

**AFTER**



Approach Speeds: 50/55

Entering AADT: 5000

Volume Split: 64%/36%

Flasher



# Before and After Crash Diagrams

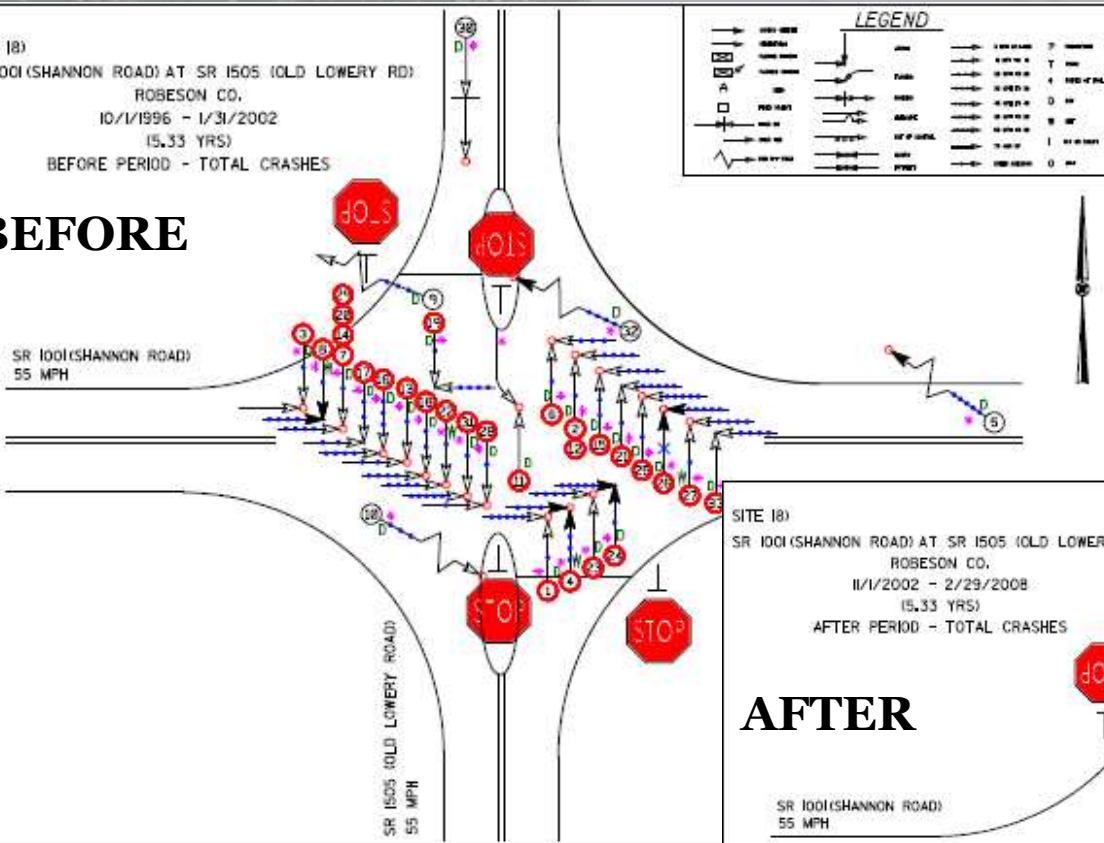
Shannon Rd at Old Lowery Rd

Robeson County

Division 6

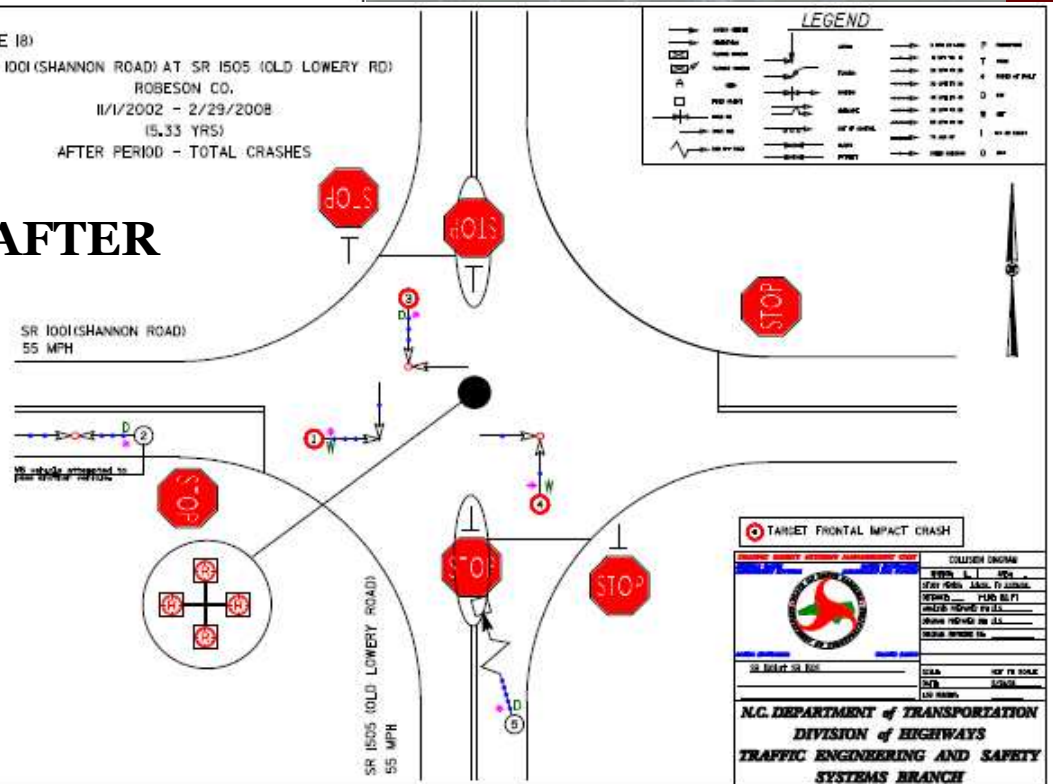
SITE 18)  
SR 1001 (SHANNON ROAD) AT SR 1505 (OLD LOWERY RD)  
ROBESON CO.  
10/1/1996 - 1/31/2002  
(5.33 YRS)  
BEFORE PERIOD - TOTAL CRASHES

