

Hazard Elimination Project Evaluation

Order # 41000006603

Hazard Elimination Project W-4834

Evaluation of the Rumble Strip Installation on Two Sections of I-77 in Mecklenburg County

Documents Prepared By:

Safety Evaluation Group
Traffic Safety Systems Management Section
Transportation Mobility and Safety Division
North Carolina Department of Transportation

Principal Investigator



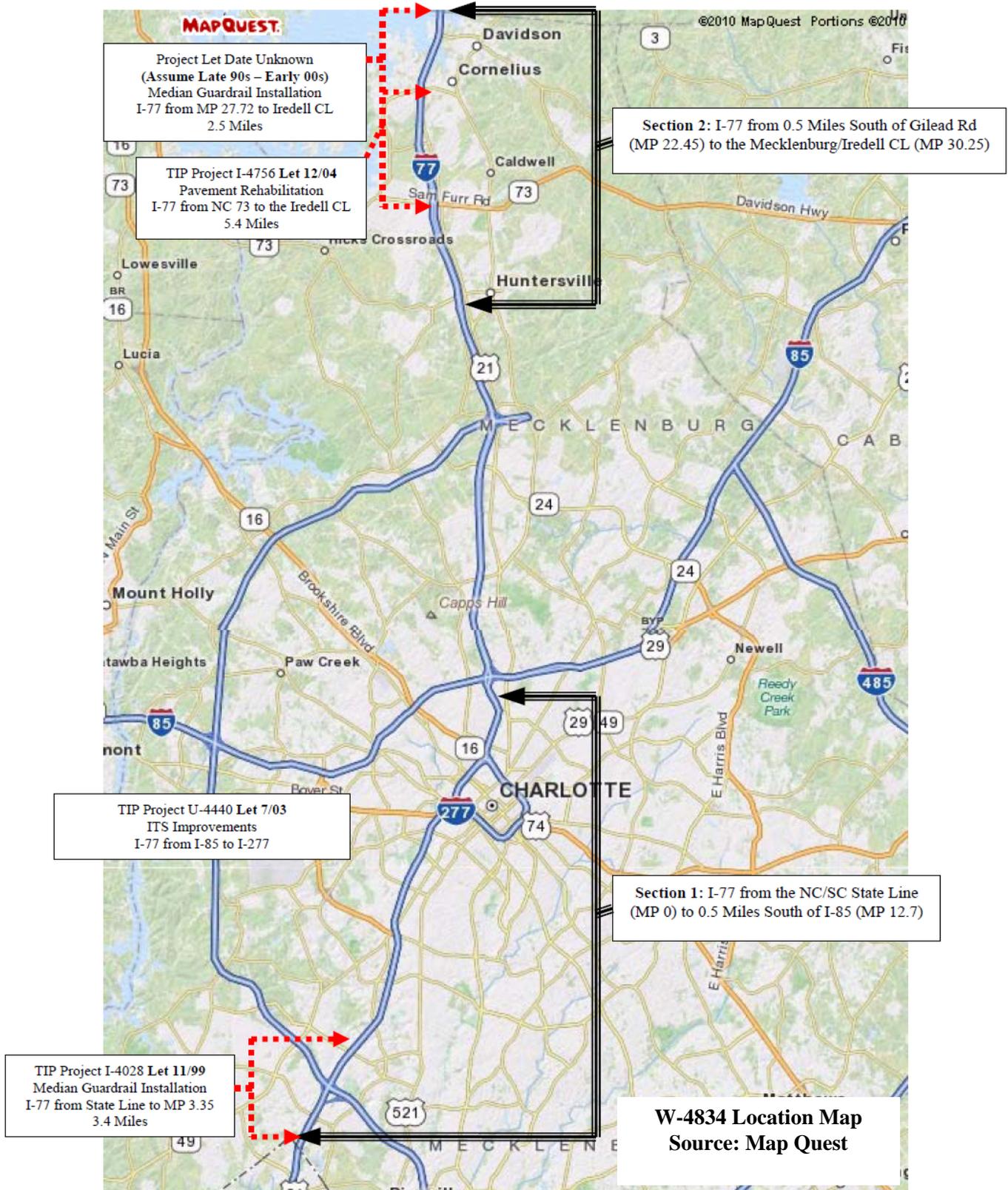
Carrie L. Simpson, PE

8/24/2010

Date

Traffic Safety Project Engineer

Hazard Elimination Project Evaluation Documentation



Subject Location

The treatment location includes two segments on I-77 in Mecklenburg County:

