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16. Abstract This report documents activities in Phase III of the Texas Department of Transportation (TxDOT) Project 0-4048, which focused on before-and-after evaluations of safety treatments installed between 1995 and 2000 at 50 locations on rural highways in Texas. Evaluations employed a review of the crash history at each site to determine the effectiveness of the treatment. On the whole, treatments reduced preventable crashes by 15 percent and preventable injury crashes by 31 percent.					
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**PRELIMINARY EVALUATIONS OF SAFETY TREATMENTS ON
RURAL HIGHWAYS IN TEXAS**

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation; nor is it intended for construction, bidding, or permit purposes. Marcus A. Brewer, P.E. (TX-92997), and Kay Fitzpatrick, P.E. (TX-86762) prepared the report. The engineer in charge of the project was Kay Fitzpatrick.

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CHAPTER 1

INTRODUCTION

The majority of the highway system in Texas, as well as the United States, consists of two- and three-lane rural roads. Specifically, the state of Texas maintains 79,513 centerline-miles (127,964 km) of paved roadways serving about 591 million vehicle-miles (951.8 million km) per day. About 62 percent of those centerline-miles are rural two-lane roads that, on average, have less than 2000 ADT (average daily traffic). These low-volume rural roadways carry less than 8 percent of the total vehicle-miles on state-maintained (or on-system) highways but have approximately 11 percent of the total on-system vehicle crashes, based on 1999 statewide figures.

Due to the low volume and relatively low crash frequency on these roads, it is often not cost-effective to upgrade the roads. However, vehicles traveling on these roadways generally have high speeds and, thus, tend to have relatively more severe injuries when vehicle crashes do occur. To address these concerns, the Texas Department of Transportation (TxDOT) sponsored Project 0-4048 with the following objectives:

- Identify common types of crashes on low-volume roadways (less than 2000 ADT).
- Identify potential low-cost safety improvements for low-volume rural Texas roadways.
- Investigate the effectiveness of selected low-cost safety improvements.

In order to fulfill these objectives, Project 0-4048 was composed of three phases, each phase containing a number of tasks to accomplish the project objectives. Those phases were:

- Phase I – Identify Characteristics of Crashes and Known Benefits of Countermeasures
- Phase II – Create State-of-the-Practice on Treatments for Crashes on Rural Two-Lane Highways
- Phase III – Create Before-and-After Evaluations of Safety Treatments on Rural Highways

PREVIOUSLY PUBLISHED REPORTS

During the first two phases of the project, researchers developed documents to provide transportation practitioners with information on: 1) crash characteristics for rural roads in Texas and 2) treatments as countermeasures to those crashes. Those documents are as follows:

- *Characteristics of and Potential Treatments for Crashes on Low-Volume, Rural Two-Lane Highways in Texas*, FHWA/TX-02/4048-1, October 2001 (1).
- *Treatments for Crashes on Rural Two-Lane Highways in Texas*, FHWA/TX-02/4048-2, April 2002 (2).
- *Additional Characteristics of Crashes on Rural Two-Lane Highways*, FHWA/TX-03/4048-3, September 2002 (3).
- *Handbook Details Crash Treatments For Rural Highways*, FHWA/TX-03/0-4048-4, Draft, March 2004 (4).
- *Summary of Treatments for Crashes on Rural Two-Lane Highways in Texas*, FHWA/TX-05/0-4048-S, Draft, September 2004 (5).

Report 4048-1 discussed activities in the initial year of the project. It provided information on:

- types of crash treatments being used in Texas and in other states,
- characteristics of vehicle crashes on low-volume, rural two-lane highways,
- evaluation of the differences in crashes between counties in the eastern and western portions of the state, and
- findings from the literature review on the types and effectiveness of crash treatments.

In Year 2 of the project, researchers developed Report 4048-2. The report presented discussion on low-cost safety treatments used on highways and at intersections, along with their known effectiveness. The report also included experiences with selected treatments in Texas, including whether to consider the treatment elsewhere. The document was developed to provide transportation practitioners with information on crash characteristics for rural roads in Texas. It was produced in a three-ring binder to allow easy additions or changes as new or updated information on the effectiveness of crash treatments became available.

Report 4048-3 provided information on other Year 2 activities within the project including:

- characteristics of animal crashes and potential treatments,
- additional insight into characteristics of crashes on low-volume, rural two-lane highways using information provided by officers in their crash narratives,
- methodology for conducting before-and-after studies, and
- findings for before-and-after evaluations performed at four sites with improvements installed in 1996 or 1997.

Report 0-4048-4 was a four-page status report describing the information contained in Report 4048-2 and its usefulness to designers, district and area engineers, and other transportation practitioners. The four-page report concluded with information on how to obtain a copy of Report 4048-2. A summary of the entire project is in 0-4048-S.

ORGANIZATION OF REPORT 0-4048-5

This report, Report 0-4048-5, describes activities and findings from Phase III of Project 0-4048. These activities include:

- developing the methodology for conducting the before-and-after studies,
- conducting before-and-after evaluations for 50 sites with improvements installed from 1995 to 2000, and
- analyzing the effectiveness of treatments in reducing crashes.

CHAPTER 2

BEFORE-AND-AFTER EVALUATION METHODOLOGY

INTRODUCTION

This chapter contains a discussion of the methodology used in conducting before-and-after (B&A) evaluations of selected sites on highways that have received roadway or intersection improvements. The following text outlines the intended purpose of these evaluations, the steps taken to conduct the evaluations, details about each step, sample evaluation forms and communications, and modifications to the evaluation process.

OVERVIEW

A large number of improvements are made to highways in the state of Texas each year, and many of them are on rural, low-volume, two-lane highways. Unfortunately, the exact benefits of these improvements are not often known, because there is no comparison of conditions on the roadway prior to and following the installation of the improvement. By conducting a before-and-after evaluation of a cross-section of improvements across the state, researchers anticipated that the effectiveness of various improvements can be realized, thereby improving the information available to TxDOT for utilizing these improvements in the future.

The evaluation process started with gathering information from TxDOT district and area engineers about improvements in their jurisdictions. Based on the information received in an initial survey of these engineers, researchers prioritized a number of sites for follow-up efforts consisting of the collection of more detailed information about the improvements made. Compiling a six-year record of the crash history at the site and visiting the site for a visual record of the improvements were also part of the evaluation plan. Specific steps in the evaluation process originally designed for this task are listed below.

- Conduct the initial mail-out survey of TxDOT engineers.
- Process findings from the survey.
- Assign an initial score to each improvement to assess the likelihood of being able to gather all necessary information.
- Attempt to determine the location and exact nature of each improvement.
- Contact the survey respondents to confirm information and add details.
- Identify a potential comparison site.
- Update likelihood of gathering necessary information based on contacts with survey respondents.
- Obtain electronic crash records for each site being evaluated.
- Reduce crash records by control section, milepoint, and time period for analysis.
- Obtain/confirm the ADT information for each site.
- Write an initial overview or summary for the information obtained for each site.
- Visit the site to take pictures, confirm information on file, and locate a comparison site.
- Request crash narratives for the specific sites for a detailed analysis.
- Follow-up with survey respondents to obtain remaining details necessary for analysis.

- Complete B&A evaluation for the site.
- Draw conclusions.

A detailed explanation of the evaluation process is described in Chapter 4 of Research Report 4048-3 (3).

MODIFICATIONS TO THE EVALUATION PROCESS

The sites evaluated during the earlier periods of this project followed the original process fairly consistently, with one notable exception. The amount of available crash data in the Department of Public Safety (DPS) statewide database often limited the evaluation to a two-year period after installation of the improvement, rather than the desired three years. Indeed, very few of the sites previously evaluated had all six years of crash data available at the time of evaluation. Four such sites are revisited in [Chapter 3](#) of this report with the inclusion of data that has become available since they were first evaluated. In addition, [Chapter 3](#) includes 14 other sites with treatments installed in 1998 or earlier.

There are 32 more sites that are included in this report. [Chapter 4](#) contains 10 sites with improvements installed in 1999, and [Chapter 5](#) contains 22 sites with improvements made in 2000. These sites all have less than three years worth of crash data in their post-installation periods because computerized records for crashes occurring after December 31, 2001, were not yet available at the time of this project. In addition, 23 more sites were originally considered for evaluation with improvements made in 2001 or 2002. These sites will not be evaluated because there is insufficient after-period crash data available in the crash database to make conclusions.

The use of the computerized DPS crash record database is excellent for retrieving large amounts of data from sites across the state and analyzing them in a standardized format. However, there is still valuable information to be obtained from the narrative of the original crash report filed by the investigating officer. The usefulness of these narratives in providing added detail and insight into the crash history is evident in the summaries of the earlier evaluations. However, because of the constraints of time, budget, and available data, researchers could not obtain crash narratives for sites with improvements installed in 1999 or later. Thus, the evaluations of crash history in [Chapters 4](#) and [5](#) are based solely on the coded information produced by the computerized records in the DPS database.

CHAPTER 3

BEFORE-AND-AFTER EVALUATIONS OF 1995 TO 1998 TREATMENTS

INTRODUCTION

This chapter examines the before-and-after evaluations of sites with treatments installed between 1995 and 1998. The number of sites available for a full B&A evaluation within this project is dependent on the date of installation. It is preferred to have three years of crash history before and after a treatment has been installed. However, several sites were previously evaluated with only two years of post-improvement crash data. This chapter contains the revised evaluations for these sites, updated for three years of after-crash data. (Currently, crash data up to December 2001 are available for analysis. To have three years of available post-improvement crash data, an improvement must have been completed in 1998.) In addition, the study periods of certain sites included the point when DPS ceased recording non-injury crashes that did not result in a vehicle being towed (July 1, 1995), which artificially lowered the number of non-injury crashes recorded after that date. The study periods for these sites have been truncated to begin no earlier than July 1, 1995. Thus, for three sites with installations prior to July 1, 1997, there are less than two years of crash data in the before period to evaluate. These three sites will be discussed in this chapter, but will not be included in the analysis in [Chapter 6](#).

Based on results from the mail-out survey completed in the initial year of Project 0-4048 and information from contacts with TxDOT districts, researchers identified 79 sites as having a treatment with potential for before-and-after evaluation. Of those sites, 18 had improvements completed in 1998 or earlier; these sites are listed in [Table 3-1](#).

Table 3-1. Study Sites for B&A Evaluation with Treatments in 1995-1998.

Site Code	Improvement	Installation Date	Number of Months	
			Before	After
95-02	Reconfigured intersection	05/03/95	0*	35*
96-01	Raised pavement markers and additional delineation	10/01/96	15*	36
96-02	All-way stop and advance warning	09/01/96	14*	36
97-01	Approach rumble strips and strobes in signal heads	08/01/97	25*	36
97-02	Lane widening	05/01/97	22*	36
97-03	Safety treat fixed objects	06/11/97	23*	36
98-01	Beacons on Stop sign and advance warning signs	02/01/98	31*	36
98-02	Widen roadway	02/01/98	31*	36
98-03	Approach rumble strips	04/01/98	33*	36
98-04	Intersection flashing beacon	06/01/98	35*	36
98-05	Grade separation structure	07/01/98	36	36
98-06	Speed detection and notification device	09/01/98	36	36
98-07	Added flashers on warning signs	11/01/98	36	36
98-08	Install safety lighting	11/06/98	36	36
98-09	Install safety lighting	11/06/98	36	36
98-10	Install safety lighting	11/06/98	36	36
98-11	Upgrade 4-way flashers and install advance warning	12/01/98	36	36
98-12	Install in-rail reflectors for guardrail	Summer 1998	36	36

*Part or all of these periods are prior to the date (July 1, 1995) when DPS changed practices on reporting non-injury crashes.

SITE 95-02: RECONFIGURED INTERSECTION

Description of Site

Site 95-02 involves two intersections 500 ft (152 m) apart: a T-intersection of a US highway with a state highway and a four-leg intersection with the same US highway and a local roadway. The state highway has a sharp curve near the T-intersection and runs roughly parallel to the US highway; thus, the state highway also intersects the local roadway in close proximity to the study site. [Figure 3-1](#) shows pictorial views of the site, and [Figure 3-2](#) contains a sketch of the site after improvement.

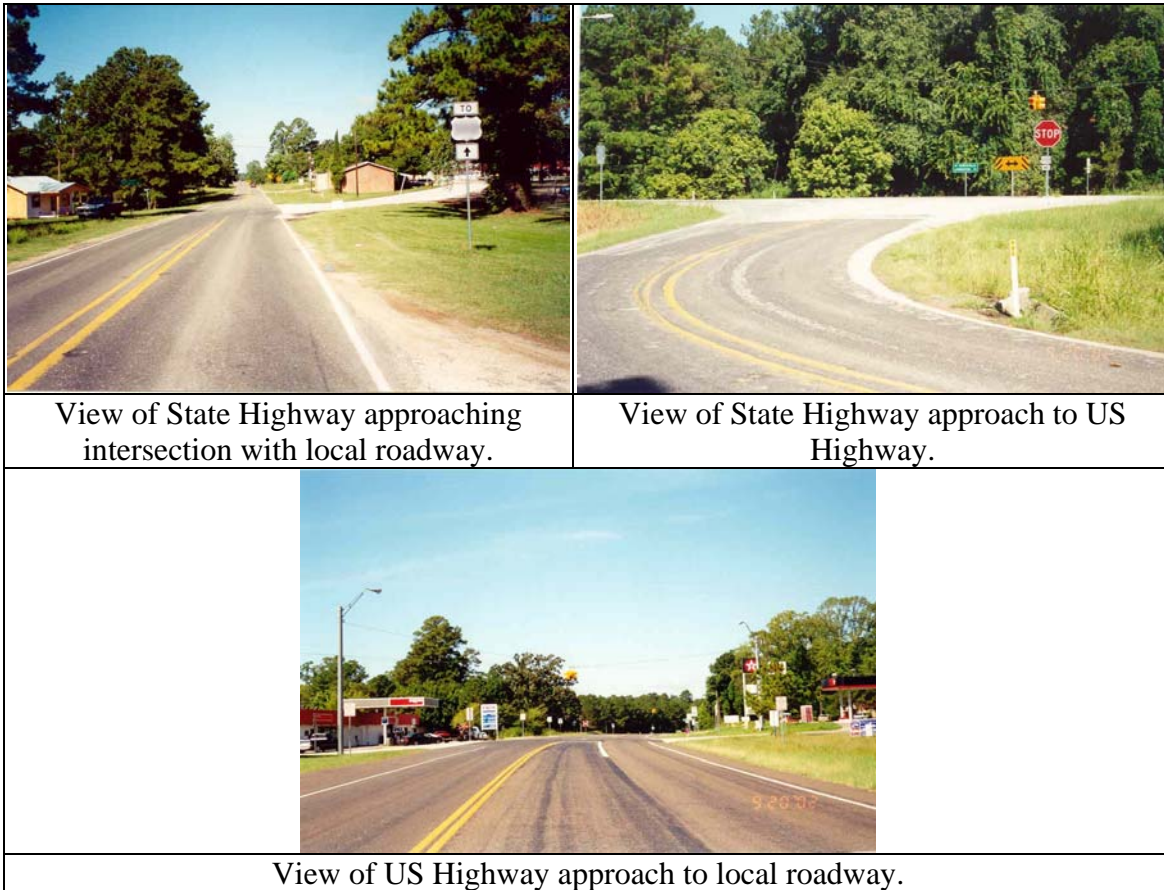


Figure 3-1. Views of Site 95-02.

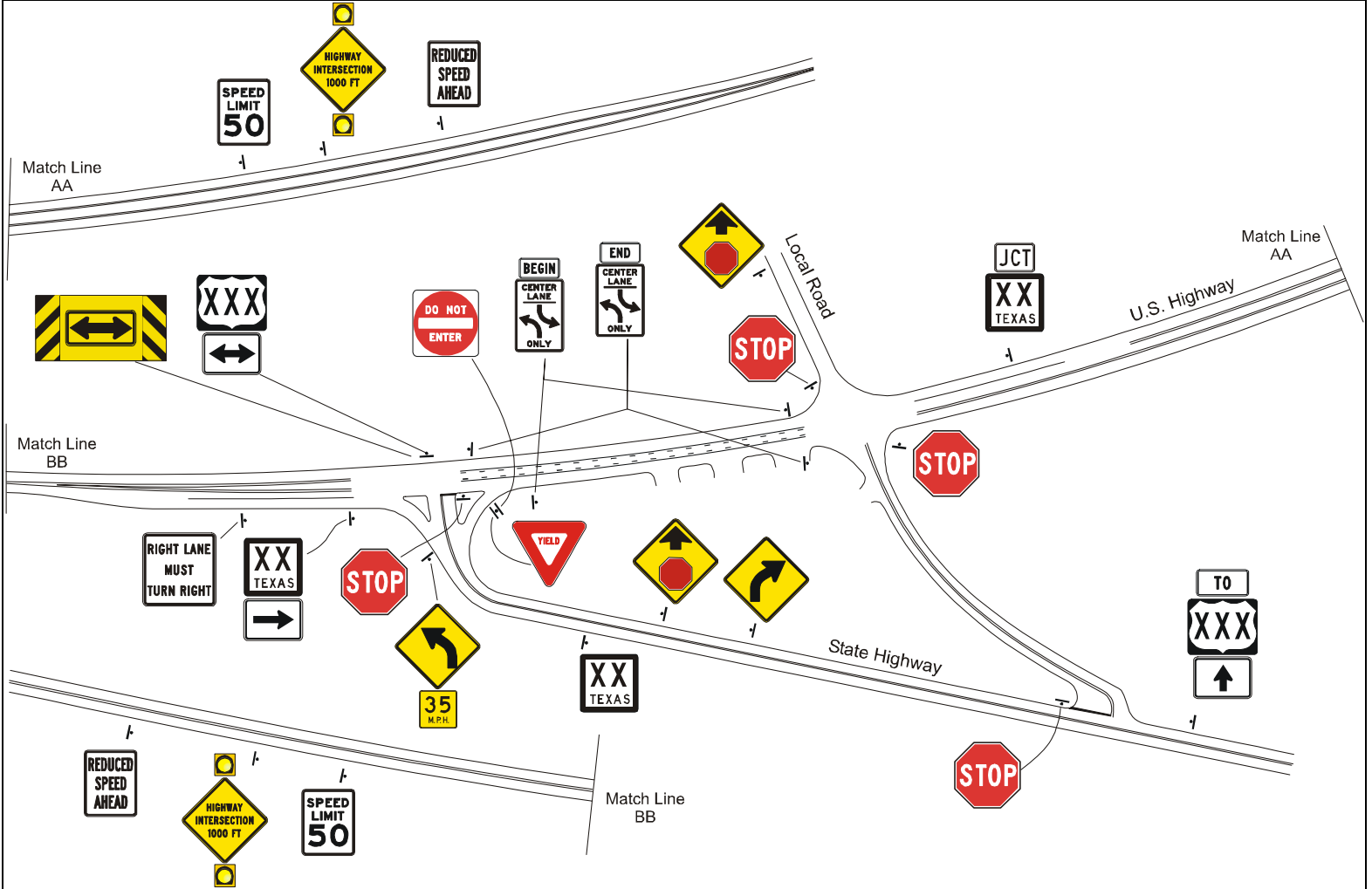


Figure 3-2. Sketch of Site 95-02 after Installation of Treatment.