**BEFORE**



SITE 18)  
SR 1001 (SHANNON ROAD) AT SR 1505 (OLD LOWERY RD)  
ROBESON CO.  
11/1/2002 - 2/29/2008  
(5.33 YRS)  
AFTER PERIOD - TOTAL CRASHES

**AFTER**

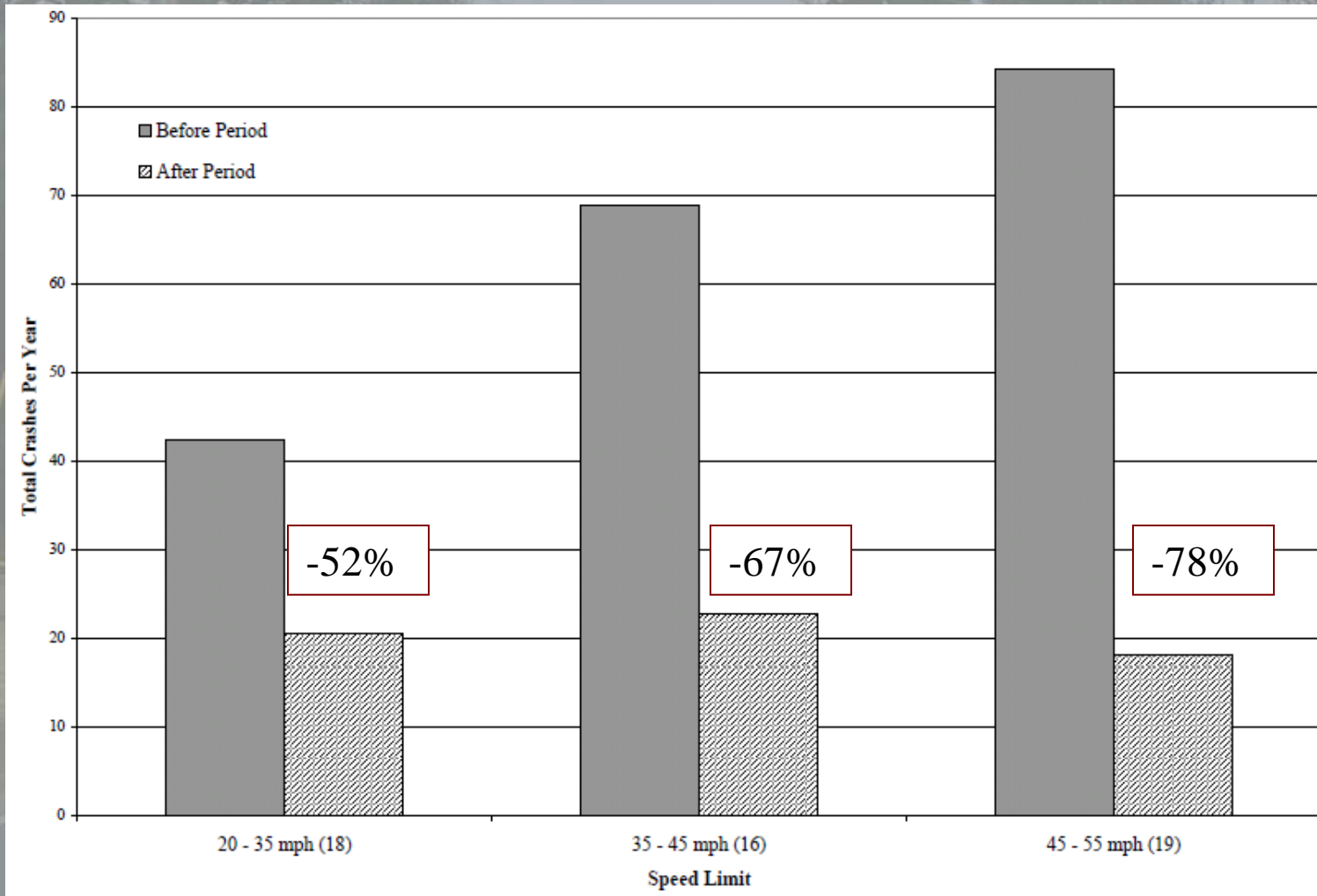


Approach Speeds: 55  
Entering AADT: 3400  
Volume Split: 60%/40%  
Flasher

TARGET FRONTAL IMPACT CRASH	
COLLISION DIAGRAM	
DATE: 11/1/2002	TIME: 12:00 PM
LOCATION: SR 1001 AT SR 1505	CRASH TYPE: FRONTAL IMPACT
VEHICLE 1: CAR	VEHICLE 2: CAR
DRIVER 1: [ ]	DRIVER 2: [ ]
WITNESSES: [ ]	REPORTING OFFICER: [ ]
<b>N.C. DEPARTMENT OF TRANSPORTATION</b> <b>DIVISION OF HIGHWAYS</b> <b>TRAFFIC ENGINEERING AND SAFETY</b> <b>SYSTEMS BRANCH</b>	

