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16. Abstract

This project evaluated the effectiveness of two previously developed enhanced sign systems at passive highway-railroad grade crossings (developed in Texas Department of Transportation Project 0-1469). The first enhanced sign system consisted of a YIELD sign (*Manual on Uniform Traffic Control Devices,* R1-2) with the supplemental message plate TO TRAINS. The second enhanced sign system consisted of a vehicle-activated flashing yellow strobe or flashing yellow beacon mounted above a railroad advance warning sign (*MUTCD* W10-1) in combination with a new yellow warning sign that reads LOOK FOR TRAIN AT CROSSING.

The goal of the enhanced sign systems was to increase driver awareness, resulting in more cautious behavior when approaching the grade crossing. Before and after speed studies were conducted, and on-site interviews were conducted near the sites of the LOOK FOR TRAIN AT CROSSING enhanced sign systems.

The project results indicate that neither of the enhanced sign systems harmed the drivers or negatively influenced their approach speeds to the grade crossings. Ninety percent of survey respondents at the four sites surveyed noticed the flashing lights at the approaches to the railroad-highway grade crossings.

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EVALUATION OF ENHANCED TRAFFIC CONTROL DEVICES AT HIGHWAY-RAILROAD GRADE CROSSINGS

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This report is dedicated to Dan Fambro, whose ideas, experience, and foresight guided the development and execution of this research project. Although he did not see the completion of the project, the results are based upon his research plan and expertise.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

INTRODUCTION

The objective of this project was to continue to evaluate the effectiveness of two experimental traffic control devices developed in TxDOT Project 0-1469—Enhanced Traffic Control Devices and Railroad Operations for Highway-Railroad Grade Crossings. The first experimental enhanced sign system consists of a 36 inch YIELD sign (*MUTCD* R1-2) *(1)* with a supplemental message 36 inch by 24 inch plate containing the phrase TO TRAINS as shown in Figure 1-1 (referred to as the YIELD TO TRAINS enhanced sign system). The second experimental enhanced sign system consists of a vehicle-activated strobe or flashing yellow beacon mounted above a standard railroad advance warning sign (*MUTCD* W10-1) *(1)* in combination with a new yellow warning sign that reads LOOK FOR TRAIN AT CROSSING as shown in Figure 1-2 (referred to as the LOOK FOR TRAIN AT CROSSING enhanced sign system).

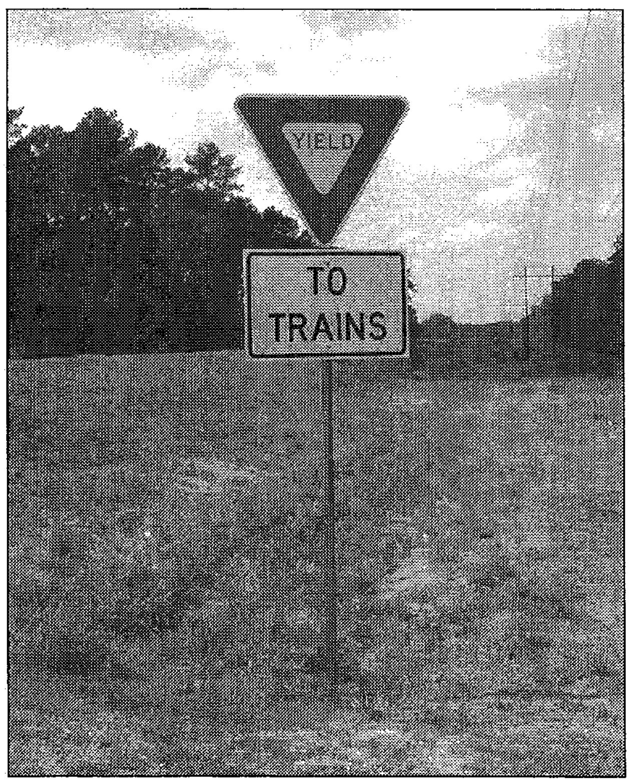


Figure 1-1. YIELD TO TRAIN Enhanced Sign System.

Figure 1-2. LOOK FOR TRAIN AT CROSSING Enhanced Sign System.

The goal of the enhanced systems is to increase driver awareness of the highway-railroad grade crossing, resulting in more cautious behavior when approaching the grade crossing. Because reduced vehicle speeds are one indication of a more cautious approach, researchers conducted before and after speed profile studies at locations where the experimental YIELD TO TRAINS and LOOK FOR TRAIN AT CROSSING enhanced sign systems were installed. Additionally, surveys of drivers traveling in the vicinity of the highway-railroad grade crossings with the LOOK FOR TRAIN AT CROSSING enhanced sign systems were conducted to obtain opinions regarding the effectiveness and usefulness of the enhanced devices.

This research report is organized into eight chapters. Chapter 1 discusses the unique nature of highway-railroad grade crossings, the use of traffic control devices at highway-railroad grade crossings, driver behavior related to highway-railroad grade crossings, and the use of experimental devices at highway-railroad grade crossings. Chapter 2 includes information on the equipment used in the enhanced sign systems. Chapter 3 includes the site selection process, design of the before and after speed studies, and data analysis procedures. Chapter 4 includes site photographs and descriptions, the before and after studies, and data analysis for the YIELD TO TRAINS enhanced sign systems. Chapter 5 includes site photographs and descriptions, the before and after studies, and data analysis for the LOOK FOR TRAIN AT CROSSING enhanced sign systems with flashing strobes. Chapter 6 includes site photographs and descriptions, the before and after studies, and data analysis for the LOOK FOR TRAIN AT CROSSING enhanced sign systems with flashing beacons. Chapter 7 presents the findings of on-site driver surveys for the LOOK FOR TRAIN AT CROSSING enhanced sign systems. Chapter 8 summarizes the study findings and offers recommendations for future enhanced sign system installations.

BACKGROUND

Highway-railroad grade crossings are unique in that two distinctly different modes of transportation compete for the same physical space. Also, the operating characteristics of a train inhibit its ability to maneuver or stop quickly to avoid a collision, unlike highway vehicles. Therefore, it is critical that drivers recognize the presence of a train at a highway-railroad grade crossing *and* yield the right-of-way. Texas law requires motorists to "slow, look, listen, and be prepared to yield the right-of-way to an approaching train" *(2)*.

Texas had 12,447 public highway-railroad grade crossings as of 1997 *(3)*. This is the largest number of highway-railroad grade crossings of any state; Illinois ranks second with 10,100 crossings, and California is third with 7864 crossings. Texas had 368 accidents at public grade crossings in 1997, resulting in 54 fatalities and 198 nonfatal injuries.

Traffic control at highway-railroad grade crossings may be active or passive. Active crossings provide warning of the approach and presence of a train through a detection circuit in the track. When equipment detects a train, it activates warning devices at the highway-railroad grade crossing. These devices may include automatic crossing gates, wigwag signals, flashing light signals, and bells. Static traffic control devices such as advance warning signs, markings, and crossbucks may also be present at active crossings.

Passive crossings lack train-activated signals or gates to warn of an approaching train. Traffic control devices at passive crossings are static; they are designed to direct the attention of the motorist toward the crossing. Passive crossings employ advance warning signs, pavement markings, and a crossbuck at the crossing location. Approximately 4646 (37 percent) of the public highway-railroad grade crossings in Texas are classified as active crossings, while approximately 7160 (58 percent) are classified as passive crossings. Both types of crossings use the same advance warning signs and pavement markings to alert drivers that a highway-railroad crossing is nearby.

A frequently cited factor in highway-railroad grade crossing accidents is driver error. There are many reasons why drivers make faulty decisions in relation to highway-railroad grade crossings. Driver error may result from the failure to perceive a train at or near the crossing. Alternatively, drivers may detect a train but fail to accurately determine the time available to clear the crossing. Also, a train's violation of driver expectancy has been cited as a leading cause of faulty decision making: drivers who rarely encounter trains at familiar grade crossings may expect the same at unfamiliar crossings with higher train volumes. Drivers familiar with only active crossings may not understand their responsibilities at passive crossings.

The current system of visual communication is another possible source of communication to drivers. The advance warning sign and railroad crossbuck sign do not differentiate between active and passive crossings, complicating the driver's decision-making task.

Because of the high percentage of passive crossings in Texas (58 percent), enhanced traffic control devices have been developed to increase driver awareness at passive crossings. This study is a follow-up study to TxDOT Project 1469, which evaluated three supplemental enhanced sign systems as enhancements to the railroad advance warning (W10-1) sign at passive highway-railroad crossings. In that study, the enhanced sign system yielded positive results and showed promise for improving safety at passive grade crossings. Project 1469 recommendations included validating the results of that study by implementing enhanced traffic control devices at rural passive highway-railroad grade crossings, specifically those scheduled for future improvements (*4,5*).

Driver Behavior and Expectancy Issues

Driver behavior and safety at highway-railroad grade crossings have been the focus of much research since the early 1970s. Numerous studies have been conducted to assess motorist understanding of the current grade crossing sign system and to evaluate improvements to the crossbuck sign and advance warning sign. This research has been important in improving driver understanding of grade crossing warning devices and in reducing the number of fatal accidents at highway-railroad grade crossings. In Texas, fatalities have decreased from 99 in 1989 to 54 in 1997, a 44 percent reduction (*6*).

A driver at a highway-railroad grade crossing reacts to what he or she physically experiences and anticipates based on past experience. An expectancy may be based on long-term (*a priori*) and or short-term (*ad hoc*) driving experience (*7*). Drivers' expectations at highway-railroad grade crossings can influence the detection of trains, comprehension of responsibilities, and action at crossings. A 1982 study by Biederman et al. (*8*) concluded that when an object appears in an improbable context, it takes longer to detect than when the same object appears in a probable context. However, once a subject perceives the object, the longer visual dwell time needed to identify the object will result in better recall. This finding may indicate that once drivers have unexpectedly encountered trains at grade crossings, they may be more aware when approaching subsequent grade crossings.

In 1979 Humphreys and Tidwell (*9*) found that 35 percent of drivers surveyed believed all highway-railroad grade crossings were actively protected. Similar findings were obtained by Fambro and Heathington (*10*) through an analogous driver survey. They determined that 12 percent of those surveyed believed that flashing light signals were present at every grade crossing. The National Transportation Safety Board (*11*) interviewed 18 drivers involved in train-vehicle accidents. Each driver underestimated the frequency of train crossings per day at his or her respective accident location by a factor of 2 to 3. Such a low estimate suggests that most drivers are not expecting to encounter trains at grade crossings. The perception is reinforced each time the driver passes a crossing without seeing a train.

Driver Comprehension Issues

The information required by the driver prior to reaching a highway-railroad grade crossing depends upon the type of control and the characteristics of the crossing. Active and passive crossings require distinctly different driving behavior, yet the advance warning signs and pavement markings for both crossings are identical. This ambiguity can confuse drivers and lead to violations of driver expectancy. Numerous studies have been conducted to assess driver understanding of the standard crossbuck and advance warning sign. In three similar studies documented by Mounce et al. (*12*), respondents correctly answered questions regarding the meaning of the standard crossbuck sign 97, 76, and 17 percent of the time. The findings seem to illustrate a discrepancy in motorist understanding of the traffic control devices present at highway-railroad grade crossings.

An early study by Sanders et al. (*13*) related driver knowledge of traffic control devices at grade crossings to observed behavior. The study concluded that the drivers' ability to make correct decisions at a highway-railroad grade crossing was directly related to knowledge of the traffic control device present. The study found that approximately 15 percent of those surveyed believed all crossings were actively controlled. Another study by Womack et al. (*14*) found that 42 percent of those surveyed were unaware that the advance warning sign is round. Sixty-four percent believed the advance warning sign is located at, rather than prior to the crossing, and 70 percent indicated they did not expect to see the crossbuck sign after the advance warning sign.

A 1988 study by Richards and Heathington (*15*) surveyed 176 drivers and 35 police officers in Tennessee and found substantial problems in the level of understanding of traffic control devices at highway-railroad grade crossings. They noted a lack of instruction and training regarding grade crossings and established the significance of driving experience to grade crossing comprehension. Eleven percent of those surveyed could not recall ever receiving instructions or training on crossing safety. Only 63 percent of drivers could identify the advance warning sign as the one placed before the crossing, and only 76 percent of drivers could correctly identify the crossbuck as being located at the crossing.

Driver decisions can also be based on perceived risk, emotional influences, and enforcement. Drivers may be willing to risk accidents to avoid delay at highway-railroad grade crossings if they have previously experienced delays at crossings or if their emotional states predispose them to such risk. Studies have also shown that drivers are more conservative when others are present in the vehicle, but in many circumstances the presence of others may be motivation to take undue risk at grade crossings (*16*).

Experimental Signs at Passive Highway-Railroad Grade Crossings

Several studies have evaluated the effects of enhanced or alternative traffic control devices at highway-railroad grade crossings. The general consensus of most of these studies is that the current passive system is inadequate for a number of reasons. Upon approaching a crossing motorists should be able to determine the type of protection and understand their responsibilities in negotiating the crossing so as to avoid accidents. However, the current system does not convey that type of clear and concise message to drivers.

In 1968, Schoppert and Hoyt (*17*) evaluated several experimental warning enhanced sign systems and formulated implementation recommendations based on a number of crossing conditions. They suggested a variety of diamond-shaped advanced warning signs that better met drivers' expectations with more meaningful graphical content that discriminated between active and passive crossings. Work by Koziol and Mengert (*18*) in 1978 tested three enhanced versions of the standard advance warning sign and crossbuck. The enhanced signs showed significant improvement over the standard signs in terms of head movement, but no significant difference with regard to speed profiles was observed. Extensive implementation recommendations were also made; however, none of the recommendations from either of these studies has ever been adopted.

Early work by the Texas Transportation Institute (*19*) also developed recommendations to enhance traffic control devices at passive highway-railroad grade crossings. These recommendations involved increasing the number, color, and size of advance warning signs in combination with pavement treatments and illumination of the crossing where possible. These recommendations were not implemented due to liability concerns and a lack of documentation regarding accident reduction.

The Consolidated Rail Corporation (Conrail) developed the "Conrail Crossbuck" to be used at passive grade crossings. This device consists of a modified crossbuck and a three-panel, retro-reflective and reflecting device installed on the post below the modified crossbuck. The retro-reflective material of the enhanced sign system reflects light from the headlights of an approaching vehicle and mirrored strips on angled panels reflect light from an approaching train toward the driver. The reflected light allows drivers to detect the presence of a train prior to reaching the crossing. The increased size of the device also helps with visibility during the day (*20*).

The Canadian Ministry of Transportation (*21*) also conducted a study at passive highway-railroad grade crossings to determine the effectiveness of a new enhanced sign system. The system consisted of a standard triangular warning sign with the message RESTRICTED VISIBILITY posted below, and two intermediate standard triangular warning signs with the words BE PREPARED TO STOP and STOP BEFORE CROSSING. These signs were placed at 590 feet, 295 feet, and 66 feet from the crossbuck, respectively. This enhanced sign system elicited significant speed reductions and increased looking behavior and braking applications. In general, the study determined that this type of enhanced sign system gave drivers more time during the approach to prepare for the crossing by reducing their approach speeds.

Regulatory signs, like those used at highway intersections, have also been studied as supplements to the existing sign system. STOP and YIELD signs are being used today at many passive crossings across the country. A 1988 study by Mortimer (*22*) reported that 8 percent of all grade crossings posted STOP signs. Critics argue that using the STOP sign in this manner develops disrespect for the sign, causes undue delay, and increases the risk of rear-end accidents. It has been suggested that changing the color scheme of the STOP and YIELD signs at highway-railroad grade crossings, or supplementing them with additional messages prevents drivers from losing respect for the standard STOP and YIELD signs.

Related Research

The earliest forms of the YIELD TO TRAINS and LOOK FOR TRAIN AT CROSSING experimental enhanced sign systems being evaluated by this research were developed by Fambro et al. (*23*) in a 1991 and 1994 projects, respectively. Through panel discussions, focus groups, and laboratory testing, a standard YIELD sign (R1-2) with a supplemental TO TRAINS message plate mounted below and a 36 inch yellow diamond warning sign with a black train locomotive symbol and a yellow backed LOOK FOR TRAINS message plate mounted below were developed. Both experimental enhanced sign systems were field tested to understand driver comprehension, understanding, and reaction.

Data were collected at eight crossings, which determined that neither enhanced sign system caused a significant increase in approach speed or decrease in driver looking behavior. The data suggest, however, that with either enhanced sign system approach speeds may be reduced and looking behavior increased. Diminishing novelty may limit the effectiveness of the signs over time. A lack of understanding of the current sign system was assumed in the analysis. Thus, it was concluded that adding a sign to the current system will help reinforce what is expected of the driver and that the implementation of either experimental system will increase driver awareness at grade crossings. The results of the driver opinion survey did not establish a preference for either of the two systems. However, results did indicate that a majority of drivers felt that the addition of either sign would improve grade crossing safety.

Development of the two experimental enhanced sign systems continued by Fambro et al. (*24*, *4*, *5*) in a 1994 project. To further develop the enhanced sign systems, the authors identified and analyzed contributing factors to three years of highway-railroad grade crossing accident data, as well as completing extensive testing of several enhanced devices. Based on the results of that research, field testing was proposed for the YIELD TO TRAINS enhanced sign system (*24*). This system was installed at five passive highway-railroad grade crossings in Coleman and Grimes County, Texas. The data suggest a decrease in vehicle approach speed immediately following the installation of the enhanced sign system, although the speeds tended to return to normal after the enhanced sign system had been in place for several months. The data also suggest that driver looking behavior and comprehension of responsibility at the grade crossing may be significantly increased after installation. As a result of this research, Fambro et al. recommended that the YIELD TO TRAINS sign be evaluated at additional passive highway-railroad grade crossings (*4*).

Driver response to enhanced railroad advance warning signs was also investigated through a closed-course driving study, a focus group discussion, and a questionnaire. The three enhancements included a vehicle-activated strobe light, a flashing yellow beacon, and high intensity sheeting. The vehicle-activated strobe light and the flashing yellow beacon were designed for passive highway-railroad grade crossings to help draw driver attention to the railroad advance warning sign. None of the three signing systems produced adverse driver reaction. There was no supporting evidence that the enhanced sign systems increased looking behavior. However, the vehicle-activated strobe light and flashing yellow beacon did positively affect driver-braking behavior. Participants indicated that the uniqueness of the vehicle-activated strobe light might be effective in gaining driver attention. Members of the focus group expressed concern regarding the interpretation of a flashing yellow light at passive highway-railroad grade crossings (*4*).