Description of Treatment

This improvement project added a two-way left-turn lane (TWLTL) on the US highway between the two intersections, corner islands on the state highway leg of the T-intersection, and additional signing. Installation was completed in May 1995 at a cost of \$163,000.

Crash Characteristics

There were no crashes recorded at this site during the evaluation period after July 1, 1995; however, extending the analysis before that date reveals that there were two non-injury crashes prior to improvement. Both of those crashes involved multiple vehicles in dry, clear conditions, and both involved a left-turning vehicle on the US highway. The presence of a TWLTL between the two intersections provides a refuge area for turning vehicles out of the through traffic stream.

The crash narratives provide more details about the nature of the conflicts:

- *“Vehicle 2 stopped attempting to turn left onto SH (XX). Driver of Vehicle 1 failed to control speed and struck Vehicle 2 in the right rear.”*
- *“Vehicle 2 was EB on US (XX) approaching an intersection. Another vehicle was stopped in EB lane attempting a turn onto (local road). Vehicle 1 was WB on US (XX) turning left onto SH (XX). Vehicle 2 passed the vehicle that was turning onto (local road) on the right shoulder. Vehicle 1 made a complete turn and was out of the EB lane of the shoulder. Vehicle 2 left XX feet of skid marks and struck Vehicle 1.”*

SITE 96-01: RAISED REFLECTIVE PAVEMENT MARKERS AND ADDITIONAL DELINEATION

Description of Site

This site is on a rural two-lane farm-to-market (FM) highway with a 2002 ADT of approximately 2600 vehicles. The location under evaluation, shown in Figures 3-3 and 3-4, is a 1.5-mile (2.4 km) section containing a bridge over a lake that is near a power plant. The power plant feeds into the lake, causing the lake water to be warm, and inducing fog under certain weather conditions. Thus, this section of roadway has been subject to heavy fog, which greatly reduces visibility near the bridge. TxDOT personnel were looking for a low-cost means of providing better information to drivers in the area. They had considered installation of a full-function weather station with variable message signs; however, the cost for such a treatment exceeded available resources. A simpler, and less costly, alternative was to increase the visibility of the centerline and edgelines of the roadway through improved delineation.



Figure 3-3. View of Bridge on Lake.



Figure 3-4. View of Added Raised Pavement Markers and Delineation.

Description of Treatment

Engineers decided to install raised reflective pavement markers and additional delineation along the bridge rails and guardrails throughout the 1.5-mile (2.4 km) section. Raised reflective yellow pavement markers were installed beside the centerline of the road on the outside edge of

both solid yellow lines. These markers begin about 100 ft (30.4 m) in advance of the beginning of the guardrail and continue throughout the section to the other side of the bridge. The delineators, rectangular white or yellow reflectors on metal posts, were attached to wooden guardrail posts at regular intervals throughout the length of the guardrail (see [Figure 3-3](#)); white delineators were used throughout the length of the guardrail, while yellow ones were used at the last guardrail post to signify the end of the guardrail.

Installation

Based on maintenance diary records, the installation of the improvements was completed in October 1996, at an estimated cost of \$3000 to \$5000.

Crash Characteristics

A summary of the crash history is shown in [Table 3-2](#); there was also one non-injury fixed-object crash reported in 1994. In addition to the reduction in crashes on this section, TxDOT personnel report fewer complaints from motorists since the installation of this improvement.

Table 3-2. Crash Summary at Site 96-01.

	Before Frequency		After Frequency	
Time Period	July 1995 to September 1996		November 1996 to October 1999	
Months in Time Period	15		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.20)	3 (0.20)	1 (0.03)	0 (0.00)
Severity				
Injury	1	1	1	0
Non-Injury	2	2	0	0
Number of Vehicles				
1	1	1	0	0
2	2	2	1	0

SITE 96-02: ALL-WAY STOP AND ADVANCE WARNING

Description of Site

This site is an intersection of two two-lane rural highways, with a 2002 ADT of approximately 1000 on the primary highway and 500 on the secondary highway (see [Figure 3-5](#)). Prior to improvements, this intersection was two-way stop-controlled on the secondary highway. The westbound approach on the primary highway has a crest vertical curve approximately 1000 ft (305 m) prior to the intersection; this curve limits the line of sight between drivers approaching the intersection on the primary highway and drivers stopped on the secondary highway. District personnel decided to address this safety concern with an all-way stop control at the intersection.



Figure 3-5. All-Way Stop-Controlled Intersection, Looking East.

Description of Treatment

District personnel installed a four-way stop control at this intersection, along with advance warning signs. This consisted of symbolic STOP AHEAD signs and HIGHWAY INTERSECTION 1500 FT (458 m) signs on each approach. [Figure 3-6](#) shows a view of these signs on one approach.

Installation

According to the maintenance diary, district maintenance personnel completed installation of signs in September 1996.

Crash Characteristics

A review of available crash data revealed that there were no crashes at this intersection after July 1, 1995.



Figure 3-6. Advance Warning Signs for Approach to Intersection.

SITE 97-01: APPROACH RUMBLE STRIPS AND STROBES IN SIGNAL HEADS

Description of Site

This site is an intersection of two US highways. One highway is the major east-west route through the county and intersects with the other highway within the limits of a small city. The primary highway is a four-lane arterial with a continuous center TWLTL having a 2002 ADT of approximately 14,000. The secondary highway at the intersection is also a four-lane arterial with an ADT of approximately 4000. This site, a signalized intersection surrounded on all sides by commercial development, is the highest-volume intersection in the city in which it is located. This site was originally given a lower priority within this project because of its high ADT and non-rural, multi-lane status; however, there have been multiple improvements made at the site that researchers can study and evaluate for use at other locations.

This intersection is the first signalized intersection encountered by eastbound drivers as they approach the west side of the city on the primary highway. There is also a high percentage of truck traffic on the primary highway. Those two factors were attributed to a high occurrence of vehicles “running the red.” Eastbound drivers have a low expectation of seeing a signalized intersection, and westbound drivers may be eager to proceed through the final signal and enter the rural highway west of town. The occurrences of red-light violations produce a high number of right-angle and left-turn crashes. TxDOT engineers were looking to increase drivers’ awareness of the upcoming signal. They selected a combination of measures implemented over a period of time.

Description of Treatment

One of the treatments to be installed at this site was approach rumble strips, shown in [Figure 3-7](#). These thermoplastic strips are installed in two places across the lanes of the eastbound approach to the intersection. The second treatment at this site is the installation of white strobe lights in the red signal heads facing west, shown in [Figure 3-8](#). These strobe lights flash at regular intervals when the red signal is lit. Because the primary highway is almost directly east-west through the city, visibility at dusk and dawn can be impeded due to the rising and setting sun. Engineers in the district felt the strobe lights would especially aid drivers during these times of day. Additionally, engineers theorized that these devices would give travelers a better recognition of a change in the roadway environment.

Note that the high-intensity strobe device is experimental. When considering new technologies not included in the *Texas Manual on Uniform Traffic Control Devices* (TMUTCD), a request for experimentation is to be submitted to the Traffic Operations Division of TxDOT and approved before installation of the device.



Figure 3-7. View of Approach Rumble Strips.



Figure 3-8. Strobes in Signal Heads.

Installation

The rumble strips, installed in August 1997, were placed in two sets. Each set consisted of 10 strips, 24 ft × 4.5 inches (7.3 m × 11.4 cm), with a space of 9.5 inches (24.1 cm) between each strip. A close-up view of the rumble strips is shown in [Figure 3-9](#). The first set is 1236 ft (377 m) from the traffic signal, and the second set is 480 ft (146.3 m) from the traffic signal. There is also a 36-inch × 36-inch (91.4 cm × 91.4 cm) “RUMBLE STRIPS AHEAD” sign located 985 ft (300 m) west of the first set of rumble strips. The cost to install the rumble strips and advance sign amounted to approximately \$500. The strobe lights, installed in March 1997, are mounted to the red lenses of the traffic signals. The cost of purchasing and installing the strobe lights was approximately \$3200.

Crash Characteristics

Researchers obtained the relevant crash data for this intersection, a summary of which is shown in [Table 3-3](#). The district also conducted its own effectiveness study, consisting of approximately 44 months of crash data. When compared to signals in the city that did not have the safety devices installed, they determined there was as much as an 85 percent reduction in crashes at the sites with the devices. In the opinion of district personnel, these devices have significantly reduced accidents at this site.



Figure 3-9. Close-Up View of Approach Rumble Strips.

Table 3-3. Crash Summary at Site 97-01.

	Before Frequency		After Frequency	
Time Period	July 1995 to July 1997		September 1997 to August 2000	
Months in Time Period	25		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	8 (0.32)	7 (0.28)	8 (0.22)	7 (0.17)
Severity				
Injury	7	6	6	5
Non-Injury	1	1	2	2
Number of Vehicles				
1	0	0	1	0
2	8	7	7	7
Intersection Crashes				
At Intersection	8	7	5	4
Intersection-Related	0	0	3	3
Collision Type				
Right Angle	5	5	2	2
Left Turn	3	2	2	2
Rear End	0	0	3	3
Overturned	0	0	1	0

SITE 97-02: ROADWAY WIDENING

Description of Site

This site is a 2.8-mile (4.5 km) section of a rural, two-lane farm-to-market highway with a number of vertical and horizontal curves. Before improvements, the cross-section of this site consisted of two 10-ft (3.1 m) lanes with no shoulders, for a total pavement width of 20 ft (6.2 m). The 2002 ADT is approximately 200. The sections of the highway on either end of the 2.8-mile (4.5 km) study site were wider and caused a “bottleneck” as vehicles approached the change in cross-section. District personnel wanted to eliminate this bottleneck.

Description of Treatment

The roadway was widened to match the cross-section of the adjacent roadway, shown in [Figure 3-10](#). An additional 3 ft (0.9 m) of lane width and 2 ft (0.6 m) of shoulder width on either side of the roadway augmented this segment, for a total pavement width of 30 ft (9.2 m).

Installation

Recycled asphalt pavement was used for the paving material, with the intent of adding a seal coat in the future. Completion of the installation occurred in May 1997; approximate cost of installation was not available.

Crash Characteristics

[Table 3-4](#) shows the summary of crash data for Site 97-02. District personnel say that people feel more comfortable driving the new section and have not lodged any complaints since completing the installation.



Figure 3-10. View of Roadway Widening.

Table 3-4. Crash Summary at Site 97-02.

	Before Frequency		After Frequency	
Time Period	July 1995 to April 1997		June 1997 to May 2000	
Months in Time Period	22		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	1 (0.05)	0 (0.00)	3 (0.08)	0 (0.00)
Severity				
Injury	0	0	3	0
Non-Injury	1	0	0	0
Number of Vehicles				
1	1	0	3	0
2	0	0	0	0
Curve Crashes				
Degree of Curve = 0	1	0	0	0
Degree of Curve > 0	0	0	3	0
Collision Type				
Fixed Object	1	0	1	0
Overturned	0	0	2	0

SITE 97-03: SAFETY TREAT FIXED OBJECTS

Description of Site

Site 97-03 is an 11.4-mile (18.3 km) section of four-lane divided US highway.

Description of Treatment

The improvement at the site was to safety treat fixed objects (installation of ET 2000s and guardrails as shown in [Figure 3-11](#)) throughout the section; installation was completed in June 1997 at a cost of \$528,000.

Crash Characteristics

[Table 3-5](#) contains the summary of the crash history at this site.

Table 3-5. Crash Summary at Site 97-03.

	Before Frequency		After Frequency	
Time Period	July 1995 to May 1997		July 1997 to June 2000	
Months in Time Period	23		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	158 (6.87)	23 (1.00)	244 (6.78)	30 (0.83)
Severity				
Injury	98	10	149	13
Non-Injury	60	13	95	17
Number of Vehicles				
1	34	18	63	23
2	112	5	160	7
3	8	0	19	0
4 or more	4	0	2	0
Light Conditions				
Daylight	111	11	192	20
Darkness – Not Lighted	29	10	31	8
Darkness – Lighted	12	0	15	2
Dawn/Dusk	6	2	6	0
Collision Type				
Fixed Object	19	17	34	23
Overturned	10	1	26	2
Other Single Vehicle	9	0	13	0
Right Angle	34	3	50	0
Rear End	60	0	70	1
Other Multiple Vehicle	26	2	51	4



Figure 3-11. Safety Treated Guardrail.

SITE 98-01: ADVANCE WARNING FOR STOP-CONTROLLED INTERSECTION

Description of Site

Site 98-01 is a T-intersection of two state highways. An unusual curve is present on the minor road approach near the intersection (see [Figure 3-12](#)).

Description of Improvements

The treatment installed in February 1998 included flashing beacons on STOP and STOP AHEAD signs to provide additional warning of the intersection. An interview with the survey respondent indicated that the intersection previously had overhead beacons and that the improvement supplemented existing devices.

Crash Characteristics

[Table 3-6](#) summarizes the crash history at Site 98-01. The crash in the after period was a single-vehicle crash in which the driver over-corrected while avoiding an opposing vehicle that crossed the centerline; this crash was not preventable by the treatment that was installed.



Figure 3-12. Improvements at Site 98-01.

Table 3-6. Crash Summary at Site 98-01.

	Before Frequency		After Frequency	
Time Period	July 1995 to January 1998		March 1998 to February 2001	
Months in Time Period	31		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	1 (0.03)	0 (0.00)
Severity				
Injury	1	1	1	0
Non-Injury	1	1	0	0
Number of Vehicles				
1	1	1	1	0
2	1	1	0	0
Light Conditions				
Daylight	2	2	0	0
Darkness – Not Lighted	0	0	1	0
Collision Type				
Fixed Object	1	1	1	0
Head-on	1	1	0	0

SITE 98-02: WIDEN ROADWAY

Description of Site

Site 98-02 consists of a 4.0-mile (6.4 km) section of rural two-lane FM roadway.

Description of Improvement

Treatment at site 98-02 included widening the roadway and adding edgeline to denote presence of shoulders (see [Figure 3-13](#)). Installation was completed in February of 1998.

Crash Characteristics

Table 3-7 summarizes the crash history for Site 98-02. The crash narratives provide additional details, indicating a trend that excessive speed, failure to yield right-of-way (ROW), or disregarding a STOP sign was the primary cause for most of the crashes. The survey respondent believes that the treatment was effective.

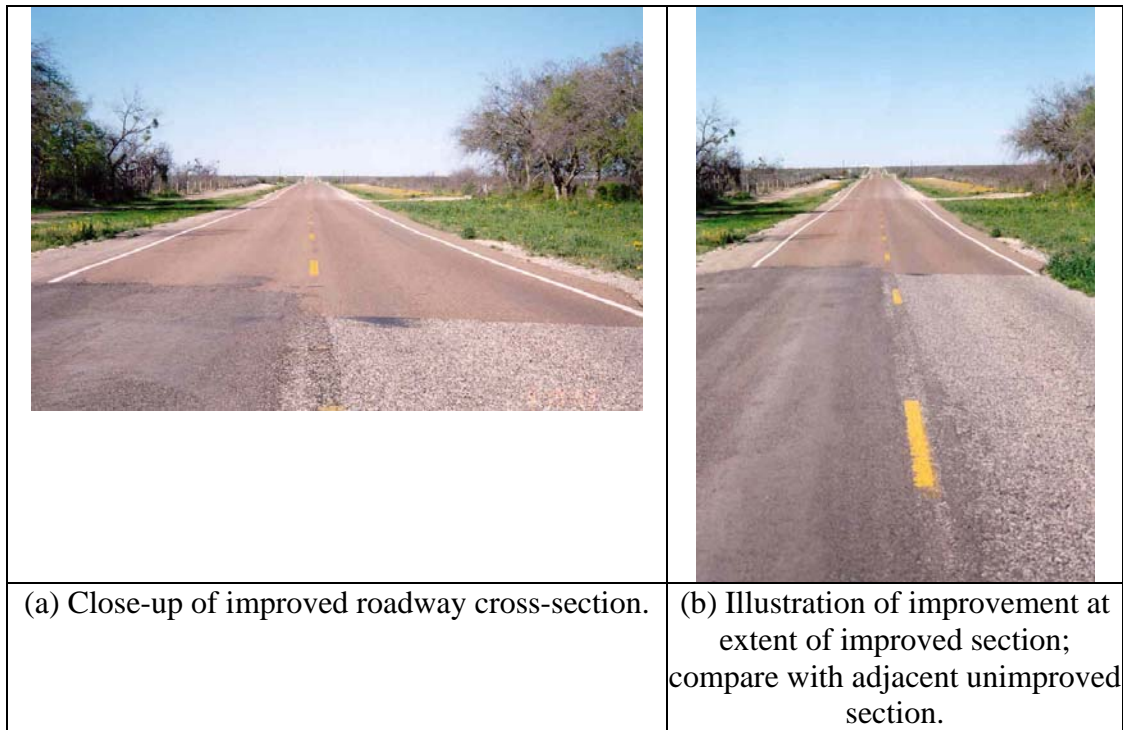


Figure 3-13. Improved Roadway Section at Site 98-02.