# Influence of Speed Limits

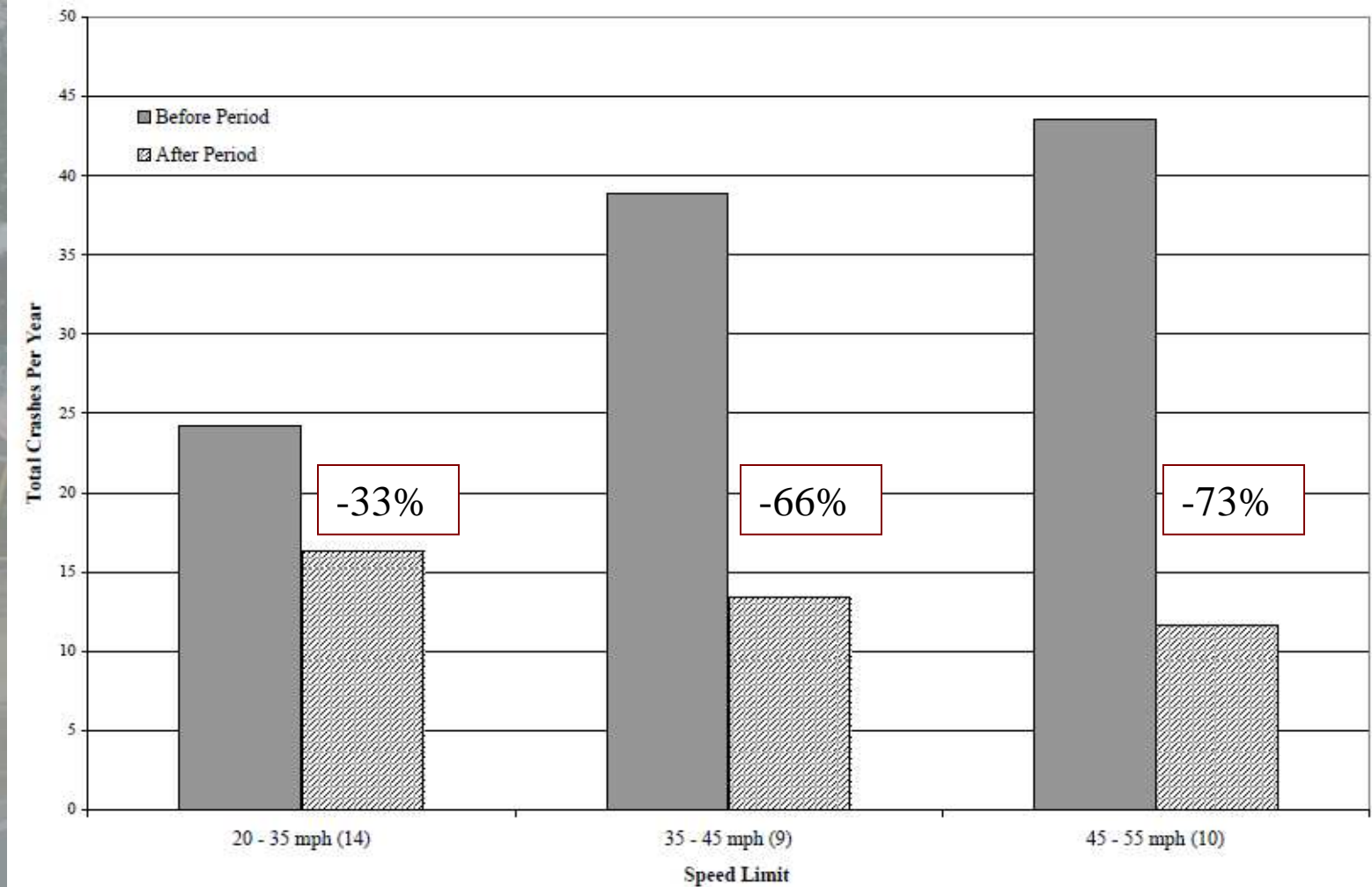
## Relationship between Speed Limits & Total Crashes at Treatment Sites All Locations



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# Influence of Speed Limits

## Relationship between Speed Limits & Total Crashes at Treatment Sites Group 1 Locations (Non-Flasher)



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# Additional Signing & Marking

Rural, 45 mph Location – 2 Weeks Post Installation



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# Safety Effect of Flashers

	Percent Reduction		
<b>Total Crashes</b>			
All Sites	-68.1%	+/-	2.2%
Group 1	-60.7%	+/-	3.3%
Group 2	-80.2%	+/-	3.9%
Group 3	-81.7%	+/-	3.5%

## **Group 1:**

Without Flashers

## **Group 2:**

With Flashers in Both  
Before & After Periods

## **Group 3:**

Flashers Installed  
With All-Way Stop

Percent of Sites with Moderate to High  
Approach Speed Limits:

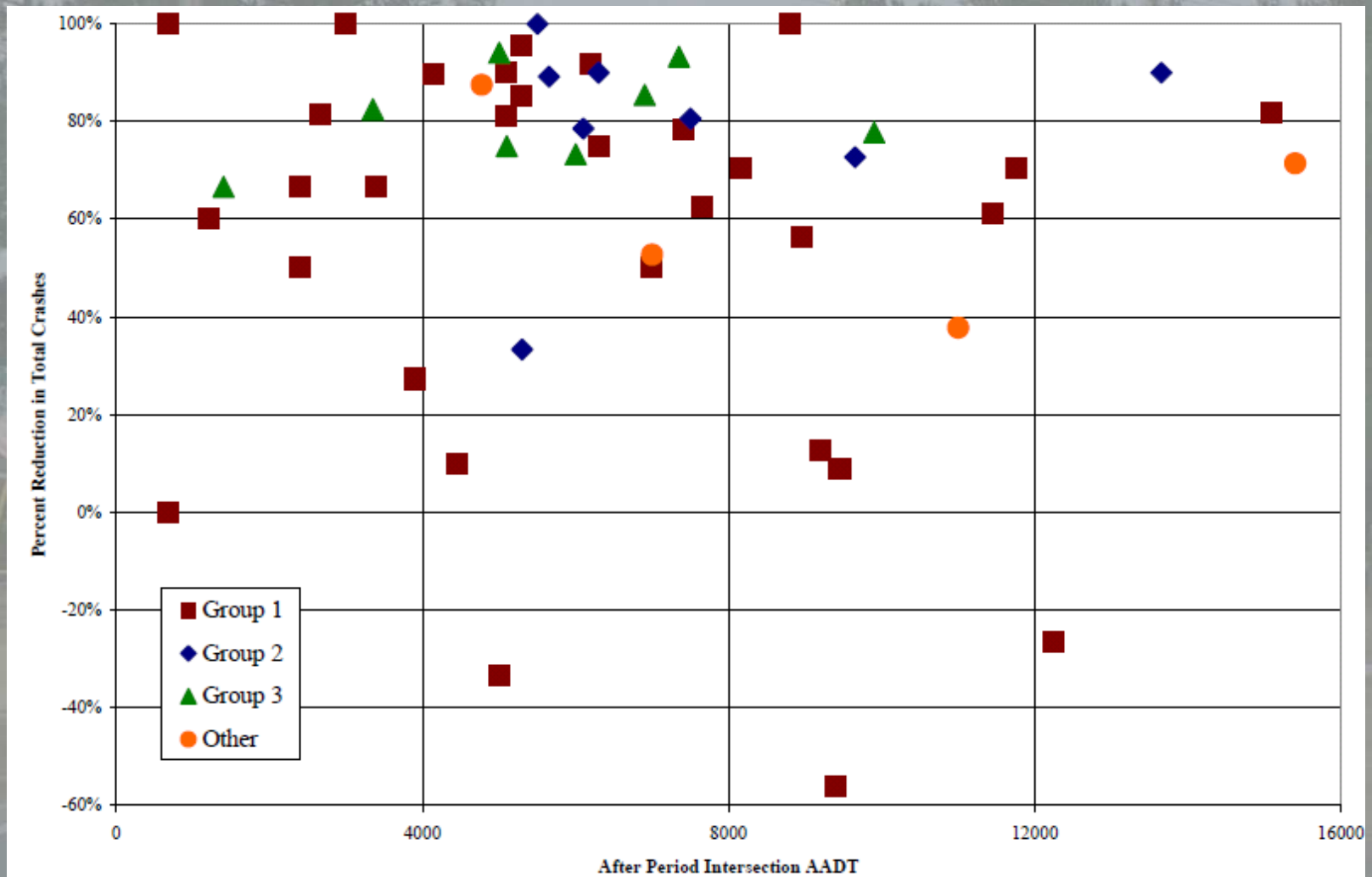
Group 1: 58%

Group 2: 87%

Group 3: 75%

# Influence of Entering AADT

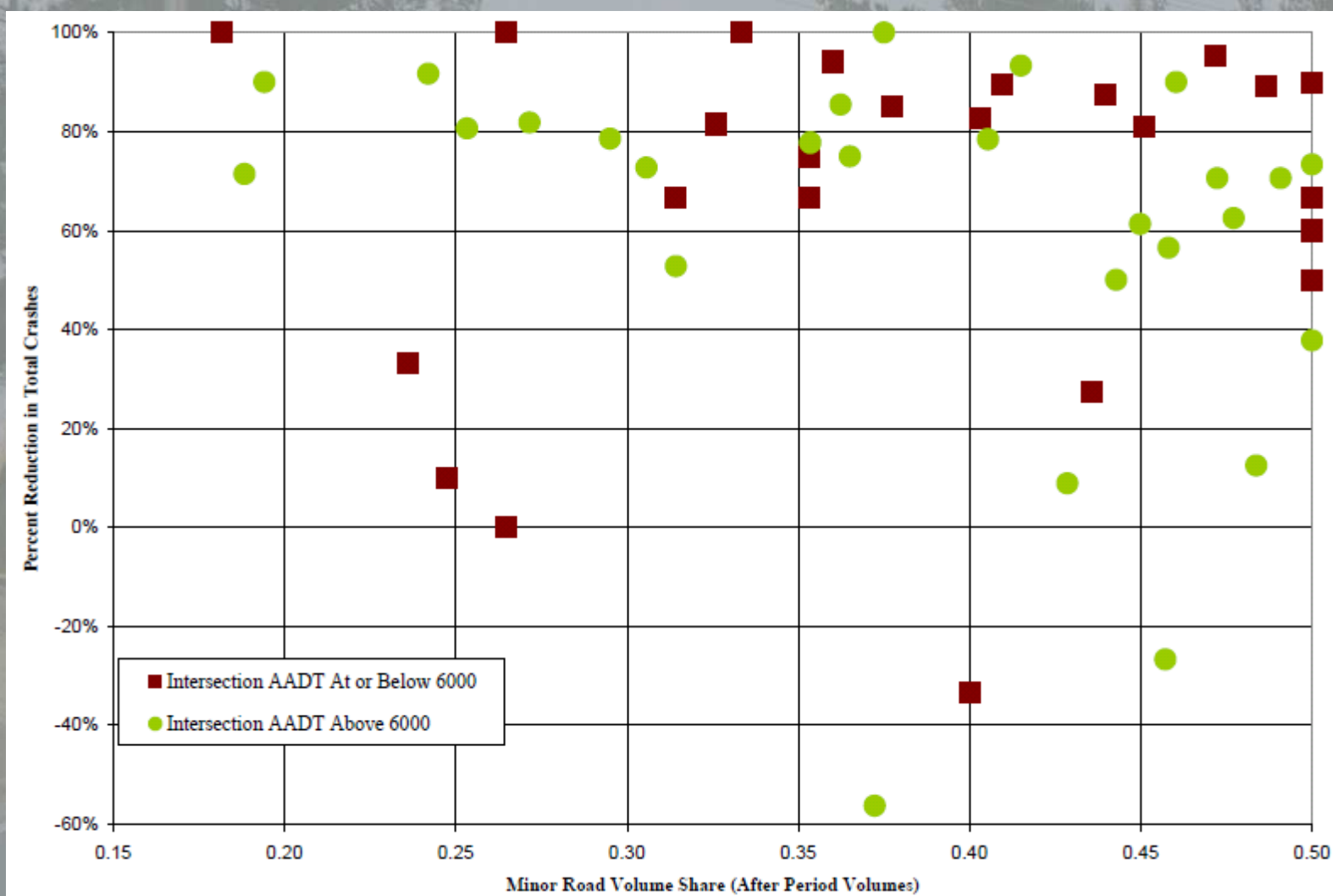
Influence of Intersection AADT on Crash Reductions at Treatment Sites