In addressing this potential problem, a LOOK FOR TRAIN AT CROSSING sign was developed as a supplemental warning device and installed below the standard railroad advance warning sign. The LOOK FOR TRAIN AT CROSSING system was installed at a crossing near Temple, Texas. The vehicle-activated strobe light was triggered by a loop detector and powered by a solar charged 12-volt battery. Three study methods were used for evaluating the effectiveness of the enhanced sign system: before and after speed profiles, a driver survey, and a driver observation study. The authors concluded that the vehicle-activated strobe system caused some drivers to approach the passive crossings with additional caution. Reductions in speed on both approaches were also observed without any adverse driver reaction. The results of this research indicated that the vehicle-activated strobe system could be an effective traffic control device at passive grade crossings (*5*).

CHAPTER 2

ENHANCED SIGNS AND SYSTEM EQUIPMENT

ENHANCED SIGNS

The first experimental enhanced sign system (YIELD to TRAINS enhanced sign system) consists of a 36 inch YIELD sign (*MUTCD* R1-2 (*1*)) with a supplemental message 36 inch by 24 inch plate containing the phrase TO TRAINS. Figure 2-1 illustrates the design and sizing requirements for the TO TRAINS supplemental sign, and Figure 2-2 illustrates the YIELD TO TRAINS enhanced sign system.

The second experimental enhanced sign system (LOOK FOR TRAIN AT CROSSING enhanced sign system) consists of a vehicle-activated strobe or flashing yellow beacon mounted above a standard railroad advance warning sign (*MUTCD* W10-1(*1*)), in combination with a new yellow warning sign that reads LOOK FOR TRAIN AT CROSSING. Figure 2-3 illustrates the design and sizing requirements for the LOOK FOR TRAIN AT CROSSING warning sign. Figure 2-4 illustrates the LOOK FOR TRAIN AT CROSSING sign system with a flashing strobe, and Figure 2-5 illustrates the LOOK FOR TRAIN AT CROSSING sign system with a flashing beacon.

TxDOT sign crews fabricated all supplemental signs required for the project sites.

SYSTEM EQUIPMENT

Equipment for the vehicle-activated sign systems was chosen for applicability to rural locations. The specific equipment installed at the project included solar panels, long-range infrared detectors, flashing strobe lights, and flashing beacons. TxDOT crews installed the enhanced sign systems at each project site as illustrated in Figure 2-6. The relays and infrared sensors were set under the direction of the equipment supplier.

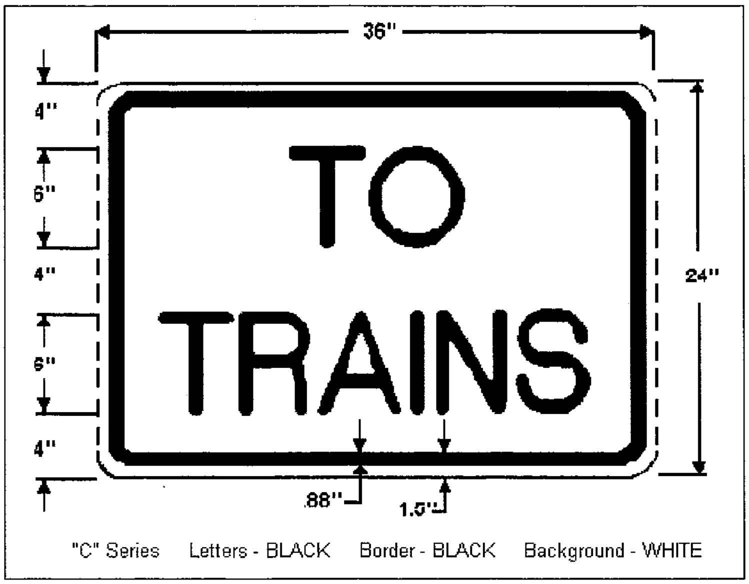


Figure 2-1. TO TRAINS Supplemental Sign.

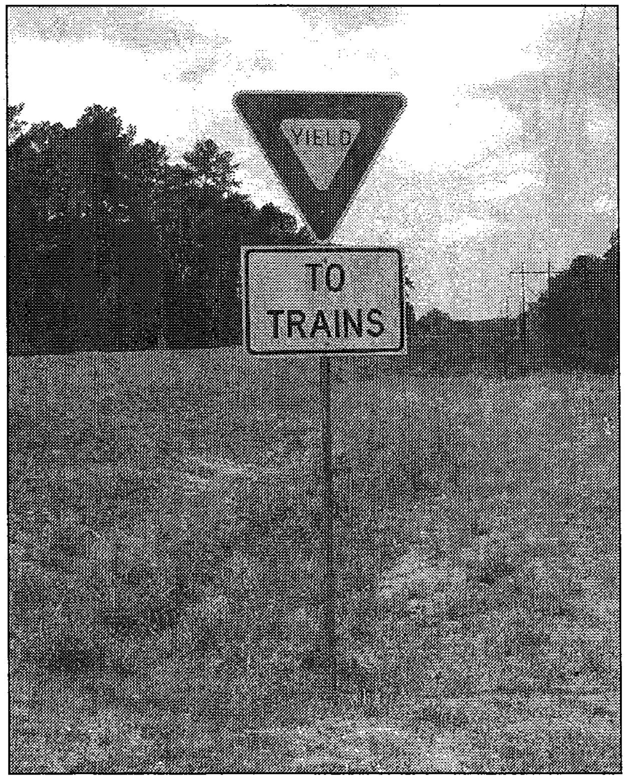


Figure 2-2. YIELD TO TRAINS Enhanced Sign System.

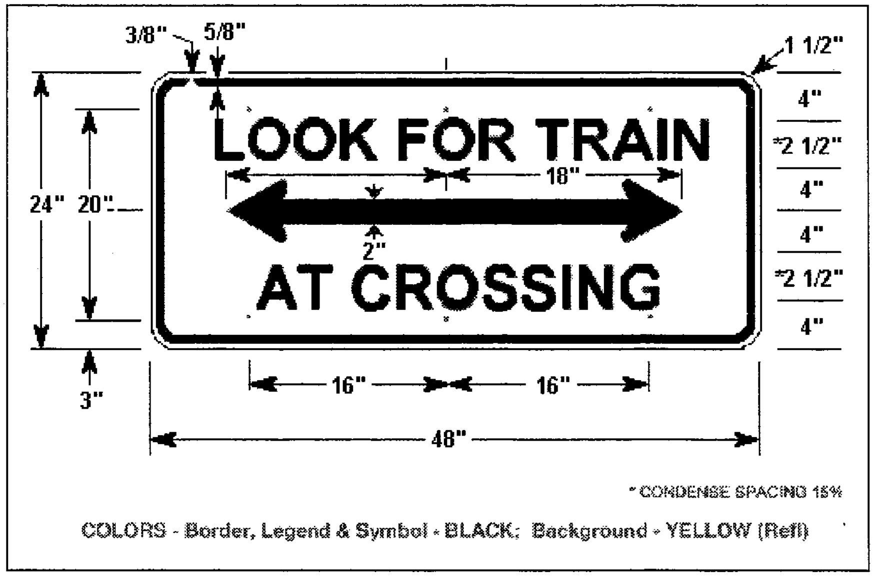


Figure 2-3. LOOK FOR TRAIN AT CROSSING Supplemental Sign.

Figure 2-4. LOOK FOR TRAIN AT CROSSING Enhanced Sign System with Flashing Strobe.

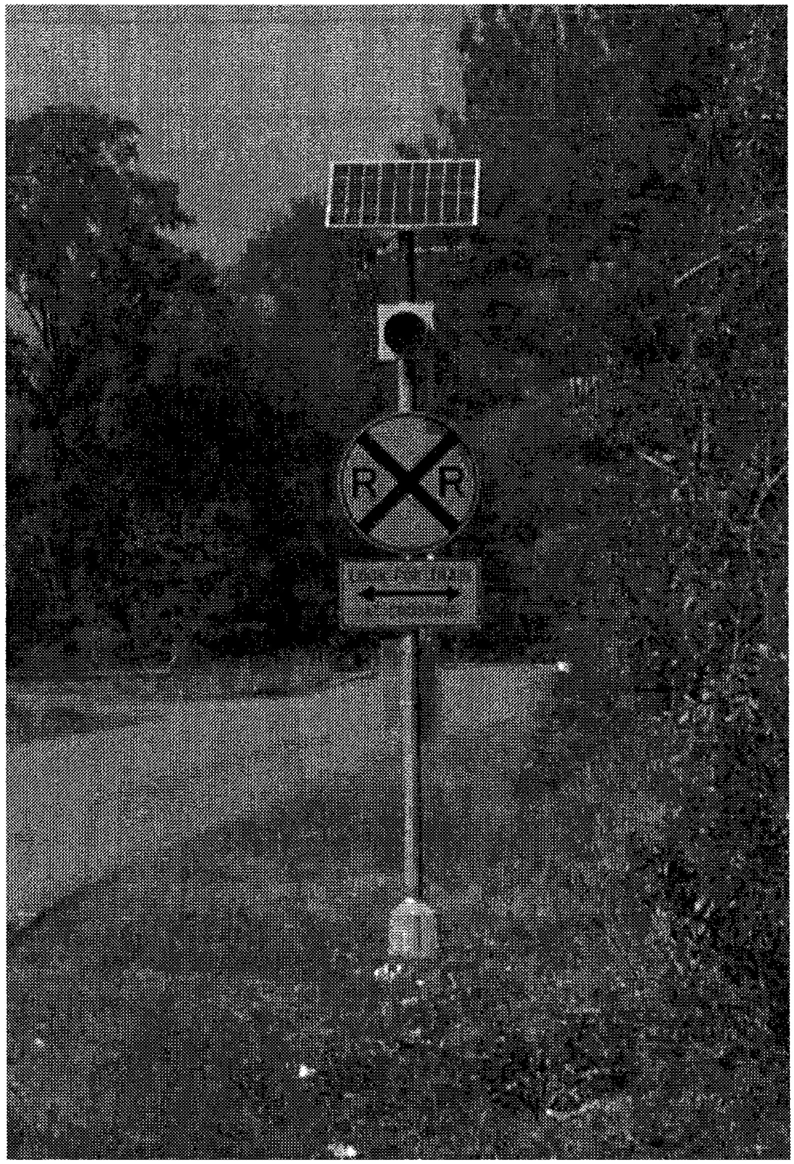


Figure 2-5. LOOK FOR TRAIN AT CROSSING Enhanced Sign System with Flashing Beacon.

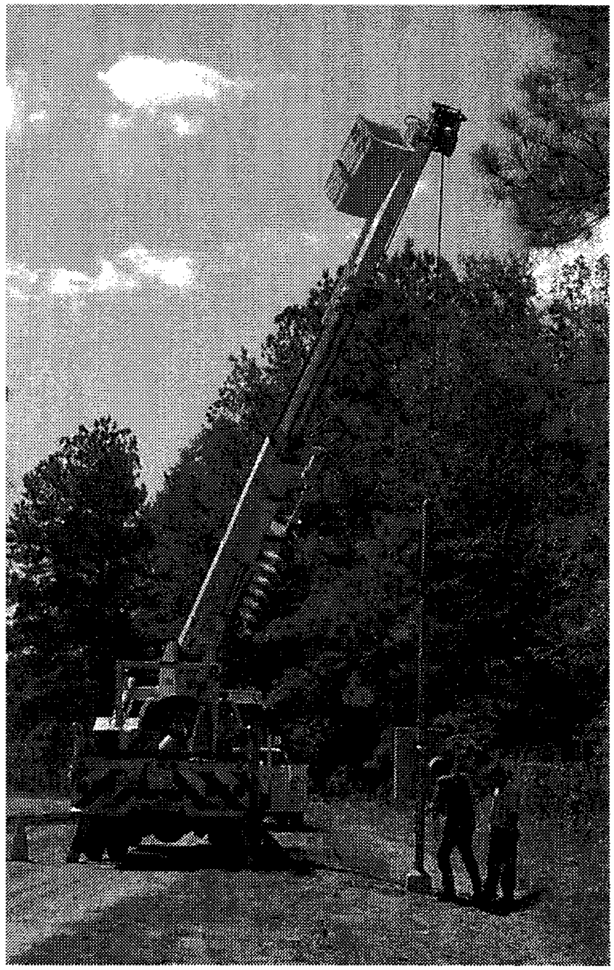


Figure 2-6. Equipment Installation in Montgomery County.

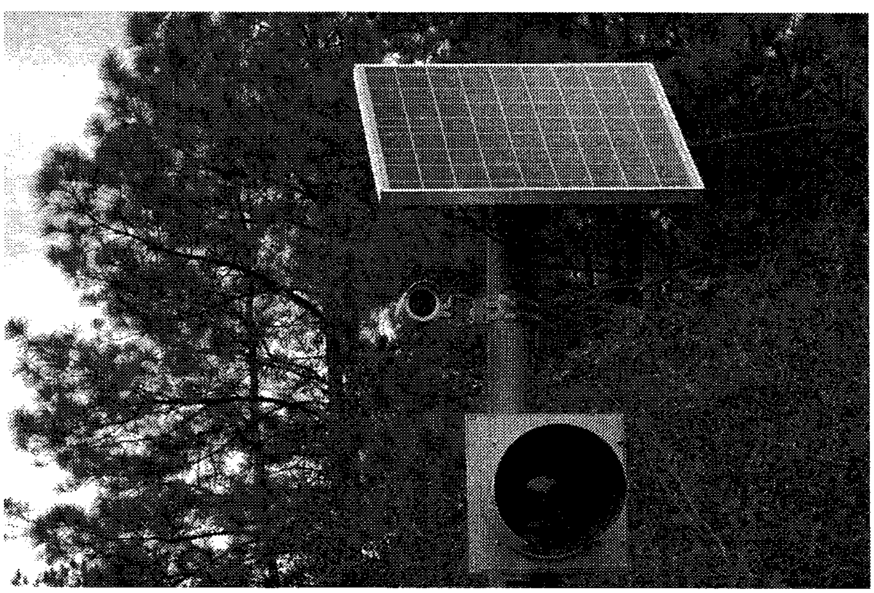


Figure 2-7. Solar Panel, Detector, Flashing Beacon Enhanced Sign Equipment.

Solar Panels

Solar panels were used because power sources were not readily available, and they were used to test their applicability for future enhanced sign system installations. The solar panels were sized to run for 24 hours to ensure an adequate power supply for the strobes or beacons and the relay and sensors, even though the strobes or beacons operated only when activated by vehicles. The solar panels were the same type used for other flashing beacons such as school beacon. They featured unbreakable triple junction technology, included shadow guard protection, were vandal resistant, were hail proof, and were heat tolerant.

Infrared Detectors

Infrared sensors were chosen for vehicle detection because this technology works for both paved and unpaved roadways, and many possible future installations are on unpaved roadways. This sensor is independent of the roadway and should work the same on paved or unpaved roadways. The Eagle PIR 3-series Advanced Long-Range Passive Infrared Motion Detector was selected to detect vehicles in order to activate the flashing beacons or flashing strobes on the enhanced sign systems. The detector discriminates between the slightest changes in thermal radiation caused by movement in its precisely defined field of view. The detector has a main zone and auxiliary zones; the angle between the main and auxiliary zones is fixed, and distances depend on the installation height. The detector is lane selective and has a functional scope adjustable by DIP switches.

Strobe Lights

The strobes used were the same brand and size as those used in Project 1469; however, they were a newer model and appeared much brighter in laboratory tests. The strobe lights were Tri-Light Mars model ST-2 full size strobe measuring 6 1/2 inches in height and 5 3/8 inches in diameter as shown in Figure 2-8. The strobe light flashed at one million-candle power and 90 flashes-per-minute.

Figure 2-8. Flashing Strobe on Enhanced Sign System.

Flashing Beacons

The flashing beacons are the same as TxDOT used for school beacons and other flashing beacon applications, which simplifies installation and maintenance for TxDOT crews since they are familiar with this equipment.

CHAPTER 3
SITE SELECTION AND DATA COLLECTION METHODS

SITE SELECTION

Five project sites each were selected for the YIELD TO TRAINS enhanced sign system and for the LOOK FOR TRAIN AT CROSSING enhanced sign system. However, due to equipment problems, researchers were unable to collect data at one of the sites for the YIELD TO TRAINS enhanced sign systems. Therefore, nine sites were included in the project.

These sites were selected from TxDOT's list of passive grade crossings slated for upgrade to active control. Only these passive crossings were considered because the enhanced traffic control devices are intended for use as an interim measure between the time a passive grade crossing is identified as needing active control and the time at which the active control is installed. These devices will be removed when the grade crossings are upgraded to active control to avoid confusing the driver.

All viable grade crossings from TxDOT's list were identified and ranked through a selection process using the following criteria based upon TxDOT's requests and previous research efforts. Researchers made extensive field visits to verify that each crossing satisfied the criteria and to assist in the ranking procedure.

- Each highway-railroad grade crossing will have passive control.
- Each highway-railroad grade crossing is scheduled to be upgraded to active control.
- Grade crossings where work orders have been issued will be excluded.
- Grade crossings will be selected to minimize the number of railroad companies involved.
- Grade crossings will be selected to minimize the number of TxDOT districts involved.
- Each grade crossing should be located in a rural area or in a residential area of a small city.
- Each grade crossing should not have geometric features that require a significant speed reduction in order to negotiate the crossing.
- Each grade crossing should have an average daily traffic between 100 and 1000 vehicles.
- Project sites should be chosen to assure a diverse geographic sample.
- At least some crossings should be on unpaved roadways.
- At least one crossing should be STOP controlled at the crossing.

Table 3-1 lists selected project sites. Sketches, photographs, and site descriptions are included in the chapters describing the site, data collection, and data analysis for each type of enhanced sign system. Figure 3-1 illustrates a portion of a Texas map showing the general locations of the project sites.

Table 3-1. Selected Study Sites for Enhanced Sign Systems.