1. I-77 from the NC/SC State Line to the beginning of the construction project south of I-85 (12.7 Miles)
2. I-77 from south of SR 2136 (Gilead Rd) at the end of the construction project to the Mecklenburg/Iredell County Line (7.8 Miles)

I-77 is mostly a six lanes fully controlled access freeway with some four lanes and eight lane sections. Section 1 has mostly 4' median shoulders and 4' outside shoulders. Section 2 has 4' median shoulders and 10' outside shoulders. Sections narrow enough to require median protection have either concrete barrier wall or cable. The posted speed limits range from 55 mph to 65 mph.

Multiple TIP projects were completed on this section of roadway prior to and after the completion of W-4834. Median guardrail was installed on several unprotected segments of I-77 under projects let in the late 90s and early 00s. Due to the number and duration of additional projects completed on I-77 in Mecklenburg County, they are noted in the Location Map for your reference but are not accounted for in this evaluation.

Project Information and Background from the Project File Folder

The hazard elimination project improvement chosen was the installation of shoulder rumble strips. The countermeasure was applied to both the median and outside shoulders of the northbound and southbound travel lanes for 20.5 miles of I-77. These sections of I-77 had experienced numerous run-off-road crashes resulting in fatalities, serious injury, and property damage. The intended purpose of the improvement was to warn motorists when their vehicle drifts out of the travel lane and to alleviate the frequency of run-off-road crashes.

The initial crash analysis was completed from July 1, 2000 to June 30, 2003 with 566 Ran-Off-Road crashes. The improvement was completed on November 30, 2005 with a total cost of \$203,000. The projected B/C Ratio was 89.68.

Location Photographs



SEGMENT 1: I-77 near MM 12



SEGMENT 2: I-77 near MM 23



SEGMENT 2: I-77 near MM 29



Naive Before and After Analysis

After reviewing the project file folder along with all the crashes at the subject location, the crash data omitted from this analysis to consider for an adequate construction period were from January 1, 2005 through December 31, 2005. The before period consisted of reported crashes from September 1, 2000 through December 31, 2004 (4.33 years); and the after period consisted of reported crashes from January 1, 2006 through April 30, 2010 (4.33 years). The ending date for this analysis was determined by the date of available crash data at the time of analysis. The before period ADT year was 2002 and the after period ADT year was 2008.

For the purposes of this evaluation, we assumed that there were no rumble strips present in the before period and continuous rumble strips present for the duration of the after period. Due to the number and duration of other TIP projects completed in the before and after periods, we were unable to account for construction periods associated with these.

The treatment data consisted of all mainline crashes on both treatment segments of I-77 in Mecklenburg County. The data is provided both combined and separately for Segments 1 and 2. The analysis was completed with a 0' y-line. Target crashes are lane departure crash types.

Note that due to crash data reporting problems within the Charlotte-Mecklenburg Police Department (CMPD), initial 2009 crash numbers are likely to be under reported. These numbers are expected to increase once the reporting problems within CMPD are resolved.

Segments 1 & 2 Combined (20.5 Miles)

<u>Segment 1 & 2 Treatment Information</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	4,738	4,886	3.1%
Total Severity Index	4.06	3.61	-11.1%
Lane Departure Crashes – Both Directions	2,146	1,972	-8.1%
Lane Departure Severity Index	4.20	3.84	-8.6%
Volume	114,800	119,100	3.7%

Segment 1 (12.7 Miles - From SC State Line to Beginning of Construction Project South of I-85)

<u>Segment 1 Treatment Information</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	3,949	3,905	-1.1%
Total Severity Index	3.85	3.58	-7.0%
Lane Departure Crashes – Both Directions	1,735	1,605	-7.5%
Lane Departure Severity Index	3.78	3.89	2.9%
Volume	137,100	140,400	2.4%

