Hazard Elimination Project Evaluation

Order # 41000017675

Hazard Elimination Project W-4824

Evaluation of the Rumble Strip Installation

Davie & Forsyth Counties

Documents Prepared By:

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

Principal Investigator

Jason B. Schronce
Traffic Safety Project Engineer

9-26-2012
Date

Hazard Elimination Project Evaluation Documentation

Subject Location

Evaluation of Hazard Elimination Project Number W-4824 located along five different segments in Davie and Forsyth Counties, around the Cities of Mocksville, Clemmons, and Winston-Salem for a total distance of 27.829 miles:

Segment 1 – Davie: I-40 from the Iredell County Line to Mile Marker 175 (MP 0.00 – 12.648)

Segment 2 – Davie & Forsyth: I-40 from 0.35 west of NC-801 in Davie County to 0.1 mile east of SR 1101 in Forsyth County (Davie MP 17.433-19.231 / Forsyth MP 0.00 – 0.980)

Segment 3 – Forsyth: I-40 from 0.35 mile west of SR 1120/1122 to 0.5 mile west of US-158 (MP 4.99 – 6.92)

Segment 4 – Forsyth: I-40 from 0.7 mile east of US-52 to US-311 (MP 12.55 – 14.090)

Segment 5 – Forsyth: US-311 from Guilford County Line to I-40 Interchange (MP 0.00 – 8.933)

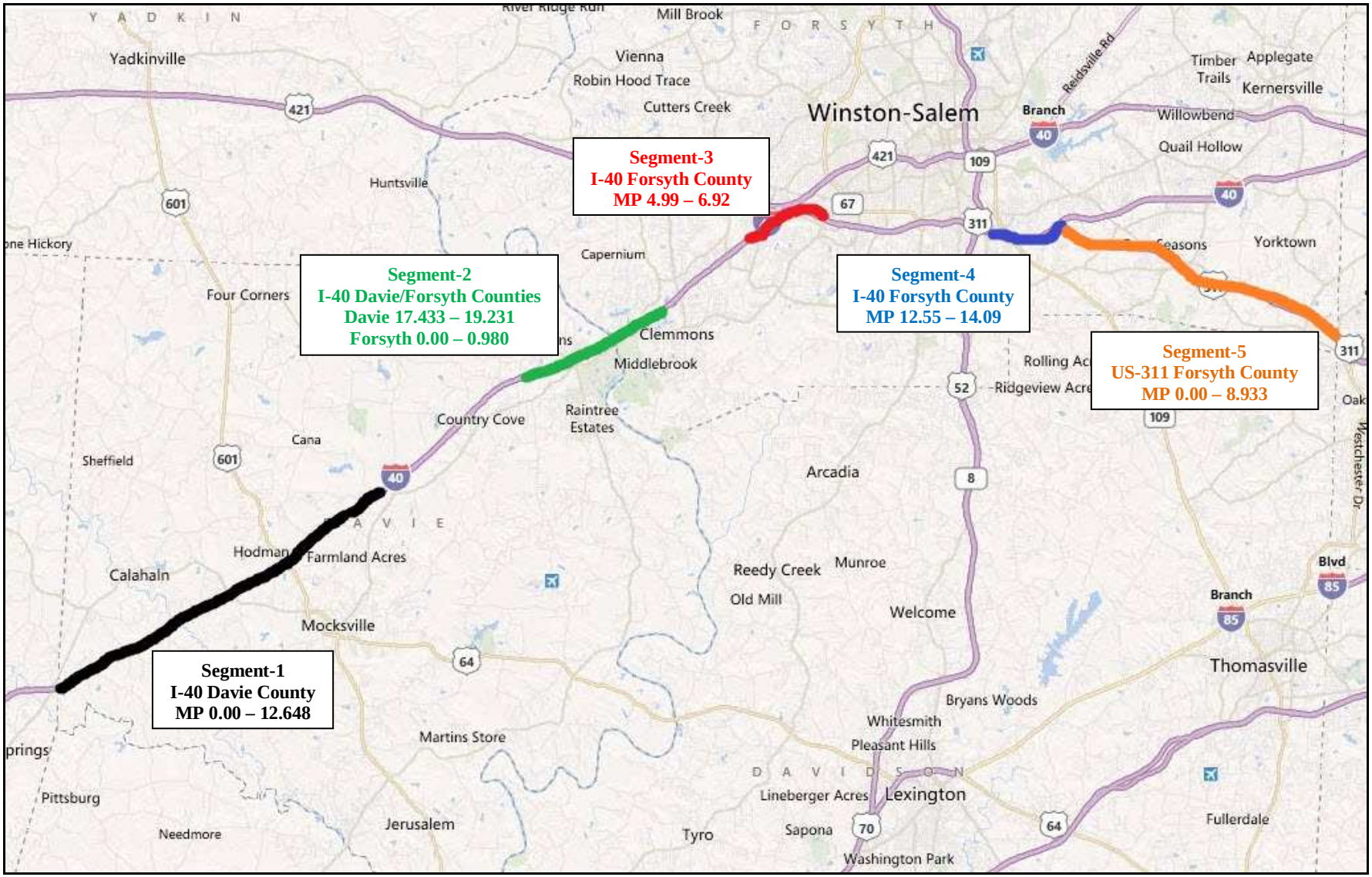
Project Information and Background from the Project File Folder

The hazard elimination project improvement chosen for the subject locations were the installation of milled rumble strips along the inside and outside shoulders of these roadway segments.