	Site Number	County / Nearest City or Town	Road	Crossing Number	TxDOT District
YIELD TO TRAINS Signs	1	Liberty / Romayor	County Road 2145	024412F	Beaumont
	2	Grimes / Stoneham	FM 1748	430120C	Bryan
	3	Collin / Wylie	Marble Street	022101X	Dallas
	4	Collin / Wylie	Oak Street	022099Y	Dallas
LOOK FOR TRAIN AT CROSSING Sign (with Strobe)	5	Collin / Copeville	State Highway 78 Business Loop	022116M	Dallas
	6	Collin / Copeville	County Road 489	022113S	Dallas
LOOK FOR TRAIN AT CROSSING Sign (with Beacon)	7	Montgomery / Cut-N-Shoot	Waukegan Road	024367N	Houston
	8	Montgomery / Cut-N-Shoot	Timberswitch Road	024369C	Houston
	9	Polk / Livingston	Marston Road	755763X	Lufkin

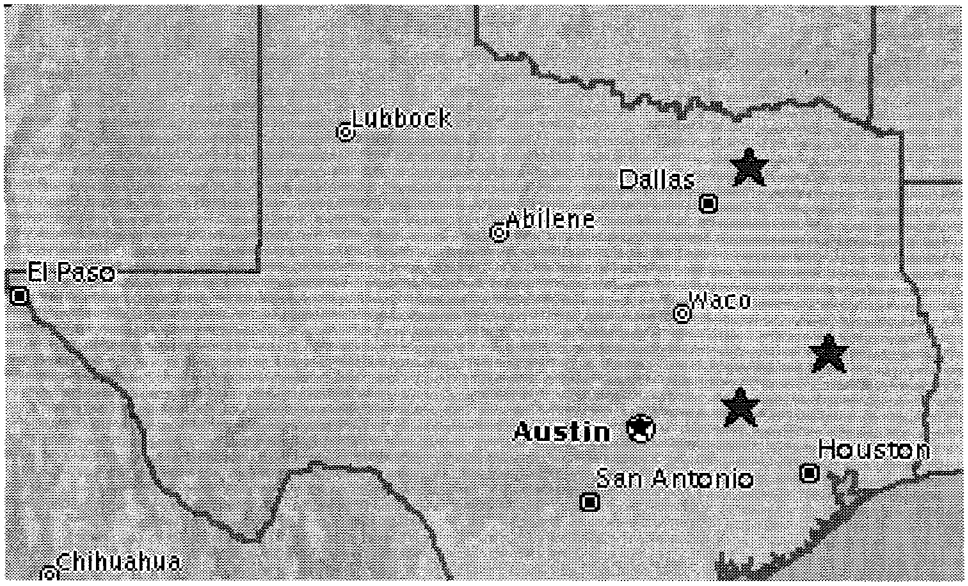


Figure 3-1. General Location of Project Study Sites.

DATA COLLECTION METHODS

Although the most effective means for determining if the enhanced sign systems improve safety at passive highway-railroad grade crossings is to evaluate before and after accident rates at each project site, accident rates are not a viable short-term measure. Driver behavior measurements may also be beneficial in some instances. However, speed profile information is more readily obtained in the field than driver behavior measurements. Also, the low volumes on the selected roadways and the open locations of the grade crossings restricted on-site observation of driver behavior; it was difficult, if not impossible, to observe driver behavior without being seen by drivers at these rural locations.

Therefore, researchers designed spot speed studies using a before and after methodology. It was hypothesized that an effective enhanced sign system would result in a speed reduction on the approach near the location of the enhanced sign system with no significant reduction in speed at the grade crossing. Railroad warning signs do not require drivers to slow upon approaching a grade crossing; however, the comparison of before and after speed profile data provided a means of determining if drivers had slowed on the approach to the grade crossings.

Before and after speed studies were conducted at each study location. The before speed studies indicated the speed conditions at the passive crossings before installation of the enhanced sign systems. The after speed studies recorded speed conditions after installation of the enhanced sign systems. These studies were used to determine if speeds changed significantly from the before conditions.

The enhanced sign systems were in place at least 30 days prior to the beginning of the after study. It was assumed that the majority of travelers at each location were familiar drivers and that after 30 days, the novelty effect of a new sign system should not affect travel speed.

In an effort to validate the speed results obtained by the traffic classifiers, radar guns were used to calibrate the traffic classifiers prior to placing them in the field. Additionally, a test vehicle was used at each study site to verify that the speed recorded by the traffic classifier matched that of the vehicle traversing the study section. The test vehicle entered the study section a minimum of 10 times at a uniform 30 mile per hour speed.

It should be noted that the number of observations varies at each data collection location for the same project site. Operational data provided by the manufacturer for each of the four types of traffic classifiers used in the before and after speed studies indicate a minimum threshold speed of 5 miles per hour. Vehicles traveling at or below 5 miles per hour may or may not have been detected by the traffic classifiers. The traffic classifiers also did not detect vehicles traveling at speeds greater than 5 miles per hour 100 percent of the time. Drivers may have intentionally avoided passing over the sensors, or they may have traversed only one of the two sensors required for determining vehicle speed. Driveways and intersecting roadways were also present on a number of the approaches, which allowed vehicles to enter or exit the study section without crossing all of the sensors.

Speed profile data were collected during day and night conditions before and after the experimental traffic control devices were installed at each crossing. Speed data were collected using piezoelectric sensors, road tubes, and traffic classifiers. The after study began approximately 30 days after the devices were installed. The duration of data collection activities varied depending upon the traffic volumes at each study location. The goal was to obtain approximately 500 speed profiles at each location. The speed profiles collected generally exceeded this number, as discussed in the following chapters.

DATA ANALYSIS

A statistical analysis comparing the before and after sample mean speeds at each study site used a two-sample t-test to determine the significance of any speed differences. The analysis was also used to test the research hypothesis that an effective enhanced sign system would result in a speed reduction on the approach near the location of the enhanced sign system with no reduction in speed at the grade crossing. It was hoped that speed profile data of individual vehicles could be used in the statistical analysis. The comparison of before and after speed profiles of individual vehicles would have provided a better indication of the effectiveness of the enhanced sign systems. However, due to equipment limitations and malfunctions, the two-sample t-test can be performed only on mean vehicle speeds at each data collection location.

The two-sample t-test procedures for comparing the before and after data sets presented in this section are based on several assumptions. The first assumption is that of independence; the before and after data sets for each study site are assumed to be drawn from two independent populations. The second assumption is that the before and after sample data sets are normal; normality is assumed because the sample data sets are assumed to be independent and the sample sizes are large. The third assumption is that the two population variances are approximately equal.

In setting up the statistical test concerning the before and after speed data, the research hypothesis (H_a) was tested against the null hypothesis (H_o) using the test statistic (T.S.) calculated from the sample data sets. It was assumed that an effective enhanced sign system would cause a reduction in speed near the sign location with no significant speed change on the rest of the approach. The null hypothesis is illustrated in Equation 1; it assumes the difference between the before mean speed and the after mean speed at each data collection location is null. The research hypothesis is illustrated in Equations 2 and 3; it assumes the difference between the before mean speeds and the after mean speeds at each data collection location is either greater or less than zero. The test statistic is given in Equation 4; it is a function of the sample mean, size, and variance. In Equations 5 through 8, a rejection region (R.R.) is determined for a specified value of α and degrees of freedom (df) of the samples. The research hypotheses are then tested against the null hypothesis using the rejection region. For this research, a two-tailed test was used with $\alpha = 0.05$. Thus, there are only five chances in 100 that the variations in mean vehicle speeds in the before and after studies are due to something other than actual differences in the samples being analyzed. Equations 1 through 8 outline the steps for the approximate t-test for independent samples with unequal variance (*25*).

$$H_o: \quad \mu_1 - \mu_2 = D_o \tag{1}$$

$$H_a: \quad \mu_1 - \mu_2 > D_o \tag{2}$$

$$\mu_1 - \mu_2 < D_o \tag{3}$$

where $D_o = 0$ μ_1 = Before Speed μ_2 = After Speed

$$\text{T.S.:} \quad t' = \frac{\bar{y}_1 - \bar{y}_2 - D_o}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \tag{4}$$

$$\text{R.R:} \quad \text{reject } Ho \text{ if } t' > t_\alpha \tag{5}$$

$$\text{reject } Ho \text{ if } t' < t_\alpha \tag{6}$$

$$df = \frac{(n_1 - 1)(n_2 - 1)}{(n_2 - 1)c^2 + (1 - c)^2 (n_1 - 1)} \quad \textbf{(7)}$$

$$c = \frac{s_1^2 / n_1}{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} \quad \textbf{(8)}$$

Data collection and analysis for each type of enhanced sign system are included in Chapters 4, 5, and 6.

DATA COLLECTION

Before studies were completed prior to any changes to the existing signs and traffic control devices at each study site. Traffic classifiers recorded vehicle speed, axle-length, and time of detection at five locations upstream of the grade crossing using piezoelectric sensors and road tubes. The traffic classifiers used for data collection were TCC-500 (version 3.19), Unicorn (version 2.30), Phoenix (version 2.10), and Golden River Marksman (series 600). Four classifiers were used per approach when using piezoelectric sensors, and five classifiers were used per approach when road tubes were used. When using piezoelectric sensors, three of the four classifiers were each attached to two piezoelectric sensors placed 10 feet apart on the approaching lane of the roadway. The remaining classifier was attached to four piezoelectric sensors recording data at two locations upstream of the grade crossing. The two sensors in each set were placed 10 feet apart on the approaching lane of the roadway. When using road tubes, each classifier was attached to two road tubes. The road tubes in each set were placed between 2 feet and 4 feet apart depending upon their location and upon the roadway geometry.

Vehicles traveling in the opposing travel lane were registered as a miss by the traffic classifiers; therefore, they did not affect the speed profile on the study approach. Figure 3-2 illustrates two piezoelectric sensors attached to the roadway and being wired into a Phoenix classifier. The four sensor locations closest to the grade crossing collected data to determine vehicle speed profiles. The sensor location furthest from the grade crossing was used as a control, since vehicles at that point were assumed to be at free-flow speed and not influenced by the grade crossing signs and traffic control devices.

Sensor spacing varied by location and experimental sign type. It was intended that speed data collected through this study could be compared to previous research using the LOOK FOR TRAIN AT CROSSING and YIELD TO TRAINS sign systems. Therefore, the sensors closest to the track and the control sensors furthest from the track were kept identical to those in previous studies (33 and 1312 feet, respectively). However, the remaining three classifier locations varied from previous studies due to sign system placement, geometry of the roadway, and with vehicle speed for the LOOK FOR TRAIN AT CROSSING sign systems. Since the LOOK FOR TRAIN AT CROSSING sign system incorporated the existing railroad advance warning sign (*MUTCD* W10-1), consideration was given to vehicle approach speed in locating the sign and sensors on each approach. Sign system placement and data collection locations are discussed in Chapters 4, 5, and 6.

Figure 3-2. Piezoelectric Sensors and Traffic Classifier.

CHAPTER 4
YIELD TO TRAINS ENHANCED SIGN SYSTEMS

INTRODUCTION

The YIELD TO TRAINS enhanced sign system consists of a 36 inch YIELD sign (*MUTCD* R1-2 (*1*)) with a supplemental message 36 inch by 24 inch plate containing the phrase TO TRAINS. Figure 4-1 illustrates the design and sizing requirements for the TO TRAINS supplemental sign.

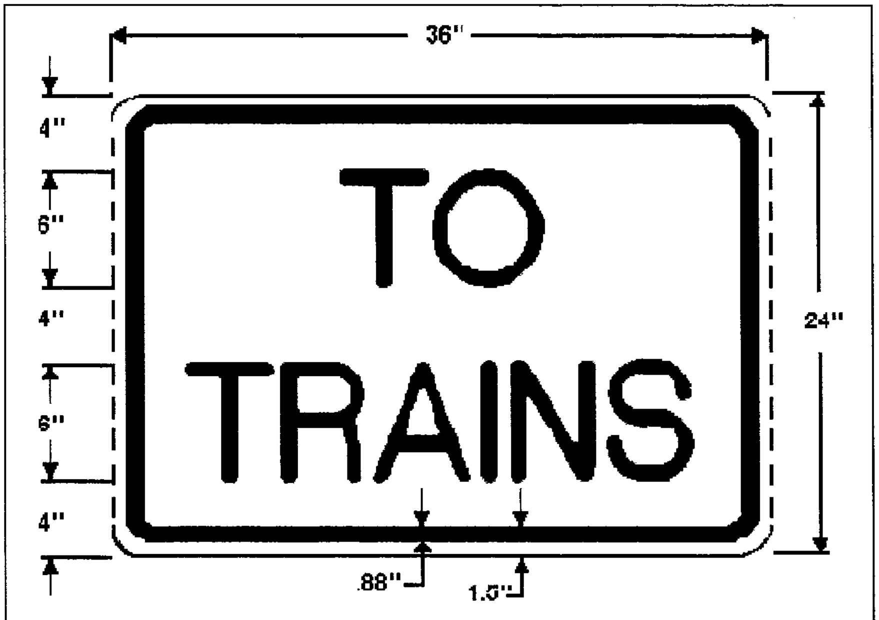


Figure 4-1. TO TRAINS Supplemental Sign Dimensions.

Data Collection Set-up for YIELD TO TRAINS Sign System

The enhanced sign system was placed as close to the railroad right-of-way as possible, eliminating any perception-reaction considerations in locating the sign system. The location of the railroad advance warning sign (W10-1) and the posted speed were irrelevant in the placement of the YIELD TO TRAINS enhanced sign systems.

The YIELD TO TRAINS sign contains 6-inch letters and was designed using the 36-inch sign dimensions shown in Figure 4-1. A ratio of legibility distance to letter height of 7:1 was again used assuming 20/20 Snellen vision. This ratio resulted in the equivalent of 344 feet of legibility distance. The only unfamiliar component of this enhanced sign system is the supplemental TO TRAINS sign. Figure 4-2 illustrates the relevant distances as related to the YIELD TO TRAINS sign system. As discussed in Chapter 2, the sensors closest to the track and the control sensors furthest from the track were kept at 33 and 1312 feet, respectively, so that they matched previous studies. Each of the remaining three sensor locations was 131 feet from the closest downstream sensor. It should be noted that these distances were varied by as much as 35 feet at certain locations to account for roadway geometry and existing obstacles.

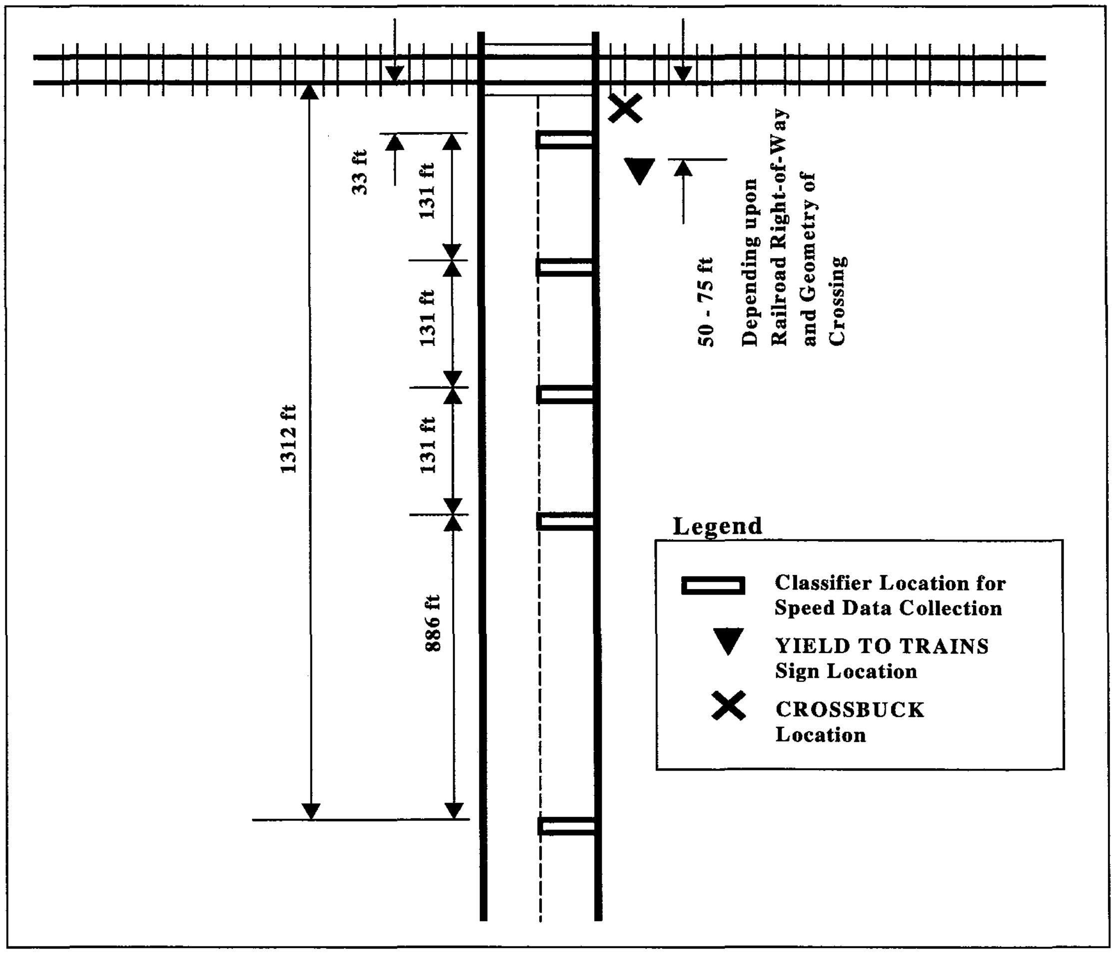


Figure 4-2. YIELD TO TRAINS Data Collection Layout.

STUDY SITES

Site 1. Grade Crossing No. 024412F on County Road 2145 in Liberty County, Texas

County Road 2145 is located northeast of Romayor, Texas. Figure 4-3 shows that the grade crossing is between two short-radius horizontal curves that form an S-curve roadway alignment. The roadway approach north of the horizontal curves is flat and straight and parallels the railroad tracks to the east. It also has limited sight distance. The vertical roadway grade increases sharply to meet the grade of the railroad tracks within 65 feet of both approaches. On the south approach, two unpaved roadways connect to CR 2145 at approximately 32 and 1350 feet from the grade crossing. On the north approach, CR 2146 connects to CR 2145 at approximately 800 feet from the grade crossing. Several private drives also connect to the north approach of CR 2145. The posted speed limit for CR 2145 is 30 miles per hour.

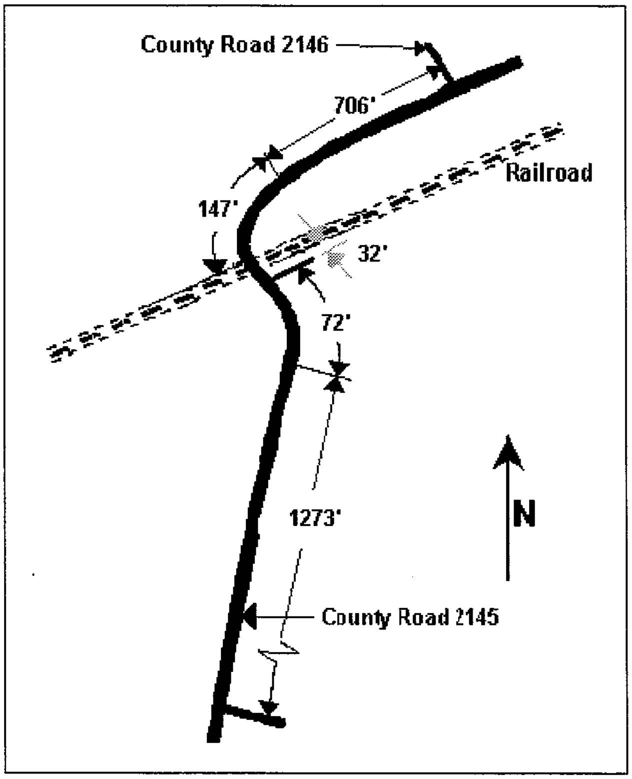


Figure 4-3. County Road 2145 in Liberty County, Texas.