Table 3-7. Crash Summary at Site 98-02.

	Before Frequency		After Frequency	
Time Period	July 1995 to January 1998		March 1998 to February 2001	
Months in Time Period	31		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.10)	1 (0.03)	4 (0.11)	0 (0.00)
Severity				
Injury	2	1	3	0
Non-Injury	1	0	1	0
Number of Vehicles				
1	1	0	3	0
2	2	1	1	0
Curve Crashes				
Degree of Curve = 0	0	0	2	0
Degree of Curve > 0	3	1	2	0

SITE 98-03: APPROACH RUMBLE STRIPS

Description of Site

Site 98-03 is at the T-intersection of two US highways. One highway has a curved approach that tees into the other highway, which is also on a curve.

Description of Improvement(s)

Approach rumble strips were installed on the leg of the tee in two sets. Each set consisted of ten 24-inch \times 4.5-inch (61.0 cm \times 11.43 cm) strips with 9.5 inches (24.1 cm) of space between each strip. The first set was located 1236 ft (377 m) from the stop line at the intersection; the second was located 480 ft (146 m) from the stop line. [Figure 3-14](#) shows views of both sets of rumble strips. The installation was completed in April 1998 at a cost of \$456.

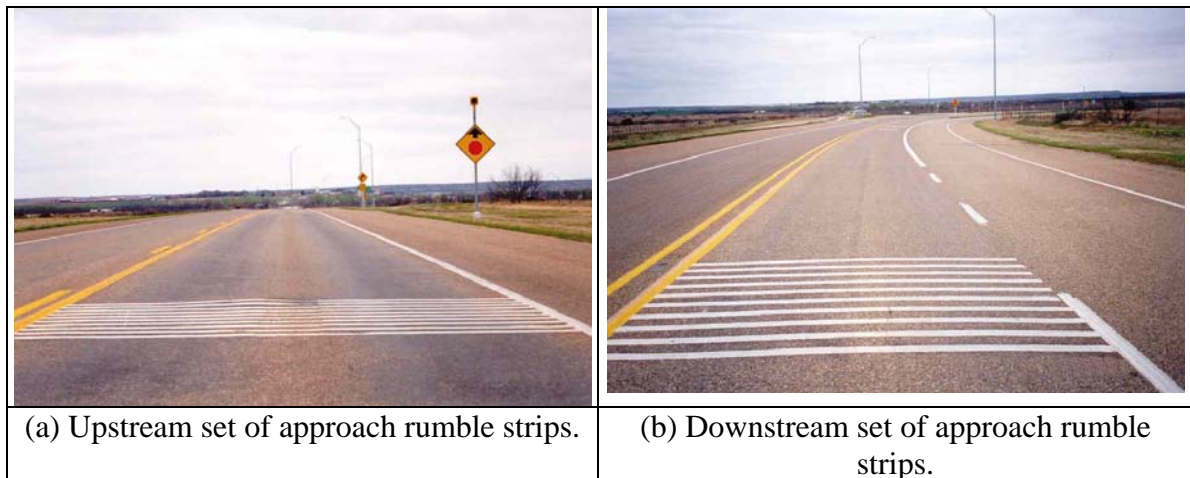


Figure 3-14. Approach Rumble Strips at Site 98-03.

Crash Characteristics

The crash distribution for this site is shown in [Table 3-8](#). Two of the three crashes in the before period involved vehicles that failed to stop at the intersection, while the third involved a flatbed semi-trailer whose load shifted while negotiating the curve on the major road approaching the intersection. In the after period, both crashes were caused by a vehicle that failed to yield the right-of-way at the intersection.

A local official reported receiving fewer complaints from the property owner opposite the stop control. The local official also mentioned that a future grade separation was in the design stage, and that the rumble strips would no longer be needed upon completion of that improvement.

Table 3-8. Crash Summary at Site 98-03.

	Before Frequency		After Frequency	
Time Period	July 1995 to March 1998		May 1998 to April 2001	
Months in Time Period	33		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.09)	2 (0.06)	2 (0.06)	0 (0.00)
Severity				
Injury	2	1	2	0
Non-Injury	1	1	0	0
Number of Vehicles				
1	3	2	0	0
2	0	0	2	0
Curve Crashes				
Degree of Curve = 0	0	0	1	0
Degree of Curve > 0	3	2	1	0
Collision Type				
Fixed Object	2	2	0	0
Right Angle	0	0	2	0
Other	1	0	0	0

SITE 98-04: INTERSECTION FLASHING BEACON

Description of Site

Site 98-04 is a four-leg intersection of a US highway with a farm-to-market roadway.

Description of Improvement

An intersection flashing beacon was installed, as shown in the approach views in [Figure 3-15](#). Installation was completed June 1, 1998; no cost information was available.



(a) Approach to intersection on FM roadway. (b) Approach to intersection on US highway.

Figure 3-15. Views of Site 98-04.

Crash Characteristics

Table 3-9 shows the crash distribution for Site 98-04. Reporting officers listed failure to yield ROW as a contributing factor in nine of the 15 crashes: four crashes before and five crashes after the improvement. Driver inattention was listed as a contributing factor or possible contributing factor in 12 of the 15 crashes: five crashes before and seven crashes after the improvement.

Table 3-9. Crash Summary at Site 98-04.

	Before Frequency		After Frequency	
Time Period	July 1995 to May 1998		July 1998 to June 2001	
Months in Time Period	35		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	5 (0.14)	5 (0.14)	10 (0.28)	10 (0.28)
Severity				
Injury	2	2	5	5
Non-Injury	3	3	5	5
Number of Vehicles				
2	5	5	8	8
3	0	0	2	2
Collision Type				
Right Angle	4	4	9	9
Rear End	1	1	1	1

SITE 98-05: GRADE SEPARATION STRUCTURE

Description of Site

Site 98-05 was originally a four-leg intersection of a state highway with a US highway. Now it is a state highway over a US highway with a connector road linking the two.

Description of Improvement

The improvement at this site was the installation of a grade separation structure, seen in Figure 3-16. It was completed in July 1998; cost information was not provided.



Figure 3-16. View of Grade Separation Structure at Site 98-05.

Crash Characteristics

Table 3-10 shows the crash history for this site. All four crashes involved vehicles that either ran the STOP sign or failed to yield the right-of-way after stopping.

Table 3-10. Crash Summary at Site 98-05.

	Before Frequency		After Frequency	
Time Period	July 1995 to June 1998		August 1998 to July 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	4 (0.11)	4 (0.11)	0 (0.00)	0 (0.00)
Severity				
Injury	3	3	0	0
Non-Injury	1	1	0	0
Number of Vehicles				
2	3	3	0	0
3	1	1	0	0
Collision Type				
Right Angle	4	4	0	0

SITE 98-06: SPEED DETECTION AND NOTIFICATION DEVICE

Description of Site

Site 98-06 is a sharp curve on a farm-to-market roadway.

Description of Improvements

A speed detection and notification device was installed in September 1998 at a cost of \$18,000. The device has a radar unit (Figure 3-17a) that detects the speeds of oncoming vehicles and activates the overhead beacons (Figure 3-17b) when vehicles are exceeding the advisory speed for the curve (25 mph).

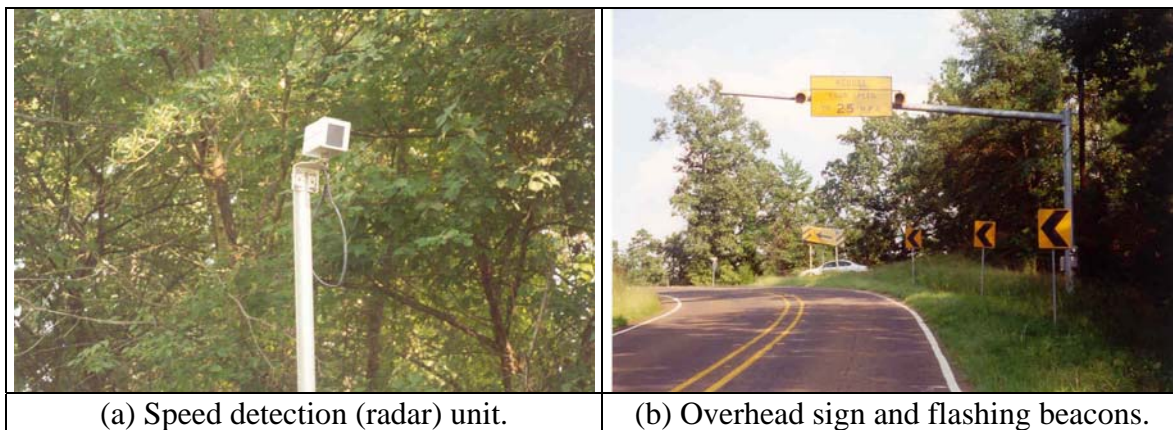


Figure 3-17. Components of Speed Detection and Notification Device.

Crash Characteristics

Table 3-11 shows the crash distribution for Site 98-06. Narratives show a high number of run-off-road crashes in the before period. Five of the seven narratives indicate a contributing factor of speeding: three unsafe under the limit and two over the limit. The survey respondent believes that the treatment has been very effective; he has received fewer complaints and there have been fewer conflicts.

Table 3-11. Crash Summary at Site 98-06.

	Before Frequency		After Frequency	
Time Period	September 1995 to August 1998		October 1998 to September 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	7 (0.19)	7 (0.19)	0 (0.00)	0 (0.00)
Severity				
Injury	6	6	0	0
Non-Injury	1	1	0	0
Number of Vehicles				
1	4	4	0	0
2	3	3	0	0
Intersection Crashes				
Intersection Related	1	1	0	0
Not Intersection Related	6	6	0	0

SITE 98-07: INSTALL FLASHERS ON ADVANCE WARNING SIGNS

Description of Site

Site 98-07 is a 1.6-mile (2.6 km) section of FM roadway as seen in [Figure 3-18a](#). This section contains a sharp (35-mph) curve and a highway intersection, both of which have advance warning signs.

Description of Improvement

This project added flashers on the advance warning signs. The installation was completed in November 1998. The flashers on the advance warning signs at the curve can be seen in [Figure 3-18b](#).

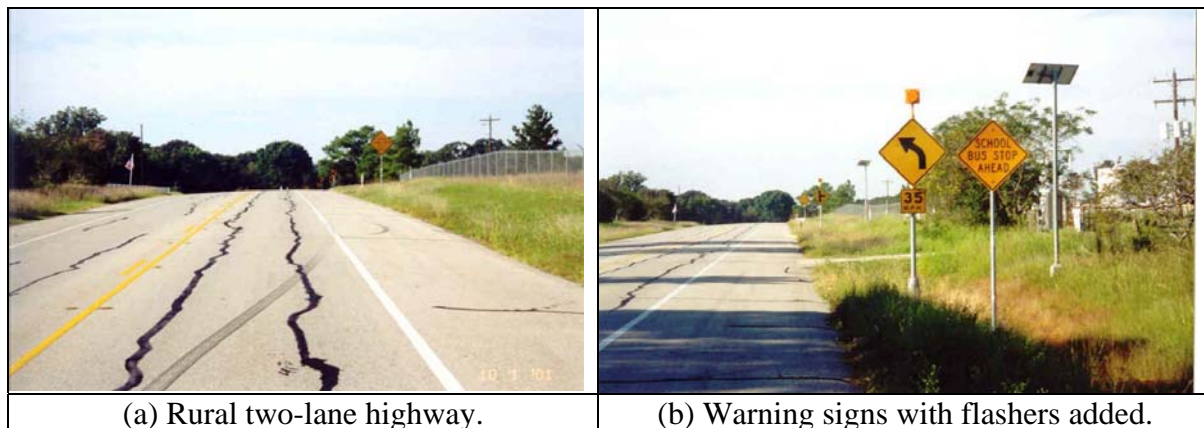


Figure 3-18. Views of Site 98-07.

Crash Characteristics

Table 3-12 contains the summary of crash history at this site. The vast majority of crashes in both periods (87 percent before and 81 percent after) occurred on the sharpest part of the curve, which has a degree of curvature between 10.0 and 11.9.

Table 3-12. Crash Summary at Site 98-07.

	Before Frequency		After Frequency	
Time Period	November 1995 to October 1998		December 1998 to November 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	23 (0.64)	23 (0.64)	21 (0.58)	21 (0.58)
Severity				
Injury	15	15	15	15
Non-Injury	8	8	6	6
Number of Vehicles				
1	16	16	14	14
2	7	7	7	7
Curve Crashes				
Degree of Curve = 0	2	2	1	1
Degree of Curve > 0	21	21	20	20
Intersection Crashes				
At Intersection	1	1	1	1
Intersection Related	2	2	2	2
Driveway Related	1	1	1	1
Not Intersection Related	19	19	17	17

SITE 98-08: INSTALL SAFETY LIGHTING

Description of Site

Site 98-08 is a T-intersection of two FM roadways. The views in Figure 3-19 show that the leg of the T is stop-controlled.

Description of Improvement

Safety lighting was added, in the form of two luminaires on opposite corners of the intersection. Installation was completed November 6, 1998.

Crash Characteristics

Only one crash occurred at this site, during the before period, as shown in Table 3-13. It was a nighttime crash (dark–no lights) in which a driver failed to stop at the STOP sign and collided with another vehicle. The driver at fault suffered an incapacitating injury. The narrative for the crash revealed that the driver at fault may have been drinking.

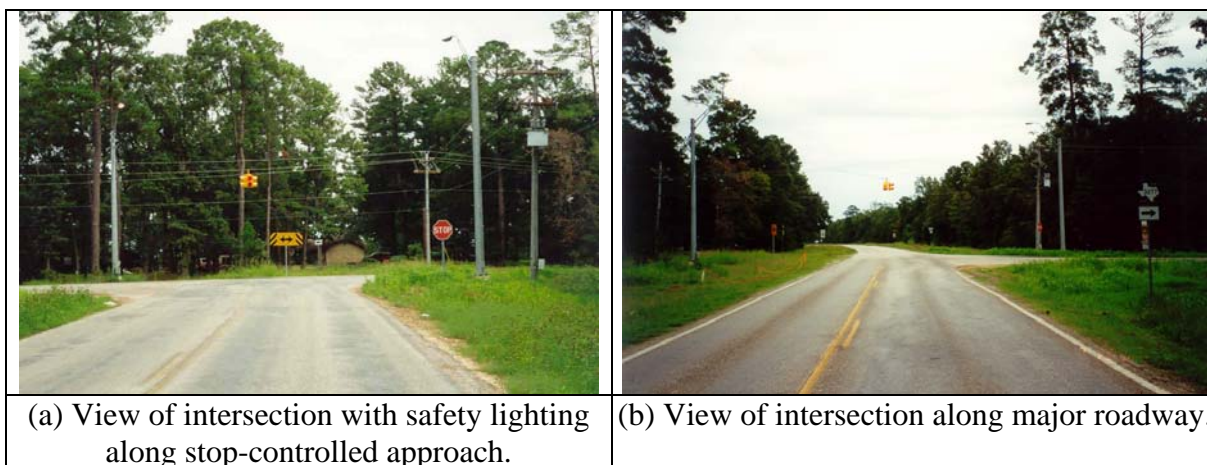


Figure 3-19. Approach Views of Site 98-08.

Table 3-13. Crash Summary at Site 98-08.

	Before Frequency		After Frequency	
Time Period	November 1995 to October 1998		December 1998 to November 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	1 (0.03)	1 (0.03)	0 (0.00)	0 (0.00)
Severity				
Injury	1	1	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	0	0	0	0
2	1	1	0	0

SITE 98-09: INSTALL SAFETY LIGHTING

Description of Site

Site 98-09 is a T-intersection of two FM roadways. Views of both roadways are shown in [Figure 3-20](#).

Description of Improvement

Safety lighting was installed on November 6, 1998.

Crash Characteristics

The distribution of the five crashes at Site 98-09 is shown in [Table 3-14](#). The narratives indicate that one single-vehicle crash was caused by a vehicle whose driver stated brake failure was the cause for her vehicle to fail to stop at the STOP sign. The two-vehicle crash in the before period involved a vehicle that missed turning at the intersection, backed up on the major road, then turned left in front of another vehicle. In the after period, one crash was caused when

a vehicle turned left in front of another vehicle; the other crash was caused when a vehicle rear-ended a series of vehicles queued behind a stopped left-turning vehicle.