The following tables divide the crash data for Segment 1 by Direction of Travel:

<u>Segment 1</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Northbound Treatment Information</u>			
Total Crashes	2,135	2,038	-4.5%
Total Severity Index	3.76	3.53	-6.1%
Lane Departure Crashes	893	829	-7.2%

<u>Segment 1</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Northbound Crash Details</u>			
Segment Crashes – Injuries			
Fatal Injury Crashes	5	5	0.0%
Non-Fatal Injury Crashes	661	590	-10.7%
Property Damage Only Crashes	1,469	1,443	-1.8%
Crashes - Contributing Factors			
Night Crashes	450	417	-7.3%
Wet Road Crashes	457	376	-17.7%
Alcohol Related	74	68	-8.1%
Lane Departure Crash Types			
Angle	43	20	-53.5%
Fixed Object	226	200	-11.5%
Head On	5	3	-40.0%
Jackknife	6	5	-16.7%
Movable Object	75	91	21.3%
Overturn / Rollover	2	13	550.0%
Parked Motor Vehicle	12	5	-58.3%
Ran Off Road (Right & Left)	92	67	-27.2%
Sideswipe, Same Direction	430	424	-1.4%
Sideswipe, Opposite Direction	2	1	-50.0%

<u>Segment 1</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Southbound Treatment Information</u>			
Total Crashes	1,814	1,867	2.9%
Total Severity Index	3.97	3.64	-8.3%
Lane Departure Crashes	842	776	-7.8%

<u>Segment 1</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Southbound Crash Details</u>			
Segment Crashes – Injuries			
Fatal Injury Crashes	7	2	-71.4%
Non-Fatal Injury Crashes	573	572	-0.2%
Property Damage Only Crashes	1,234	1,293	4.8%
Crashes - Contributing Factors			
Night Crashes	381	440	15.5%
Wet Road Crashes	381	361	-5.2%
Alcohol Related	69	65	-5.8%
Lane Departure Crash Types			
Angle	40	37	-7.5%
Fixed Object	215	186	-13.5%
Head On	7	1	-85.7%
Jackknife	1	2	100.0%
Movable Object	65	53	-18.5%
Overturn / Rollover	10	14	40.0%
Parked Motor Vehicle	6	4	-33.3%
Ran Off Road (Right & Left)	93	61	-34.4%
Sideswipe, Same Direction	402	414	3.0%
Sideswipe, Opposite Direction	3	4	33.3%

The naive before and after analysis for Segment 1 on I-77 resulted in an overall 1 percent decrease in Total Crashes and a 7 percent decrease in the Total Severity Index. There was also an 8 percent decrease in Target Crashes and a 3 percent increase in the Target Severity Index. Both directions of travel for Segment 1 experienced reductions in Lane Departure Crashes.

Segment 2 (7.8 Miles - From South of SR 2136 (Gilead Rd) North to Iredell County Line)

<u>Segment 2 Treatment Information</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	789	981	24.3%
Total Severity Index	5.10	3.74	-26.7%
Lane Departure Crashes – Both Directions	411	367	-10.7%
Lane Departure Severity Index	5.97	3.65	-38.9%
Volume	78,400	84,500	7.8%

The following tables divide the crash data for Segment 2 by Direction of Travel:

<u>Segment 2</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Northbound Treatment Information</u>			
Total Crashes	366	491	34.2%
Total Severity Index	4.47	3.80	-15.0%
Lane Departure Crashes	196	198	1.0%

<u>Segment 2</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Northbound Crash Details</u>			
Segment Crashes – Injuries			
Fatal Injury Crashes	1	2	100.0%
Non-Fatal Injury Crashes	106	156	47.2%
Property Damage Only Crashes	259	333	28.6%
Crashes - Contributing Factors			
Night Crashes	89	97	9.0%
Wet Road Crashes	41	61	48.8%
Alcohol Related	18	19	5.6%
Lane Departure Crash Types			
Angle	13	5	-61.5%
Fixed Object	65	43	-33.8%
Head On	1	0	-100.0%
Jackknife	0	1	N/A
Movable Object	23	16	-30.4%
Overturn / Rollover	6	9	50.0%
Parked Motor Vehicle	3	4	33.3%
Ran Off Road (Right & Left)	30	41	36.7%
Sideswipe, Same Direction	55	78	41.8%
Sideswipe, Opposite Direction	0	1	N/A