Sensors were placed at 58, 180, 312, 444, and 1332 feet from the grade crossing to conduct the before speed studies, and the two sensors comprising a set were separated by 10 feet. The distances were measured from the closest rail to the first sensor in each set. Figure 4-4 is a diagram of the before and after sensor locations and YIELD TO TRAINS sign locations. Sensors were placed only on the south approach due to the sharp horizontal curve near the crossing on the north approach. The before study was conducted between June 15 and June 23, 1999. Table 4-1 summarizes the data collected during the before study. The data show vehicles slowing as they approach the grade crossing, with the largest decrease in speed occurring between 58 and 180 feet from the grade crossing.

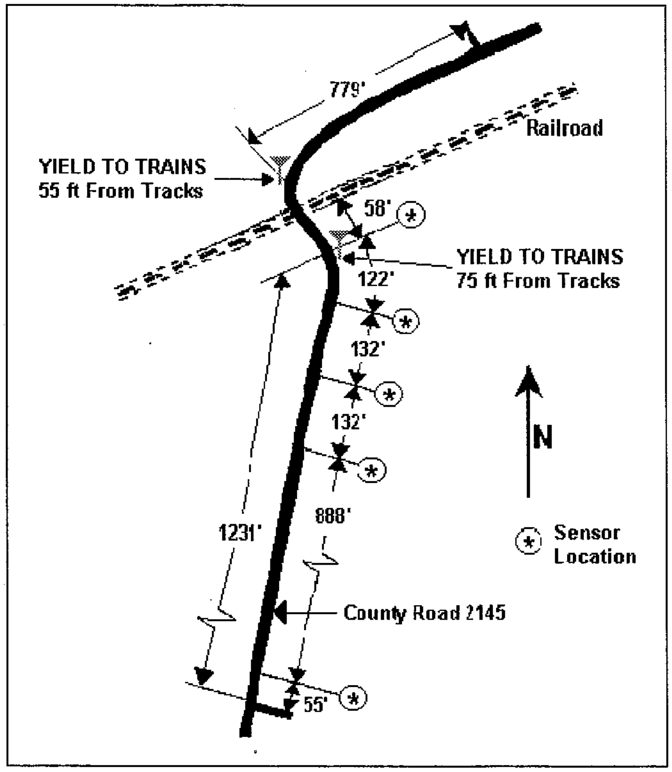


Figure 4-4. Installation Diagram for County Road 2145.

On August 11, 1999, TxDOT personnel installed a YIELD TO TRAINS enhanced sign system on each approach of the crossing. The YIELD TO TRAINS sign was placed 75 feet from the first rail of the crossing on the south approach to avoid locating the sign in the horizontal curve. Although speed data were collected only on the south approach, a YIELD TO TRAINS sign system was also placed on the north approach to create uniformity in driver behavior when approaching the crossing from either direction. The YIELD TO TRAINS sign system on the north approach was placed 55 feet from the first rail of the crossing. This sign system was placed closer to the grade crossing than the sign on the south approach to avoid placing the sign near a private driveway. However, the sign was still located outside the railroad right-of-way.

The after study was conducted from September 14 to September 20, 1999, using the same setup used in the before study. Table 4-2 summarizes the data collected during the after study. The data also show vehicles slowing as they approach the grade crossing, with the largest decrease in speed occurring between 58 and 180 feet from the grade crossing.

Table 4-1. Before Speed Data: Grade Crossing No. 024412F (CR 2145).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	58	416	16.1	28.0	31.4	3.4	10.6	22.7	4.4	19.7
	180	665	29.3	52.5	56.6	4.1	24.2	35.0	6.6	43.4
	312	622	34.7	47.7	54.5	6.8	28.0	42.6	8.0	63.4
	444	665	37.5	53.2	60.0	6.8	30.1	46.0	8.5	72.7
	1332	485	39.9	76.4	79.8	3.4	32.5	50.0	10.7	115.4

Table 4-2. After Speed Data: Grade Crossing No. 024412F (CR 2145).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	58	320	16.8	26.6	30.0	3.4	12.1	20.2	5.6	31.5
	180	552	29.4	39.5	42.9	3.4	25.2	35.1	5.6	30.8
	312	560	35.0	49.8	56.6	6.8	27.5	42.9	7.3	53.6
	444	572	37.7	57.2	70.9	13.7	29.2	46.3	8.2	67.3
	1332	523	40.9	72.9	81.1	8.2	31.1	50.2	9.3	86.9

Figures 4-5 and 4-6 illustrate the northbound and southbound approaches of CR 2145 after the YIELD TO TRAINS enhanced sign systems were installed.

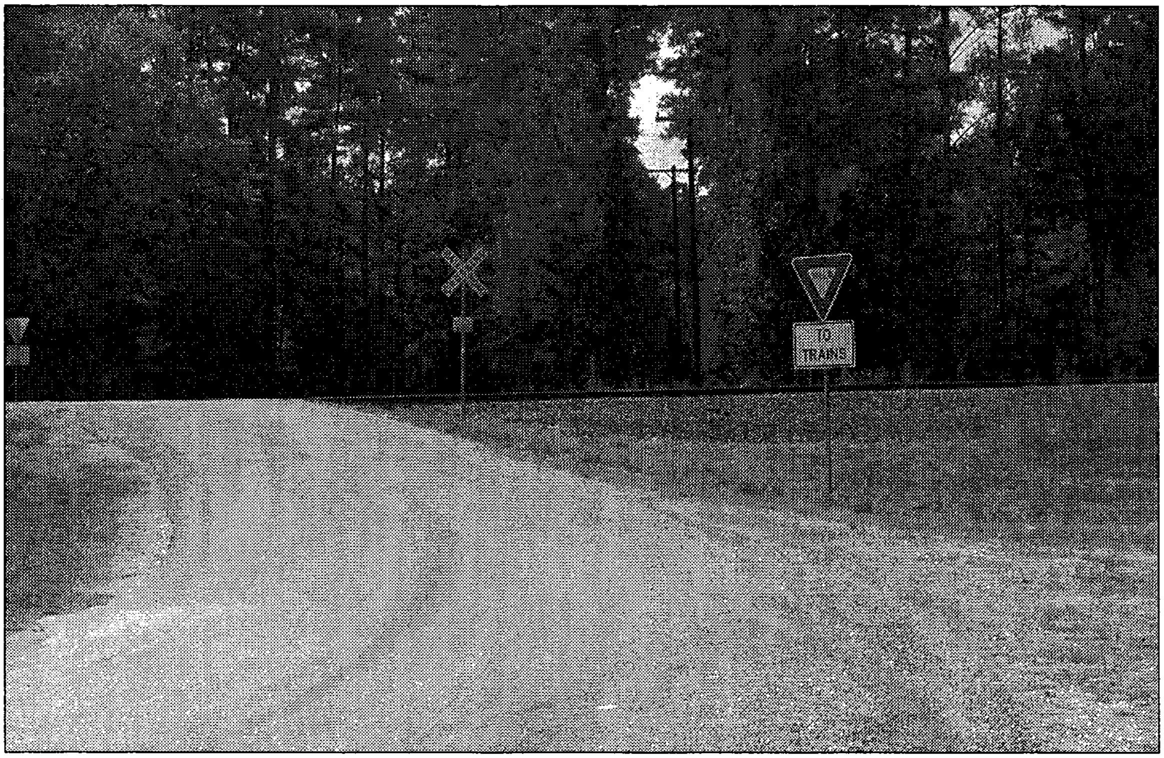


Figure 4-5. Southbound Approach on County Road 2145.

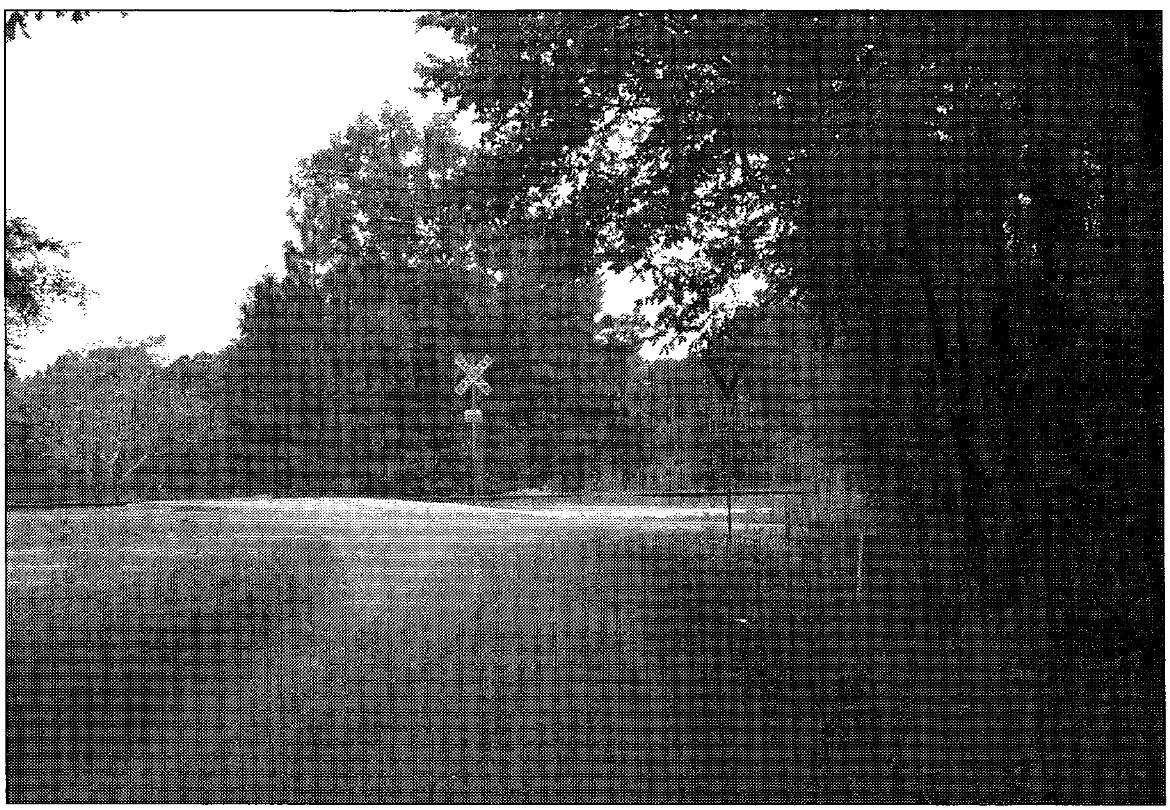


Figure 4-6. Northbound Approach on County Road 2145.

The before and after speed data for grade crossing 024412F on CR 2145 were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 4-3 presents the results of the two-sample t-test, and Figure 4-7 presents a graphical representation of the before and after mean speeds along the study approach. Linear interpolation was used to approximate before and after mean speeds between data collection locations. The vertical line at 75 feet on Figure 4-7 represents the location of the enhanced sign system during the after study.

Table 4-3. Statistical Comparison: Grade Crossing No. 024412F (CR 2145).

Approach and Location from Crossing (feet)		Mean Speed (mph)							Significant
		Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	at $\alpha = 0.05$
South	58	16.1	16.8	0.7	504	0.231	0.32	1.96	NO
	180	29.3	29.4	0.1	1187	0.622	0.05	1.96	NO
	312	34.7	35.0	0.3	1175	0.557	0.09	1.96	NO
	444	37.5	37.7	0.2	1228	0.501	0.05	1.96	NO
	1332	39.9	40.9	1.0	896	0.655	0.15	1.96	NO

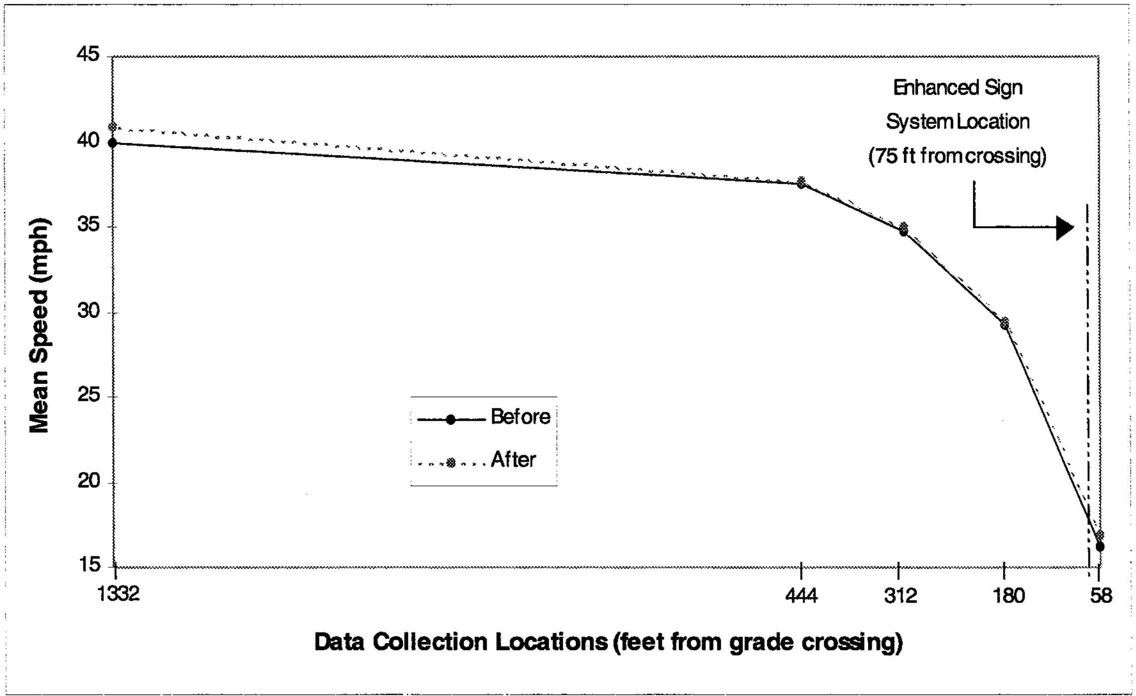


Figure 4-7. Mean Speed Comparison: Grade Crossing No. 024412F (CR 2145).

No significant speed increase or decrease was found at $\alpha = 0.05$ when comparing the before and after mean speeds at each data collection location. Mean speeds were slightly higher at each data collection location after the enhanced sign system was placed in the field. The largest difference in before and after mean speeds, a 1.0-mile per hour increase, came at the control location 1332 feet from the grade crossing. This increase in speed could be the result of turning traffic from the unpaved road that connects to CR 2145 approximately 1350 feet from the grade crossing.

Researchers observed a large volume of truck traffic entering CR 2145 from this unpaved road during the before study, but little to no truck traffic during the after study. The presence of these large trucks in the before study could have caused the mean speeds to be artificially lower due to their poor acceleration characteristics and length of approach.

A 0.7-mile per hour increase was recorded 58 feet from the grade crossing. There is no apparent difference between the 85th percentile speeds at each data collection location except at 58 feet from the crossing. A 2.2 mile per hour decrease in the 85th percentile speed was seen at 58 feet between the before and after studies. This may suggest that the YIELD TO TRAINS sign is more effective in slowing drivers traveling at higher rates of speed. However, the YIELD TO TRAINS sign system had no statistically significant effect on drivers approaching this grade crossing. The two-sample t-test does not provide enough evidence to reject the null hypothesis outlined in Equation 1 (Chapter 3).

Site 2. Grade Crossing No. 430120C in Grimes County, Texas

This site on Farm to Market (FM) 1748 is northwest of Stoneham, Texas. The grade crossing is located in a tangent section as shown in Figure 4-8. The approach roadway north of the crossing is straight and slopes upward toward the crossing. There was basically no sight distance on the north approach due to vegetation along the right-of-way. The approach roadway south of the grade crossing is level and straight, but it also has limited sight distance due to vegetation along the railroad right-of-way. On the south approach, an unpaved private drive connects to FM 1748 at approximately 65 feet from the crossing. On the north approach, FM 1748 connects to State Highway 105 approximately 570 feet from the grade crossing. The posted speed limit for FM 1748 is 60 miles per hour.

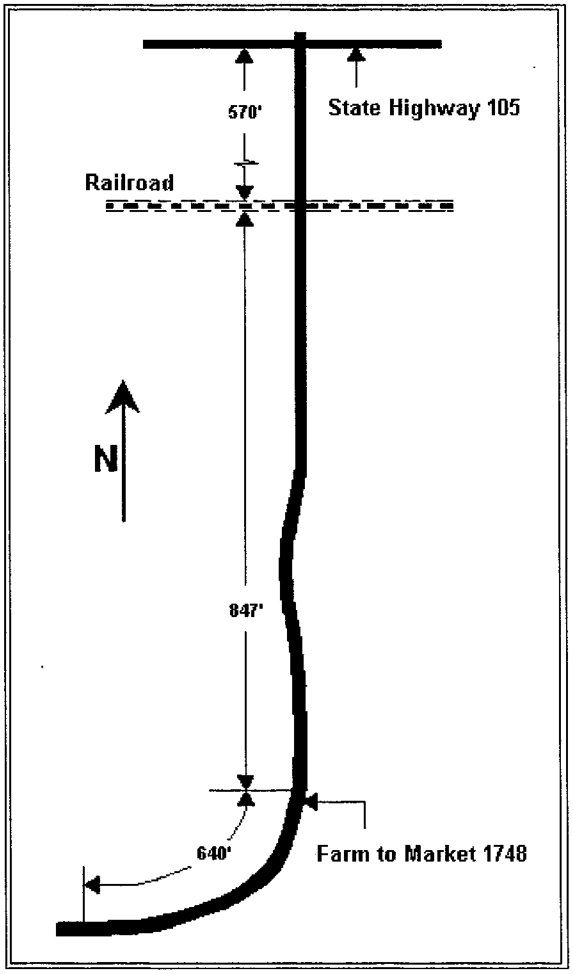


Figure 4-8. FM 1748 in Grimes County, Texas.