I-40 and US-311 are both divided controlled access highways with constant median w-beam or cable barriers. The lane configurations vary between 2 and 4 lanes per direction along these routes. The paved median shoulder width varies from 2 to 8 feet and the paved outside shoulder width varies from 2 to 12 feet. The interstate speed limit ranges from 70-mph in Davie County to 55-mph through the City of Winston-Salem in Forsyth County. The total countermeasure improvement distance is 27.829 miles.

The original statement of problem mentioned that vehicles were running off the road resulting in fatalities, serious injuries, and property damage. Lane departure crashes often result from fatigued or inattentive drivers. Rumble strips provide both noise and vibration as a warning to motorists that they are leaving the travel lane.

The initial crash analysis was completed from August 1, 2000 to August 1, 2003 with 692 reported crashes, with 375 crashes considered correctable Ran-Off Road collisions. The improvement was completed on June 30, 2006 with a total cost of $175,000. The projected B/C Ratio was 78.28.


Segment-3
I-40 Forsyth County
MP 4.99 – 6.92
Segment-2
I-40 Davie/Forsyth Counties
Davie 17.433 – 19.231
Forsyth 0.00 – 0.980
Segment-4
I-40 Forsyth County
MP 12.55 – 14.09
Segment-5
US-311 Forsyth County
MP 0.00 – 8.933
Segment-1
I-40 Davie County
MP 0.00 – 12.648
Yadkinville
Vienna
Robin Hood Trace
Cutters Creek
Winston-Salem
Huntsville
Capernium
Four Corners
Clemmons
Middlebrook
Country Cove
Raintree Estates
Cana
Sheffield
Arcadia
Calahaln
Hodman
Farmland Acres
Mocksville
Reedy Creek
Munroe
Old Mill
Welcome
Thomasville
Bryans Woods
Whitesmith
Pleasant Hills
Martins Store
Lineberger Acres
Lexington
Pittsburg
Needmore
Jerusalem
Tyro
Sapona
Washington Park
Fullerdale
Timber Trails
Applegate
Kernersville
Willowbend
Quail Hollow
Yorktown
Rolling Ac
Ridgeview Acre
Reidsville Rd
Branch
Blvd
Westchester Dr

Google Maps – Typical I-40 Roadway Segment

Naive Before and After Analysis

After reviewing the project file folder along with all the crashes along the subject segment, the crash data omitted from this analysis to consider for an adequate construction period were the months of April through June 2006. The before period consisted of reported crashes from June 1, 2000 through March 31, 2006 (5 years, 10 months); and the after period consisted of reported crashes from July 1, 2006 through April 30, 2012 (5 years, 10 months). The ending date for this analysis was determined by the date of available crash data at the time of analysis.

The treatment data consisted of all crashes along these segments with a zero (0) foot y-line (No Ramps). *Please see attached location map for further details.*

The following data table depicts the Naive Before and After Analysis for the treatment location. Please note that Freeway Lane Departure Crashes were the target crashes for the applied countermeasure. The Freeway Lane Departure Crash types considered are as follows: Angle; Fixed Object; Head-On; Jackknife; Overturn/Rollover; Parked Motor Vehicle; Ran-Off Roadway (Right, Left, Straight); and Sideswipe (Same and Opposite Direction). All lane departure crashes were independently verified from the fiche analysis.

Treatment Information – All 5 Segments	**Before**	**After**	**Percent Reduction (-)/ Percent Increase (+)**
Total Crashes – All 5 Segments	1532	1778	16.1 %
Total Severity Index	4.49	4.13	- 8.0 %
LD Crashes – All 5 Segments	1063	1186	11.6 %
Lane Departure Severity Index	4.66	4.45	- 4.5 %