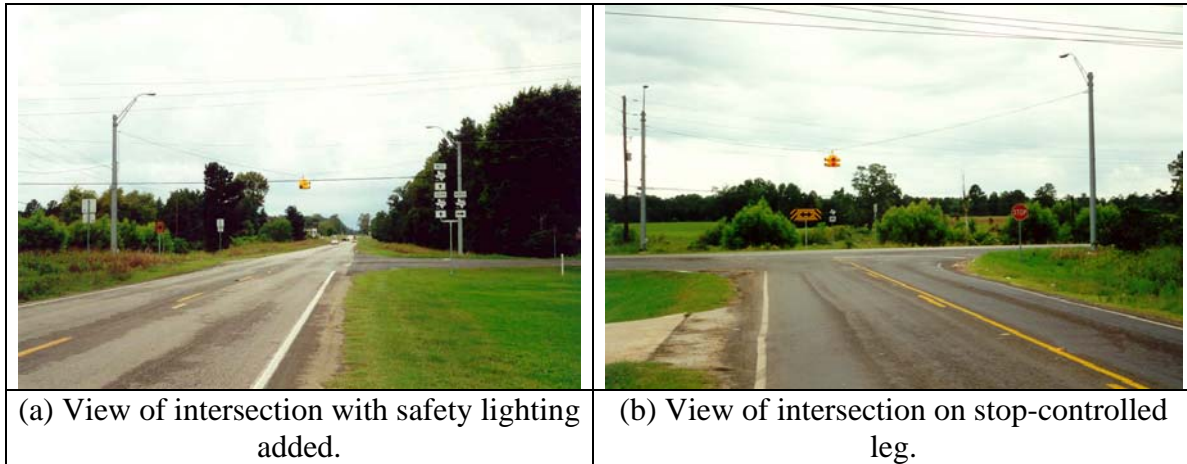


Figure 3-20. Views of 98-09 with Safety Lighting Installed.

Table 3-14. Crash Summary at Site 98-09.

	Before Frequency		After Frequency	
Time Period	November 1995 to October 1998		December 1998 to November 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	2 (0.06)	2 (0.06)	0 (0.00)
Severity				
Injury	2	1	2	0
Non-Injury	1	1	0	0
Number of Vehicles				
1	2	1	0	0
2 or more	1	1	2	0
Lighting Conditions				
Darkness – Not Lighted	2	2	0	0
Daylight	1	0	2	0
Collision Type				
Fixed Object	2	1	0	0
Left Turn	1	1	1	0
Rear End	0	0	1	0

SITE 98-10: INSTALL SAFETY LIGHTING

Description of Site

Site 98-10 is a four-leg intersection of a US highway with a farm-to-market roadway.

Description of Improvement

Safety lighting was installed on November 6, 1998, as seen in [Figure 3-21](#).

Crash Characteristics

There were no crashes at Site 98-10 during the three-year before period or the three-year after period.



Figure 3-21. View of Safety Lighting at Site 98-10.

SITE 98-11: UPGRADE 4-WAY FLASHERS AND INSTALL ADVANCE WARNING

Description of Site

Site 98-11 is a four-leg intersection of two state highways. The minor road is a two-lane road that widens to four lanes at the intersection, while the major road is a four-lane road with a center left-turn lane.

Description of Improvements

The purpose of the improvement to this site was to upgrade the intersection flashing beacon and install advance warning beacons. The improved intersection has a pair of overhead flashing beacons over each lane at the intersection, with supplemental overhead STOP signs over

the minor approaches (see [Figure 3-22a](#)). An overhead STOP AHEAD sign with two pairs of alternating flashing beacons (see [Figure 3-22b](#)) were also added on the minor road approaches, to supplement existing roadside STOP AHEAD signs. The installation was completed on December 11, 1998, at an approximate cost of \$37,500.



(a) Overhead STOP sign and flashing beacons on minor leg approach.



(b) Overhead advance warning flashers and additional STOP AHEAD sign on minor approach.

Figure 3-22. Flashing Beacon Improvements at Site 98-11.

Crash Characteristics

Table 3-15 lists the details of the crash summary for Site 98-11. Narratives showed that all four crashes were two-vehicle crashes where one vehicle either ran the STOP sign or failed to yield right-of-way after stopping.

Table 3-15. Crash Summary at Site 98-11.

	Before Frequency		After Frequency	
Time Period	December 1995 to November 1998		January 1999 to December 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	2 (0.06)	2 (0.06)
Severity				
Injury	2	2	2	2
Non-Injury	0	0	0	0
Number of Vehicles				
1	0	0	0	0
2	2	2	2	2
Lighting Conditions				
Daylight	1	1	2	2
Dawn	1	1	0	0
Collision Type				
Right Angle	2	2	2	2

SITE 98-12: INSTALL IN-RAIL REFLECTORS

Description of Site

Site 98-12 is a rural two-lane section of state highway (see Figure 3-23a). This 3.1-mile (5.0 km) site is located on the northern edge of a small town; the first 2.8 miles (4.5 km) are in rural conditions, while the last 0.3 mile (0.5 km) is in the city limits with an increasing ADT and a major intersection. The section termini are a county line and a second major intersection.

Description of Improvement

In-line guardrail reflectors (see Figure 3-23b) were installed on existing guardrails throughout a 3.1-mile (5.0 km) section. The installation was completed in the summer of 1998 at a cost of \$2.72 per reflector.

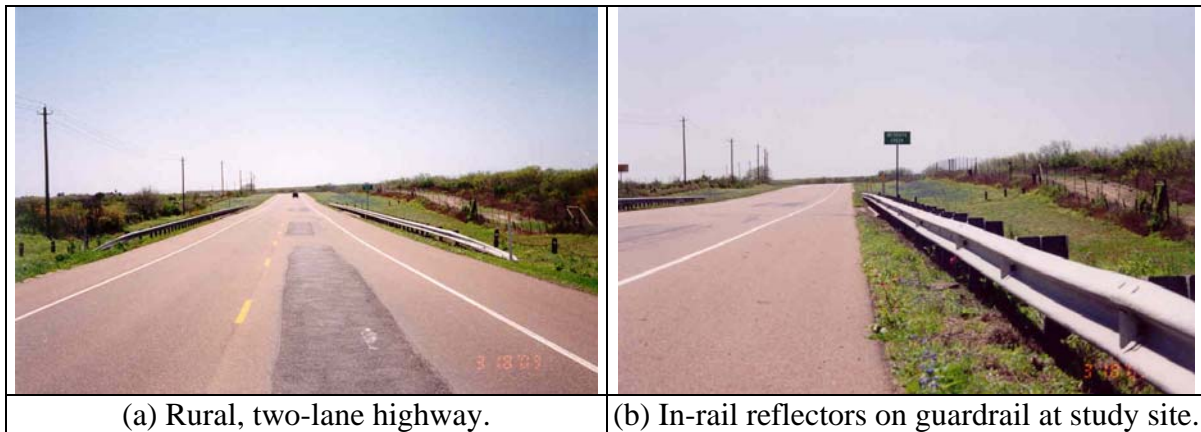


Figure 3-23. In-Rail Guardrail Reflectors.

Crash Characteristics

The crash distribution of Site 98-12 is shown in [Table 3-16](#). A TxDOT representative believes the reflectors have been effective in reducing the number of guardrail impacts on the section of roadway where they have been installed. The representative also concluded that this reduction was greater than that of the comparison site with no reflectors installed.

Table 3-16. Crash Summary at Site 98-12.

	Before Frequency		After Frequency	
Time Period	August 1995 to July 1998		September 1998 to August 2001	
Months in Time Period	36		36	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	18 (0.50)	0 (0.00)	10 (0.28)	0 (0.00)
Severity				
Injury	13	0	10	0
Non-Injury	5	0	0	0
Number of Vehicles				
1	4	0	1	0
2	14	0	9	0
Intersection Crashes				
At Intersection	6	0	6	0
Intersection Related	4	0	3	0
Driveway Related	3	0	1	0
Not Intersection Related	5	0	0	0

CHAPTER 4 BEFORE-AND-AFTER EVALUATIONS OF 1999 TREATMENTS

INTRODUCTION

This chapter discusses the before-and-after evaluations of sites with treatments installed in 1999. These 10 sites are being evaluated in a manner similar to that used for previous evaluations, but these sites have between 24 and 35 months of available post-improvement crash data. The exact amount of data will be specified for each site, but all have an after period that ends on December 31, 2001. The sites with treatments installed in 1999 are shown in [Table 4-1](#).

Table 4-1. Study Sites for B&A Evaluation with Treatments in 1999.

Site Code	Improvement	Installation Date	Number of Months	
			Before	After
99-02	Add shoulders, safety treat fixed objects, resurface	07/30/99	36	29
99-04	Reconfigure intersection, safety treat fixed objects	08/01/99	36	28
99-05	Add shoulders, safety treat fixed objects, resurface	08/02/99	36	28
99-06	Install safety lighting	08/11/99	36	28
99-07	Approach rumble strips and advance warning signs	09/01/99	36	27
99-08	Widen road, remove trees, safety treat headwalls	09/01/99	36	27
99-10	Advance warning sign with flashing beacon	10/01/99	36	26
99-11	Beacons, pavement markings, turning lanes	10/07/99	36	26
99-12	Overhead beacons	10/07/99	36	26
99-13	Replace raised median with flush median	10/13/99	36	26

SITE 99-02: ADD SHOULDERS, SAFETY TREAT FIXED OBJECTS, RESURFACE

Description of Site

This site consists of a rural two-lane section of US highway. This 13-mile (20.9 km) section runs from the intersection with another US highway to a county line.

Description of Treatment

The improvement project involved adding shoulders, safety treating fixed objects, and resurfacing. [Figure 4-1](#) shows the improved section compared to the adjacent unimproved roadway. Improvements were completed on July 30, 1999; approximate cost of installation was not available.

Crash Characteristics

A review of the crash data showed 15 total crashes in the section during the study period, as shown in [Table 4-2](#).



Figure 4-1. Limit of Improved Section of Roadway.

Table 4-2. Crash Summary at Site 99-02.

	Before Frequency		After Frequency	
Time Period	June 1996 to May 1999		July 1999 to December 2001	
Months in Time Period	36		30	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	6 (0.17)	1 (0.03)	9 (0.31)	2 (0.07)
Severity				
Injury	5	1	6	1
Non-Injury	1	0	3	1
Number of Vehicles				
1	3	0	5	1
2	3	1	4	2
Intersection Crashes				
At Intersection	2	0	2	0
Intersection Related	0	0	1	0
Not Intersection Related	4	1	6	2
Collision Type				
Fixed Object	0	0	4	0
Rear End	0	0	1	1
Sideswipe (Passing)	1	1	1	1
Right Angle	2	0	2	0
Other	3	0	1	0

SITE 99-04: RECONFIGURED INTERSECTION, SAFETY TREAT FIXED OBJECTS

Description of Site

This site is an 18-mile (29.0 km) segment of rural FM highway, from a four-leg intersection with a state highway to a T-intersection with a minor FM highway. The minor FM road, on the leg of the T, has an unusual curve on the approach to the intersection.

Description of Treatment

Engineers reconfigured the intersection to provide an improved approach on the curve on the minor FM road (Figure 4-2a). Chevrons were also added on the curve, and the approach on the previous alignment was closed off. Safety end treatments were also added on the 18-mile (29.0 km) segment of the major FM road (Figure 4-2b). Completion of the installation occurred in August 1999; approximate cost of installation was not available.



Figure 4-2. Improvements at Site 99-04.

Crash Characteristics

There were two crashes at this site, both in the before period. Table 4-3 summarizes the crash history.

Table 4-3. Crash Summary at Site 99-04.

	Before Frequency		After Frequency	
Time Period	August 1996 to July 1999		September 1999 to December 2001	
Months in Time Period	36		28	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	0 (0.00)	0 (0.00)	0 (0.00)
Severity				
Injury	2	0	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	2	0	0	0
2	0	0	0	0
Intersection Crashes				
Not Intersection Related	2	0	0	0
Collision Type				
Overturned	2	0	0	0

SITE 99-05: ADD SHOULDERS, SAFETY TREAT FIXED OBJECTS, RESURFACE

Description of Site

This site consists of a 7-mile (11.3 km) segment of rural two-lane state highway. This segment is the entire portion of this state highway within a county, running from county line to county line.

Description of Treatment

The improvement project involved adding shoulders, safety treating fixed objects, and resurfacing. Improvements were completed on August 2, 1999; approximate cost of installation was not available. [Figure 4-3](#) shows a portion of the improved segment.

Crash Characteristics

Crash data for this segment are provided in [Table 4-4](#). However, out of the 73 crashes shown, only five were considered preventable by the treatment: four in the period prior to improvement and one in the period following the improvement.



Figure 4-3. Added Shoulders, Resurfacing, and Safety Treatments.

Table 4-4. Crash Summary at Site 99-05.

	Before Frequency		After Frequency	
Time Period	August 1996 to July 1999		September 1999 to December 2001	
Months in Time Period	36		28	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	47 (1.31)	4 (0.11)	26 (0.93)	1 (0.04)
Severity				
Injury	30	1	16	0
Non-Injury	17	3	10	1
Number of Vehicles				
1	11	4	6	1
2	32	0	20	0
3	4	0	0	0
Collision Type				
Fixed Object	5	4	2	1
Right Angle	8	0	7	0
Left Turn	7	0	7	0
Rear End	19	0	5	0
Other	8	0	5	0

SITE 99-06: INSTALL SAFETY LIGHTING

Description of Site

This site is a rural intersection of a US highway and a state highway loop. The US highway is a divided four-lane highway, and the loop is a two-lane highway. This is a four-leg intersection; the loop tees into the US highway, but there is a private driveway opposite the loop.

Description of Treatment

Safety lighting was installed at this intersection in the form of three luminaires, one on each corner of the loop approach and one at the private driveway, shown in [Figure 4-4](#). Installation was completed on August 11, 1999, at an approximate cost of \$24,600.

Crash Characteristics

Crash data showed no crashes at the intersection during the study period.



Figure 4-4. Safety Lighting at Site 99-06.

SITE 99-07: APPROACH RUMBLE STRIPS AND ADVANCE WARNING SIGNS

Description of Site

This site is a four-leg intersection of a state highway and a state highway loop. Both highways are rural two-lane highways, although the loop has left-turn bays at the intersection and there are right turn lanes on each approach.

Description of Treatment

STOP AHEAD (W1-10) signs, HIGHWAY INTERSECTION AHEAD signs, and approach rumble strips were installed at this intersection, completed in September 1999. The approximate cost of installation was unavailable. Examples of the signs are shown in [Figure 4-5](#).



Figure 4-5. Advance Warning Signs on Intersection Approach.

Crash Characteristics

[Table 4-5](#) summarizes crash data for this site. Survey respondents indicated they believed the treatment has been effective at reducing crashes.

Table 4-5. Crash Summary at Site 99-07.

	Before Frequency		After Frequency	
Time Period	September 1996 to August 1999		October 1999 to December 2001	
Months in Time Period	36		27	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	5 (0.14)	0 (0.00)	2 (0.07)	0 (0.00)
Severity				
Injury	2	0	2	0
Non-Injury	3	0	0	0
Number of Vehicles				
1	4	0	1	0
2	1	0	1	0
Intersection Crashes				
At Intersection	2	0	0	0
Intersection Related	3	0	2	0
Collision Type				
Fixed Object	3	0	2	0
Other	2	0	0	0

SITE 99-08: WIDEN ROAD, REMOVE TREES, SAFETY TREAT HEADWALLS

Description of Site

This site is a 15.1-mile (24.3 km) segment of FM highway. This rural two-lane segment runs from the intersection with a US highway to a county line.

Description of Treatment

The roadway was widened, trees were removed, and headwalls received safety treatments (see [Figure 4-6](#)). Completion of the installation occurred in September 1999; approximate cost of installation was not available.

Crash Characteristics

Crash data showed 10 crashes in the section during the 36 months prior to improvement and 16 crashes in the 27 months following installation. Selected characteristics of the crashes are shown in [Table 4-6](#).



Figure 4-6. Improvements at Site 99-08.

Table 4-6. Crash Summary at Site 99-08.

	Before Frequency		After Frequency	
Time Period	September 1996 to August 1999		October 1999 to December 2001	
Months in Time Period	36		27	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	10 (0.28)	10 (0.28)	16 (0.59)	16 (0.59)
Severity				
Injury	8	8	13	13
Non-Injury	2	2	3	3
Number of Vehicles				
1	8	8	11	11
2 or more	2	2	5	5
Intersection Crashes				
At Intersection	0	0	1	1
Intersection Related	1	1	0	0
Driveway Related	1	1	1	1
Not Intersection Related	8	8	14	14
Collision Type				
Fixed Object	2	2	7	7
Overturned	6	6	4	4
Other	2	2	5	5

SITE 99-10: ADVANCE WARNING SIGN WITH FLASHING BEACON

Description of Site

This site is an intersection of a US highway and a FM highway. The US highway has a small hill on one approach, which obscures the intersection for approaching drivers.

Description of Treatment

A HIGHWAY INTERSECTION AHEAD sign with a flashing beacon (Figure 4-7) was installed on the approach upstream of the hill's upgrade to improve advance warning to drivers about the upcoming intersection. Completion of the installation occurred in October 1999; approximate cost of installation was not available.



Figure 4-7. Advance Warning Sign with Flashing Beacons on Obscured Approach.

Crash Characteristics

Crash data show no crashes at the intersection during the 36 months prior to improvement (October 1996 through September 1999) and the 26 months following installation (November 1999 through December 2001).

SITE 99-11: BEACONS, PAVEMENT MARKINGS, TURNING LANES

Description of Site

This site is a rural four-leg intersection of a state highway and a farm-to-market highway.

Description of Treatment

The improvement project included adding “bouncing” beacons, pavement marker buttons, and turning lanes at the intersection. Installation was completed on October 7, 1999; the approximate cost of installation was not available. The STOP sign-mounted beacons are shown in [Figure 4-8](#).



Figure 4-8. Beacons Mounted on STOP Sign.

Crash Characteristics

[Table 4-7](#) summarizes crash data for Site 99-11. Survey respondents stated that, in their opinion, the treatments were effective.