Sensors were placed 35, 164, 295, 426, and 1312 feet from grade crossing number 430120C on FM 1748. Sensors were placed only on the south approach due to the close proximity of State Highway 105. Each distance was measured from the closest rail to the first sensor in each set, and 10 feet separated the two sensors in each set. The before study was conducted between September 7 and September 13, 1999. Table 4-4 summarizes the data collected during the before study. The data show vehicles slowing as they approach the grade crossing, with the largest decrease in speed, 13.7 miles per hour, occurring between 35 and 164 feet from the grade crossing.

On September 29, 1999, TxDOT personnel installed a YIELD TO TRAINS sign system on each approach of the crossing. The YIELD TO TRAINS sign was placed 59 feet from the first rail of the crossing on the north approach and at 60 feet from the first rail on the south approach. Again, a YIELD TO TRAINS sign was placed on both approaches to create uniformity in driver behavior when approaching the crossing from either direction. Both signs were located outside the railroad right-of-way.

The after study was conducted from November 2 to November 9, 1999, using the same setup used in the before study. Table 4-5 summarizes the data collected during the after study. The data show vehicles slowing as they approach the grade crossing, with the largest decrease in speed, 13.9 miles per hour, occurring between 35 and 164 feet from the grade crossing.

Figure 4-9 is a diagram of the before and after sensor locations and YIELD TO TRAINS sign locations. Figure 4-10 shows the northbound approach to DOT grade crossing No. 430120C on FM 1748, and Figure 4-11 shows the southbound approach.

Table 4-4. Before Speed Data: Grade Crossing No. 430120C (FM 1748).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
South	35	139	14.2	30.7	34.1	3.4	8.3	20.7	6.4	40.9
	164	164	28.1	42.2	51.1	8.9	19.5	34.3	7.8	61.2
	295	164	35.4	46.3	59.3	13.0	26.2	43.3	8.7	75.0
	426	135	40.2	46.4	60.7	14.3	32.9	48.4	8.6	74.5
	1312	122	47.0	60.7	67.5	6.8	38.6	56.2	9.7	94.3

Table 4-5. After Speed Data: Grade Crossing No. 430120C (FM 1748).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	35	139	14.2	30.7	34.1	3.4	8.3	56.2	6.4	40.9
	164	164	28.1	42.2	51.1	8.9	19.5	48.4	7.8	61.2
	295	164	35.4	46.3	59.3	13.0	26.2	43.3	8.7	75.0
	426	135	40.2	46.4	60.7	14.3	32.9	34.3	8.6	74.5
	1312	122	47.0	60.7	67.5	6.8	38.6	20.7	9.7	94.3

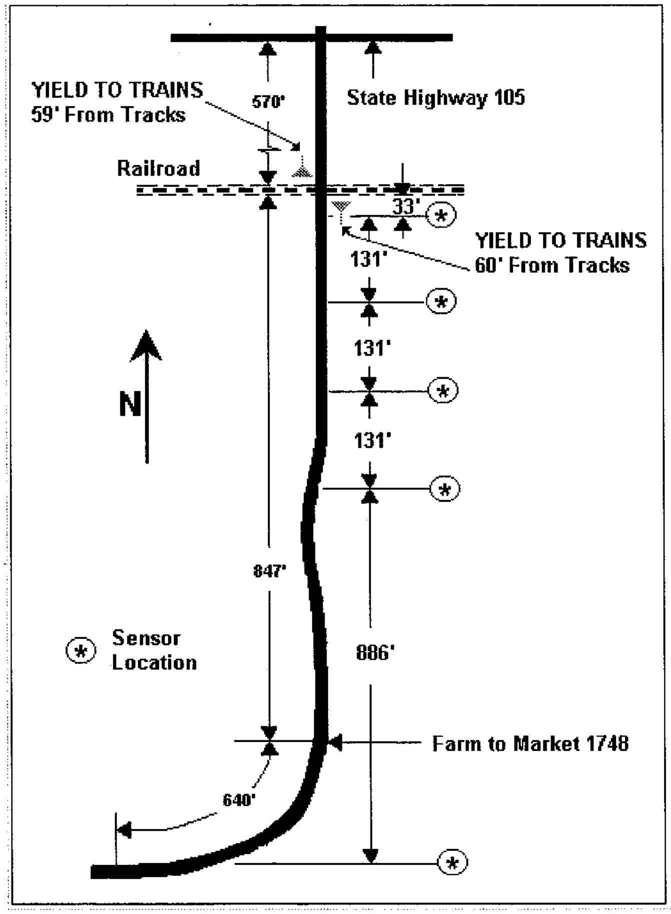


Figure 4-9. Installation Diagram for Farm to Market Road 1748.

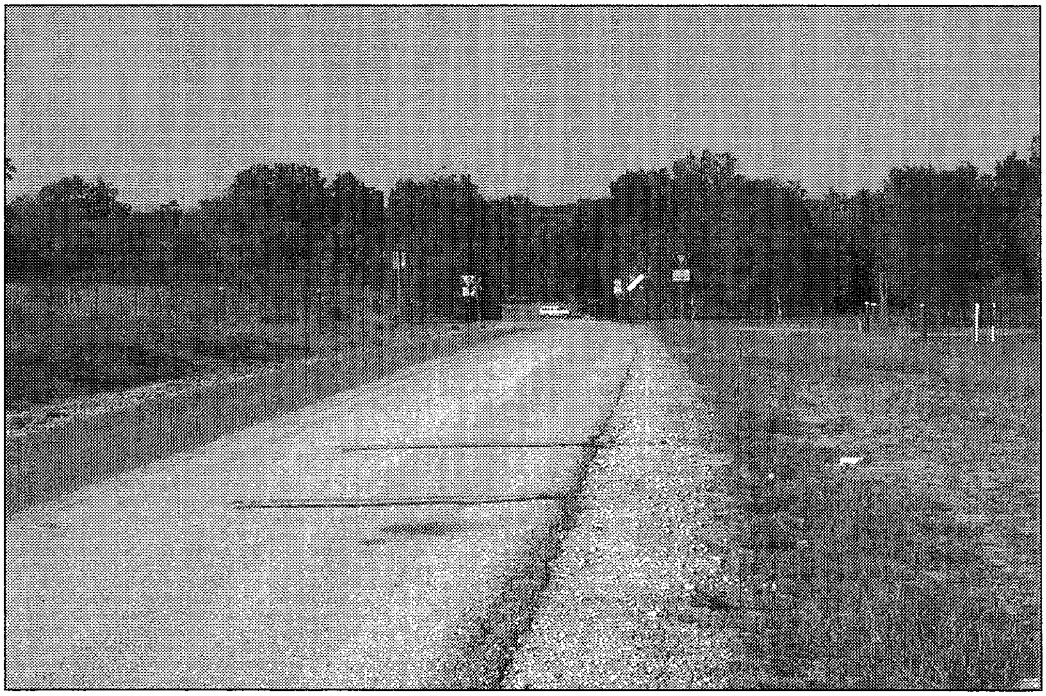


Figure 4-10. Northbound Approach on Farm to Market Road 1748.

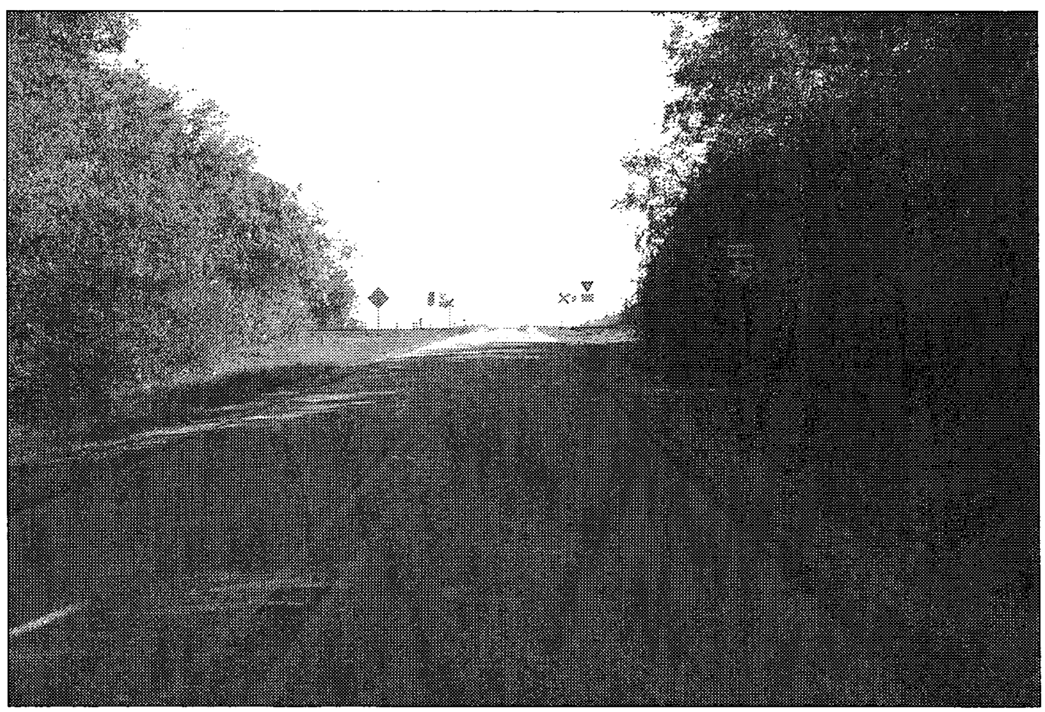


Figure 4-11. Southbound Approach on Farm to Market Road 1748.

The before and after speed data for grade crossing 430120C on FM 1748 were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 4-6 presents the results of the two-sample t-test, and Figure 4-12 presents a graphical representation of the before and after mean speeds along the study approach. Linear interpolation was used to approximate before and after mean speeds between data collection locations. The vertical line at 60 feet on Figure 4-12 represents the location of the enhanced sign system during the after study.

Table 4-6. Statistical Comparison: Grade Crossing No. 430120C (FM 1748).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
South	33	15.3	14.2	1.1	274	0.51	0.22	1.96	NO
	164	29.0	28.1	0.9	282	0.35	0.15	1.96	NO
	295	37.1	35.4	1.7	252	0.23	0.26	1.96	NO
	426	41.2	40.2	1.0	266	0.36	0.13	1.96	NO
	1312	52.0	47.0	5.0	214	0.28	0.50	1.96	NO

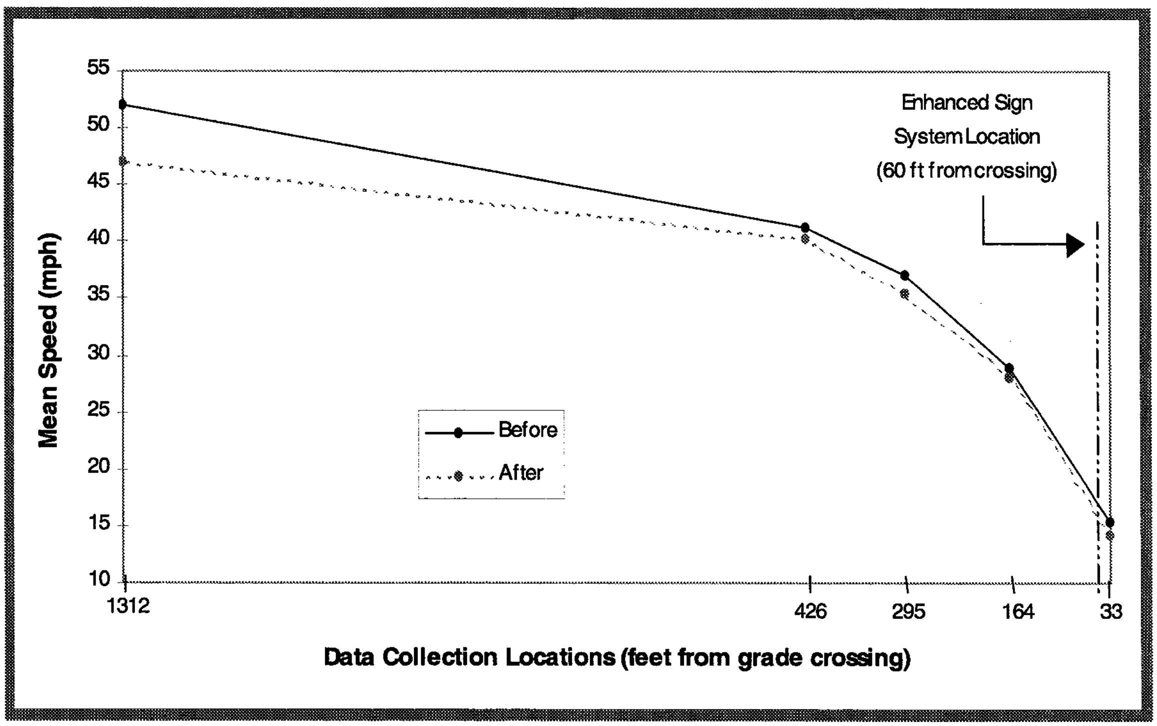


Figure 4-12. Mean Speed Comparison: Grade Crossing No. 430120C (FM 1748).

No significant speed increase or decrease was found at $\alpha = 0.05$ when comparing the before and after mean speeds at each data collection location. Mean speeds were slightly lower at each data collection location after the enhanced sign system was placed in the field. The largest difference in before and after mean speeds, a 5-mile per hour decrease, came at the control location 1312 feet from the grade crossing. The second largest difference in before and after mean speeds, a 1.7-mile per hour decrease, came at 295 feet from the grade crossing. There is also no apparent difference between 85^{th} percentile speeds at each data collection location, except at 1312 feet. A 3.5 mile per hour increase in the 85^{th} percentile speed was seen between the before and after studies at 1312 feet. The two-sample t-test does not provide enough evidence to reject the null hypothesis outlined in Equation 1 (Chapter 3). It appears drivers slowed slightly on the approach. However, this decrease in speed cannot be conclusively attributed to the installation of the YIELD TO TRAINS sign system.

Site 3. Crossing No. 02210X in Collin County, Texas

The third site for the YIELD TO TRAINS sign was on Marble Street in Wylie, Texas. Marble Street has several prominent geometric features as shown in Figure 4-13. The grade crossing is located on a tangent section on the west side of State Highway 78. The approach roadway east of the grade crossing is flat and straight with limited sight distance due to development in the area. The approach roadway west of the grade crossing is also flat and straight with limited but adequate sight distance due to development. The vertical grade of the roadway increases slightly to meet the grade of the railroad tracks within 100 feet of the crossing on both approaches. On the east approach, Birmingham Street and Jackson Avenue cross Marble Street at approximately 110 and 419 feet from the crossing, respectively. Several private drives also connect to the east and west approaches of Marble Street. The speed limit on Marble Street is 30 miles per hour.

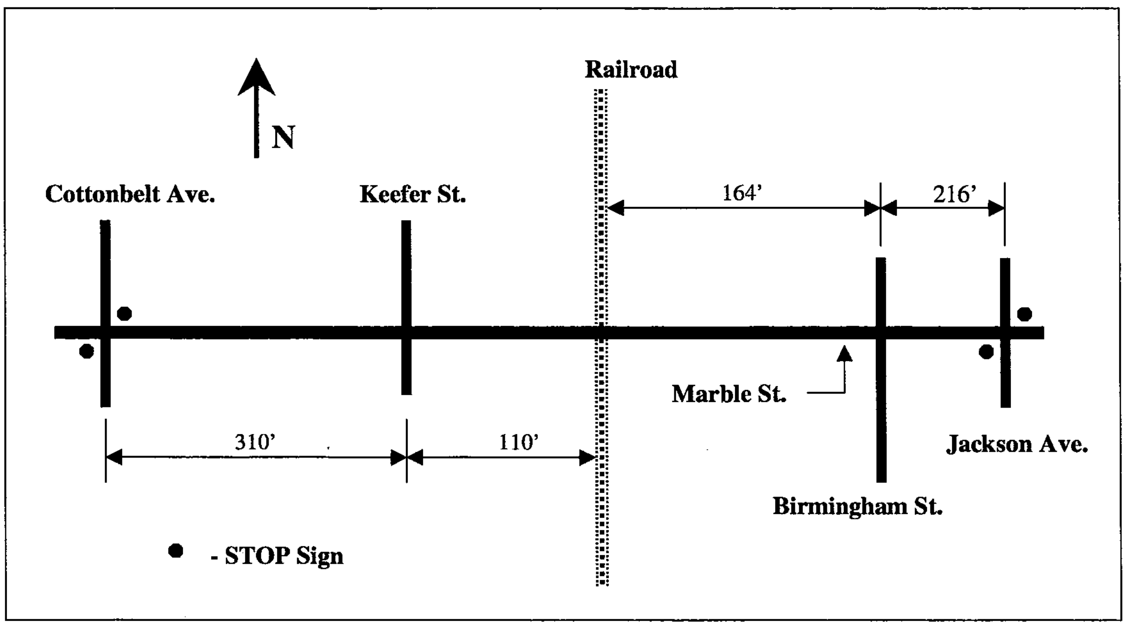


Figure 4-13. Marble Street in Wylie, Texas.

Road tubes were placed 33, 164 and 262 feet from the grade crossing to collect the before speed data. Each distance was measured from the closest rail to the first road tube in each set. The proximity of the intersecting roadways to the grade crossing prohibited speed data collection on the east approach, and only three sets of road tubes were placed on the west approach due to the close proximity of the stop controlled intersections. Two feet separated the two road tubes placed at 33 feet from the track, while four feet separated the road tubes in each set at 164 feet and 262 feet. The before study was conducted from July 6 to July 9, 1999. Table 4-7 summarizes the data collected during the before study. The data show vehicles slowing as they approach the grade crossing, with the largest decrease in speed, 6.6 miles per hour, occurring between 33 and 164 feet from the grade crossing.

On September 2, 1999, TxDOT personnel installed a YIELD TO TRAINS sign system on each approach of Marble Street. The YIELD TO TRAINS signs were placed 62 feet from the first rail of each crossing, and both signs were located outside the railroad right-of-way. The after study was conducted from October 10 to October 13, 1999, using the same setup as used in the before study. Table 4-8 summarizes the data collected during the after study. The after data also show vehicles slowing as they approach the grade crossing, with the largest decrease, 3.1 miles per hour, occurring between 33 and 164 feet. This decrease is less than half of that experienced during the before study on the same segment of roadway.

