

Hazard Elimination Project Evaluation

Order # 41000003161 & 41000003162

Hazard Elimination Project W-4440 & W-4444

Evaluation of Six Dynamic Message Signs on I-40 and I-26 in Buncombe and Henderson Counties

Documents Prepared By:

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Date

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Hazard Elimination Project Evaluation Documentation

SUBJECT LOCATION

On I-40 at MM 40.7 eastbound, MM 48.4 westbound, and MM 59.9 westbound in Buncombe County. On I-26 at MM 40.1 westbound in Buncombe County and on I-26 at MM 46.8 westbound and MM 50.9 eastbound in Henderson County.



Location Map and Approximate Dynamic Message Sign Placement (Map Source: MapQuest)

PROJECT INFORMATION

The safety countermeasures chosen were to install three Dynamic Message Signs (DMS) on I-40 under project W-4440 and three DMS on I-26 under project W-4444 in the vicinity of Asheville.

The projects were requested by the NC State Highway Patrol. The statement of problem was that a lack of incident management devices contributed to motorists' inability to react to a crash or other hazard ahead of time. According to the project files, a lack of warning of crashes or other dangers ahead aided in Rear End and Run Off Road crashes. Numerous secondary crashes were occurring because motorists were unaware of incidents ahead of them. The signs were intended to inform motorists of incidents that occurred and suggest alternate detours where applicable. Below is a photo of the DMS at MM 48.4 on I-40, obtained from Google Maps.



DMS at I-40 MM 48.4 Westbound

The initial crash analyses were completed from January 1, 1999 through December 31, 2001. For the I-26 project, there were 403 Total Crashes, including 187 Rear End Crashes and 216 Ran Off Road Crashes. For the I-40 project, there were 285 Total Crashes, including 150 Rear End Crashes and 135 Ran Off Road Crashes.

The approximate final completion date was on June 1, 2004 with a total estimated cost of \$990,000 for the I-26 signs and \$990,000 for the I-40 signs, for a total of \$1,980,000. The projected benefit cost ratios were 17.27:1 for the I-26 signs and 13.18:1 for the I-40 signs.

NAÏVE BEFORE AND AFTER ANALYSIS

After reviewing the hazard elimination project file folders along with all the crashes at the subject locations, the crash data omitted from this analysis to consider for an adequate construction period was from October 1, 2003 through June 30, 2004. The before period consisted of reported crashes from June 1, 1998 through September 30, 2003 (5 years, 4 months) and the after period consisted of reported crashes from July 1, 2004 through October 31, 2009 (5 years, 4 months). The ending date

for this analysis was determined by the available crash data at the time the crash analysis was completed. The before period ADT year was 2001 and the after period ADT year was 2007.

The treatment data consisted of crashes on I-40 and I-26 that occurred from 0.1 miles upstream of a DMS to 5 miles downstream of a DMS. Crashes were only analyzed in the direction of the DMS.

Target crashes were secondary crashes that occurred from ½ hour - 2 hours after a prior crash and were upstream of the prior crash. The ½ hour is an estimation of the time it takes to display a message on the DMS after an initial crash. Messages are displayed after NCDOT is alerted of an incident by the NC State Highway Patrol. It then takes an average of 12-15 minutes to display a message on the DMS using a dial-up connection. The 2 hours is an estimation of the time it takes to clear up the initial crash and resume traffic flow. We also analyzed the number of multiple crash events and total secondary crashes, which include non-target secondary crashes that happened shortly after an initial crash (within ½ hour).

The total number of Rear End Crashes and Ran Off Road Crashes were used to justify the project, so these crash types are also provided for completeness. Note that Ran Off Road Crashes include: Ran Off Road-Right, Ran Off Road-Left, Ran Off Road-Straight, Overturn/Rollover, Fixed Object, Parked Motor Vehicle, Head On, and Sideswipe-Opposite Direction.

The following tables depict the Naïve Before and After Analysis. Data is provided separately for the three DMS on I-40 and the three DMS on I-26.