Table 4-7. Crash Summary at Site 99-11.

	Before Frequency		After Frequency	
Time Period	October 1996 to September 1999		November 1999 to December 2001	
Months in Time Period	36		26	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	8 (0.22)	8 (0.22)	1 (0.04)	0 (0.00)
Severity				
Injury	6	6	0	0
Non-Injury	2	2	1	0
Number of Vehicles				
1	0	0	0	0
2	8	8	1	0
Intersection Crashes				
At Intersection	7	7	0	0
Intersection Related	1	1	1	0
Collision Type				
Right Angle	8	8	1	0

SITE 99-12: OVERHEAD BEACONS

Description of Site

This site is a rural four-leg intersection of a state highway and a farm-to-market highway.

Description of Treatment

Two sets of four-directional overhead alternating beacons were installed at the intersection, as shown in [Figure 4-9](#). Completion of the installation occurred on October 7, 1999; approximate cost of installation was not available.

Crash Characteristics

Crash data showed seven crashes at the intersection, all during the 36 months prior to improvement. Characteristics of these crashes are contained in [Table 4-8](#).



Figure 4-9. Overhead “Bouncing” Beacons.

Table 4-8. Crash Summary at Site 99-12.

	Before Frequency		After Frequency	
Time Period	October 1996 to September 1999		November 1999 to December 2001	
Months in Time Period	36		26	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	7 (0.19)	7 (0.19)	0 (0.00)	0 (0.00)
Severity				
Injury	7	7	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	1	1	0	0
2 or more	6	6	0	0
Intersection Crashes				
At Intersection	4	4	0	0
Intersection Related	3	3	0	0
Collision Type				
Rear End	4	4	0	0
Left Turn	2	2	0	0
Fixed Object	1	1	0	0

SITE 99-13: REPLACE RAISED MEDIAN WITH FLUSH MEDIAN

Description of Site

This site is an intersection of a state highway and a farm-to-market highway.

Description of Treatment

Raised median islands were removed and replaced with striped islands. Installation was completed on October 13, 1999; approximate cost of installation was not available.

Crash Characteristics

Examination of the crash data revealed three crashes in the section prior to improvement and one crash in the 26 months after installation, as shown in [Table 4-9](#).

Table 4-9. Crash Summary at Site 99-13.

	Before Frequency		After Frequency	
Time Period	October 1996 to September 1999		November 1999 to December 2001	
Months in Time Period	36		26	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	0 (0.00)	1 (0.04)	0 (0.00)
Severity				
Injury	3	0	1	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	2	0	0	0
2	1	0	1	0
Intersection Crashes				
At Intersection	1	0	1	0
Intersection Related	2	0	0	0
Collision Type				
Fixed Object	2	0	0	0
Right Angle	1	0	0	0
Left Turn	0	0	1	0

CHAPTER 5

BEFORE-AND-AFTER EVALUATIONS OF 2000 TREATMENTS

INTRODUCTION

This chapter discusses the before-and-after evaluations of sites with treatments installed in 2000. These 22 sites are being evaluated in a manner similar to that used for previous evaluations, but these sites have between 12 and 23 months of available post-improvement crash data. The exact amount of data will be specified for each site, but all have an after period that ends on December 31, 2001. [Table 5-1](#) shows the sites with treatments installed in 2000.

Table 5-1. Study Sites for B&A Evaluation with Treatments in 2000.

Site Code	Improvement	Installation Date	Number of Months	
			Before	After
100-02	Add shoulders, safety treat fixed objects, resurface	02/22/00	36	22
100-03	Stop Ahead signs	02/01/00	36	22
100-04	Reflective strips on Stop sign	05/01/00	36	19
100-05	Widen roadway	05/01/00	36	19
100-06	Add shoulders, resurface, safety treat structures	06/01/00	36	18
100-07	Safety lighting	06/06/00	36	18
100-08	Safety lighting	06/06/00	36	18
100-09	Safety lighting	06/06/00	36	18
100-10	Widen roadway, remove trees, safety treat headwalls	07/01/00	36	17
100-11	Chevrons on curve approaches	07/01/00	36	17
100-12	Advance warning signs and pavement markings	07/01/00	36	17
100-13	Add turning lanes and pavement markings	07/01/00	36	17
100-14	Chevrons on curve approach	07/12/00	36	17
100-15	Raised pavement markers	08/01/00	36	16
100-16	Approach rumble strips and advance warning sign	10/01/00	36	14
100-17	Approach rumble strips, flashing beacons, pavement markings	10/01/00	36	14
100-18	Right-turn lane and No Parking signs	10/01/00	36	14
100-19	Paved shoulders	10/01/00	36	14
100-20	High-center traffic signals, approach rumble strips, advance signing	10/04/00	36	14
100-22	Channelizing islands	10/30/00	36	14
100-23	Overheight warning system	11/13/00	36	13
100-24	Widen roadway	12/01/00	36	12

SITE 100-02: ADD SHOULDERS, SAFETY TREAT FIXED OBJECTS, RESURFACE

Description of Site

This site is an 11-mile (17.7 km) segment of rural two-lane US highway.

Description of Treatment

This segment of roadway was resurfaced, shoulders were added, and safety treatments were applied to fixed objects, pictured in [Figure 5-1](#). Completion of the installation occurred on February 22, 2000; approximate cost of installation was not available.



Figure 5-1. New Shoulders and Resurfacing at Site 100-02.

Crash Characteristics

Crash data showed 15 crashes in the segment during the study period, of which nine were considered preventable for this treatment. The summary of crash data is shown in [Table 5-2](#).

Table 5-2. Crash Summary at Site 100-02.

	Before Frequency		After Frequency	
Time Period	February 1997 to January 2000		March 2000 to December 2001	
Months in Time Period	36		22	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	6 (0.17)	4 (0.11)	9 (0.41)	5 (0.23)
Severity				
Injury	4	3	7	3
Non-Injury	2	1	2	2
Number of Vehicles				
1	5	3	6	3
2	1	1	3	2
Intersection Crashes				
At Intersection	0	0	2	1
Not Intersection Related	6	4	7	4
Collision Type				
Fixed Object	3	3	2	2
Animal	1	0	3	1
Overtaken	1	0	1	0
Rear End	1	1	2	2
Right Angle	0	0	1	0

SITE 100-03: STOP AHEAD SIGNS

Description of Site

This site is a rural T-intersection of two farm-to-market highways. The leg of the T has a series of moderate and sharp curves on the approach to the intersection, which reduces the visibility of the intersection for approaching drivers. One such curve is pictured in [Figure 5-2](#).

Description of Treatment

STOP AHEAD signs were installed on the leg of the T. Completion of the installation occurred in February 2000; approximate cost of installation was \$500.

Crash Characteristics

There were only two crashes at the intersection during the study period, both occurring in the 36 months prior to improvement (see [Table 5-3](#)).



Figure 5-2. STOP AHEAD Sign on Intersection Approach in Advance of Curve.

Table 5-3. Crash Summary at Site 100-03.

	Before Frequency		After Frequency	
Time Period	February 1997 to January 2000		March 2000 to December 2001	
Months in Time Period	36		22	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	0 (0.00)	0 (0.00)
Severity				
Injury	2	2	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	2	2	0	0
2	0	0	0	0
Intersection Crashes				
At Intersection	1	1	0	0
Intersection Related	1	1	0	0
Collision Type				
Fixed Object	1	1	0	0
Overturned	1	1	0	0
Curve Crashes				
Degree of Curve = 0	0	0	0	0
Degree of Curve > 0	2	2	0	0

SITE 100-04: REFLECTIVE STRIPS ON STOP SIGN

Description of Site

This site is a rural T-intersection of a farm-to-market highway and a local road. The intersection is stop-controlled on the local road, which is the leg of the T.

Description of Treatment

In May 2000, red reflective strips were installed on the STOP sign post on the local road to increase visibility, as shown in [Figure 5-3](#). Approximate cost of installation was not available.



Figure 5-3. Reflective Strips on STOP Sign Post.

Crash Characteristics

There were only two crashes at the intersection during the study period, both occurring in the 36 months prior to improvement (see [Table 5-4](#)).

Table 5-4. Crash Summary at Site 100-04.

	Before Frequency		After Frequency	
Time Period	May 1997 to April 2000		June 2000 to December 2001	
Months in Time Period	36		19	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	0 (0.00)	0 (0.00)
Severity				
Injury	1	1	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	2	2	0	0
2	0	0	0	0
Intersection Crashes				
Intersection Related	2	2	0	0
Collision Type				
Fixed Object	2	2	0	0
Light Conditions				
Dark – No Lights	2	2	0	0

SITE 100-05: WIDEN ROADWAY

Description of Site

This site is a 24-mile (38.6 km) segment of rural two-lane farm-to-market highway.

Description of Treatment

The roadway was widened along the entire 24-mile (38.6 km) segment. The project was completed in May 2000; approximate cost of installation was not available. [Figure 5-4](#) shows the improved roadway.

Crash Characteristics

Crash data showed 13 crashes in the section prior to improvement and five crashes in the following installation. [Table 5-5](#) contains the summary of crash data for Site 100-05.



Figure 5-4. Widened Roadway at Site 100-05.

Table 5-5. Crash Summary at Site 100-05.

	Before Frequency		After Frequency	
Time Period	May 1997 to April 2000		June 2000 to December 2001	
Months in Time Period	36		19	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	13 (0.36)	13 (0.36)	5 (0.26)	5 (0.26)
Severity				
Injury	11	11	1	1
Non-Injury	2	2	4	4
Number of Vehicles				
1	9	9	4	4
2	4	4	1	1
Intersection Crashes				
At Intersection	0	0	1	1
Intersection Related	1	1	1	1
Not Intersection Related	12	12	3	3
Collision Type				
Overturned	6	6	1	1
Fixed Object	3	3	3	3
Other	4	4	1	1

SITE 100-06: ADD SHOULDERS, SAFETY TREAT STRUCTURES, RESURFACE

Description of Site

This site is a 7-mile (11.3 km) section of rural two-lane US highway.

Description of Treatment

The roadway was resurfaced, 10-ft (3.0 m) shoulders were added, and safety treatments were added to structures throughout the section, a portion of which is shown in [Figure 5-5](#). Installation was completed in June 2000; approximate cost of installation was not available.



Figure 5-5. View of Resurfaced Roadway and Added Shoulders at Site 100-06.

Crash Characteristics

The crashes at Site 100-06 are summarized in [Table 5-6](#).

Table 5-6. Crash Summary at Site 100-06.

	Before Frequency		After Frequency	
Time Period	June 1997 to May 2000		July 2000 to December 2001	
Months in Time Period	36		18	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	15 (0.42)	15 (0.42)	7 (0.39)	7 (0.39)
Severity				
Injury	11	11	3	3
Non-Injury	4	4	4	4
Number of Vehicles				
1	8	8	3	3
2 or more	7	7	4	4
Intersection Crashes				
At Intersection	1	1	3	3
Intersection Related	2	2	0	0
Not Intersection Related	12	12	4	4
Collision Type				
Overturned	5	5	1	1
Fixed Object	3	3	2	2
Rear End	5	5	1	1
Other	2	2	3	3

SITE 100-07: SAFETY LIGHTING

Description of Site

This site is a rural grade-separated intersection of a state highway over a US highway.

Description of Treatment

Safety lighting was added in the form of four luminaires placed at both approaches of the state highway bridge and the entrance of both ramps from the US highway. Installation was completed on June 6, 2000; the cost of installation was approximately \$40,600. Two of the four luminaires are shown in [Figure 5-6](#).

Crash Characteristics

The summary of crash data in [Table 5-7](#) shows two crashes at the intersection during the study period, both in the 36 months prior to improvement. The data show that both crashes were rear-end crashes where the vehicle in front had stopped, presumably to turn. However, both of these crashes occurred in daylight hours. Thus, the number and characteristics of these crashes makes it difficult to make definitive conclusions on effectiveness without other information about the site.



Figure 5-6. Safety Lighting at Site 100-07.

Table 5-7. Crash Summary at Site 100-07.

	Before Frequency		After Frequency	
Time Period	June 1997 to May 2000		July 2000 to December 2001	
Months in Time Period	36		18	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	0 (0.00)	0 (0.00)	0 (0.00)
Severity				
Injury	2	0	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	0	0	0	0
2	2	0	0	0
Intersection Crashes				
At Intersection	1	0	0	0
Intersection Related	1	0	0	0
Collision Type				
Rear End	2	0	0	0
Light Conditions				
Daylight	2	0	0	0

SITE 100-08: SAFETY LIGHTING

Description of Site

This site is a rural T-intersection of a state highway and a farm-to-market highway. The intersection is stop-controlled on the FM road, which is the leg of the T.

Description of Treatment

Two luminaires were installed, one on either corner of the FM road approach (see [Figure 5-7](#)), to provide additional safety lighting. Installation was completed on June 6, 2000; the cost of installation was approximately \$19,000.



Figure 5-7. Luminaires at T-Intersection.

Crash Characteristics

Crash data showed two crashes at the intersection during the 36 months prior to improvement and one crash in the 18 months following installation. [Table 5-8](#) contains the summary of the crash data.

Table 5-8. Crash Summary at Site 100-08.

	Before Frequency		After Frequency	
Time Period	June 1997 to May 2000		July 2000 to December 2001	
Months in Time Period	36		18	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	1 (0.06)	0 (0.00)
Severity				
Injury	1	1	1	0
Non-Injury	1	1	0	0
Number of Vehicles				
1	2	2	0	0
3	0	0	1	0
Intersection Crashes				
At Intersection	1	1	1	0
Intersection Related	1	1	0	0
Collision Type				
Fixed Object	2	2	0	0
Right Angle	0	0	1	0
Light Conditions				
Dark – No Lights	2	2	0	0
Daylight	0	0	1	0

SITE 100-09: SAFETY LIGHTING

Description of Site

This site is a rural four-leg intersection of a state highway and a farm-to-market highway. The intersection is stop-controlled on the two FM road approaches.

Description of Treatment

Two luminaires were installed on opposite corners of the intersection to improve lighting conditions, as shown in [Figure 5-8](#). Installation was completed on June 6, 2000; the cost of installation was approximately \$23,300.

Crash Characteristics

The crash data, summarized in [Table 5-9](#), showed three crashes at the intersection, all during the 36 months prior to improvement. All three crashes were two-vehicle crashes. However, all three crashes were also during daylight hours, so determining the effectiveness of this treatment from only the crash history is inconclusive.



Figure 5-8. Luminaires on Opposite Corners of Four-Leg Intersection.

Table 5-9. Crash Summary at Site 100-09.

	Before Frequency		After Frequency	
Time Period	June 1997 to May 2000		July 2000 to December 2001	
Months in Time Period	36		18	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	0 (0.00)	0 (0.00)	0 (0.00)
Severity				
Injury	2	0	0	0
Non-Injury	1	0	0	0
Number of Vehicles				
1	0	0	0	0
2	3	0	0	0
Intersection Crashes				
At Intersection	1	0	0	0
Intersection Related	2	0	0	0
Light Conditions				
Daylight	3	0	0	0

SITE 100-10: WIDEN ROADWAY, REMOVE TREES, SAFETY TREAT HEADWALLS

Description of Site

This site is a section of rural, two-lane FM highway approximately 8 miles (12.9 km) in length (see [Figure 5-9](#)).

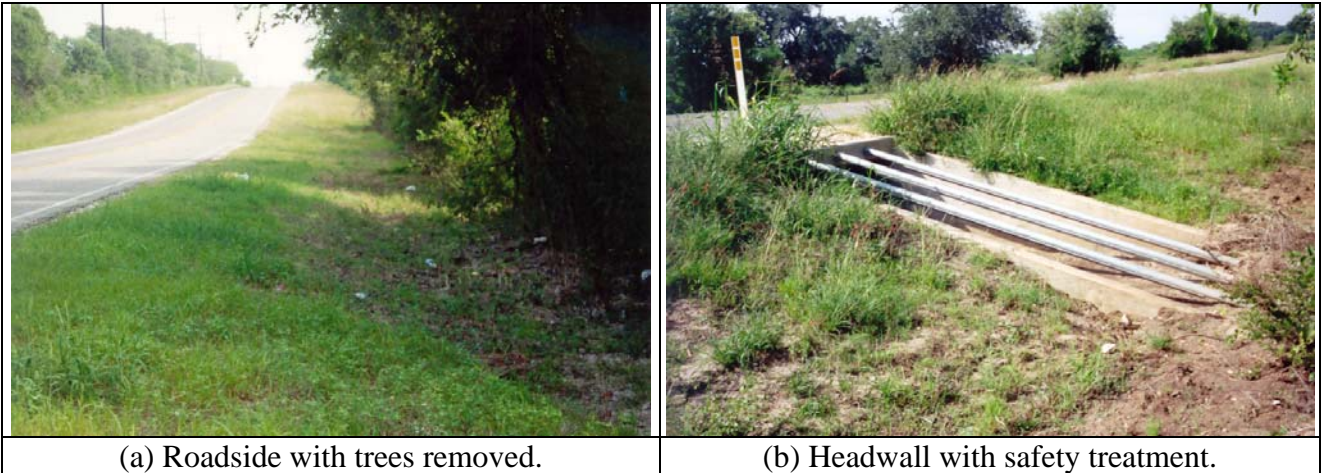


Figure 5-9. Improvements at Site 100-10.

Description of Treatment

The roadway was widened, some trees near the roadway were removed, and safety treatments were applied to headwalls throughout the section. Completion of the installation occurred in July 2000; approximate cost of installation was not available.

Crash Characteristics

Crash data showed three crashes in the section during the 36 months prior to improvement and four crashes in the 17 months following installation, as shown in [Table 5-10](#).

Table 5-10. Crash Summary at Site 100-10.