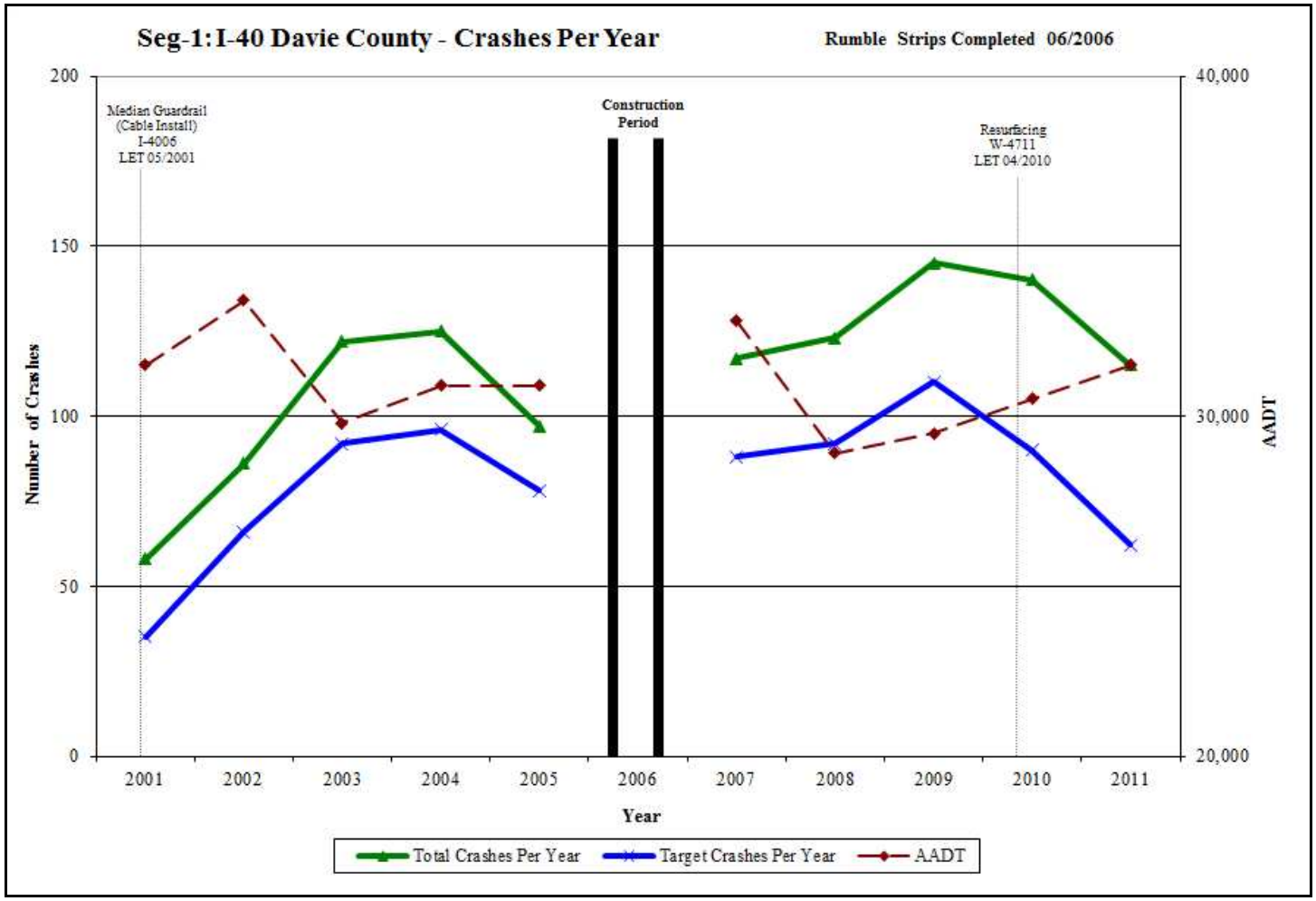
The following tables and charts examine the data by segment. Each segment is further displayed by direction and provided a chart of crashes per year that also list out other TIP projects that were discovered to have occurred on the route by LET date.

S1-Davie: I-40 (MP 0.00 – 12.648)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	542	722	33.2 %
Total Severity Index	4.51	4.27	- 6.0 %
LD Crashes – Both Directions	400	497	24.3 %
Lane Departure Severity Index	4.56	4.66	2.2 %
Volume (2003, 2009)	29,800	29,500	- 1.0 %
Total Crash Rate (100 Million Vehicle Miles)	67.51	90.81	34.5 %
Injury Crashes			
Fatal Injury Crashes	3	6	100.0 %
Class-A Injury Crashes	11	9	- 18.2 %
Class-B Injury Crashes	52	71	36.5 %
Class-C Injury Crashes	62	94	51.6 %
Property Damage Only Crashes	414	542	30.9 %
Contributing Factors			
Night Crashes	142	256	80.3 %
Animal Crashes	43	83	93.0 %
Wet Road Crashes	272	308	13.2 %
Alcohol / Drug Related	12	27	125.0 %

Seg-1 I-40 Eastbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
EB Total Crashes	271	359	32.5 %
EB Total Severity Index	5.05	4.65	- 7.9 %
EB Lane Departure Crashes	204	239	17.2 %
EB Lane Departure Severity Index	5.16	5.49	6.4 %

Seg-1 I-40 Westbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
WB Total Crashes	271	363	33.9 %
WB Total Severity Index	3.98	3.88	- 2.5 %
WB Lane Departure Crashes	196	258	31.6 %
WB Lane Departure Severity Index	3.93	3.90	- 0.8 %

Segment-1 experienced an increase of 33 percent in Total Crashes with a 24 percent increase in Lane Departure Crashes. However, the Total Severity Index saw a 6 percent reduction but Severe Injury Crashes (Fatal and A-injury) increased slightly from fourteen (14) to fifteen (15) from the before to the after period. Contributing factors include an 80 percent increase in night crashes with a significant increase in Animal crashes from 43 to 83 through the evaluation.