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# Influence of Volume Share

Influence of Minor Road Volume Share on Crash Reductions at Treatment Sites



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# Typical Installation Cost

## ALL-WAY STOP INSTALLATION COST

### SIGNING COST

	Price/Unit	Unit	Total
Two Transportation Workers (per hour)	\$55.10	4	\$220
Sign Truck (per hour)	\$32.13	4	\$129
48" stop sign (per sign)	\$119.45	4	\$478
48" stop ahead sign (per sign)	\$162.25	4	\$649
36"x12" all-way plaque (per sign)	\$27.21	8	\$218
12 ft. U-channel post (per post)	\$27.55	16	\$441
			<b>\$2,134</b>

### MARKING COST

	Price/Unit	Unit	Total
Labor	\$55.10	4	\$220
Equipment	\$37.40	1	\$37
Two Stop Bar Pack	\$127.80	1	\$128
Stop Symbols	\$190.70	2	\$381
Ahead Symbols	\$264.60	2	\$529
			<b>\$1,296</b>
PE Cost			<b>\$1,000</b>

NON-FLASHER TOTAL (LOW END) **\$4,430** <= Round Up to \$5,000

FLASHER (INSTALLATION / UPGRADES) TOTAL (HIGH END) **\$20,000**



# Benefit-Cost Analysis Example

## Hopewell Church Rd at Welborn Rd, Randolph County

### All-Way Stop with Overhead Flasher

INSTALLATION DATE: 7/28/2004

ITEMS	TOTAL	SERVICE	CRP	ANNUAL COST					
Signs (Regular Size)	\$1,000	6	0.216	\$216	Contract = \$7000 Utilities = \$1000 PE = \$1500 <b>TOTAL = \$9500</b>				
Pavement Markings (Minimal)	\$1,000	2	0.561	\$561					
Overhead Flasher (Utilities & PE Included)	\$7,500	10	0.149	\$1,118					
<b>TOTALS</b>	<b>\$9,500</b>	<b>7</b>	<b>0.199</b>	<b>\$1,895</b>					
ESTIMATED INCREASE IN ANNUAL MAINT. COST =				\$600	(Overhead Flasher & Markings)				
ESTIMATED INCREASE IN ANNUAL UTILITY COST =				\$350	(Overhead Flasher)				
TOTAL ANNUAL COST=				\$2,845					
TOTAL COST OF PROJECT=				\$9,500					
COMPREHENSIVE COST REDUCTION:									
ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES									
TIME PERIOD	YEARS	K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	PDO CRASHES	PDO CRASHES PER YR	ANNUAL COSTS	
BEFORE	4.58	0	0.00	7	1.53	10	2.18	\$36,026	
AFTER	4.58	0	0.00	1	0.22	0	0.00	\$3,930	
Annual Benefits from Crash Cost Savings								\$32,096	
NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST				=	\$29,251				
BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST				=	11.28				
TOTAL COST OF PROJECT		-	\$9,500	COMPREHENSIVE B/C RATIO		-	11.28		

**B/C = 11.28/1**

# Benefit-Cost Analysis Example

## Courtland Rd at Harkey Rd, Lee County

### All-Way Stop w/Overhead Flasher & Two Solar Powered Stop Sign Flashers INSTALLATION DATE: 3/19/2003

ITEMS	TOTAL	SERVICE	CRF	ANNUAL C				
Signs (Regular Size)	\$1,000	6	0.216	\$216				
Pavement Markings (Minimal)	\$1,000	2	0.561	\$561				
Overhead & Sign Flashers (Utilities & PE Included)	\$13,000	10	0.149	\$1,937				
<b>TOTALS</b>	<b>\$15,000</b>	<b>8</b>	<b>0.181</b>	<b>\$2,714</b>				
ESTIMATED INCREASE IN ANNUAL MAINT. COST =				\$700	(Overhead/Sign Flashers & Markings)			
ESTIMATED INCREASE IN ANNUAL UTILITY COST =				\$350	(Overhead Flasher)			
TOTAL ANNUAL COST=				\$3,764				
TOTAL COST OF PROJECT=				\$15,000				
COMPREHENSIVE COST REDUCTION:								
ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES								
TIME PERIOD	YEARS	K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	PDO CRASHES	PDO CRASHES PER YR	ANNUAL COSTS
BEFORE	5.92	0	0.00	22	3.72	33	5.57	\$88,632
AFTER	5.92	0	0.00	2	0.34	6	1.01	\$10,034
Annual Benefits from Crash Cost Savings								\$78,598
NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST				=	\$74,834			
BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST				=	20.88			
TOTAL COST OF PROJECT		-	\$15,000	COMPREHENSIVE B/C RATIO		-	20.88	

Spot Safety \$10,000 +  
Overhead Flasher \$5000  
**ESTIMATED TOTAL =**  
\$15,000