	Before Frequency		After Frequency	
Time Period	July 1997 to June 2000		August 2000 to December 2001	
Months in Time Period	36		17	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	1 (0.03)	4 (0.24)	2 (0.12)
Severity				
Injury	2	1	3	1
Non-Injury	1	0	1	1
Number of Vehicles				
1	3	1	4	2
Intersection Crashes				
Intersection Related	1	0	3	2
Not Intersection Related	2	1	1	0
Type of Collision				
Overturned	2	1	0	0
Animal	1	0	0	0
Fixed Object	0	0	4	2

SITE 100-11: CHEVRONS ON CURVE APPROACHES

Description of Site

This site is an 8.6-mile (13.8 km) section of FM roadway with a number of sharp curves.

Description of Treatment

Chevrons were installed on curves throughout the section, one of which is shown in [Figure 5-10](#). The chevrons were completely installed by July 2000; approximate cost of installation was \$55 per chevron.



Figure 5-10. Chevrons on Horizontal Curve.

Crash Characteristics

A review of the crash data, shown in [Table 5-11](#), reveals one crash in the section in the before period and two in the after period.

Table 5-11. Crash Summary at Site 100-11.

	Before Frequency		After Frequency	
Time Period	July 1997 to June 2000		August 2000 to December 2001	
Months in Time Period	36		17	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	1 (0.03)	1 (0.03)	2 (0.12)	1 (0.06)
Severity				
Injury	1	1	1	1
Non-Injury	0	0	1	0
Number of Vehicles				
1	1	1	2	1
Curve Crashes				
Degree of Curve = 0	0	0	1	0
Degree of Curve > 0	1	1	1	1
Type of Collision				
Fixed Object	1	0	2	1

SITE 100-12: ADVANCE WARNING SIGNS AND PAVEMENT MARKINGS

Description of Site

This site is a rural T-intersection of two FM highways. The leg of the T is stop-controlled.

Description of Treatment

Advance warning signs, including STOP AHEAD pavement markings, were installed on the stop-controlled approach. Completion of the installation occurred in July 2000; approximate cost of installation was \$450. [Figure 5-11](#) shows one set of pavement markings.

Crash Characteristics

No crashes were reported at the intersection during the study period.



Figure 5-11. Advance Warning Pavement Markings on Intersection Approach.

SITE 100-13: ADD TURNING LANES AND PAVEMENT MARKINGS

Description of Site

This site is a rural intersection of two farm-to-market highways.

Description of Treatment

New pavement markings were added, and left-turn lanes were installed on the major road. As seen in [Figure 5-12](#), the turning lanes were installed to allow turning vehicles in either direction of the major road to approach their turns separated from through traffic. Completion of the installation occurred in July 2000; approximate cost of installation was not available.

Crash Characteristics

No crashes were reported at the intersection during the study period.



Figure 5-12. New Left-Turn Lanes at Intersection.

SITE 100-14: CHEVRONS ON CURVE APPROACH

Description of Site

This site is a curve on a rural FM highway. This curve has an advisory speed more than 25 mph below the posted speed.

Description of Treatment

Fluorescent yellow chevrons were installed on this curve, with material donated by the manufacturer. Installation occurred on July 12, 2000. Because materials were donated, the total cost of installation was not available, but it was estimated to be \$125 per chevron for this type of sheeting.

Crash Characteristics

No crashes were reported at the curve during the study period.

SITE 100-15: RAISED PAVEMENT MARKERS

Description of Site

This site is an 11.3-mile (18.2 km) section of rural two-lane farm-to-market roadway.

Description of Treatment

Raised pavement markers (shown in [Figure 5-13](#)) were installed throughout this section as part of a statewide action to improve nighttime visibility. Installation was completed in August 2000. Installation costs were approximately \$350 per mile.



Figure 5-13. Centerline Raised Pavement Marker.

Crash Characteristics

Two crashes were reported in this section during the 36 months prior to improvement (August 1997 through July 2000) and one in the 16 months following installation (September 2000 through December 2001), as [Table 5-12](#) shows.

Table 5-12. Crash Summary at Site 100-15.

	Before Frequency		After Frequency	
Time Period	August 1997 to July 2000		September 2000 to December 2001	
Months in Time Period	36		16	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	2 (0.06)	2 (0.06)	1 (0.06)	1 (0.06)
Severity				
Injury	1	1	1	1
Non-Injury	1	1	0	0
Number of Vehicles				
1	2	2	1	1
Light Conditions				
Daylight	1	1	0	0
Dark – No Lights	1	1	1	1
Type of Collision				
Fixed Object	1	1	1	1
Overturned	1	1	0	0

SITE 100-16: APPROACH RUMBLE STRIPS AND ADVANCE WARNING SIGN

Description of Site

This site is a rural T-intersection of a farm-to-market highway and a county road. One approach on the FM road has a significant vertical curve just prior to the intersection, which restricts drivers’ ability to see the intersection and any traffic within it.

Description of Treatment

Approach rumble strips and a T-intersection advance warning sign were installed on the approach to provide visual notification to drivers approaching on the FM road and audible notification of approaching vehicles to drivers stopped at the intersection on the county road. These improvements are illustrated in [Figure 5-14](#). Completion of the installation occurred in October 2000; approximate cost of installation was \$2000.

Crash Characteristics

The crash history at this site, summarized in [Table 5-13](#), showed seven crashes at the intersection during the 36 months prior to improvement and two crashes after installation; however, there was only one preventable crash, which occurred in the before period. This preventable crash was a driveway-related crash occurring during daylight hours; it was a rear-end crash that resulted in a possible injury. The survey respondent indicated that there had not been a major crash problem at the intersection to promote the treatments; rather, the treatments were intended as more of a preventive solution in response to local comments and complaints. Indeed, the respondent stated that local complaints had decreased significantly, and positive remarks had likewise increased.



Figure 5-14. Approach Rumble Strips and Intersection Advance Warning Sign.

Table 5-13. Crash Summary at Site 100-16.

	Before Frequency		After Frequency	
Time Period	October 1997 to September 2000		November 2000 to December 2001	
Months in Time Period	36		14	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	7 (0.19)	1 (0.03)	2 (0.14)	0 (0.00)
Severity				
Injury	5	1	2	0
Non-Injury	2	0	0	0
Number of Vehicles				
1	4	0	2	0
2	3	1	0	0
Intersection Crashes				
Intersection Related	4	0	2	0
Driveway Related	1	1	0	0
Not Intersection Related	2	0	0	0
Light Conditions				
Daylight	3	1	1	0
Dark – No Lights	3	0	1	0
Dark – With Lights	1	0	0	0
Type of Collision				
Fixed Object	3	0	2	0
Right Angle	2	0	0	0
Rear End	1	1	0	0
Animal	1	0	0	0

SITE 100-17: APPROACH RUMBLE STRIPS, FLASHING BEACONS, PAVEMENT MARKINGS

Description of Site

This site is a rural intersection of two farm-to-market highways.

Description of Treatment

New pavement markings, approach rumble strips, and flashing beacons were installed at this intersection to increase drivers' awareness of the presence of the intersection. Completion of the installation occurred in October 2000; approximate cost of installation was \$15,000. An example of each treatment is shown in [Figure 5-15](#).

Crash Characteristics

Three crashes were reported at the intersection prior to installation, and no crashes were recorded in the 14 months following installation; [Table 5-14](#) further describes these crashes.



Figure 5-15. Multiple Treatments at Site 100-17.

Table 5-14. Crash Summary at Site 100-17.

	Before Frequency		After Frequency	
Time Period	October 1997 to September 2000		November 2000 to December 2001	
Months in Time Period	36		14	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	3 (0.08)	0 (0.00)	0 (0.00)
Severity				
Injury	3	3	0	0
Non-Injury	0	0	0	0
Number of Vehicles				
1	0	0	0	0
2	3	3	0	0
Intersection Crashes				
At Intersection	3	3	0	0
Light Conditions				
Daylight	3	3	0	0
Type of Collision				
Right Angle	3	3	0	0

SITE 100-18: RIGHT-TURN LANE AND NO PARKING SIGNS

Description of Site

This site is a signalized T-intersection of a farm-to-market highway and the entrance to an elementary school.

Description of Treatment

A right-turn lane (shown in [Figure 5-16](#)) was added to the FM road for vehicles turning into the school, and NO PARKING signs were added to the roadside adjacent to the school on the FM road. Completion of the installation occurred in October 2000; approximate cost of installation was not available.

Crash Characteristics

No crashes were reported at this location during the study period.



Figure 5-16. Right-Turn Lane Adjacent to School.

SITE 100-19: PAVED SHOULDERS

Description of Site

This site is a section of US highway approximately 8 miles (12.9 km) in length. This section is a two-lane highway in a rural setting.

Description of Treatment

The shoulders on this section were paved in a project that was completed in October 2000. The approximate cost of installation was not available.

Crash Characteristics

There were three crashes in the section during the 36 months prior to improvement and one crash in the 14 months following installation, as shown in [Table 5-15](#).

Table 5-15. Crash Summary at Site 100-19.

	Before Frequency		After Frequency	
Time Period	October 1997 to September 2000		November 2000 to December 2001	
Months in Time Period	36		14	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	3 (0.08)	0 (0.00)	1 (0.17)	0 (0.00)
Severity				
Non-Injury	3	0	1	0
Number of Vehicles				
1	3	0	1	0
Intersection Crashes				
Not Intersection Related	3	0	1	0
Light Conditions				
Daylight	2	0	1	0
Dark – No Lights	1	0	0	0
Type of Collision				
Fixed Object	2	0	0	0
Animal	1	0	0	0
Overturned	0	0	1	0

SITE 100-20: HIGH-CENTER TRAFFIC SIGNALS, APPROACH RUMBLE STRIPS, ADVANCE SIGNING

Description of Site

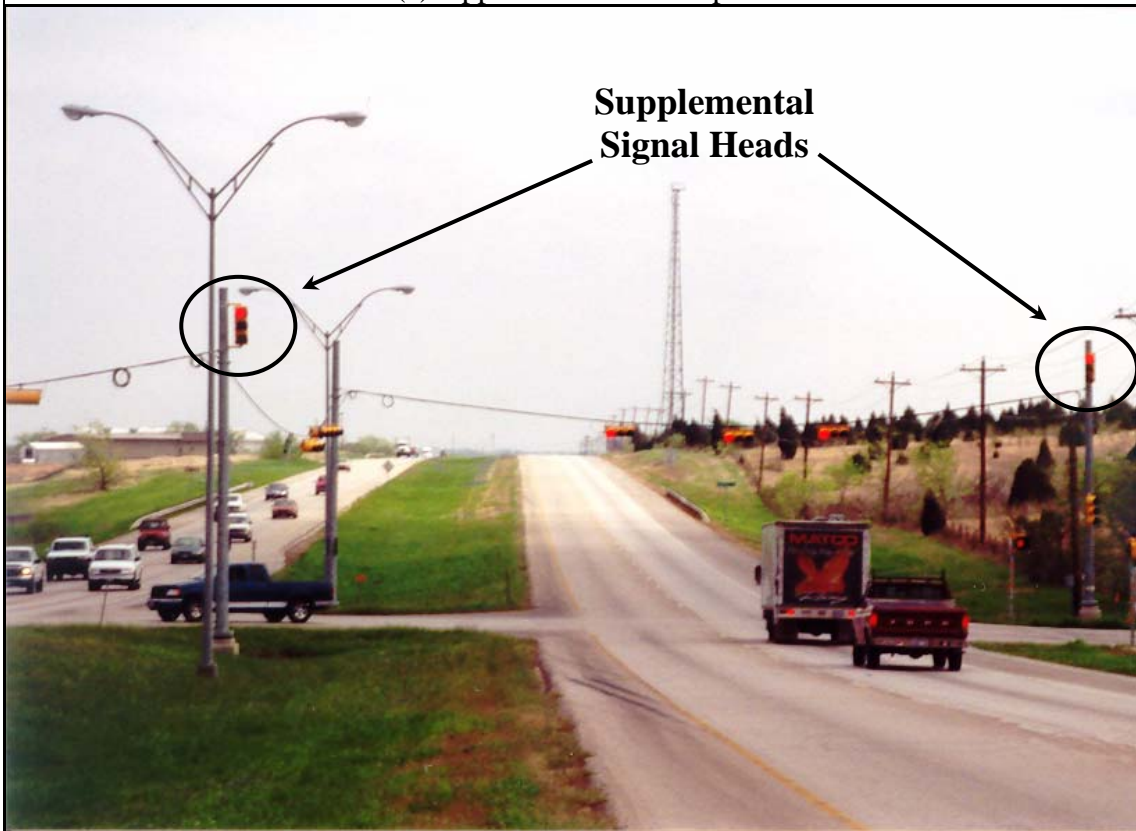
This site is an intersection of a US highway and a farm-to-market highway. This intersection is in a developing suburban fringe area. The US highway is a four-lane divided highway, and the FM road is a four-lane undivided highway. There are vertical curves on the US highway near the intersection that obscure drivers' view of the intersection. Prior to improvement, the intersection was stop-controlled on the FM road, with overhead flashing beacons for all four approaches.

Description of Treatment

Supplemental traffic signal heads, advance signing, and approach rumble strips were installed at this intersection to accommodate increasing traffic volumes and address the issue of approach visibility. Supplemental signal heads were mounted near the top of the support poles on both sides of the travel lanes on the US highway. These high-centered signals are more visible to drivers on the upgrade of the vertical curves approaching the intersection. The rumble strips are placed on the upgrade of those vertical curves to notify drivers that the intersection is ahead. [Figure 5-17](#) shows examples of these treatments. Installation was completed on October 4, 2000; approximate cost of installation was not available.



(a) Approach rumble strips.



(b) Traffic signals on high center.

Figure 5-17. Improvements at Site 100-20.

Crash Characteristics

Crash data for Site 100-20 is summarized in [Table 5-16](#).

Table 5-16. Crash Summary at Site 100-20.

	Before Frequency		After Frequency	
Time Period	October 1997 to September 2000		November 2000 to December 2001	
Months in Time Period	36		14	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	25 (0.69)	18 (0.50)	15 (1.07)	11 (0.79)
Severity				
Injury	18	15	11	7
Non-Injury	7	3	4	4
Number of Vehicles				
1	6	0	2	0
2	17	16	13	11
3	2	2	0	0
Intersection Crashes				
At Intersection	13	13	0	0
Intersection Related	8	5	13	11
Not Intersection Related	4	0	2	0
Light Conditions				
Daylight	20	15	9	6
Dawn	0	0	1	1
Dark – No Lights	4	3	3	3
Dark – With Lights	1	0	2	1
Type of Collision				
Right Angle	12	12	0	0
Rear End	7	6	13	11
Fixed Object	4	0	0	0
Overturned	2	0	2	0

SITE 100-22: CHANNELIZING ISLANDS

Description of Site

This site is an intersection of a US highway and a state highway.

Description of Treatment

Channelizing islands were added to this intersection, completed on October 30, 2000. The cost of the treatment was approximately \$251,000. One island is shown in [Figure 5-18](#).

Crash Characteristics

There were 11 crashes at the intersection during the study period. [Table 5-17](#) shows details for those crashes.



Figure 5-18. Right-Turn Lane with Channelizing Island.

Table 5-17. Crash Summary at Site 100-22.

	Before Frequency		After Frequency	
Time Period	October 1997 to September 2000		November 2000 to December 2001	
Months in Time Period	36		14	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	7 (0.19)	7 (0.19)	4 (0.29)	4 (0.29)
Severity				
Injury	5	5	2	2
Non-Injury	2	2	2	2
Number of Vehicles				
2	6	6	4	4
3	1	1	0	0
Light Conditions				
Daylight	5	5	3	3
Dark – No Lights	0	0	1	1
Dark – With Lights	1	1	0	0
Dusk	1	1	0	0
Type of Collision				
Right Angle	3	3	3	3
Left Turn	4	4	1	1

SITE 100-23: OVERHEIGHT WARNING SYSTEM

Description of Site

This site consists of a railroad bridge over a divided four-lane rural US highway. The highway under the railroad bridge has limited height and width, causing significant potential for oversized trucks to strike the bridge when passing through the site. [Figure 5-19a](#) shows a near-oversized vehicle traveling under the bridge.

Description of Treatment

The roadway was fitted with an overheight warning system that detected the height of approaching vehicles upstream of the railroad bridge. When an oversized vehicle passed through the system, the detectors recognized the height of the vehicle and activated beacons on a warning sign ([Figure 5-19b](#)), which informed drivers of an alternate route they should take. The system was completed on November 13, 2000, at an approximate cost of \$65,800.

Crash Characteristics

Crash data, as summarized in [Table 5-18](#), showed one crash at the site, occurring prior to improvement.

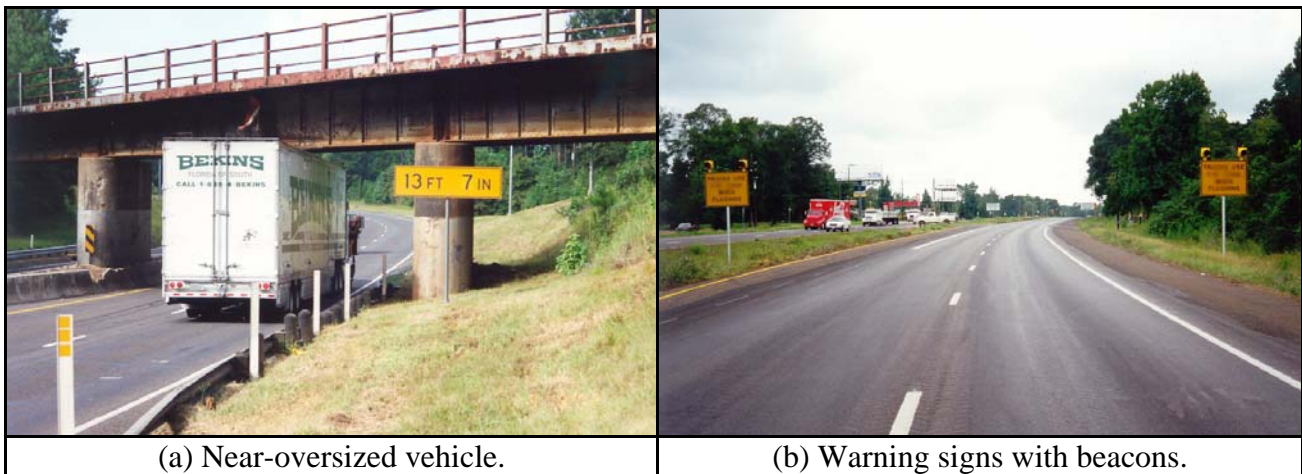


Figure 5-19. Warning System and Railroad Bridge at Site 100-23.