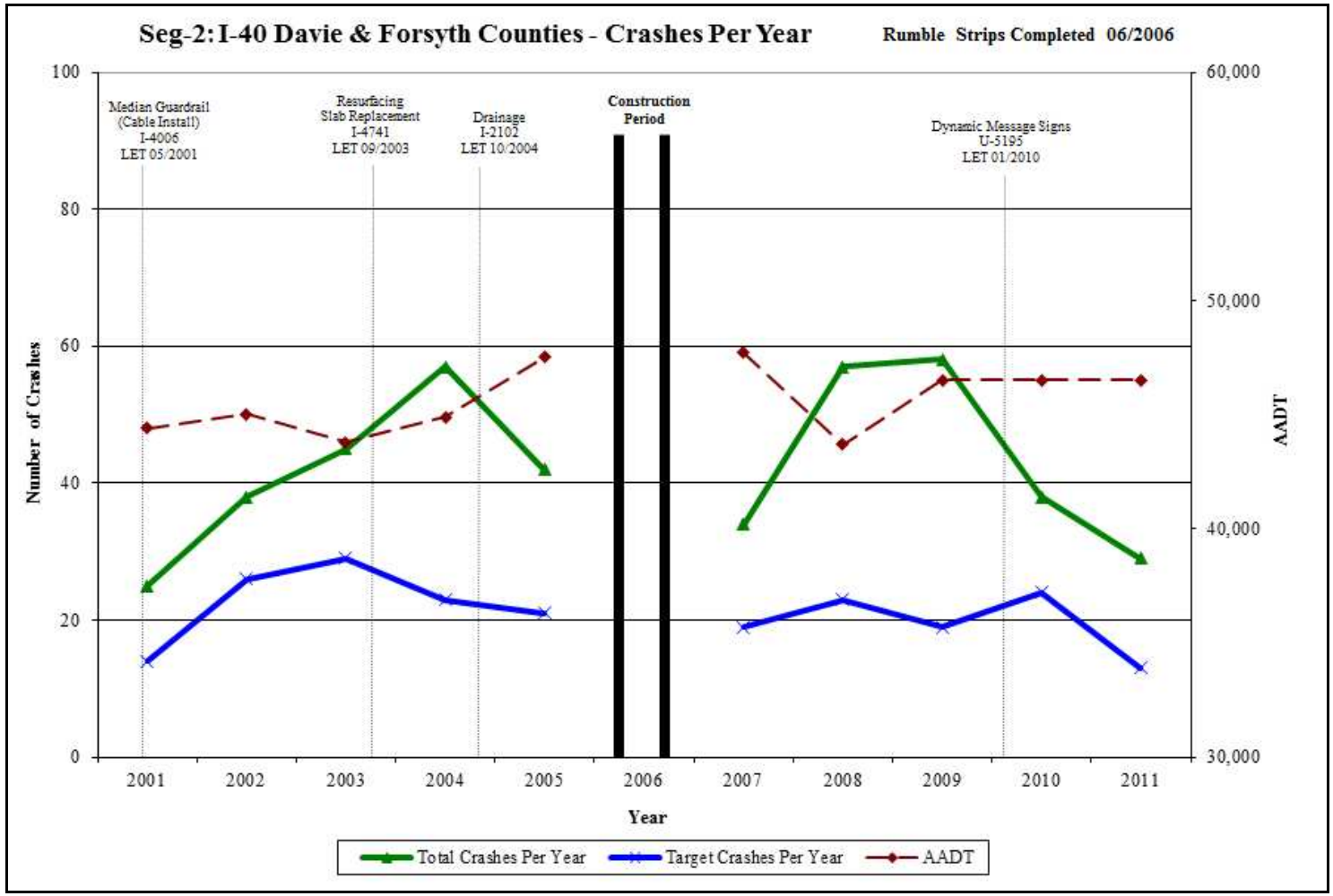
The previous chart depicts the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for this segment. Segment-1 total crashes per year increased significantly in the before period following the installation of median guardrail. Also, after period crashes per year decreased following the W-4711 Resurfacing project. The TIP Letting website was searched for projects that were completed along this routes and two were discovered. However, the Safety Evaluation Group cannot conclude that other funds may have been used to complete construction, safety, or resurfacing projects along this roadway segment that may have affected crashes during the study periods.

S2-Davie/Forsyth: I-40 (MP 17.433–19.231 & 0.00–0.980)	**Before**	**After**	**Percent Reduction (-)/ Percent Increase (+)**
Total Crashes – Both Directions	230	233	1.3%
Total Severity Index	5.23	4.01	- 23.3 %
LD Crashes – Both Directions	128	110	- 14.1 %
Lane Departure Severity Index	5.91	4.04	- 31.6 %
Volume (2003, 2009)	43,800	46,500	6.2 %
Total Crash Rate (100 Million Vehicle Miles)	88.74	84.64	- 4.6 %
Injury Crashes			
Fatal Injury Crashes	3	1	- 66.7 %
Class-A Injury Crashes	3	2	- 33.3 %
Class-B Injury Crashes	30	17	- 43.3 %
Class-C Injury Crashes	40	47	17.5 %
Property Damage Only Crashes	154	166	7.8 %
Contributing Factors			
Night Crashes	84	80	- 4.8 %
Animal Crashes	17	20	17.6 %
Wet Road Crashes	42	34	- 19.0%
Alcohol / Drug Related	12	7	- 41.7 %

Seg-2 I-40 Eastbound Only	**Before**	**After**	**Percent Reduction (-)/ Percent Increase (+)**
EB Total Crashes	111	115	3.6 %
EB Total Severity Index	4.30	3.59	- 16.5 %
EB Lane Departure Crashes	62	59	- 4.8 %
EB Lane Departure Severity Index	4.13	4.79	16.0 %

Seg-2 I-40 Westbound Only	**Before**	**After**	**Percent Reduction (-)/ Percent Increase (+)**
WB Total Crashes	119	118	- 0.8 %
WB Total Severity Index	6.10	4.42	- 27.5 %
WB Lane Departure Crashes	66	51	- 22.7 %
WB Lane Departure Severity Index	7.58	3.18	- 58.0 %

Segment-2 experienced a 1 percent increase in Total Crashes and a 14 percent reduction in Lane Departure Crashes through the evaluation periods. The Total Severity Index reduced by 23 percent with a reduction in Severe Injury Crashes (Fatals and A-injury) from six (6) to three (3) from the before to the after periods. The section of roadway improved slightly in the after period with the westbound direction showing a 23 percent reduction in lane departure crashes.