<u>Segment 2</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Southbound Treatment Information</u>			
Total Crashes	423	490	15.8%
Total Severity Index	5.64	3.68	-34.8%
Lane Departure Crashes	215	169	-21.4%

<u>Segment 2</u>	Before	After	Percent Reduction (-)/ Percent Increase (+)
<u>Southbound Crash Details</u>			
Segment Crashes – Injuries			
Fatal Injury Crashes	3	0	-100.0%
Non-Fatal Injury Crashes	142	150	5.6%
Property Damage Only Crashes	278	340	22.3%
Crashes - Contributing Factors			
Night Crashes	120	101	-15.8%
Wet Road Crashes	96	90	-6.3%
Alcohol Related	21	15	-28.6%
Lane Departure Crash Types			
Angle	14	1	-92.9%
Fixed Object	66	44	-33.3%
Head On	1	1	0.0%
Jackknife	3	0	-100.0%
Movable Object	24	19	-20.8%
Overturn / Rollover	10	9	-10.0%
Parked Motor Vehicle	5	0	-100.0%
Ran Off Road (Right & Left)	32	37	15.6%
Sideswipe, Same Direction	60	58	-3.3%
Sideswipe, Opposite Direction	0	0	N/A

The naive before and after analysis for Segment 2 on I-77 resulted in an overall 24 percent increase in Total Crashes and a 27 percent decrease in the Total Severity Index. There was also an 11 percent decrease in Target Crashes and a 39 percent decrease in the Target Severity Index. For Segment 2, the northbound direction experienced a slight increase in Lane Departure Crashes (Night and Wet Road Crashes also increased in this direction); while the southbound direction experienced a substantial decrease in Lane Departure Crashes.

Results and Discussion

Overall, using naïve before and after analysis, the number of Total Crashes increased while the number of Target Crashes decreased. Overall, the severity index of both Total and Target Crashes decreased. The results broken down by segment are as follows:

Segment 1 (SL-SC to MM 12.7) experienced a 1 percent decrease in Total Crashes and a 7 percent decrease in the Total Severity Index. There was also an 8 percent decrease in Target Crashes and a 3 percent increase in the Target Severity Index. For Segment 1, results were fairly similar between directions of travel. Both directions of travel experienced reductions in the Severity Index, Target Crashes, and Wet Road Crashes.

Segment 2 (MM 22.45 to CL-Iredell) experienced a 24 percent increase in Total Crashes and a 27 percent decrease in the Total Severity Index. There was also an 11 percent decrease in Target Crashes and a 39 percent decrease in the Target Severity Index. For Segment 2, there appears to be some difference in the results by direction, with generally greater crash increases in the NB direction. Some of this may be attributed to a 49 percent increase in the number of Wet Road Crashes for NB Segment 2, which increased from 41 to 61 crashes.

The number of Fatal and Class-A injury crashes decreased substantially (by 46%) in the After Period, some of which may be attributed to a decrease in high severity Target Lane Departure Crashes for both directions of Segment 2. For Segment 2, the number of Fatal and Class-A injury Lane Departure Crashes decreased from 16 Crashes in the before period to 2 Crashes in the after period.