Table 4-7. Before Speed Data: Grade Crossing No. 022101X (Marble Street).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	1578	15.8	34.0	35.0	1.0	10.1	21.8	5.4	29.5
	164	639	22.4	60.0	62.0	2.0	14.8	29.0	8.0	63.3
	262	691	23.3	36.0	40.0	4.0	17.5	29.6	5.8	33.3

Table 4-8. After Speed Data: Grade Crossing No. 022101X (Marble Street).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	1115	18.7	38.0	40.0	2.0	14.1	24.7	5.1	26.3
	164	667	21.8	41.0	43.0	2.0	14.9	28.8	6.4	40.7
	262	790	22.5	35.0	39.0	4.0	17.1	28.6	5.7	32.8

Figure 4-14 is a diagram of the before and after sensor locations and YIELD TO TRAINS sign locations for Marble Street. Figures 4-15 and 4-16 illustrate the eastbound and westbound approaches of the grade crossing on Marble Street.

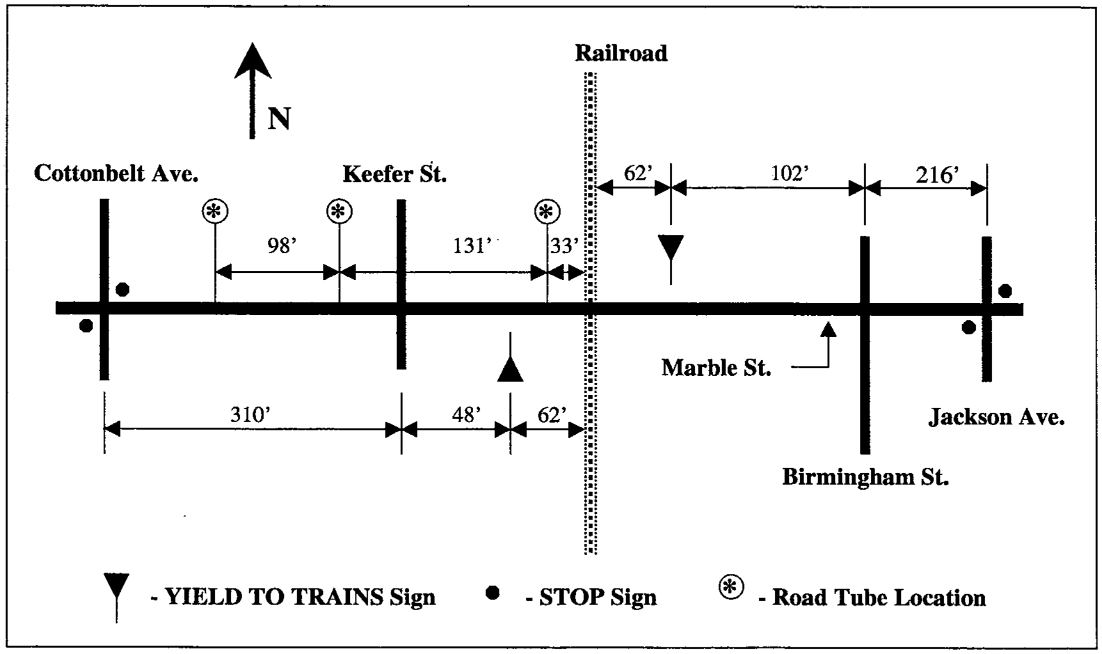


Figure 4-14. Installation Diagram for Marble Street in Wylie, Texas.

The before and after speed data for grade crossing 022101X were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 4-9 presents the results of the two-sample t-test, and Figure 4-15 presents a graphical representation of the before and after mean speeds along the study approach. Linear interpolation was used to approximate before and after mean speeds between data collection locations. The vertical line at 62 feet on Figure 4-17 represents the location of the enhanced sign system during the after study.

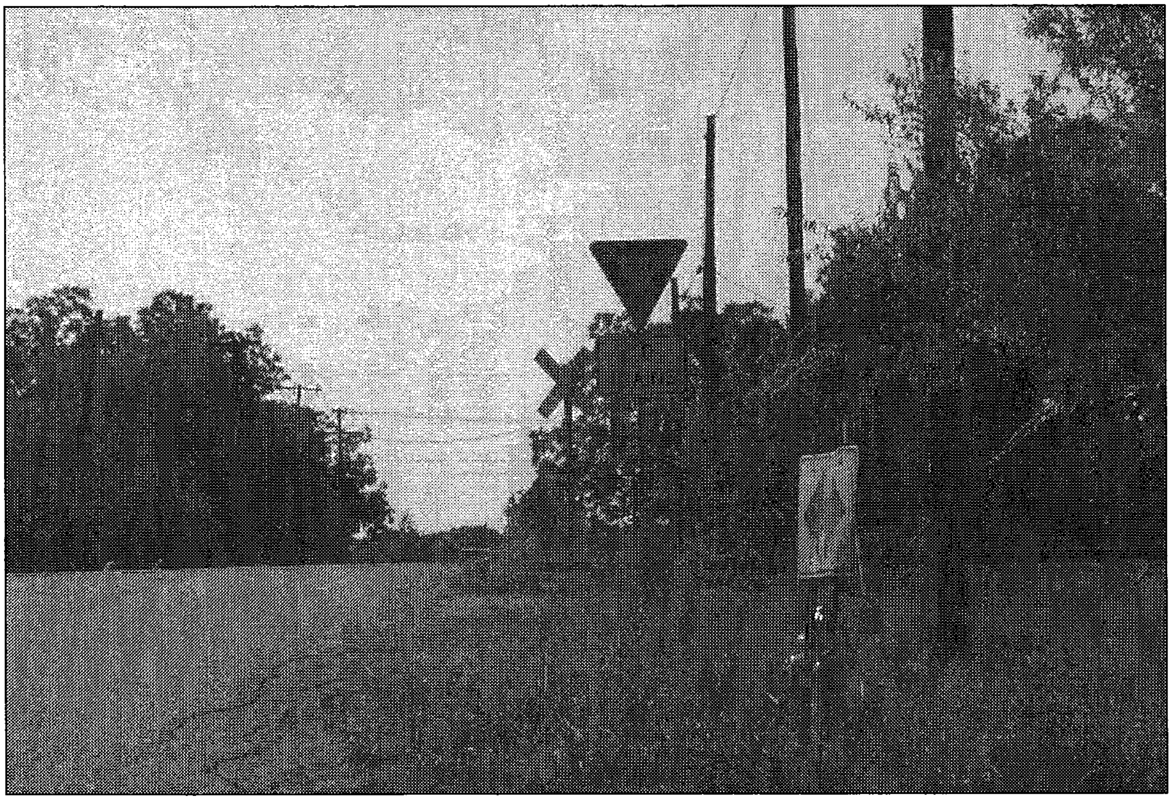


Figure 4-15. Westbound Approach on Marble Street in Wylie, Texas.

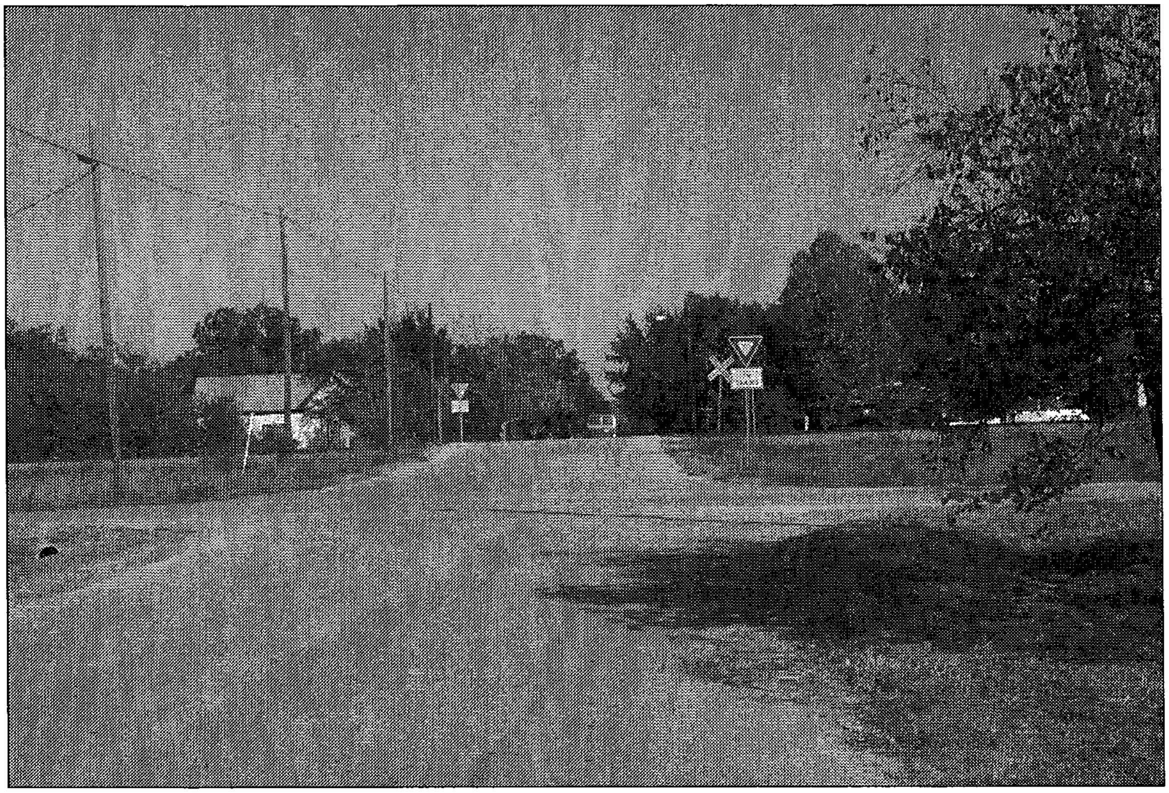


Figure 4-16. Eastbound Approach on Marble Street in Wylie, Texas.

Table 4-9. Statistical Comparison: Grade Crossing No. 022101X (Marble Street).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
East	33	15.8	18.7	2.9	2550	0.471	2.68	1.96	Yes
	164	22.4	21.8	0.6	1081	0.716	0.20	1.96	No
	262	23.2	22.5	0.7	1446	0.541	0.41	1.96	No

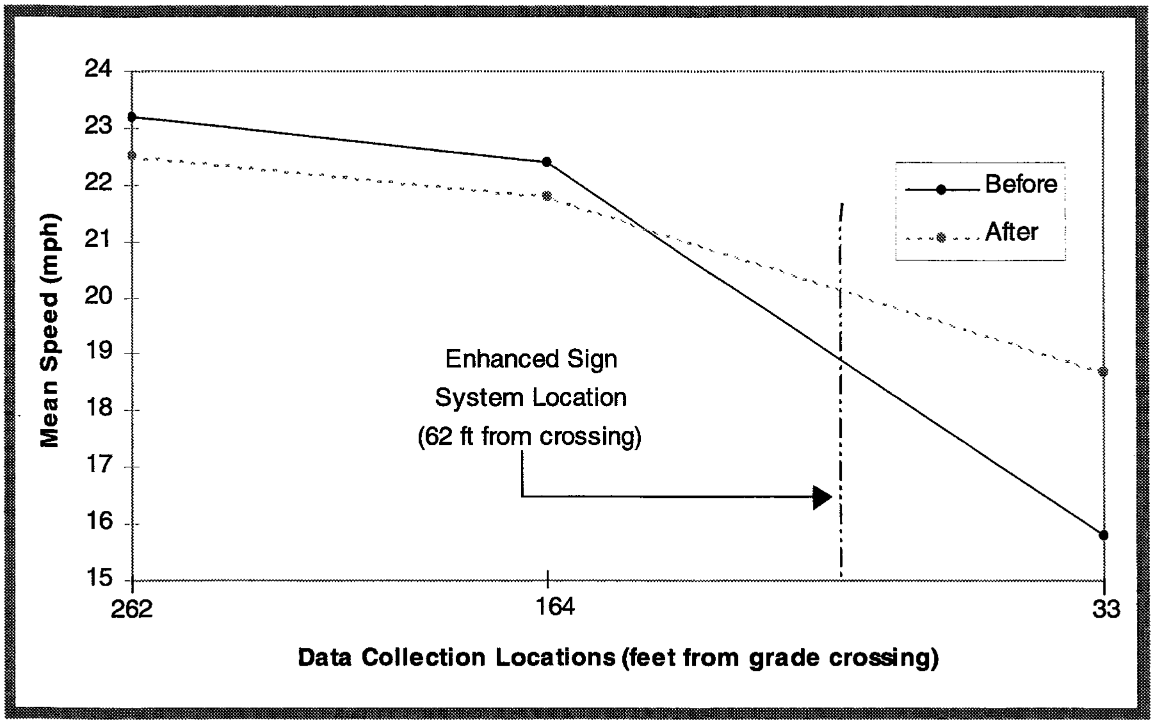


Figure 4-17. Mean Speed Comparison: Grade Crossing No. 022101X (Marble Street).

No significant speed increase or decrease was found at $\alpha = 0.05$ when comparing the before and after mean speeds at 164 and 262 feet from the grade crossing. Speeds decreased at 164 and 262 feet from the grade crossing after the installation of the YIELD TO TRAINS sign system. However, a significant speed increase of 2.9 miles per hour is found at 33 feet from the grade crossing. It is unclear from the data why the speed increased significantly near the grade crossing. Tables 4-7 and 4-8 indicate the sample sizes of the before and after studies are both greater than 1100 vehicles at 33 feet, and the before and after sample standard deviations and variances are similar. Also, no geometric changes or other signage changes occurred between the before and after studies, and no suspect driving behavior was witnessed during data collection.

Equipment failure or malfunction cannot be ruled out as a cause. Incorrect road tube spacing could have been entered into the classifier, indicating artificially high speeds. There is no apparent difference between the 85^{th} percentile speed at 164 and 262 feet. At 33 feet, a 2.9 mile per hour increase in 85^{th} percentile speed was seen between the before and after studies. This supports the statistically significant increase in mean vehicle speed found at 33 feet from the grade crossing. The data suggest that the YIELD TO TRAINS at crossing sign system appears to have an adverse effect on drivers approaching this particular grade crossing. The null hypothesis given in Equation 1 (Chapter 3) is rejected for the data collected at 33 feet from the grade crossing. However, the null hypothesis cannot be rejected for the data collected at 164 and at 262 feet.

Site 4. Crossing No. 022099Y in Collin County, Texas

Researchers selected Oak Street in Wylie, Texas, as the fourth site for installation of the YIELD TO TRAINS enhanced sign system. Oak Street is located on the west side of State Highway 78, and the grade crossing is located in a tangent section of Oak Street. As shown in Figure 4-18, the approach roadways both east and west of the grade crossing are flat and straight, and sight distance is limited on both approaches by development in the area. The vertical grade of the roadway increases slightly to meet the grade of the railroad tracks on both approaches. On the east approach, Birmingham Street crosses Oak Street at approximately 164 feet from the grade crossing. On the west approach, Keefer Street connects to Oak Street at 110 feet from the crossing, while Cottonbelt Avenue crosses Oak Street at 419 feet from the crossing. Several private drives also connect to the east and west approaches of Oak Street. Oak Street is STOP controlled at Birmingham Avenue, and the speed limit on Oak Street is 30 miles per hour.

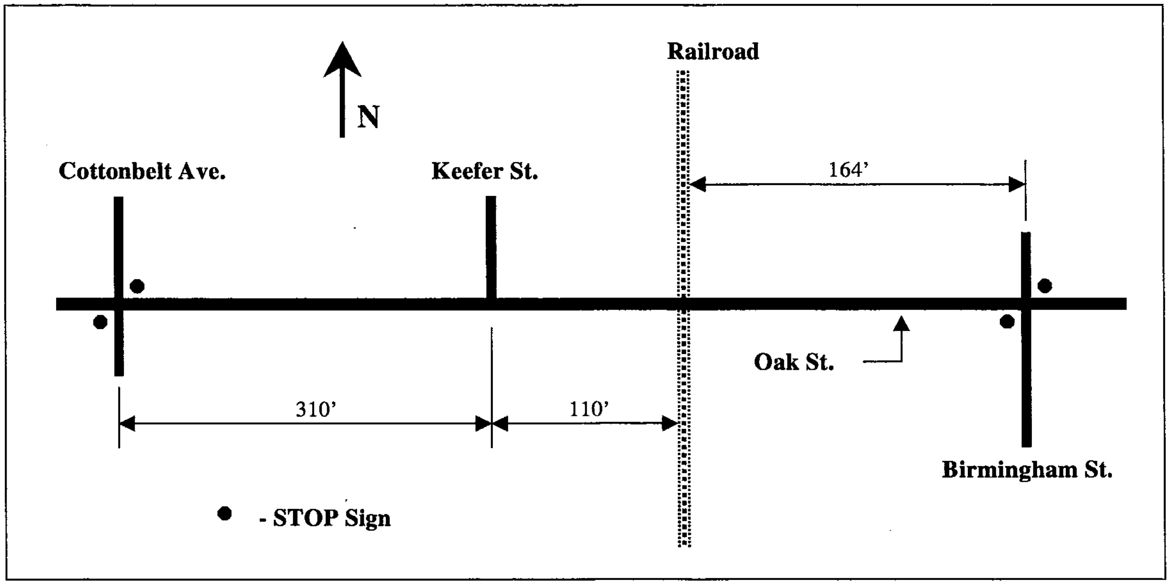


Figure 4-18. Oak Street in Wylie, Texas.

Road tubes were placed 33, 164 and 262 feet from the closest rail to collect before speed data. The proximity of the intersecting roadways to the grade crossing prohibited speed data collection on the east approach. Only three sets of road tubes were placed on the west approach due to the close proximity of the stop controlled intersections. Each distance was measured from the closest rail to the first road tube in each set. Two feet separated the two road tubes placed at

33 feet from the track, while 4 feet separated the road tubes in each set at 164 and 262 feet. The before study was conducted between July 6 and July 8, 1999. Table 4-10 summarizes the data collected during the before study. The before speed data show vehicles slowing as they approach the grade crossing, with the largest decrease, 10.6 miles per hour, occurring between 33 and 164 feet from the grade crossing.

On September 2, 1999, TxDOT personnel installed a YIELD TO TRAINS sign system on each approach of grade crossing on Oak Street. The YIELD TO TRAINS signs were placed 62 feet from the first rail of each crossing, and both signs were located outside the railroad right-of-way.

The after study was conducted from October 10 to October 12, 1999, using the same setup as used in the before study. Table 4-11 summarizes the data collected during the after study. The after data also show vehicles slowing as they approach the grade crossing, with the largest decrease in speed, 8.5 miles per hour, occurring between 33 and 164 feet. This decrease is 2 miles per hour less than that demonstrated during the before study.