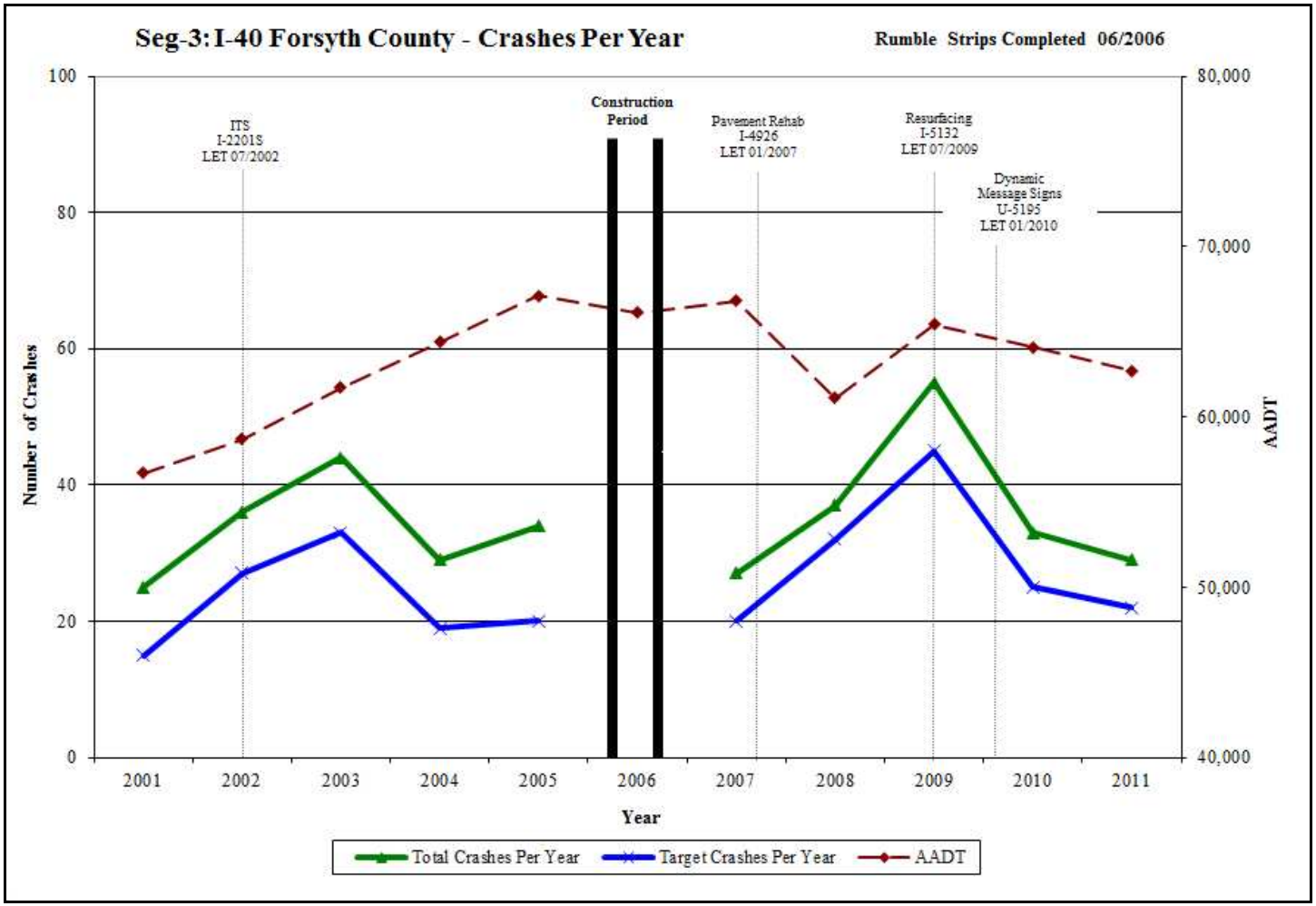
The previous chart depicts the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for this segment. Segment-2 total crashes per year appear to have increased steadily in the before period then spiked in 2008/2009 for an unknown conclusive reason. The lane departure target crashes stayed consistent through the analysis. The TIP Letting website was searched for projects that were completed along these routes and four were discovered. However, the Safety Evaluation Group cannot conclude that other funds may have been used to complete construction, safety, or resurfacing projects along this roadway segment that may have affected crashes throughout the study periods.

S3-Forsyth: I-40 (MP 4.99 – 6.92)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	186	212	14.0 %
Total Severity Index	3.48	4.06	16.7 %
LD Crashes – Both Directions	122	156	27.9 %
Lane Departure Severity Index	3.87	3.72	- 3.9 %
Volume (2003, 2009)	61,700	65,400	6.0 %
Total Crash Rate (100 Million Vehicle Miles)	73.33	78.82	7.5 %
Injury Crashes			
Fatal Injury Crashes	1	0	- 100.0 %
Class-A Injury Crashes	0	3	300.0 %
Class-B Injury Crashes	10	24	140.0 %
Class-C Injury Crashes	42	33	- 21.4 %
Property Damage Only Crashes	133	152	14.3 %
Contributing Factors			
Night Crashes	50	70	40.0 %
Animal Crashes	12	7	- 41.7 %
Wet Road Crashes	77	84	9.1 %
Alcohol / Drug Related	10	10	0.0 %

Seg-3 I-40 Eastbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
EB Total Crashes	67	95	41.8 %
EB Total Severity Index	2.33	3.75	60.9 %
EB Lane Departure Crashes	33	66	100.0 %
EB Lane Departure Severity Index	2.79	3.35	20.1 %

Seg-3 I-40 Westbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
WB Total Crashes	119	117	- 1.7 %
WB Total Severity Index	4.12	4.32	4.9 %
WB Lane Departure Crashes	89	90	1.1 %
WB Lane Departure Severity Index	4.26	3.98	- 6.6 %

Segment-3 experienced a 14 percent increase in Total Crashes and a 28 percent increase in Lane Departure Crashes through the evaluation periods. The Total Severity Index reduced by 17 percent with an increase in Severe Injury Crashes (Fatals and A-injury) from one (1) to three (3) from the before to the after periods. The directional analysis indicates that the crash increase along this segment occurred in the eastbound direction. The westbound direction shows a 1 percent increase in lane departure crashes while the eastbound direction doubled from the before to the after period.