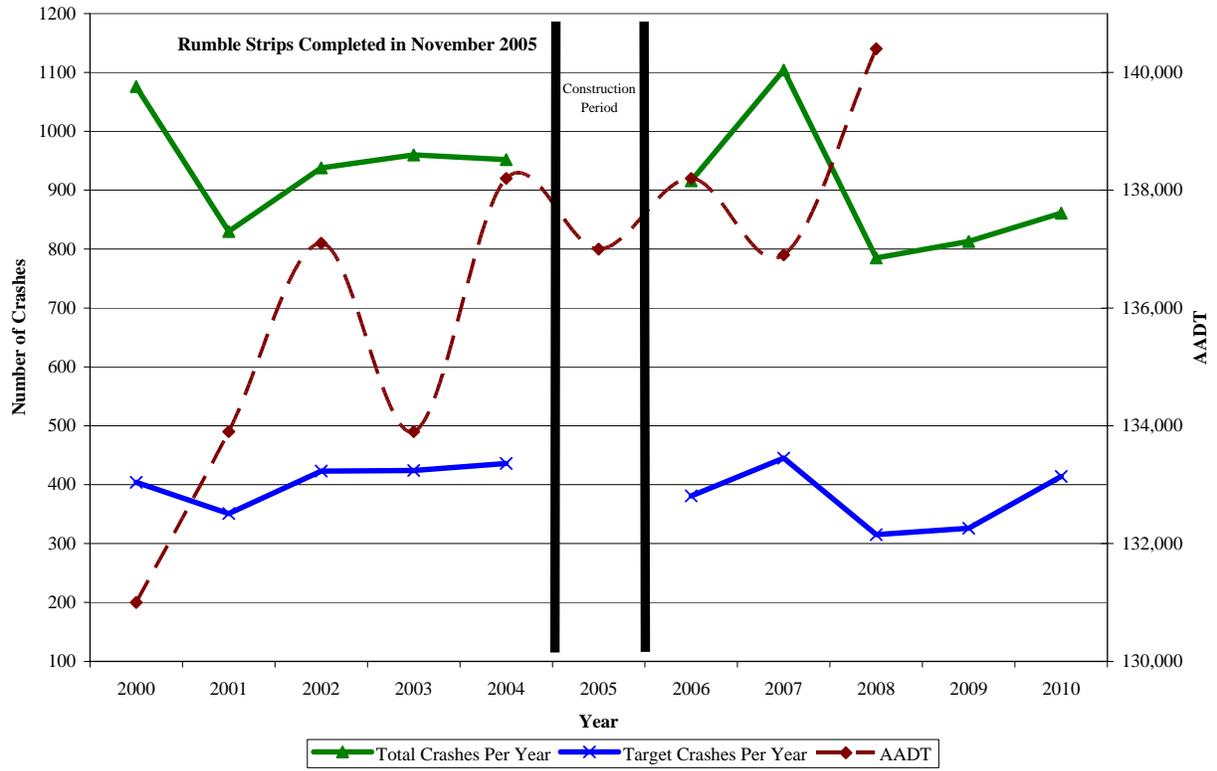
The calculated benefit to cost ratio for W-4834 is **104.76** considering Total Crashes. The benefit to cost ratio considering only Target Crashes is **75.70**. The benefits are calculated using the change in annual crash costs from the before to the after period. Operational and other benefits related to the project are not considered in this analysis. The costs of the project include the actual construction costs as well as the increase in annual maintenance costs when applicable.

Due to other projects that may have influenced crashes in our before and after periods but that we are unable to account for in the analysis, the change in crashes cannot be attributed solely to the rumble strip installations. The impact of these other projects on crashes is not known.