**B/C = 20.88/1**

# Benefit-Cost Analysis Example

## Honeycutt Rd at Brassfield Rd, Wake County

### All-Way Stop INSTALLATION DATE: 12/3/2003

DETAILED COST:		TYPE IMPROVEMENT - All-Way Stop				ESTIMATED TOTAL = \$5,000		
ITEMS	TOTAL	SERVICE	CRP	ANNUAL COST				
Signs (Oversize Stops)	\$2,500	6	0.216	\$541				
Pavement Markings (With Stop Ahead)	\$1,500	2	0.561	\$841				
PE	\$1,000	10	0.149	\$149				
<b>TOTALS</b>	<b>\$5,000</b>	<b>4</b>	<b>0.306</b>	<b>\$1,531</b>				
ESTIMATED INCREASE IN ANNUAL MAINT. COST =				\$200	(Markings)			
ESTIMATED INCREASE IN ANNUAL UTILITY COST =				\$0				
TOTAL ANNUAL COST=				\$1,731				
TOTAL COST OF PROJECT=				\$5,000				
COMPREHENSIVE COST REDUCTION:								
ESTIMATED NUMBER OF ANNUAL ACCIDENT DECREASES								
TIME PERIOD	YEARS	K & A CRASHES	K & A CRASHES PER YR	B & C CRASHES	B & C CRASHES PER YR	PDO CRASHES	PDO CRASHES PER YR	ANNUAL COSTS
BEFORE	5.16	1	0.19	14	2.71	12	2.33	\$154,806
AFTER	5.16	0	0.00	1	0.19	3	0.58	\$5,756
Annual Benefits from Crash Cost Savings								\$149,050
NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST					=	\$147,319		
BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST					=	86.11		
TOTAL COST OF PROJECT		-	\$5,000	COMPREHENSIVE B/C RATIO		-	86.11	

**B/C = 86.11/1**

# Before & After Delay Studies

Two Locations:

- Junction at Ferrell in Durham Co.
- Cornwallis at Josephine/ Shiloh in Johnston Co.

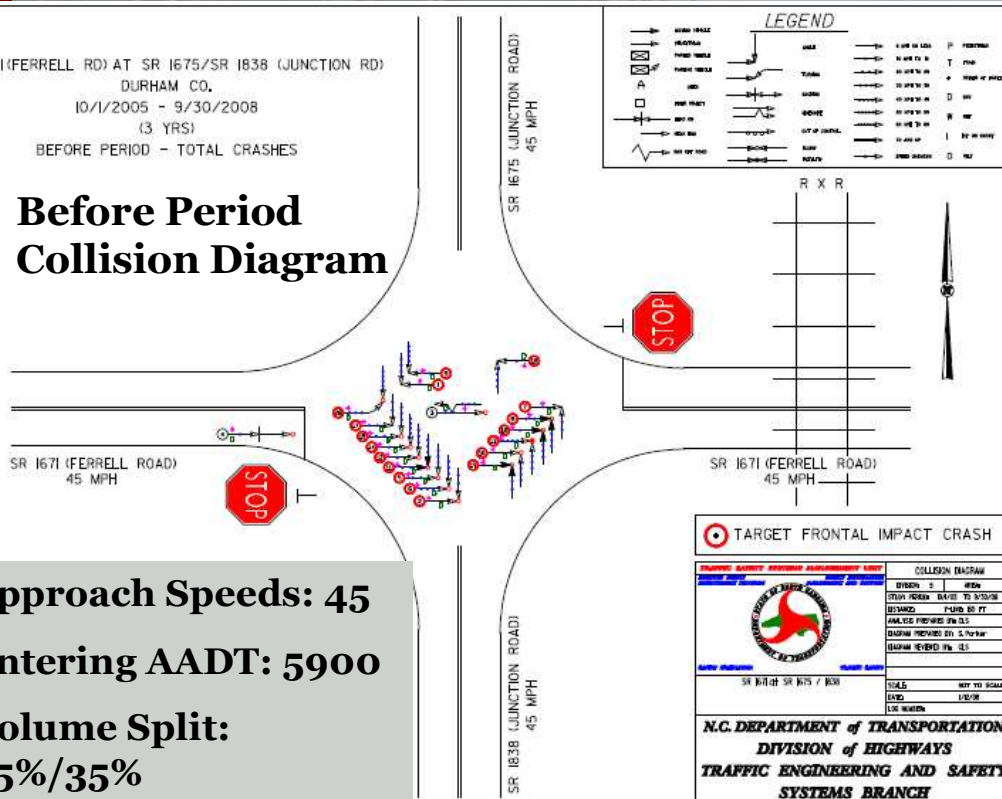
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# Before & After Delay Studies

## Junction at Ferrell, Durham Co.

SR 1671 (FERRELL RD) AT SR 1675/SR 1838 (JUNCTION RD)  
 DURHAM CO.  
 10/1/2005 - 9/30/2008  
 (3 YRS)  
 BEFORE PERIOD - TOTAL CRASHES

### Before Period Collision Diagram



**Approach Speeds: 45**  
**Entering AADT: 5900**  
**Volume Split: 65%/35%**

	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes/Yr	8.3	2.4	-71%
Injury Crashes/Yr	5.7	0	-100%

Converted April 7, 2009  
 After Period Site Photos

# Before & After Delay Studies

## Junction at Ferrell in Durham Co : AM PEAK

### Control Delay Analysis

SR 1838 (Junction Rd) at SR 1671 (Ferrell Rd)

 Shaded Area from May 2006 Counts

AM Peak - Before 11/3/08

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	63	0.806	78	7.9	14.5	1133.4	B
WB	162	0.773	210	7.1	13.7	2871.2	B
NB	96	0.923	104	0	0	0.0	A
SB	46	0.719	64	0	0	0.0	A
	Sum(FR)		456		Sum(FR*CD)	4004.5	

Intersection Control Delay 

8.8	A
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AM Peak - After 4/22/09

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	83	0.806	103	4.7	11.3	1163.6	B
WB	187	0.773	242	5.8	12.4	2999.7	B
NB	78	0.923	85	4.6	11.2	946.5	B
SB	42	0.719	58	5.4	12	701.0	B
	Sum(FR)		488		Sum(FR*CD)	5810.8	