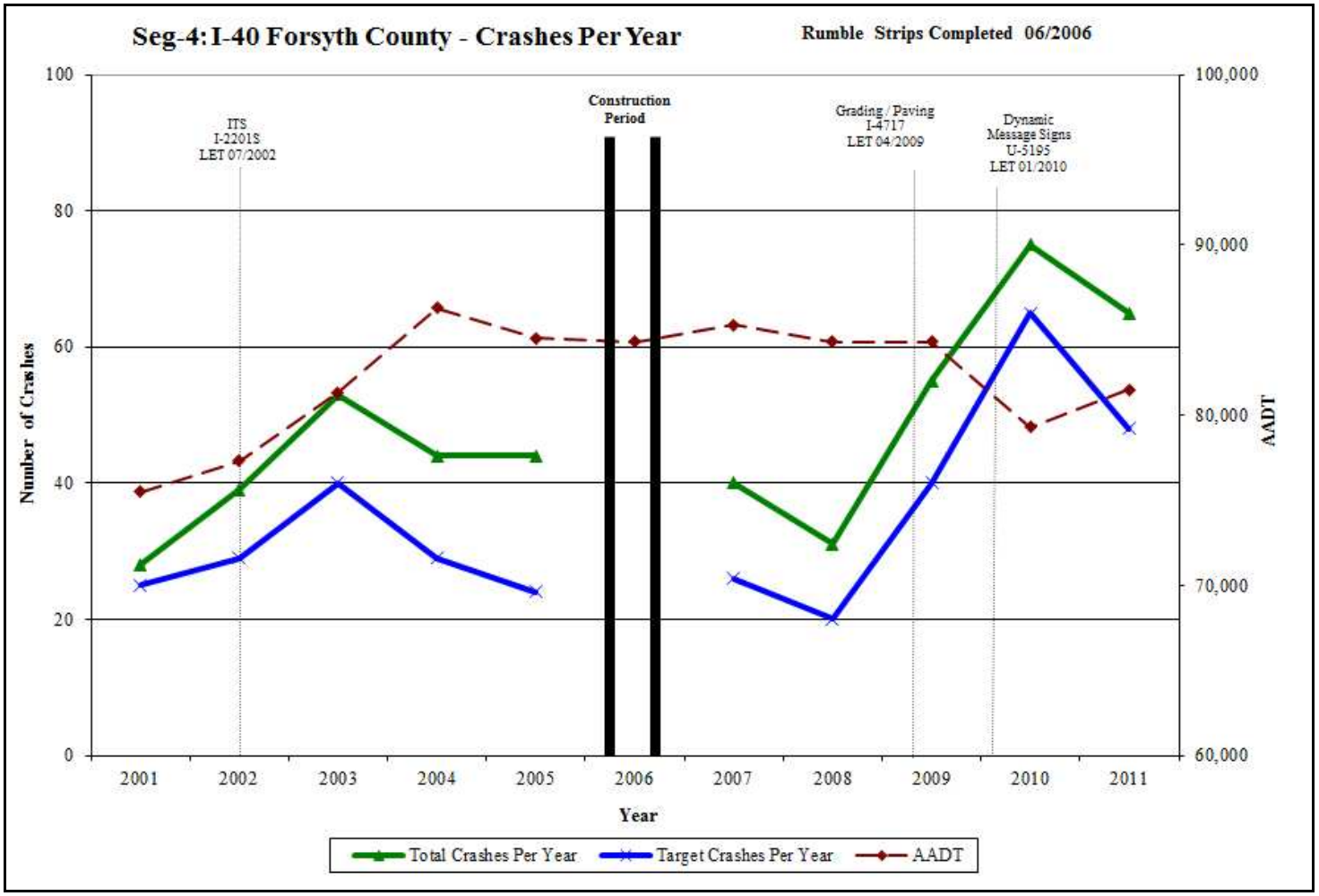
The previous chart depicts the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for this segment. Segment-3 total and lane departure crashes per year appear to have spiked in 2008 and 2009 following the pavement rehab project. However, the crashes per year have been declining since the resurfacing project in July 2009. The TIP Letting website was searched for projects that were completed along these routes and four were discovered. The Safety Evaluation Group cannot conclude that other funds may have been used to complete construction, safety, or resurfacing projects along this roadway segment that may have affected crashes throughout the evaluation periods.