Table 4-10. Before Speed Data: Grade Crossing No. 022099Y (Oak Street).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	1563	15.1	37.0	38.0	1.0	12.2	19.1	3.4	11.6
	164	1542	25.7	66.0	67.0	1.0	19.7	31.0	9.0	81.3
	262	1334	22.5	33.0	37.0	4.0	19.3	26.8	4.0	16.0

Table 4-11. After Speed Data: Grade Crossing No. 022099Y (Oak Street).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	1607	14.9	29.0	30.0	1.0	11.7	19.3	3.7	13.8
	164	1630	23.4	34.0	40.0	6.0	19.9	27.8	4.2	17.5
	262	1482	23.0	38.0	40.0	2.0	19.7	27.5	4.2	17.7

Figure 4-19 is a diagram of the before and after sensor locations and YIELD TO TRAINS sign locations for the grade crossing on Oak Street. Figures 4-20 and 4-21 illustrate the eastbound and westbound approaches of the grade crossing.

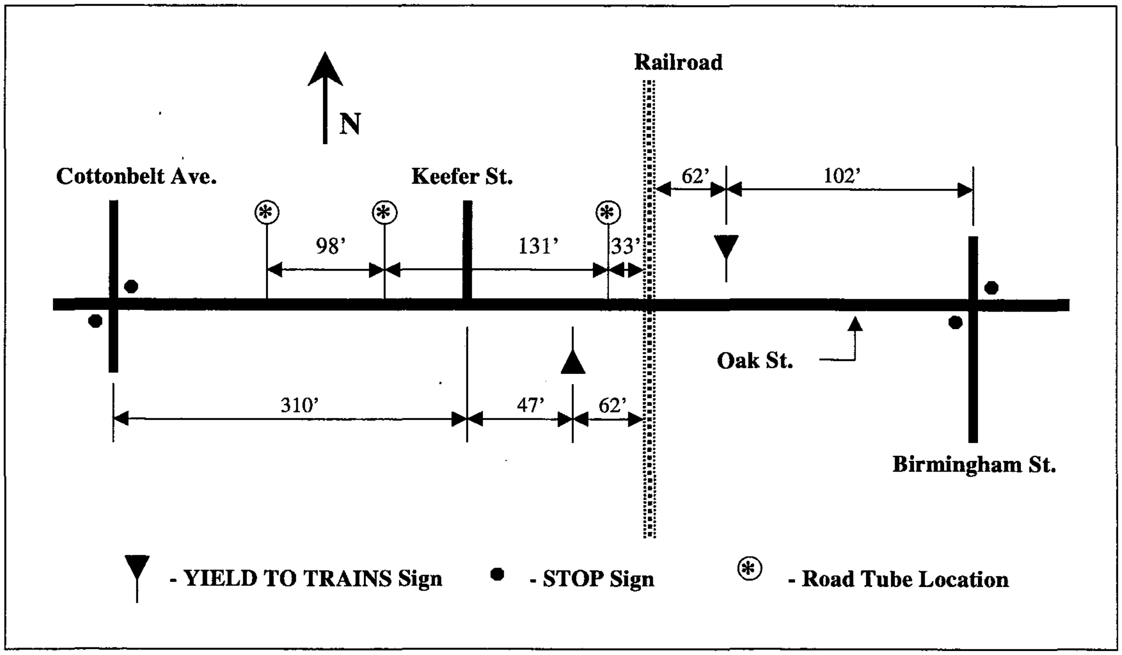


Figure 4-19. Installation Diagram for Oak Street in Wylie, Texas.

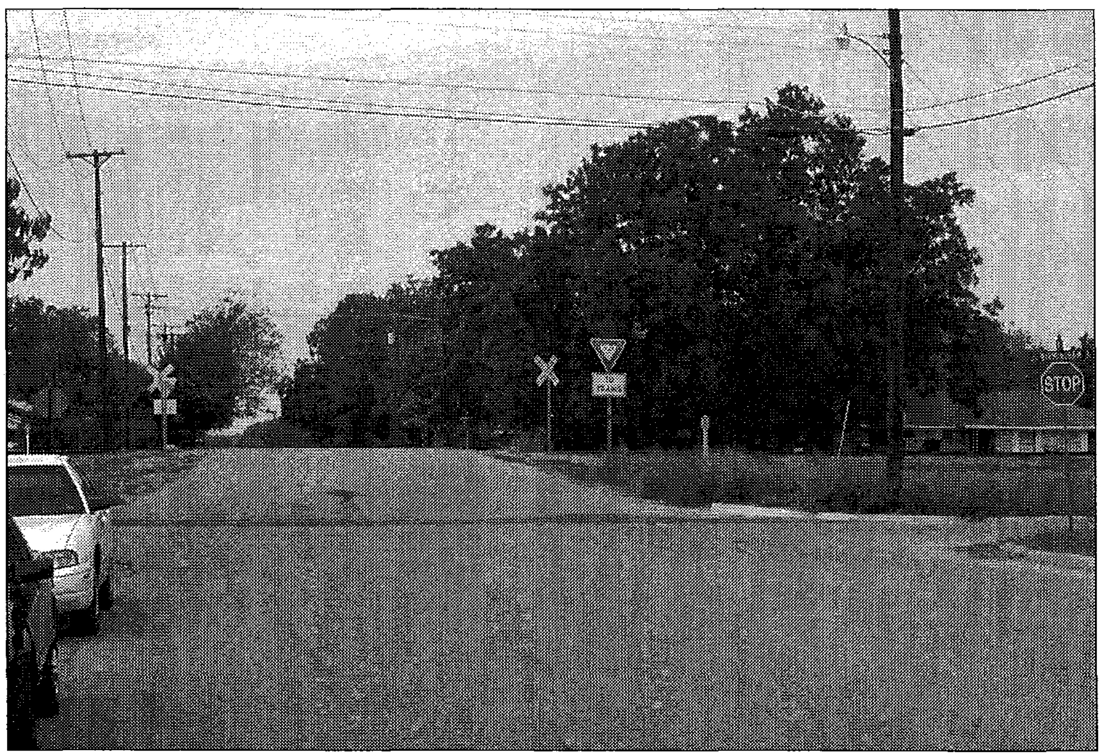


Figure 4-20. Westbound Approach on Oak Street in Wylie, Texas.

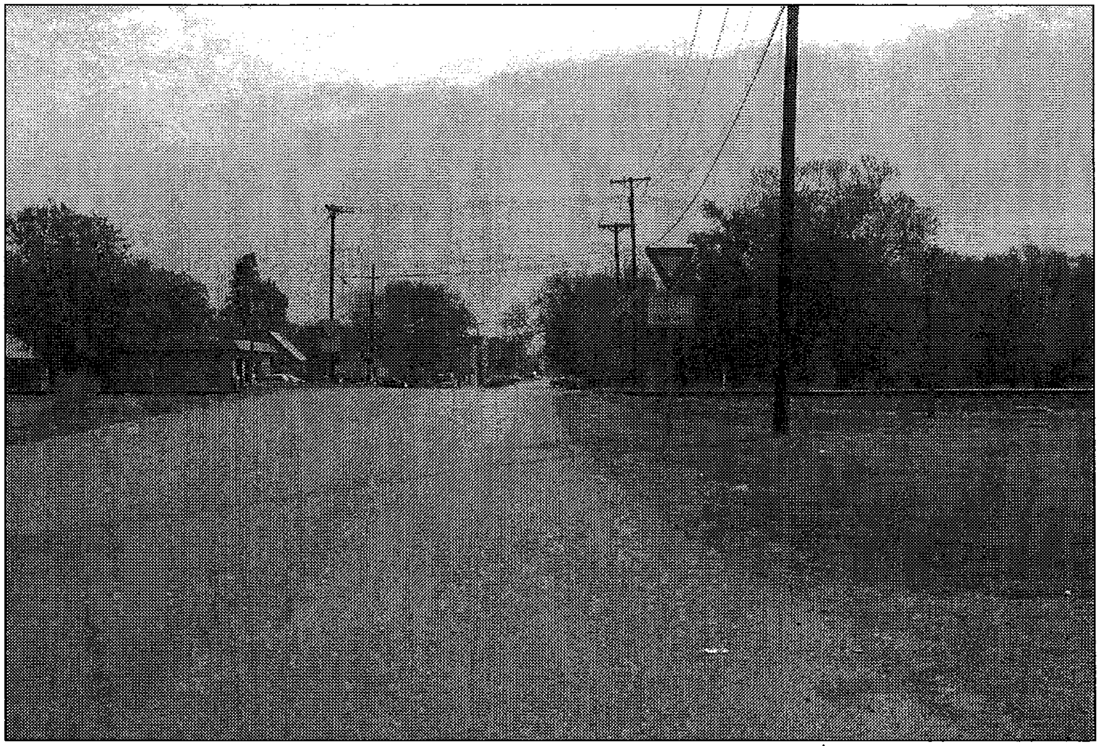


Figure 4-21. Eastbound Approach on Oak Street in Wylie, Texas.

The before and after speed data for grade crossing 022099Y on Oak Street were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 4-12 presents the results of the two-sample t-test, and Figure 4-22 presents a graphical representation of the before and after mean speeds along the study approach. Linear interpolation was used to approximate before and after mean speeds between data collection locations. The vertical line at 62 feet on Figure 4-22 represents the location of the enhanced sign system during the after study.

Table 4-12. Statistical Comparison: Grade Crossing No. 022099Y (Oak Street).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
East	33	15.1	14.9	0.2	3103	0.421	0.44	1.96	NO
	164	25.7	23.4	2.3	1676	0.958	1.09	1.96	NO
	262	22.5	23.0	0.5	2813	0.476	0.79	1.96	NO

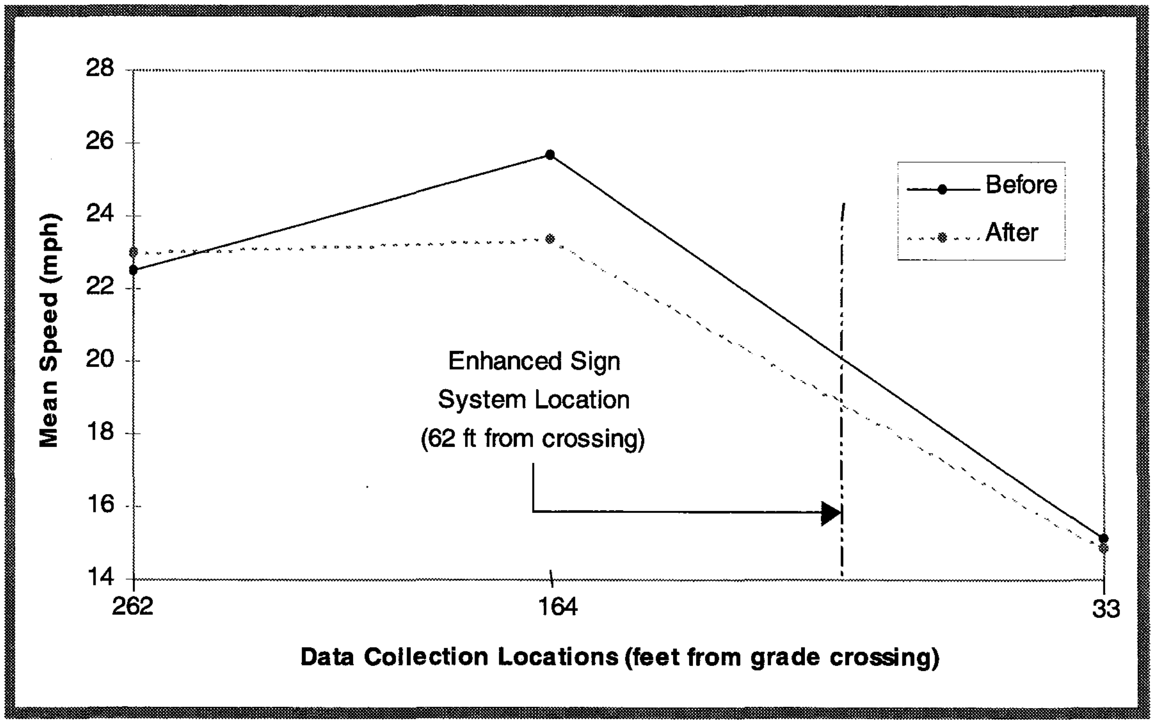


Figure 4-22. Mean Speed Comparison: Grade Crossing No. 022099Y (Oak Street).

No significant speed increase or decrease was found at $\alpha = 0.05$ when comparing the before and after mean speeds at 33, 164, and 262 feet from the grade crossing. Mean speed decreased at 33 and 164 feet from the grade crossing, while mean speed increased at 262 feet after the installation of the YIELD TO TRAINS sign system. The largest difference in mean speed, a 2.3 mile per hour decrease, occurred 164 feet from the grade crossing.

The YIELD TO TRAINS at crossing sign system had no statistically significant effect on drivers approaching the grade crossing. There is not enough evidence to reject the null hypothesis, given in Equation 1 (Chapter 3), at any of the data collection locations. However, researchers assumed that an effective sign system would cause a reduction in speed near the enhanced sign system location with no significant speed change on the rest of the approach. The data collected at this location exhibit this trend, but the speed decrease near the sign system is not statistically significant. It was, however, substantially larger than the differences observed at the other two data collection locations.

Grade crossing 022101X (Marble Street) and 022099Y (Oak Street) are located on virtually identical parallel streets that are approximately 300 feet apart. It is unclear why crossing 022101X would have a statistically significant mean speed increase at 33 feet and crossing 022099Y would have a non-significant mean speed decrease at 33 feet. The before and after speed studies at each location were conducted simultaneously, and researchers assumed that mean speeds would be similar at each location. No obvious difference in driver behavior was witnessed during the data collection efforts at each location.

CHAPTER 5

LOOK FOR TRAINS ENHANCED SIGN SYSTEM WITH FLASHING STROBES

INTRODUCTION

The first two sites for the LOOK FOR TRAIN AT CROSSING enhanced sign systems used flashing strobe lights with the LOOK FOR TRAIN AT CROSSING supplemental sign. The designed sign dimensions for the supplemental sign are shown in Figure 5-1. Other equipment used in the enhanced sign systems included a solar panel and infrared detector as described in Chapter 2.

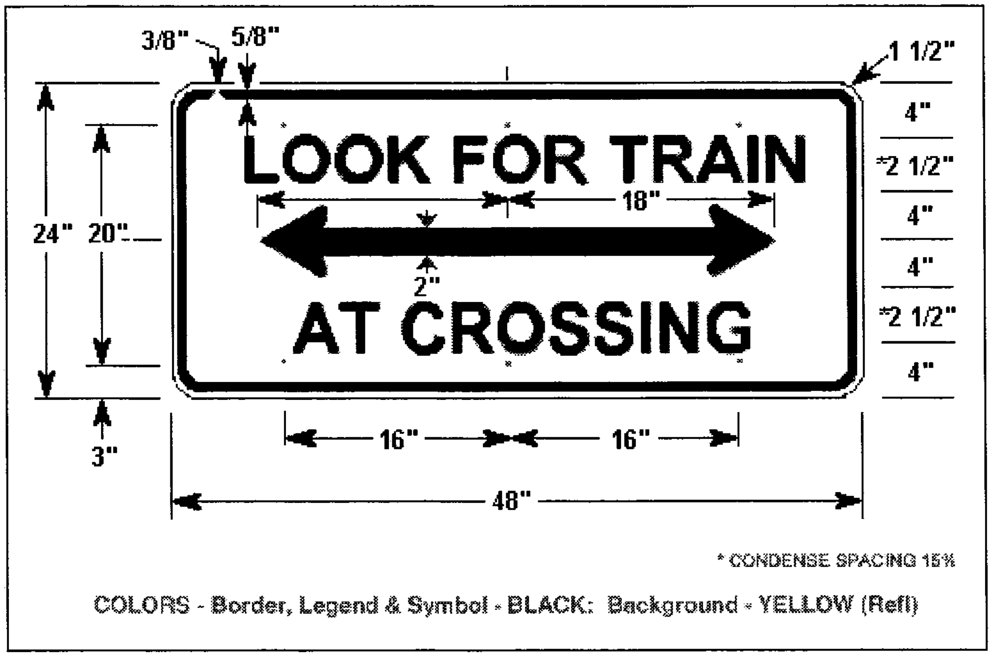


Figure 5-1. LOOK FOR TRAIN AT CROSSING Supplemental Sign Dimensions.

Data Collection Set-up for LOOK FOR TRAIN AT CROSSING Sign System

The location of the railroad advance warning sign (W10-1) was determined by *MUTCD* requirements based on the posted speed or assumed speed of the roadway. The LOOK FOR TRAIN AT CROSSING sign contained 3.94-inch letters and was designed using the 48-inch sign dimensions in Figure 5-1. A ratio of legibility distance to letter height of 7:1 was used assuming 20/20 Snellen vision. This ratio resulted in the equivalent of 226 feet of legibility distance. Drivers with less than 20/20 Snellen vision require shorter legibility distances. However, they would only benefit from the additional observation time provided. Since the LOOK FOR TRAIN AT CROSSING sign system had an unfamiliar flashing strobe, a five-second perception-reaction time was assumed. Another three seconds was allocated for the driver to observe and focus attention on the railroad advance warning sign and LOOK FOR TRAIN AT CROSSING supplemental sign. This provided a travel time of eight seconds from the point at which the vehicle was detected with a long-range passive infrared detector until it arrived at the enhanced sign system. Figure 5-2 illustrates the relevant distances related to the LOOK FOR TRAIN AT CROSSING sign system.

The information in Figure 5-2 was used to create a generic data collection layout for LOOK FOR TRAIN AT CROSSING sign system locations that could be customized to the posted speed of the roadway. As stated previously, the sensors closest to the track and the control sensors furthest from the track remained at 33 and 1312 feet, respectively. However, the remaining three locations varied depending upon the posted speed of the roadway. Each of the remaining three sensor locations was equidistant from the closest downstream sensor. Figure 5-3 illustrates the data collection setup to be used with Figure 5-2 to calculate the required distances for the posted speed of the roadway. It should be noted that researchers altered these distances by as much as 200 feet at certain locations to account for roadway geometry and existing obstacles.

Note that the supplemental LOOK FOR TRAIN AT CROSSING supplemental signs fabricated and delivered by TxDOT were 36 inches wide rather than 48 inches wide. Time didn't allow for additional signs to be fabricated; therefore, the 36-inch wide signs were used. It is unknown what effect this change had on the data.