Table 5-18. Crash Summary at Site 100-23.

	Before Frequency		After Frequency	
Time Period	November 1997 to October 2000		December 2000 to December 2001	
Months in Time Period	36		13	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	12 (0.33)	1 (0.03)	12 (0.92)	0 (0.00)
Severity				
Injury	9	1	8	0
Non-Injury	3	0	4	0
Number of Vehicles				
1	0	0	4	0
2	10	0	8	0
3	2	1	0	0
Type of Collision				
Right Angle	8	0	5	0
Fixed Object	1	1	3	0
Other	3	0	4	0

SITE 100-24: WIDEN LANES

Description of Site

This site is a section of rural FM roadway approximately 6.5 miles (10.5 km) in length.

Description of Treatment

The project added 2 ft of lane width to each side of the roadway. Construction ended on December 4, 2001; approximate cost of installation was not available. [Figure 5-20](#) shows a portion of the section.

Crash Characteristics

As shown in [Table 5-19](#), there were four crashes in the section during the 36 months prior to improvement and one crash in the 12 months after completion.



Figure 5-20. Widened Lanes at Site 100-24.

Table 5-19. Crash Summary at Site 100-24.

	Before Frequency		After Frequency	
Time Period	January 1994 to April 1997		January 2001 to December 2001	
Months in Time Period	36		12	
	All Crashes	Preventable Crashes	All Crashes	Preventable Crashes
Number of Crashes (Crashes/Month)	4 (0.11)	4 (0.11)	1 (0.08)	1 (0.08)
Severity				
Injury	2	2	0	0
Non-Injury	2	2	1	1
Number of Vehicles				
1	4	4	1	1
Light Conditions				
Dark – No Lights	4	4	1	1
Type of Collision				
Overturned	2	2	0	0
Fixed Object	1	1	1	1
Animal	1	1	0	0

CHAPTER 6 CRASH DATA ANALYSIS

CRASH RATES

In order to normalize the crash data among all the sites, the crashes in this chapter are expressed as crash rates divided over time or traffic volumes. There are three rates that will be used in this analysis: crashes per month, crashes per million entering vehicles (MEV), and crashes per million vehicle miles traveled (MVMT). The first rate can be used for all sites, while the latter two rates are used only for intersections and roadway segments, respectively. The set of crashes to be analyzed can also vary. There are three sets of crashes used in this analysis, as defined below:

- total crashes – all crashes occurring at the study site during the study period,
- preventable crashes – crashes defined as being preventable by the treatment installed; the type(s) of crashes that the treatment is intended to reduce, and
- non-PDO crashes – crashes resulting in a possible or confirmed injury; crashes with a severity code other than “non-injury.”

SITE DESCRIPTION

Researchers assigned each site an identifying number, based on the date its treatment was installed. If possible, each site was evaluated for a period of six years; three years prior to and three years after the installation of the selected treatment. For sites with treatments installed prior to July 1, 1998, there were fewer than 36 months of crash data before installation; because there was a change in the method of reporting PDO crashes on July 1, 1995, all data before this date were removed from the evaluations. For sites with treatments installed after December 31, 1998, crash data are not yet available for the three years after installation; these sites were evaluated with all available data, which ended on December 31, 2001. [Table 6-1](#) contains the description of each site and its evaluation study period.

TOTAL CRASHES

The total number of crashes for each study site was compiled for the applicable study period. For the 50 study sites considered, there were 868 total crashes within the study periods. Because the length of the study period differed for sites with treatments installed after 1998, a direct comparison of the number of crashes at each site is not valid. Therefore, the three crash rates mentioned above were calculated for each site’s total crashes. [Tables 6-2](#) and [6-3](#) contain the crash rates for each site by month and by volume, respectively.

Table 6-1. Study Site Descriptions.

Site	Treatment	Date	Months Before	Months After
95-02	Reconfigured intersection	05/03/95	0*	35*
96-01	Raised pavement markers, delineation	10/01/96	15*	36
96-02	All-way stop and advance warning	09/01/96	14*	36
97-01	Approach rumble strips, strobes in signal heads	08/01/97	25*	36
97-02	Lane widening	05/01/97	22*	36
97-03	Safety treat fixed objects	06/11/97	23*	36
98-01	Beacons on Stop sign and advance warning signs	02/01/98	31*	36
98-02	Widen roadway	02/01/98	31*	36
98-03	Approach rumble strips	04/01/98	33*	36
98-04	Intersection flashing beacon	06/01/98	35*	36
98-05	Grade separation structure	07/01/98	36	36
98-06	Speed detection and notification device	09/01/98	36	36
98-07	Added flashers on warning signs	11/01/98	36	36
98-08	Install safety lighting	11/06/98	36	36
98-09	Install safety lighting	11/06/98	36	36
98-10	Install safety lighting	11/06/98	36	36
98-11	Upgrade beacons, add advance warning	12/01/98	36	36
98-12	Install in-rail reflectors for guardrail	Summer 1998	36	36
99-02	Add shoulders, safety treat fixed objects, resurface	07/30/99	36	29
99-04	Improve horizontal alignment, safety treat fixed objects	08/01/99	36	28
99-05	Add shoulders, safety treat fixed objects, resurface	08/02/99	36	28
99-06	Install safety lighting	08/11/99	36	28
99-07	Approach rumble strips, advance warning signs	09/01/99	36	27
99-08	Widen road, remove trees, safety treat headwalls	09/01/99	36	27
99-10	Advance warning sign with flashing beacon	10/01/99	36	26
99-11	Beacons, pavement markings, turning lanes	10/07/99	36	26
99-12	Overhead beacons	10/07/99	36	26
99-13	Replace raised median with flush median	10/13/99	36	26
100-02	Add shoulders, safety treat fixed objects, resurface	02/22/00	36	22
100-03	Stop Ahead signs	02/01/00	36	22
100-04	Reflective strips on Stop sign	05/01/00	36	19
100-05	Widen roadway	05/01/00	36	19
100-06	Add shoulders, resurface, safety treat structures	06/01/00	36	18
100-07	Safety lighting	06/06/00	36	18
100-08	Safety lighting	06/06/00	36	18
100-09	Safety lighting	06/06/00	36	18
100-10	Widen road, remove trees, safety treat headwalls	07/01/00	36	17
100-11	Chevrons on curve approaches	07/01/00	36	17
100-12	Advance warning signs and pavement markings	07/01/00	36	17
100-13	Add turning lanes and pavement markings	07/01/00	36	17
100-14	Chevrons on curve approach	07/12/00	36	17
100-15	Raised pavement markers	08/01/00	36	16
100-16	Approach rumble strips and advance warning sign	10/01/00	36	14
100-17	Approach rumble strips, beacons, pavement markings	10/01/00	36	14
100-18	Right-turn lane and No Parking signs	10/01/00	36	14
100-19	Paved shoulders	10/01/00	36	14
100-20	High-center signals, approach rumble strips, signing	10/04/00	36	14
100-22	Channelizing islands	10/30/00	36	14
100-23	Overheight warning system	11/13/00	36	13
100-24	Widen roadway	12/01/00	36	12

*Part or all of these periods are prior to July 1, 1995, when DPS changed practices on reporting non-injury crashes.

Table 6-2. Total Crash Rates by Month.

Site Number	Crashes/Month		% Reduction in Rate		Site Number	Crashes/Month		% Reduction in Rate
	Before	After				Before	After	
95-02	--	0.00	--		99-11	0.22	0.04	83
96-01	0.20	0.03	86		99-12	0.19	0.00	100
96-02	0.00	0.00	--		99-13	0.08	0.04	54
97-01	0.32	0.22	31		100-02	0.17	0.41	-145
97-02	0.05	0.08	-83		100-03	0.06	0.00	100
97-03	6.87	6.78	1		100-04	0.06	0.00	100
98-01	0.06	0.03	57		100-05	0.36	0.26	27
98-02	0.10	0.11	-15		100-06	0.42	0.39	7
98-03	0.09	0.06	39		100-07	0.06	0.00	100
98-04	0.14	0.28	-94		100-08	0.06	0.06	0
98-05	0.11	0.00	100		100-09	0.08	0.00	100
98-06	0.19	0.00	100		100-10	0.08	0.24	-182
98-07	0.64	0.58	9		100-11	0.03	0.12	-324
98-08	0.03	0.00	100		100-12	0.00	0.00	--
98-09	0.08	0.06	33		100-13	0.00	0.00	--
98-10	0.00	0.00	--		100-14	0.00	0.00	--
98-11	0.06	0.06	0		100-15	0.06	0.06	-13
98-12	0.75	0.29	62		100-16	0.19	0.14	27
99-02	0.17	0.31	-86		100-17	0.08	0.00	100
99-04	0.06	0.00	100		100-18	0.00	0.00	--
99-05	1.31	0.93	29		100-19	0.08	0.07	14
99-06	0.00	0.00	--		100-20	0.69	1.07	-54
99-07	0.14	0.07	47		100-22	0.19	0.29	-47
99-08	0.28	0.59	-113		100-23	0.03	0.31	-1008
99-10	0.00	0.00	--		100-24	0.11	0.08	25

An examination of [Table 6-2](#) shows that there are 10 sites with a total (i.e., 100 percent) reduction in crashes after installation of the treatment. There are 17 more sites with a positive reduction (i.e., greater than zero percent). In total, 27 of 50 sites had a positive reduction in total crashes after improvements were made. Conversely, there are 12 sites that returned a negative reduction in crashes and two sites with no change in crashes. There are also nine sites that had no crashes in either period, designated by "--" in the reduction in rate. [Table 6-2](#) also shows that all but two sites had crash rates in the before period lower than 1.00 crash/month, and all but five had crash rates in the before period lower than 0.50 crash/month. This clearly demonstrates that most sites did not have a large number of total crashes from which to evaluate the crash history; the effect this has on the percent reduction in rate will be explored further in the Preventable Crashes section later in this chapter.

[Table 6-3](#) normalizes the crash data with the traffic volumes at each site. All but six sites have crash rates less than 3.00 crashes/MEV or crashes/MVMT in the before period, and 34 of the 50 sites have rates less than 1.00. This again underscores the low number of crashes at each site.

Table 6-3. Total Crash Rates by Volume.

Intersections				Roadway Segments			
Site Number	Crashes/MEV		% Reduction in Rate	Site Number	Crashes/MVMT		% Reduction in Rate
	Before	After			Before	After	
95-02	--	0.00	--	96-01	1.69	0.23	86
96-02	0.00	0.00	--	97-02	2.05	3.76	-83
97-01	0.67	0.47	31	97-03	0.75	0.74	1
98-01	0.47	0.20	57	98-02	6.63	7.61	-15
98-03	1.11	0.68	39	98-06	38.51	0.00	100
98-04	0.15	0.30	-94	98-07	4.38	4.00	9
98-05	1.33	0.00	100	98-12	3.54	1.96	44
98-08	0.23	0.00	100	99-02	0.21	0.39	-86
98-09	0.37	0.25	33	99-04	0.32	0.00	100
98-10	0.00	0.00	--	99-05	2.45	1.74	29
98-11	0.70	0.70	0	99-08	0.68	1.45	-113
99-06	0.00	0.00	--	100-02	0.23	0.56	-145
99-07	2.12	1.13	47	100-05	0.99	0.72	27
99-10	0.00	0.00	--	100-06	0.56	0.52	7
99-11	3.34	0.58	83	100-10	0.68	1.91	-182
99-12	1.33	0.00	100	100-11	0.30	1.28	-324
99-13	0.48	0.22	54	100-14	0.00	0.00	--
100-03	0.45	0.00	100	100-15	0.64	0.72	-13
100-04	0.19	0.00	100	100-19	0.43	0.37	14
100-07	0.20	0.00	100	100-23	0.37	4.05	-1008
100-08	0.34	0.34	0	100-24	0.32	0.24	25
100-09	1.19	0.00	100				
100-12	0.00	0.00	--				
100-13	0.00	0.00	--				
100-16	3.46	2.54	27				
100-17	1.47	0.00	100				
100-18	0.00	0.00	--				
100-20	0.69	1.07	-54				
100-22	0.60	0.88	-47				

PREVENTABLE CRASHES

An installed treatment may not affect all crashes at a site, so analyzing only total crashes does not provide an accurate representation of the crash characteristics of a treatment. Instead, preventable crashes should be considered. For each type of treatment evaluated in this project, researchers defined a set of characteristics for preventable crashes. The treatment for each site and its corresponding preventable crash characteristics are listed in Tables 6-4 through 6-6.

Table 6-4. 1995-1998 Treatments and Preventable Crash Characteristics.

Site Number	Treatment	Preventable Crash Characteristics
95-02	Reconfigured intersection	Crash occurs at an intersection or is intersection-related AND collision type is a rear-end, sideswipe, or left-turn collision.
96-01	Raised pavement markers, delineation	Surface condition is wet OR light conditions are dark (with or without lighting).
96-02	All-way stop and advance warning	Crash occurs at an intersection or is intersection-related.
97-01	Approach rumble strips, strobes in signal heads	Crash occurs at an intersection or is intersection-related AND collision type is a right-angle, rear-end, or left-turn collision or a crash involving a single vehicle traveling straight AND the first harmful event is striking another motor vehicle in transport.
97-02	Lane widening	Crash occurs off the roadway on or beyond the shoulder OR collision type is right-angle (right turn), sideswipe, or rear-end (right turn).
97-03	Safety treat fixed objects	(Crash occurs off the roadway on or beyond the shoulder OR the object struck is a non-work zone roadside fixed object) AND the population category is rural or town less than 2,500.
98-01	Beacons on Stop sign and advance warning signs	Crash occurs at an intersection or is intersection-related AND other contributing factor (if applicable) is not an avoidance maneuver or compliance with a traffic control device or an officer.
98-02	Widen roadway	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe (opposite directions) OR the first harmful event is striking another motor vehicle in transport.
98-03	Approach rumble strips	Crash occurs at an intersection or is intersection-related AND collision type is a crash involving a single vehicle traveling straight.
98-04	Intersection flashing beacon	Crash occurs at an intersection or is intersection-related.
98-05	Grade separation structure	All crashes.
98-06	Speed detection and notification device	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
98-07	Added flashers on warning signs	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
98-08	Install safety lighting	Light conditions are dark.
98-09	Install safety lighting	Light conditions are dark.
98-10	Install safety lighting	Light conditions are dark.
98-11	Upgrade beacons, add advance warning	Crash occurs at an intersection or is intersection-related.
98-12	Install in-rail reflectors for guardrail	Population category is rural AND crash occurs off the roadway beyond the shoulder AND the object struck is a guardrail.

Table 6-5. 1999 Treatments and Preventable Crash Characteristics.

Site Number	Treatment	Preventable Crash Characteristics
99-02	Add shoulders, safety treat fixed objects, resurface	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe OR the first harmful event is striking another motor vehicle in transport.
99-04	Reconfigure intersection, safety treat fixed objects	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
99-05	Add shoulders, safety treat fixed objects, resurface	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe OR the first harmful event is striking another motor vehicle in transport OR (the manner of collision is a single vehicle traveling straight AND the first harmful event is an overturned vehicle, striking a parked vehicle, or striking a fixed or other object AND the object struck is highway sign, culvert, guardrail, utility pole, tree, bridge rail, attenuation device, or ditch).
99-06	Install safety lighting	Light conditions are dark.
99-07	Approach rumble strips, advance warning signs	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
99-08	Widen road, remove trees, safety treat headwalls	Crash occurs off the roadway on or beyond the shoulder OR the collision type is any sideswipe or any collision involving a right-turning vehicle.
99-10	Advance warning sign with flashing beacon	Crash occurs at an intersection or is intersection-related.
99-11	Beacons, pavement markings, turning lanes	Collision type is right-angle, rear-end, sideswipe, or left-turn.
99-12	Overhead beacons	Crash occurs at an intersection or is intersection-related.
99-13	Replace raised median with flush median	Object struck is curb or other undefined fixed object.

Table 6-6. 2000 Treatments and Preventable Crash Characteristics.