S4-Forsyth: I-40 (MP 12.55 – 14.09)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	230	290	26.1 %
Total Severity Index	5.07	3.83	- 30.4 %
LD Crashes – Both Directions	163	217	33.1 %
Lane Departure Severity Index	5.50	4.27	- 22.4 %
Volume (2003, 2009)	81,300	84,300	3.7 %
Total Crash Rate (100 Million Vehicle Miles)	86.25	104.83	21.5 %
Injury Crashes			
Fatal Injury Crashes	3	1	- 66.7 %
Class-A Injury Crashes	3	3	0.0 %
Class-B Injury Crashes	19	21	10.5 %
Class-C Injury Crashes	46	49	6.5 %
Property Damage Only Crashes	159	216	35.8 %
Contributing Factors			
Night Crashes	56	80	42.9 %
Animal Crashes	6	5	- 16.7 %
Wet Road Crashes	54	115	113.0 %
Alcohol / Drug Related	10	8	- 20.0 %

Seg-4 I-40 Eastbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
EB Total Crashes	99	101	2.0 %
EB Total Severity Index	4.47	3.58	- 19.9 %
EB Lane Departure Crashes	70	72	2.9 %
EB Lane Departure Severity Index	5.28	4.01	- 24.1 %

Seg-4 I-40 Westbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
WB Total Crashes	131	189	44.3 %
WB Total Severity Index	5.52	3.97	- 28.1 %
WB Lane Departure Crashes	93	145	55.9 %
WB Lane Departure Severity Index	5.67	4.41	- 22.2 %

Segment-4 experienced a 26 percent increase in Total Crashes and a 33 percent increase in Lane Departure Crashes through the evaluation periods. The Total Severity Index reduced by 30 percent with a reduction in Severe Injury Crashes (Fatals and A-injury) from six (6) to four (4) from the before to the after periods. The directional analysis indicates that the crash increase occurred solely in westbound direction of this segment. The eastbound direction only experienced a 2 percent increase in total and target crashes whereas westbound saw increases greater than 40 percent.



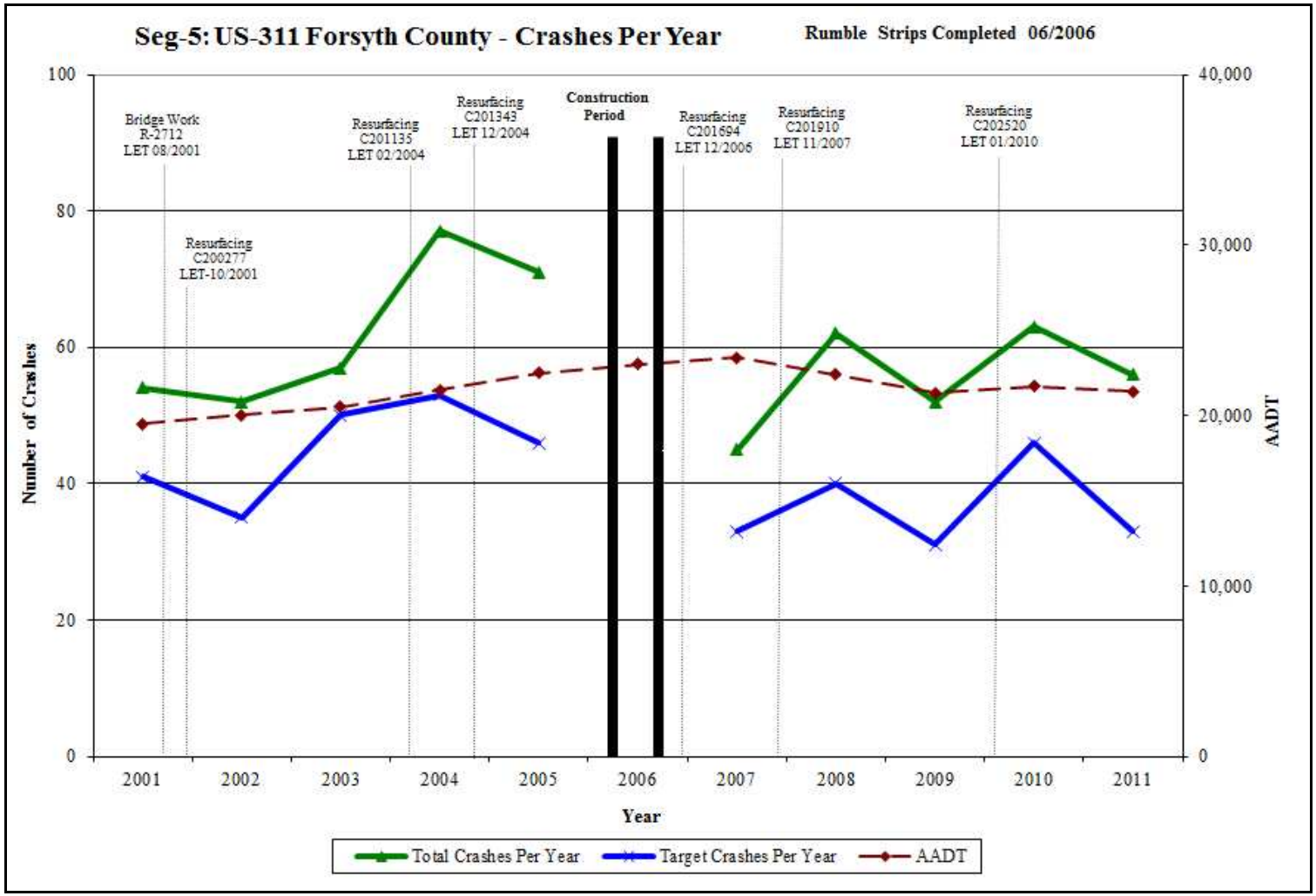
The previous chart depicts the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for this segment. Segment-4 total and lane departure crashes per year appear to have spiked in 2009 and 2010 following the I-4717 paving project. However, crashes per year did experience a reduction in 2011 for an unknown conclusive reason. The TIP Letting website was searched for projects that were completed along these routes and three were discovered. The Safety Evaluation Group cannot conclude that other funds may have been used to complete construction, safety, or resurfacing projects along this roadway segment that may have affected crashes throughout the study periods.