Intersection Control Delay 

11.3	B
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AM Peak Intersection Control Delay Difference: 

3.1	sec/vehicle Increase
-----	----------------------

  
 AM Peak Intersection Control Delay % Change: 

36%	Increase
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# Before & After Delay Studies

## Junction at Ferrell in Durham Co : PM PEAK

### Control Delay Analysis

SR 1838 (Junction Rd) at SR 1671 (Ferrell Rd)

 Shaded Area from May 2006 Counts

PM Peak - Before 11/3/08

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	296	0.881	336	12.4	19	6383.7	C
WB	68	0.809	84	2.9	9.5	798.5	A
NB	130	0.793	164	0	0	0.0	A
SB	62	0.722	72	0	0	0.0	A
	Sum(FR)		656		Sum(FR*CD)	7182.2	

Intersection Control Delay 

10.9	B
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PM Peak - After 4/22/09

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	274	0.881	311	9.6	16.2	5038.4	C
WB	80	0.809	99	3.0	9.6	949.3	A
NB	113	0.793	142	5.8	12.4	1767.0	B
SB	48	0.722	66	6.9	13.5	897.5	B
	Sum(FR)		619		Sum(FR*CD)	8652.2	

Intersection Control Delay 

14.0	B
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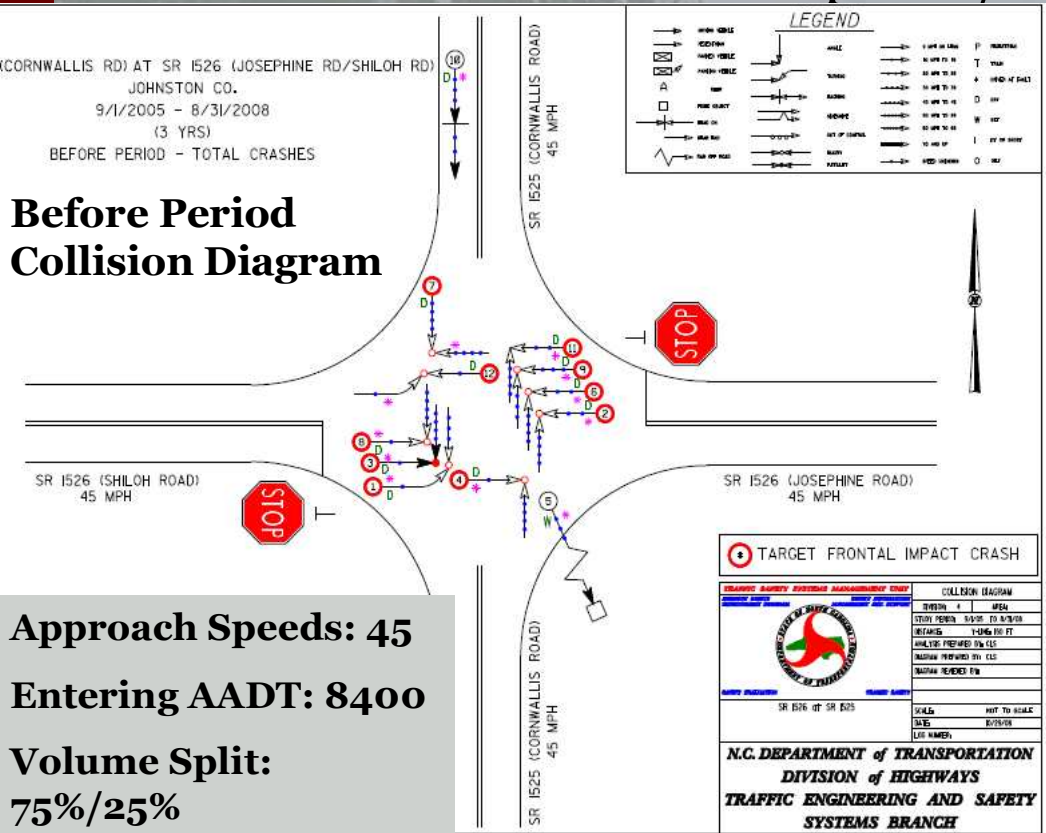
PM Peak Intersection Control Delay Difference:	3.0	sec/vehicle Increase
PM Peak Intersection Control Delay % Change:	28%	Increase

# Before & After Delay Studies

## Cornwallis at Josephine/ Shiloh, Johnston Co.

(CORNWALLIS RD) AT SR 1526 (JOSEPHINE RD/SHILOH RD)  
 JOHNSTON CO.  
 9/1/2005 - 8/31/2008  
 (3 YRS)  
 BEFORE PERIOD - TOTAL CRASHES

### Before Period Collision Diagram



**Approach Speeds: 45**  
**Entering AADT: 8400**  
**Volume Split:**  
**75%/25%**

**1 TARGET FRONTAL IMPACT CRASH**

TRAFFIC SAFETY SYSTEMS MANAGEMENT UNIT		COLLISION DIAGRAM	
STATE OF NORTH CAROLINA		SECTION 4 AREA	
N.C. DEPARTMENT OF TRANSPORTATION		STUDY PERIOD: 9/1/05 TO 8/31/08	
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH		DISTANCE: 1-1/4 MILE TO FT	
SR 1526 AT SR 1525		ANALYST: PREPARED BY: LEE	
DATE: 10/30/08		REVISION: 01	
SCALE: NOT TO SCALE		DATE: 10/30/08	
PROJECT NAME: SR 1526 AT SR 1525		DATE: 10/30/08	
PROJECT NUMBER: 1526-1525		DATE: 10/30/08	
PROJECT NAME: SR 1526 AT SR 1525		DATE: 10/30/08	
PROJECT NUMBER: 1526-1525		DATE: 10/30/08	

**N.C. DEPARTMENT of TRANSPORTATION**  
**DIVISION of HIGHWAYS**  
**TRAFFIC ENGINEERING AND SAFETY**  
**SYSTEMS BRANCH**