I-40 DMS

Three DMS Signs on I-40 in Buncombe Co.	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	567	598	5.5%
Rear End Crashes	226	251	11.1%
Ran Off Road Crashes	195	155	-20.5%
Multiple Crash Events	40	45	12.5%
Total Secondary Crashes	66	59	-10.6%
Secondary Crashes (< 1/2 Hr From Initial Crash)	39	34	-12.8%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	27	25	-7.4%

Three DMS Signs on I-40 in Buncombe Co. - Target Secondary Crashes	Before	After	Percent Increase (+)/ Percent Reduction (-)
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	27	25	-7.4%
Percent of Total Crashes	4.8%	4.2%	-12.5%
Severity Index	3.74	6.1	63.1%
Fatal Crashes	0	1	n/a
Class-A Injury Crashes	0	0	n/a
Class-B Injury Crashes	2	1	-50.0%
Class-C Injury Crashes	8	6	-25.0%
PDO Crashes	17	17	0.0%

I-40 DMS Sign at MM 40.7 in EB Direction (MP 3.8-8.9)	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	288	246	-14.6%
Rear End Crashes	131	127	-3.1%
Ran Off Road Crashes	83	47	-43.4%
Multiple Crash Events	28	27	-3.6%
Total Secondary Crashes	49	36	-26.5%
Secondary Crashes (< 1/2 Hr From Initial Crash)	30	20	-33.3%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	19	16	-15.8%
AADT	48,100	57,800	20.2%

I-40 DMS Sign at MM 48.4 in WB Direction (MP 6.6-11.7)	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	166	225	35.5%
Rear End Crashes	71	94	32.4%
Ran Off Road Crashes	47	47	0.0%
Multiple Crash Events	8	10	25.0%
Total Secondary Crashes	8	11	37.5%
Secondary Crashes (< 1/2 Hr From Initial Crash)	2	7	250.0%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	6	4	-33.3%
AADT	44,900	57,800	28.7%

I-40 DMS Sign at MM 59.9 in WB Direction (MP 18.1-23.2)	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	113	127	12.4%
Rear End Crashes	24	30	25.0%
Ran Off Road Crashes	65	61	-6.2%
Multiple Crash Events	4	8	100.0%
Total Secondary Crashes	9	12	33.3%
Secondary Crashes (< 1/2 Hr From Initial Crash)	7	7	0.0%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	2	5	150.0%
AADT	42,600	48,700	14.3%

I-26 DMS

Three DMS Signs on I-26 in Buncombe/ Henderson Co.	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	464	614	32.3%
Rear End Crashes	160	244	52.5%
Ran Off Road Crashes	168	214	27.4%
Multiple Crash Events	35	47	34.3%
Total Secondary Crashes	48	66	37.5%
Secondary Crashes (< 1/2 Hr From Initial Crash)	23	37	60.9%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	25	29	16.0%

Three DMS Signs on I-26 in Buncombe/Henderson Co.- Target Secondary Crashes	Before	After	Percent Increase (+)/ Percent Reduction (-)
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	25	29	16.0%
Percent of Total Crashes	5.4%	4.7%	-13.0%
Severity Index	2.18	3.04	39.4%
Fatal Crashes	0	0	n/a
Class-A Injury Crashes	0	0	n/a
Class-B Injury Crashes	1	1	0.0%
Class-C Injury Crashes	3	7	133.3%
PDO Crashes	21	21	0.0%

I-26 DMS Sign at MM 40.1 in WB Direction (MP 22.5-27.6 in Buncombe Co.)	Before	After	Percent Increase (+)/ Percent Reduction (-)
Total Crashes	232	307	32.3%
Rear End Crashes	109	165	51.4%
Ran Off Road Crashes	56	75	33.9%
Multiple Crash Events	20	32	60.0%
Total Secondary Crashes	26	43	65.4%
Secondary Crashes (< 1/2 Hr From Initial Crash)	11	25	127.3%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	15	18	20.0%
AADT	61,600	70,100	13.8%

I-26 DMS Sign at MM 46.8 in WB Direction (MP 0.87-5.97 in Henderson Co.)			Percent Increase (+)/ Percent Reduction (-)
	Before	After	
Total Crashes	136	176	29.4%
Rear End Crashes	44	59	34.1%
Ran Off Road Crashes	55	66	20.0%
Multiple Crash Events	12	10	-16.7%
Total Secondary Crashes	16	18	12.5%
Secondary Crashes (< 1/2 Hr From Initial Crash)	9	9	0.0%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	7	9	28.6%
AADT	46,800	50,500	7.9%