S5-Forsyth: US-311 (MP 0.00 – 8.933)	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes – Both Directions	344	321	- 6.7 %
Total Severity Index	4.11	4.24	3.2%
LD Crashes – Both Directions	250	206	- 17.6 %
Lane Departure Severity Index	4.01	4.92	22.7 %
Volume (2003, 2009)	20,500	21,300	3.9 %
Total Crash Rate (100 Million Vehicle Miles)	88.19	79.17	- 10.2 %
Injury Crashes			
Fatal Injury Crashes	2	5	150.0 %
Class-A Injury Crashes	4	1	- 75.0 %
Class-B Injury Crashes	18	26	44.4 %
Class-C Injury Crashes	65	53	- 18.5 %
Property Damage Only Crashes	255	236	- 7.5 %
Contributing Factors			
Night Crashes	133	133	0.0 %
Animal Crashes	50	62	24.0 %
Wet Road Crashes	138	129	- 6.5 %
Alcohol / Drug Related	23	17	- 26.1 %

Seg-5 US-311 Northbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
NB Total Crashes	176	165	- 6.3 %
NB Total Severity Index	4.53	3.67	- 19.0 %
NB Lane Departure Crashes	130	114	- 12.3 %
NB Lane Departure Severity Index	4.33	4.34	0.2 %

Seg-5 US-311 Southbound Only	Before	After	Percent Reduction (-)/ Percent Increase (+)
SB Total Crashes	168	156	- 7.1 %
SB Total Severity Index	3.66	4.84	32.2 %
SB Lane Departure Crashes	120	92	- 23.3 %
SB Lane Departure Severity Index	3.67	5.64	53.7 %

Segment-5 experienced a 7 percent reduction in Total Crashes and an 18 percent reduction in Lane Departure Crashes through the evaluation periods. The Total Severity Index increased by 3 percent with the same number (6) of Severe Injury Crashes (Fatals and A-injury) in both the before and after periods. The crash data shows that this segment performed similarly in the after period with the southbound direction experiencing the greatest benefit with a 23 percent reduction in lane departure collisions.



The previous chart depicts the number of Total and Target Crashes per year plotted in the before and after period, along with the AADT for this segment. Segment-5 total crashes per year appear to fairly consistent in the after period following a before period spike in 2004. The TIP Letting website was searched for projects that were completed along these routes and seven were discovered. The Safety Evaluation Group cannot conclude that other funds may have been used to complete construction, safety, or resurfacing projects along this roadway segment that may have affected crashes throughout the study period.

Results and Discussion

Reviewing the tables above, the combined segments overall increased crashes by 16 percent with an 11 percent increase in Lane Departure collisions from the before to the after period. However, there was a slight decrease in the Total Severity Index by 8 percent. Please see the previous tables for a breakdown of each segment individually.

The calculated benefit to cost ratio for this project is **(-3.99) considering total crashes (all five segments)**. The benefit to cost ratio **considering only lane departure target crashes is (-6.36)**. 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 and utility costs.

As the Safety Evaluation Group completes additional 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.

BENEFIT-COST ANALYSIS WORKSHEET - Total Crashes (5 Segments)

LOCATION: 5 Segmets of I-40/US-311 BY: JBS
COUNTY: Davie / Forsyth DATE: 9/12/2012
FILE NO.: W-4824

DETAILED COST: TYPE IMPROVEMENT - Median & Shoudler Rumblestips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	$175,000	10	0.149	$26,080
	$0	0	0.000	$0
Right-of-Way	$0	0	0.000	$0
TOTALS	$175,000	10	0.149	$26,080

ESTIMATED INCREASE IN ANNUAL MAINT. COST = $0
ESTIMATED INCREASE IN ANNUAL UTILITY COST = $0

TOTAL ANNUAL COST= $26,080
TOTAL COST OF PROJECT= $175,000

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	5.84	33	5.65	384	65.75	1115	190.92	$5,695,976
AFTER	5.84	31	5.31	435	74.49	1312	224.66	$5,799,932

Annual Benefits from Crash Cost Savings ($103,955)

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = ($130,036)

BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = -3.99

TOTAL COST OF PROJECT - $175,000 COMPREHENSIVE B/C RATIO - -3.99

BENEFIT-COST ANALYSIS WORKSHEET - Target Crashes (5 Segments)

LOCATION: 5 Segmets of I-40/US-311 BY: JBS
COUNTY: Davie / Forsyth DATE: 9/12/2012
FILE NO.: W-4824 Lane Departure Crashes

DETAILED COST: TYPE IMPROVEMENT - Median & Shoudler Rumblestips

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	$175,000	10	0.149	$26,080
	$0	0	0.000	$0
Right-of-Way	$0	0	0.000	$0
TOTALS	$175,000	10	0.149	$26,080

ESTIMATED INCREASE IN ANNUAL MAINT. COST = $0
ESTIMATED INCREASE IN ANNUAL UTILITY COST = $0

TOTAL ANNUAL COST= $26,080
TOTAL COST OF PROJECT= $175,000

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	5.84	23	3.94	290	49.66	750	128.42	$4,026,541
AFTER	5.84	23	3.94	318	54.45	845	144.69	$4,192,380

Annual Benefits from Crash Cost Savings ($165,839)

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = ($191,919)

BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = -6.36

TOTAL COST OF PROJECT - $175,000 COMPREHENSIVE B/C RATIO - -6.36