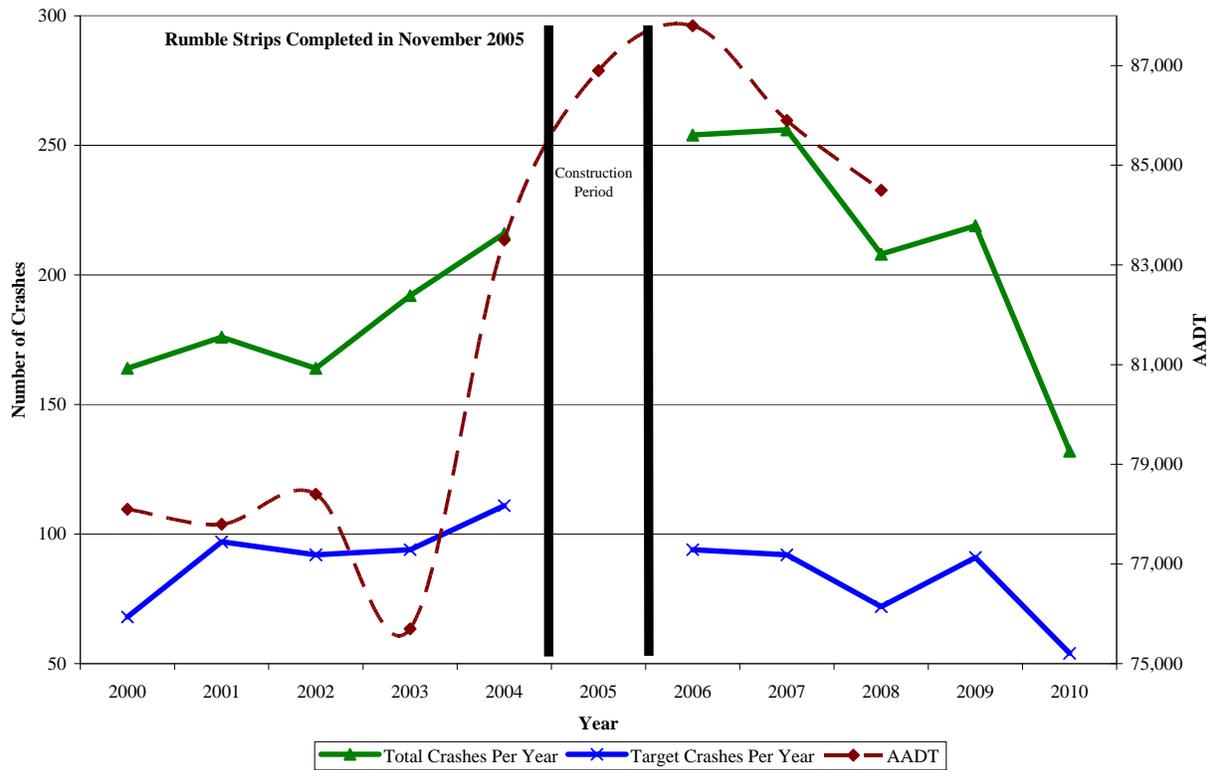
As the Safety Evaluation Group completes additional spot safety reviews for this type of countermeasure, we will be able to provide objective and definite information regarding actual crash reduction factors for this type of treatment.

The following charts depict the crash trends along Segments 1 and 2 on I-77 in Mecklenburg County. The number of Total and Target Crashes per year are plotted in the before and after period, along with the AADT.

I-77 Mecklenburg County - Segment 1 Crashes Per Year



I-77 Mecklenburg County - Segment 2 Crashes Per Year



BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-77
 COUNTY: Mecklenburg
 FILE NO.: W-4834

BY: CLS
 DATE: 8/18/2010

TOTAL CRASHES

DETAILED COST: TYPE IMPROVEMENT - Rumblestrips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$203,000	10	0.149	\$30,253
		0	0.000	\$0
		0	0.000	\$0
TOTALS	\$203,000	10	0.149	\$30,253

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$0
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$0
 TOTAL ANNUAL COST= \$30,253
 TOTAL COST OF PROJECT= \$203,000

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	4.33	50	11.55	1448	334.41	3240	748.27	\$17,180,600
AFTER	4.33	27	6.24	1450	334.87	3409	787.30	\$14,011,247

Annual Benefits from Crash Cost Savings \$3,169,353

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = \$3,139,100

BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = 104.76

TOTAL COST OF PROJECT - \$203,000 COMPREHENSIVE B/C RATIO - 104.76

BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-77
 COUNTY: Mecklenburg
 FILE NO.: W-4834
 TARGET CRASHES

BY: CLS
 DATE: 8/18/2010

DETAILED COST: TYPE IMPROVEMENT - Rumblestrips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$203,000	10	0.149	\$30,253
		0	0.000	\$0
		0	0.000	\$0
TOTALS	\$203,000	10	0.149	\$30,253

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$0
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$0
 TOTAL ANNUAL COST= \$30,253
 TOTAL COST OF PROJECT= \$203,000

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	4.33	35	8.08	569	131.41	1542	356.12	\$9,251,871
AFTER	4.33	21	4.85	543	125.40	1408	325.17	\$6,961,755

Annual Benefits from Crash Cost Savings \$2,290,115

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = \$2,259,862

BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = 75.70

TOTAL COST OF PROJECT - \$203,000 COMPREHENSIVE B/C RATIO - 75.70