I-26 DMS Sign at MM 50.9 in EB Direction (MP 9.88-14.98 in Henderson Co.)			Percent Increase (+)/ Percent Reduction (-)
	Before	After	
Total Crashes	96	131	36.5%
Rear End Crashes	7	20	185.7%
Ran Off Road Crashes	57	73	28.1%
Multiple Crash Events	3	5	66.7%
Total Secondary Crashes	6	5	-16.7%
Secondary Crashes (< 1/2 Hr From Initial Crash)	3	3	0.0%
Secondary Crashes (1/2 Hr - 2 Hr From Initial Crash)	3	2	-33.3%
AADT	37,800	48,000	27.0%

RESULTS

I-40 DMS

Using naïve before and after analysis methodologies, there was a 6 percent increase in Total Crashes, an 11 percent increase in Rear End Crashes, and a 21 percent decrease in Ran Off Road Crashes on I-40 within the influence area of the DMS. There was a 13 percent increase in multiple crash events. The number of Target Secondary Crashes decreased by 7 percent from 27 crashes in the before period to 25 crashes in the after period. Target Secondary Crashes comprised about 4 percent of Total Crashes in the after period.

Two of the I-40 DMS sites experienced slight decreases in Target Secondary Crashes, while the other experienced an increase. For the DMS at I-40 MM 40.7 Eastbound, the number of Target Secondary Crashes decreased by 16 percent, from 19 crashes in the before period to 16 crashes in the after period. For the DMS at I-40 MM 48.4 Westbound, the number of Target Secondary Crashes decreased by 33 percent, from 6 crashes in the before period to 4 crashes in the after period. For the DMS at I-40 MM 59.9 Westbound, the number of Target Secondary Crashes increased by 150 percent, from 2 crashes in the before period to 5 crashes in the after period.

The average increase in AADT was 21 percent from the before to the after period.

I-26 DMS

Using naïve before and after analysis methodologies, there was a 32 percent increase in Total Crashes, a 53 percent increase in Rear End Crashes, and a 27 percent increase in Ran Off Road Crashes on I-26 within the influence area of the DMS. There was a 34 percent increase in multiple crash events. The number of Target Secondary Crashes increased by 16 percent from 25 crashes in the before period to 29 crashes in the after period. Target Secondary Crashes comprised about 5 percent of Total Crashes in the after period.

One of the I-26 DMS sites experienced a slight decrease in Target Secondary Crashes, while the other two experienced a slight increase. For the DMS at I-26 MM 40.1 Westbound, the number of Target Secondary Crashes increased by 20 percent, from 15 crashes in the before period to 18 crashes in the after period. For the DMS at I-26 MM 46.8 Westbound, the number of Target Secondary Crashes increased by 29 percent, from 7 crashes in the before period to 9 crashes in the after period. For the DMS at I-26 MM 50.9 Eastbound, the number of Target Secondary Crashes decreased by 33 percent, from 3 crashes in the before period to 2 crashes in the after period.

The average increase in AADT was 16 percent from the before to the after period.

DISCUSSION

The calculated benefit to cost ratio for project W-4440 on I-40 is **16.95** considering Total Crashes and **-1.04** considering only Target Crashes. The calculated benefit to cost ratio for project W-4444 on I-26 is **1.38** considering Total Crashes and **-0.15** considering only Target Crashes. See the attached Benefit-Cost Analysis Worksheets for more information. Note that the benefits are calculated using the change in annual crash costs from the before to the after period. The 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.

This evaluation does not account for other treatments that took place within the vicinity of the DMS over the course of the study period. For example, countywide rumble strips were installed on I-40 in Buncombe County in 2006, a rehab project was constructed in 2006 near the I-40 DMS at MM 59.9, and other projects were constructed on I-40 and I-26 that may influence the results. This evaluation also does not account for crash migration due to traffic detoured as a result of incident information and alternate detours displayed on the DMS.

Because there were no records of when messages were displayed on the DMS, it was not possible to match up sign usage with multiple event days in the after period. We do not know how often the signs were utilized to warn motorists of incidents ahead of them.

This evaluation specifically analyzed the safety aspect of the DMS. It appears that, overall, the DMS have not been very effective at reducing the number of secondary crashes on I-40 and I-26 as intended. However, there are other potential benefits of the system that this evaluation does not measure, such as improvements in operational efficiency, incident management emergency response, and traveler information. The signs have specifically been useful for providing traveler information in recent months. The westbound signs are currently being used to display detour information regarding the closure of I-40 in Haywood County due to a rock slide.