After Period Site Photos



Converted October 30, 2008

	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes/Yr	<b>4.0</b>	<b>2.4</b>	<b>-40%</b>
Injury Crashes/Yr	<b>3.0</b>	<b>0.8</b>	<b>-73%</b>



# Before & After Delay Studies

Cornwallis at Josephine/Shiloh in Johnston Co: AM PEAK

Control Delay Analysis							
SR 1525 (Cornwallis Rd) at SR 1526 (Josephine Rd / Shiloh Rd)							
<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 10px; background-color: #ADD8E6; border: 1px solid black; margin-right: 5px;"></div>           Shaded Area from September 2007 Counts         </div>							
AM Peak - Before 10/27/08							
	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	65	0.72	118	10.9	17.5	2066.0	C
WB	190	0.75	253	8.6	15.2	3850.7	C
NB	346	0.78	444	0	0	0.0	A
SB	237	0.7	339	0	0	0.0	A
	Sum(FR)		1154		Sum(FR*CD)	5916.6	
Intersection Control Delay						5.1	A
AM Peak - After 11/12/08							
	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	92	0.72	128	8.5	15.1	1929.4	C
WB	173	0.75	231	6.8	13.4	3090.9	B
NB	324	0.78	415	6.5	13.1	5441.5	B
SB	155	0.7	221	10.1	16.7	3697.9	C
	Sum(FR)		995		Sum(FR*CD)	14159.8	
Intersection Control Delay						14.2	B
AM Peak Intersection Control Delay Difference:						9.1	sec/vehicle increase
AM Peak Intersection Control Delay % Change:						178%	Increase

NCDOT Transportation Mobility & Safety Division

# Before & After Delay Studies

## Cornwallis at Josephine/Shiloh in Johnston Co: PM PEAK

### Control Delay Analysis

SR 1525 (Cornwallis Rd) at SR 1526 (Josephine Rd / Shiloh Rd)

 Shaded Area from September 2007 Counts

PM Peak - Before 10/27/08

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	107	0.84	127	17.1	23.7	3018.9	C
WB	84	0.83	101	10.7	17.3	1750.8	C
NB	199	0.82	243	0	0	0.0	A
SB	519	0.87	597	0	0	0.0	A
	Sum(FR)		1068		Sum(FR*CD)	4769.8	

Intersection Control Delay 

4.5	A
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PM Peak - After 11/12/08

	Volume	PHF	Flow Rate	Stopped Delay	Control Delay	FR*CD	LOS
EB	68	0.84	81	7.3	13.9	1125.2	B
WB	81	0.83	98	6.9	13.5	1317.5	B
NB	157	0.82	191	4.5	11.1	2125.2	B
SB	455	0.87	523	15.2	21.8	11401.1	C
	Sum(FR)		893		Sum(FR*CD)	15969.1	

Intersection Control Delay 

17.9	C
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PM Peak Intersection Control Delay Difference:	13.4	sec/vehicle increase
PM Peak Intersection Control Delay % Change:	288%	increase

NCDOT Transportation Mobility & Safety Division

# Delay and LOS Analysis

Comparison of the Delays and Level-of-Services for Two-Way Stop Control, All-Way Stop Control, and Signalization at the Intersection of SR 1525 (Cornwallis Rd) with SR 1526 (Josephine Rd)

Time Period	LOS / Delay		
	Two-Way Stop	All-Way Stop	Signalization
<b>AM Peak Hour</b> (7:15 – 8:15 AM)			
Northbound (Cornwallis Rd)	A / 0.5	D / 26.8	A / 8.9
	A / 2.4	C / 18.7	A / 8.1
Southbound (Cornwallis Rd)	F / 168.0	B / 13.7	B / 10.6
Eastbound (Shiloh Rd)	D / 25.2	C / 16.0	A / 9.9
Westbound (Josephine Rd)	<b>NA</b>	<b>C / 20.3</b>	<b>A / 9.1</b>
<b>Overall Intersection</b>			
<b>PM Peak Hour</b> (5:15 – 6:15 PM)			
Northbound (Cornwallis Rd)	A / 0.2	B / 11.8	A / 4.5
	A / 2.6	D / 26.5	A / 7.4
Southbound (Cornwallis Rd)	E / 44.9	B / 11.4	B / 16.1
Eastbound (Shiloh Rd)	C / 16.1	B / 10.3	B / 14.1
Westbound (Josephine Rd)	<b>NA</b>	<b>C / 19.6</b>	<b>A / 8.5</b>
<b>Overall Intersection</b>			

NA = Not Available

F / 999.9 = LOS / Delay (second/vehicle)

Central Office System Timing (COST) Group

NCDOT - Division of Mobility and Safety

**NCDOT Transportation Mobility & Safety Division**

# Conclusions

## Recommended Crash Reduction Factors:

<b>Total Crashes</b>	<b>-68%</b>
<b>Injury Crashes</b>	<b>-77%</b>
<b>Frontal Impact Crashes</b>	<b>-75%</b>
<b>Ran Stop Sign Crashes</b>	<b>-15%</b>

# Conclusions

- Substantial reductions in total and target crash frequency & severity (no after-period fatalities at 53 sites)
- No noticeable increase in rear end crashes
- Overall decrease in “ran stop sign” crashes and much lower speeds at impact
- Effective at a wide range of AADT & volume share
- Greater reductions at higher speed limit sites
- Greater reductions at flasher sites
- Additional signing and marking likely contributes to greater crash reductions
- Extremely cost effective from a safety standpoint
- Increase in intersection delay

# QUESTIONS?

**Presentation & Report Soon Available  
at**

**[http://www.ncdot.org/doh/preconstruct/  
traffic/safety/Reports/completed.html](http://www.ncdot.org/doh/preconstruct/traffic/safety/Reports/completed.html)**

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**NCDOT Transportation Mobility & Safety Division**