Site Number	Treatment	Preventable Crash Characteristics
100-02	Add shoulders, safety treat fixed objects, resurface	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe OR the first harmful event is striking another motor vehicle in transport OR the object struck is a non-work zone roadside fixed object.
100-03	Stop Ahead signs	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
100-04	Reflective strips on Stop sign	Crash occurs at an intersection or is intersection-related AND light conditions are dark AND the first harmful event is striking another motor vehicle in transport or a fixed object.
100-05	Widen roadway	Crash occurs off the roadway on or beyond the shoulder OR the collision type is any sideswipe or any collision involving a right-turning vehicle.
100-06	Add shoulders, resurface, safety treat structures	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe OR the first harmful event is striking another motor vehicle in transport.
100-07	Safety lighting	Light conditions are dark.
100-08	Safety lighting	Light conditions are dark.
100-09	Safety lighting	Light conditions are dark.
100-10	Widen road, remove trees, safety treat headwalls	Crash occurs off the roadway on or beyond the shoulder OR the collision type is any sideswipe or any collision involving a right-turning vehicle.
100-11	Chevrons on curve approaches	Crash occurs at a point where the degree of curvature is greater than zero.
100-12	Advance warning signs and pavement markings	Crash occurs at an intersection or is intersection-related.
100-13	Add turning lanes and pavement markings	Collision type is rear-end, sideswipe, or left-turn.
100-14	Chevrons on curve approach	Crash occurs at a point where the degree of curvature is greater than zero.
100-15	Raised pavement markers	Surface condition is wet, OR light conditions are dark (with or without lighting).
100-16	Approach rumble strips and advance warning sign	Crash occurs off the roadway on or beyond the shoulder OR collision type is rear-end or sideswipe.
100-17	Approach rumble strips, beacons, pavement markings	Crash occurs at an intersection or is intersection-related.
100-18	Right-turn lane and No Parking signs	The first harmful event is striking a pedestrian or parked car OR the manner of collision involves a vehicle entering or leaving a parking space OR the manner of collision is right angle with both vehicles traveling straight.
100-19	Paved shoulders	Crash occurs off the roadway on or beyond the shoulder OR the first harmful event is striking another motor vehicle in transport.
100-20	High-center traffic signals, approach rumble strips, advance signing	(Crash occurs at an intersection or is intersection-related AND the manner of collision is a right-angle crash or any crash involving two vehicles traveling the same direction or opposite directions) OR the first harmful event is striking a pedestrian or pedalcyclist.
100-22	Channelizing islands	The manner of collision is a right-angle left-turn crash.
100-23	Overheight warning system	Object struck is bottom of bridge deck/top of underpass or tunnel.
100-24	Widen roadway	Crash occurs off the roadway on or beyond the shoulder OR the collision type is any sideswipe or any collision involving a right-turning vehicle.

When the total crash values are filtered through the preventable crash characteristics specified in Tables 6-4 through 6-6, the number of crashes can change substantially, as can the

corresponding crash rates. Tables 6-7 and 6-8 contain the crash rates by month and by volume for preventable crashes.

Table 6-7. Preventable Crash Rates by Month.

Site Number	Crashes/Month		% Reduction in Rate		Site Number	Crashes/Month		% Reduction in Rate
	Before	After				Before	After	
95-02	0.00	0.00	--		99-11	0.22	0.00	100
96-01	0.20	0.00	100		99-12	0.19	0.00	100
96-02	0.00	0.00	--		99-13	0.00	0.00	--
97-01	0.28	0.19	31		100-02	0.11	0.23	-105
97-02	0.00	0.00	--		100-03	0.06	0.00	100
97-03	1.00	0.83	17		100-04	0.06	0.00	100
98-01	0.06	0.00	100		100-05	0.36	0.26	27
98-02	0.03	0.00	100		100-06	0.42	0.39	7
98-03	0.06	0.00	100		100-07	0.00	0.00	--
98-04	0.14	0.28	-94		100-08	0.06	0.00	100
98-05	0.11	0.00	100		100-09	0.00	0.00	--
98-06	0.19	0.00	100		100-10	0.03	0.12	-324
98-07	0.64	0.58	9		100-11	0.03	0.06	-112
98-08	0.03	0.00	100		100-12	0.00	0.00	--
98-09	0.06	0.00	100		100-13	0.00	0.00	--
98-10	0.00	0.00	--		100-14	0.00	0.00	--
98-11	0.06	0.06	0		100-15	0.06	0.06	-13
98-12	0.00	0.00	--		100-16	0.03	0.00	100
99-02	0.03	0.07	-148		100-17	0.08	0.00	100
99-04	0.00	0.00	--		100-18	0.00	0.00	--
99-05	0.11	0.04	68		100-19	0.00	0.00	--
99-06	0.00	0.00	--		100-20	0.50	0.79	-57
99-07	0.00	0.00	--		100-22	0.19	0.29	-47
99-08	0.28	0.59	-113		100-23	0.03	0.00	100
99-10	0.00	0.00	--		100-24	0.11	0.08	25

As shown in Table 6-7, 16 sites had a 100 percent reduction in preventable crashes after installation of the treatment. Seven more sites had a reduction greater than zero. In total, 23 of 50 sites had a positive percent reduction in preventable crashes after improvements were made. Conversely, nine sites had a negative reduction in crashes and one had no change. In addition, there are 17 sites that had no preventable crashes in either period.

Comparing total crashes with preventable crashes, more sites had a reduction in preventable crashes than in total crashes. In addition, the number of sites with no preventable crashes in either period is also substantially higher. The large increase in the number of sites with no crashes is a function of a small number of total crashes at a site. After removing crashes that are not preventable by the treatment, often there are very few crashes left to consider. While there were 868 total crashes at the 50 study sites (17.02 crashes/site), there were only 314 preventable crashes (6.16 crashes/site). This also emphasizes the volatility of percentages when the number of crashes is small. Only six sites had 10 or more preventable crashes in the period before installation, while 39 sites had five or fewer crashes. The distribution is similar in the period after installation, when only five sites had 10 or more crashes, while 43 had five or fewer. If a site has five or fewer crashes in the before period, a change of one or two crashes either way will result in a substantial change in percentage, which may exaggerate the effectiveness (or lack

thereof) of a particular treatment at that site. In this situation, it is necessary to have a greater number of study sites to properly evaluate the effectiveness of a treatment.

Table 6-8. Preventable Crash Rates by Volume.

Intersections					Roadway Segments			
Site Number	Crashes/MEV		% Reduction in Rate		Site Number	Crashes/MVMT		% Reduction in Rate
	Before	After				Before	After	
95-02	--	0.00	--		96-01	1.69	0.00	100
96-02	0.00	0.00	--		97-02	0.00	0.00	--
97-01	0.59	0.41	31		97-03	0.11	0.09	17
98-01	0.47	0.00	100		98-02	2.21	0.00	100
98-03	0.74	0.00	100		98-06	38.51	0.00	100
98-04	0.15	0.30	-94		98-07	4.38	4.00	9
98-05	1.33	0.00	100		98-12	0.00	0.00	--
98-08	0.23	0.00	100		99-02	0.03	0.09	-148
98-09	0.25	0.00	100		99-04	0.00	0.00	--
98-10	0.00	0.00	--		99-05	0.21	0.07	68
98-11	0.70	0.70	0		99-08	0.68	1.45	-113
99-06	0.00	0.00	--		100-02	0.15	0.31	-105
99-07	0.00	0.00	--		100-05	0.99	0.72	27
99-10	0.00	0.00	--		100-06	0.56	0.52	7
99-11	3.34	0.00	100		100-10	0.23	0.96	-324
99-12	1.33	0.00	100		100-11	0.30	0.64	-112
99-13	0.00	0.00	--		100-14	0.00	0.00	--
100-03	0.45	0.00	100		100-15	0.64	0.72	-13
100-04	0.19	0.00	100		100-19	0.00	0.00	--
100-07	0.00	0.00	--		100-23	0.37	0.00	100
100-08	0.34	0.00	100		100-24	0.32	0.24	25
100-09	0.00	0.00	--					
100-12	0.00	0.00	--					
100-13	0.00	0.00	--					
100-16	0.49	0.00	100					
100-17	1.47	0.00	100					
100-18	0.00	0.00	--					
100-20	0.50	0.78	-57					
100-22	0.60	0.88	-47					

TREATMENT EFFECTIVENESS

By combining the before-and-after evaluations of sites with similar treatments, the overall effectiveness of a treatment can be reviewed. There are 27 primary treatments applied to sites in this project. In this analysis, the crash data from each site with a particular treatment have been combined to produce an overall crash rate reduction for each treatment. Because the length of the after period varies from site to site, the crash data are expressed in preventable crashes per month to normalize the data. In addition, for sites with more than one treatment, all preventable crashes were included under the treatment considered by the research team to be most significant. Table 6-7 lists the treatments, the site numbers corresponding to each treatment, the combined crash rates from those study sites, and overall reduction in crash rate, in order of decreasing reduction in crash rate.

Results from [Table 6-9](#) show that 12 of the 27 treatments had positive reductions, while six sites had zero or negative reductions in monthly crash rates. Finally, nine treatments had no preventable crashes to evaluate.

Table 6-9. Reduction in Preventable Crashes by Treatment.

Primary Treatment	Number of Sites	Site Numbers	Crashes/Month before Improvement	Crashes/Month after Improvement	% Reduction in Rate
Add left-turn lane	2	99-11	0.22	0.00	100
Advance warning signs	3	99-07, 100-03, 100-16	0.08	0.00	100
Grade separation structure	1	98-05	0.11	0.00	100
Install safety lighting	7	98-08, 98-09, 98-10, 99-06, 100-07, 100-08, 100-09	0.14	0.00	100
Overheight warning system	1	100-23	0.03	0.00	100
Reflective strips on Stop sign	1	100-04	0.06	0.00	100
Speed detection and notification device	1	98-06	0.19	0.00	100
Raised pavement markers	2	96-01	0.26	0.06	76
Approach rumble strips	2	97-01, 98-03	0.34	0.19	43
Intersection flashing beacons	4	98-01, 98-04, 99-12, 100-17	0.49	0.28	43
Safety treat fixed objects	1	97-03	1.00	0.83	17
Add flashers on curve warning signs	1	98-07	0.64	0.58	9
Add advance warning signs with beacons	1	98-11	0.06	0.06	0
Add shoulders	5	98-02, 99-02, 99-05, 100-02, 100-06	0.70	0.72	-3
Widen lanes	5	97-02, 99-08, 100-05, 100-10, 100-24	0.78	1.06	-36
Channelizing islands	1	100-22	0.19	0.29	-47
Add traffic signals	1	100-20	0.50	0.79	-57
Chevrons on horizontal curves	2	100-11, 100-14	0.03	0.06	-112
Add advance warning signs	1	100-12	0.00	0.00	--
Add flashers on intersection warning signs	1	99-10	0.00	0.00	--
All-way stop	1	96-02	0.00	0.00	--
Eliminate parking	1	100-18	0.00	0.00	--
Improve horizontal alignment	1	99-04	0.00	0.00	--
In-rail reflectors	1	98-12	0.00	0.00	--
Install continuous turn lane	1	95-02	0.00	0.00	--
Pave shoulders	1	100-19	0.00	0.00	--
Remove raised median	1	99-13	0.00	0.00	--
Average (per site)	N/A	N/A	0.12	0.10	15

EFFECTIVENESS OF TREATMENTS EVALUATED IN THIS PROJECT

The overall reduction in preventable crashes at the 50 study sites was 15 percent, based on an average crash rate for all sites of 0.12 crash per month per site in the before period (4.18 crashes per site in an assumed 36-month before period) and 0.10 crash per month per site in the after period (3.54 crashes per site in an assumed 36-month after period). Adding all the preventable crashes per site yields totals of 209 preventable before-period crashes and 177 preventable after-period crashes over assumed 36-month periods. So, there was a noticeable reduction in the crash rate from a percentage evaluation, with the actual reduction in the number of preventable crashes being 32 crashes (0.64 crash per site) over a three-year period.

To further emphasize the treatments' effects on safety, a similar before-and-after comparison can be made with non-PDO crashes, as shown in [Table 6-10](#). A total of 142 non-PDO crashes occurred in the before period while 98 non-PDO crashes occurred in the after period (after adjusting to 36-month periods). The non-PDO crash data from all 50 study sites show a remarkable 31 percent reduction in injury crashes following installation of their respective treatments, resulting in a decrease of 44 injury crashes over 36 months.

Table 6-10. Distribution of Preventable Crashes by Severity.

	Before ¹	After ¹	% Reduction
Non-PDO	142	98	31
PDO	67	79	-17
All Crashes	209	177	15

¹Number of crashes is based on an assumed 36-month period.

The substantial drop in preventable non-PDO crashes (31 percent) exceeds the aforementioned 15 percent decrease in all preventable crashes.

Another example of the benefit of the treatments can be shown in the percent of crashes with injuries. In the before period, 70 percent of the preventable crashes at the 50 sites involved some type of injury (142 non-PDO crashes/209 total crashes). In the after period only 56 percent of preventable crashes involved injuries (98 non-PDO crashes/177 total crashes). So in addition to decreasing the total number of crashes, the treatments at the 50 sites also decreased the percentage of crashes with injuries.

DISCUSSION

Based on the results of the crash data analysis, several issues warrant special mention.

- The results from these evaluations should be considered preliminary since only eight of the 50 sites have the desired six full years of crash data history and time constraints limited the ability of researchers to review crash narratives and identify suitable comparison sites within the project.
- The usefulness of original crash report narratives in providing added detail and insight into the crash history is evident in the summaries of the earliest evaluations. However, because of the constraints of time and available data, crash narratives could not be obtained for sites with improvements installed in 1999 or later. Thus, the evaluations of crash history for those sites were based solely on the coded information produced by the computerized records in the DPS database.

- During the process of evaluating the appropriateness of sites for evaluation, a number of other sites were added to or dropped from the list. Several sites were dropped from consideration because their locations could not be sufficiently defined or the date of improvement wasn't documented. Other sites were added based on input from project panel members and other TxDOT personnel who provided detailed descriptions of improved sites in their districts.
- The increase in the number of sites with no crashes during the study period when considering only preventable crashes is a function of the small number of total crashes at a site. After removing crashes that are not preventable by the treatment, often there are very few crashes left to consider. Only six sites had 10 or more preventable crashes in the period before installation, while 39 sites had five or fewer crashes. The distribution is similar in the period after installation, when only five sites had 10 or more crashes, while 43 had five or fewer crashes.
- The amount of crash data also emphasizes the volatility of percentages when the number of crashes is small. If a site has five or fewer crashes in the before period, a change of one or two crashes either way will result in a substantial change in percentage, which may exaggerate the effectiveness (or lack thereof) of a particular treatment at that site.

CHAPTER 7 CONCLUSIONS

The state of Texas maintains 79,513 centerline-miles (127,964 km) of paved roadways, over 62 percent of which are low-volume rural two-lane roads. These roadways carry less than 8 percent of the total vehicle-miles on state-maintained (or on-system) highways but have approximately 11 percent of the total on-system vehicle crashes. Therefore, despite the relatively low volumes and the infrequency of crashes on many of these roads, improving safety on rural highways is an issue that needs to be addressed.

There are a variety of treatments available to reduce the number and severity of crashes, but certain treatments are not appropriate for low-volume rural roadways because they are impractical or too costly to be effective. However, a number of promising treatments are being implemented, and an evaluation of the performance of these treatments in reducing crashes will aid in quantifying their effectiveness.

EVALUATION OF STUDY SITES

There were 27 primary treatments applied to 50 sites in this study. These treatments were installed between 1995 and 2000 at intersections and roadway segments throughout Texas. Researchers conducted before-and-after evaluations on each of the 50 sites, utilizing crash data from the DPS statewide crash database. The results from these evaluations should be considered preliminary since only eight of the 50 sites have the desired amount of crash data history and time constraints limited the ability of researchers to review crash narratives and identify suitable comparison sites within the project. The desired amount of crash data for each site was a six-year period, three years prior to installation of the treatment and three years after the treatment was installed. However, 10 sites had part or all of their study periods prior to July 1, 1995, when DPS made a change in the reporting process for non-injury crashes; the data for these sites were truncated to include only crashes after July 1, 1995. Furthermore, crash data were only available through December 31, 2001, so the 32 sites with installations in 1999 and 2000 had less than three years of after-period crash data to conduct the evaluation.

The available crash data were used to determine the effectiveness of each treatment in reducing crashes at each site. Both total and preventable crashes were considered in this analysis; total crashes include all crashes that occurred at the study site during the study period, while preventable crashes are the subset of total crashes that meet the characteristics of a crash that could be prevented by the treatment that was installed. There were 868 total crashes at the 50 study sites (17.02 crashes/site), compared to 314 preventable crashes (6.16 crashes/site). [Table 7-1](#) illustrates the distribution of sites with respect to reductions in monthly crash rate.

Table 7-1. Distribution of Reductions in Monthly Crash Rate at Each Study Site.

	Total Crashes	Preventable Crashes
Number of sites with positive reductions in monthly crash rate	27	23
Number of sites with no change in monthly crash rate	2	1
Number of sites with negative reductions in monthly crash rate	12	9
Number of sites with no crashes during the study period	9	17

EVALUATION OF TREATMENTS

By combining the before-and-after evaluations of sites with similar treatments, the overall effectiveness of each treatment was determined. The crash data from each site with a particular treatment were combined to produce an overall crash rate reduction for each treatment. The findings from the evaluation of treatments are as follows:

- Overall, the reduction in preventable crashes for all treatments at the 50 study sites was 15 percent, based on an average crash rate of 0.12 crash per month before treatments were installed and 0.10 crash per month after installation.
- Of the 27 treatments evaluated, 12 had positive reductions, one treatment had no change in crash rate, five treatments had negative reductions, and nine treatments had no preventable crashes to evaluate.
- All told, there were 209 preventable before-period crashes and 177 preventable after-period crashes (after adjusting to 36-month periods), yielding an estimated reduction of 32 preventable crashes (0.64 crash per site) over a three-year period.
- A similar before-and-after comparison was made with non-PDO crashes. The non-PDO crash data from all 50 study sites show a remarkable 31 percent reduction in injury crashes following installation of their respective treatments, resulting in a decrease of 44 injury crashes over an assumed 36 months.
- In the before period, 70 percent of the preventable crashes at the 50 sites involved some type of injury (142 non-PDO crashes/209 total crashes). In the after period only 56 percent of preventable crashes involved injuries (98 non-PDO crashes/177 total crashes).

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