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

BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-40 near MM 40.7, MM 48.4, and MM 59.9
 COUNTY: Buncombe
 FILE NO.: W-4440
 TOTAL CRASHES

BY: CLS
 DATE: 2/10/2010

DETAILED COST: TYPE IMPROVEMENT - 3 DMS

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$990,000	20	0.102	\$100,834
			0.000	\$0
			0.000	\$0
TOTALS	\$990,000	20	0.102	\$100,834

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$50
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$2,000
 TOTAL ANNUAL COST= \$102,884
 TOTAL COST OF PROJECT= \$990,000

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	5.33	23	4.32	220	41.28	324	60.79	\$3,799,400
AFTER	5.33	9	1.69	178	33.40	411	77.11	\$2,055,572

Annual Benefits from Crash Cost Savings \$1,743,827

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = \$1,640,944
 BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = 16.95

TOTAL COST OF PROJECT - \$990,000 COMPREHENSIVE B/C RATIO - 16.95

BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-40 near MM 40.7, MM 48.4, and MM 59.9
 COUNTY: Buncombe
 FILE NO.: W-4440
 TARGET CRASHES

BY: CLS
 DATE: 2/10/2010

DETAILED COST: TYPE IMPROVEMENT - 3 DMS

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$990,000	20	0.102	\$100,834
			0.000	\$0
			0.000	\$0
TOTALS	\$990,000	20	0.102	\$100,834

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$50
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$2,000
 TOTAL ANNUAL COST= \$102,884
 TOTAL COST OF PROJECT= \$990,000

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	5.33	0	0.00	10	1.88	17	3.19	\$50,919
AFTER	5.33	1	0.19	7	1.31	17	3.19	\$157,861

Annual Benefits from Crash Cost Savings (\$106,942)

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = (\$209,826)
 BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = -1.04

TOTAL COST OF PROJECT - \$990,000 COMPREHENSIVE B/C RATIO - -1.04

BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-26 near MM 40.1, MM 46.8, and MM 50.9
 COUNTY: Buncombe & Henderson
 FILE NO.: W-4444
 TOTAL CRASHES

BY: CLS
 DATE: 2/10/2010

DETAILED COST: TYPE IMPROVEMENT - 3 DMS

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$990,000	20	0.102	\$100,834
			0.000	\$0
			0.000	\$0
TOTALS	\$990,000	20	0.102	\$100,834

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$50
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$2,000
 TOTAL ANNUAL COST= \$102,884
 TOTAL COST OF PROJECT= \$990,000

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	5.33	11	2.06	162	30.39	291	54.60	\$2,137,373
AFTER	5.33	8	1.50	193	36.21	413	77.49	\$1,995,235

Annual Benefits from Crash Cost Savings \$142,139

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = \$39,255
 BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = 1.38

TOTAL COST OF PROJECT - \$990,000 COMPREHENSIVE B/C RATIO - 1.38

BENEFIT-COST ANALYSIS WORKSHEET

LOCATION: I-26 near MM 40.1, MM 46.8, and MM 50.9
 COUNTY: Buncombe & Henderson
 FILE NO.: W-4444
 TARGET CRASHES

BY: CLS
 DATE: 2/10/2010

DETAILED COST: TYPE IMPROVEMENT - 3 DMS

ITEMS	TOTAL	SERVICE	CRF	ANNUAL COST
Construction	\$990,000	20	0.102	\$100,834
			0.000	\$0
			0.000	\$0
TOTALS	\$990,000	20	0.102	\$100,834

ESTIMATED INCREASE IN ANNUAL MAINT. COST = \$50
 ESTIMATED INCREASE IN ANNUAL UTILITY COST = \$2,000
 TOTAL ANNUAL COST= \$102,884
 TOTAL COST OF PROJECT= \$990,000

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	5.33	0	0.00	4	0.75	21	3.94	\$31,557
AFTER	5.33	0	0.00	8	1.50	21	3.94	\$46,567

Annual Benefits from Crash Cost Savings (\$15,009)

NET AVG. ANNUAL BENEFITS = AVG. ANNUAL BENEFITS - TOTAL ANNUAL COST = (\$117,893)
 BENEFIT-COST RATIO = AVG ANNUAL BENEFITS/TOTAL ANNUAL COST = -0.15

TOTAL COST OF PROJECT - \$990,000 COMPREHENSIVE B/C RATIO - -0.15