Posted Speed (mph)	Speed (fps)	Dist. Travel in 8 sec	X (ft)	Y (ft)	Z (ft)	X+Y (ft)	Z+X+Y (ft)
25	37	293	67	226	250	293	543
30	44	352	126	226	325	352	677
35	51	411	185	226	400	411	811
40	59	469	243	226	475	469	944
45	66	528	302	226	550	528	1078
50	73	587	361	226	625	587	1212
55	81	645	419	226	700	645	1345
60	88	704	478	226	775	704	1479
65	95	763	537	226	850	763	1613

Letter height to legibility distance (20/20 vision) = 57.3 ft/in

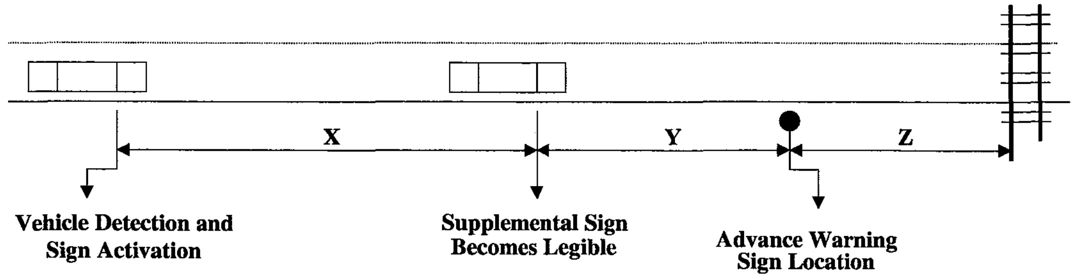


Figure 5-2. LOOK FOR TRAIN AT CROSSING Experimental Setup.

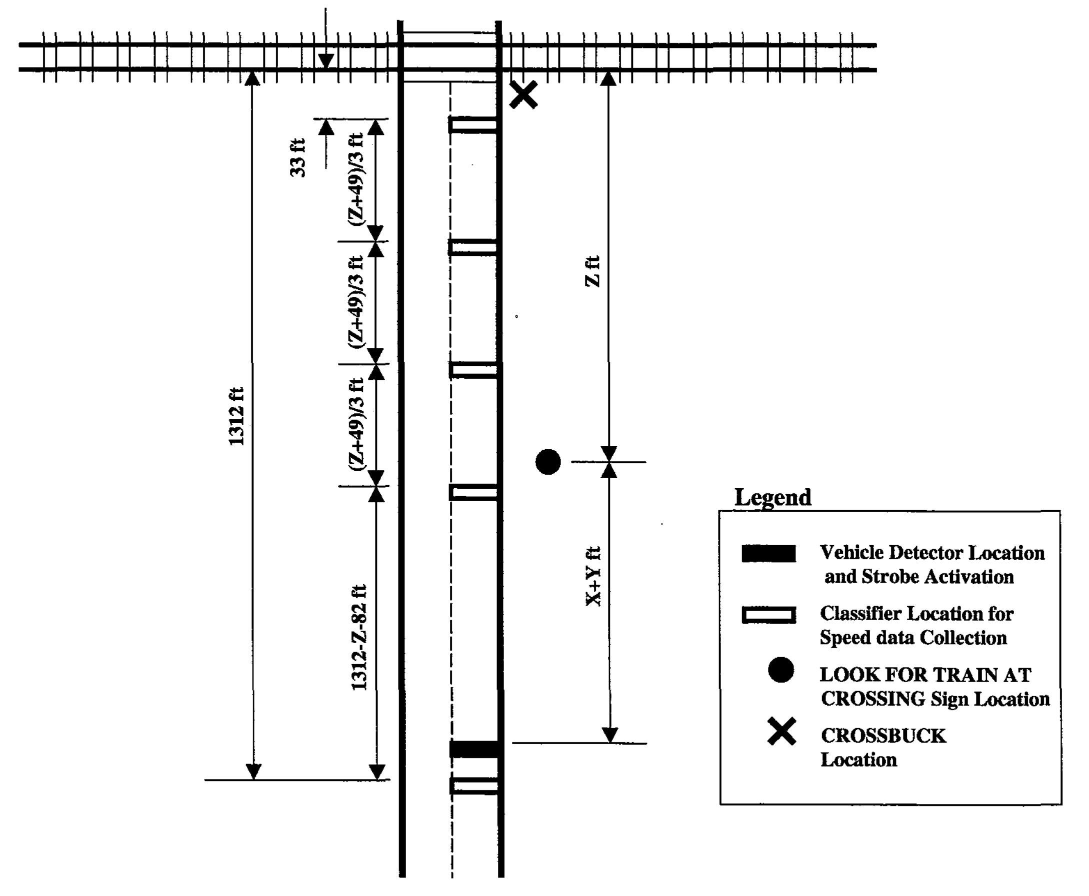


Figure 5-3. LOOK FOR TRAIN AT CROSSING Data Collection Layout.

STUDY SITES

As listed in Table 2-2 of Chapter 2, two sites were selected for the LOOK FOR TRAIN AT CROSSING enhanced sign system with *flashing strobes*. The project sites, data collection, and data analysis are included for each site.

Site 5. Grade Crossing No. 022116M in Collin County, Texas

This crossing on the Business Loop of State Highway 78 is south of Copeville, Texas. As shown in Figure 5-4, the grade crossing is located between two horizontal curves that form an S-curve roadway alignment. The approach roadway west of the horizontal curves is relatively flat and straight and has limited sight distance due to trees along the right-of-way. The approach roadway east of the horizontal curves is flat and relatively straight; it also has limited sight distance. The vertical grade of the roadway increases slightly to meet the grade of the railroad tracks near the grade crossing on both approaches. On the east approach, CR 545 connects with Business 78 at approximately 35 feet from the grade crossing. Several private drives also connect to the east and west approaches of Business 78. The posted speed limit for Business 78 is 55 miles per hour.

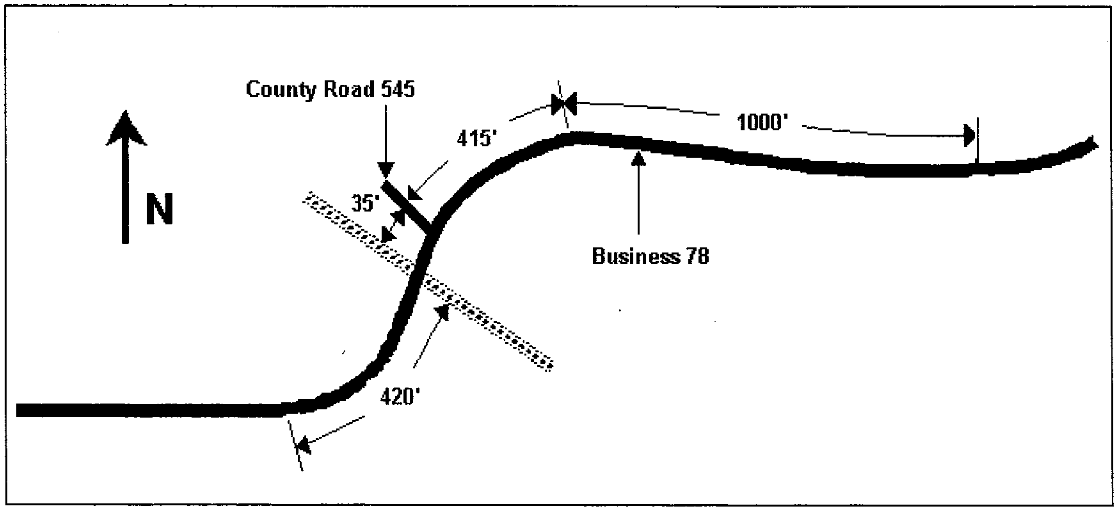


Figure 5-4. Business 78 in Collin County, Texas.

Researchers placed sensors on the north approach at 33, 207, 381, 758, and 1312 feet and on the south approach at 30, 266, 417, 554, and 1312 feet from the grade crossing to collect before data. Each distance was measured from the closest rail to the first sensor in each set.

Four feet separated the two sensors in each set. The before study was conducted between June 18 and June 21, 1999, for the north approach and between June 22 and June 28, 1999, for the south approach. Tables 5-1 and 5-2 summarize the data collected during the before study. The data show that vehicles slowed as they approached the grade crossing on the north and south approaches. Overall, speeds were higher on the north approach than the south approach. The largest decrease on the north approach in mean vehicle speed, 15.9 miles per hour, occurred between 33 and 207 feet from the grade crossing. The largest decrease on the south approach in mean vehicle speed, 9.2 miles per hour, occurred between 30 and 266 feet from the grade crossing.

On September 24, 1999, TxDOT personnel installed a LOOK FOR TRAIN AT CROSSING enhanced sign system with flashing strobes on each approach of the crossing. The LOOK FOR TRAIN AT CROSSING sign system was placed 776 feet from the first rail of the crossing on the north approach to avoid locating the sign in the horizontal curve. The LOOK FOR TRAIN AT CROSSING sign system on the south approach was placed 745 feet from the first rail of the crossing. The sign system on the south approach was placed closer to the grade crossing than the sign system on the north approach to avoid placing the system near a private driveway.

The after study was conducted from October 25 to October 28, 1999, for the north approach and from November 15 to November 18,1999, for the south approach. The same setup was used as in the before study. Tables 5-3 and 5-4 summarize the data collected during the after study. The after data also show vehicles slowing as they approach the grade crossing on each approach. Overall, speeds were higher on the north approach than the south approach. The largest decrease in speed on the north approach, 14.4 miles per hour, occurred between 33 and 207 feet from the grade crossing, a decrease similar to that recorded in the before study. The largest decrease in speed on the south approach, 9.9 miles per hour, occurred between 30 and 266 feet from the grade crossing. This decrease is also similar to that recorded in the before study for the same segment of roadway.

Table 5-1. Before Speed Data: North Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
North	33	920	17.8	39.0	44.0	5.0	12.1	24.8	6.3	40.1
	207	892	33.7	31.0	48.0	17.0	29.7	39.3	4.8	22.6
	381	839	40.9	47.0	58.0	11.0	36.1	47.3	5.6	31.6
	758	919	48.2	56.0	73.0	17.0	42.3	55.5	7.0	49.3
	1312	954	50.2	86.0	89.0	3.0	43.3	59.8	10.6	111.4

Table 5-2. Before Speed Data: South Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	30	803	18.6	42.0	45.0	3.0	10.0	28.6	8.2	67.8
	266	701	27.8	56.0	63.0	7.0	24.3	32.7	4.9	23.6
	417	738	34.7	46.0	52.0	6.0	29.7	40.7	6.3	39.2
	554	486	40.0	68.0	69.0	1.0	34.2	47.5	8.2	67.7
	1312	753	42.6	55.0	69.0	14.0	34.6	52.2	8.8	77.0

Table 5-3. After Speed Data: North Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
North	33	792	19.0	45.0	47.0	2.0	12.0	27.2	7.6	57.2
	207	759	33.4	54.0	60.0	6.0	29.2	39.3	5.3	28.3
	381	780	39.9	41.0	57.0	16.0	35.2	46.3	6.1	37.6
	758	802	46.3	57.0	68.0	11.0	39.9	54.7	9.0	80.7
	1312	834	47.7	76.0	80.0	4.0	39.1	57.7	11.1	124.0

Table 5-4. After Speed Data: South Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	30	657	18.4	45.0	47.0	2.0	9.3	30.0	9.5	90.2
	266	491	28.3	57.0	63.0	6.0	24.3	34.1	5.8	33.1
	417	533	34.3	49.0	53.0	4.0	27.8	41.4	7.9	61.9
	554	529	38.9	54.0	64.0	10.0	30.8	47.2	8.9	78.3
	1312	515	41.2	66.0	73.0	7.0	32.4	51.8	10.9	119.0

Figure 5-5 is a diagram of the before and after sensor locations and LOOK FOR TRAIN AT CROSSING sign locations on the Business Loop of State Highway 78. Figures 5-6 and 5-7 illustrate the northbound and southbound approaches of the grade crossing on Business 78.

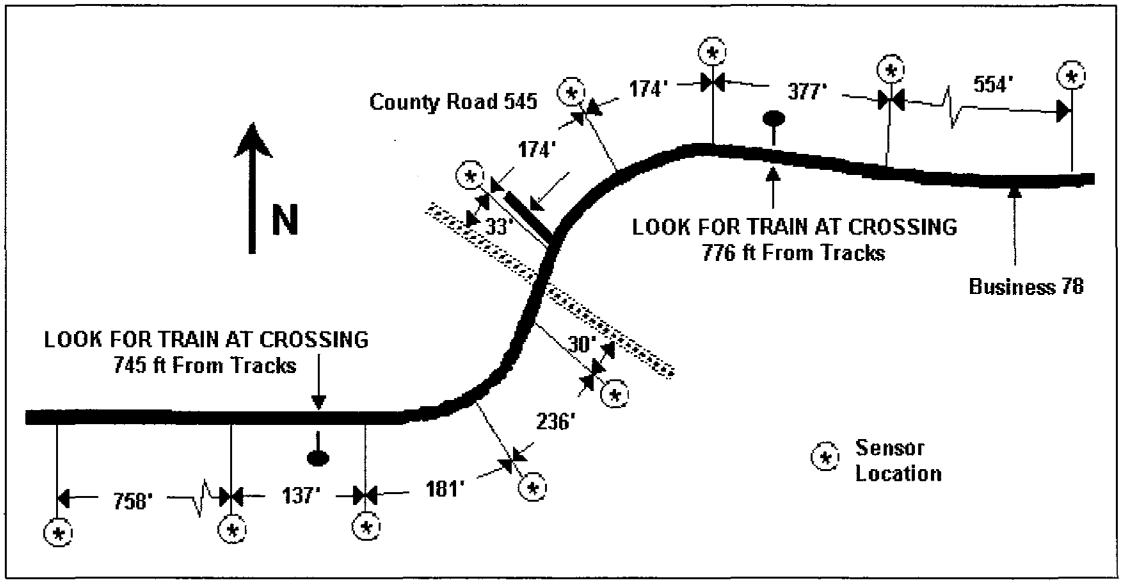


Figure 5-5. Installation Diagram for Business 78.

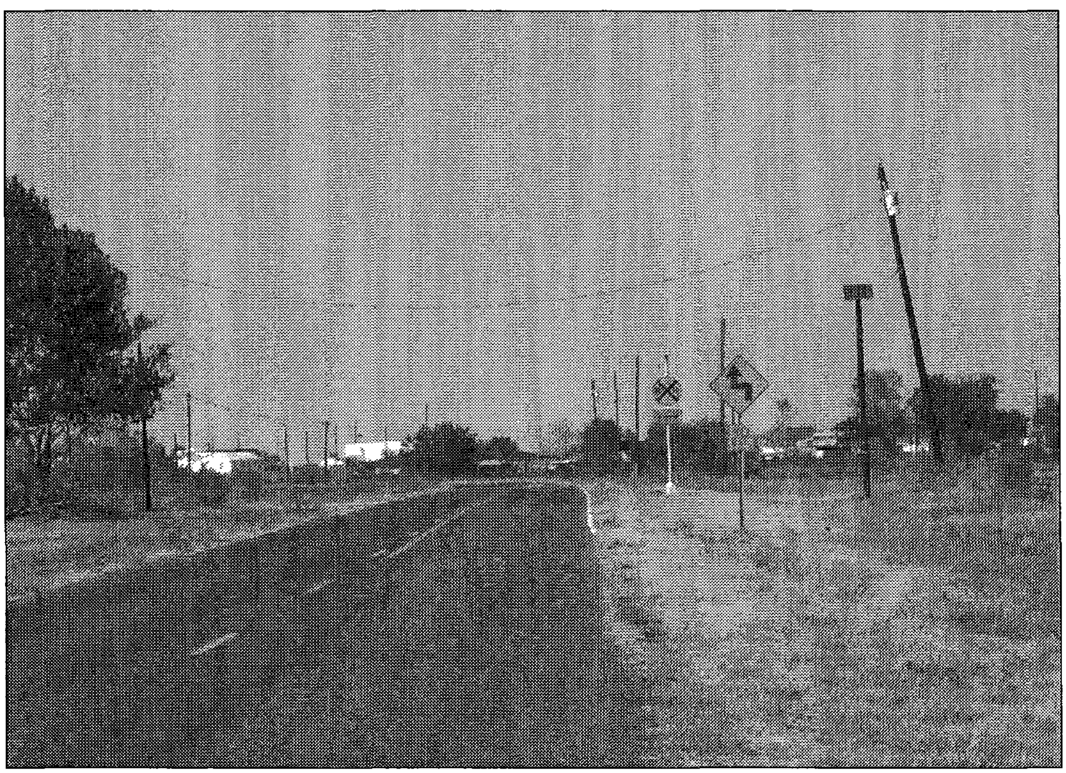


Figure 5-6. Northbound Approach on Business 78.

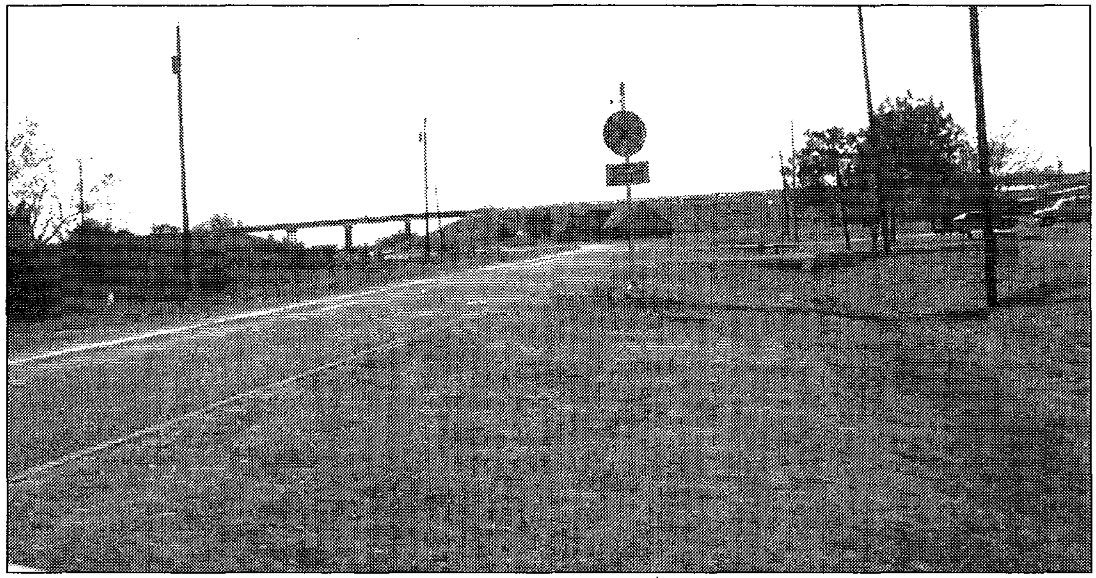


Figure 5-7. Southbound Approach on Business 78.

Researchers compared before and after speed data for the north approach of grade crossing 022116M on Business 78 using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 5-5 presents the results of the two-sample t-test for the north approach, and Figure 5-8 is a graphical representation of the before and after mean speeds along the north approach. Linear interpolation was used to approximate before and after mean speeds between data collection points. The vertical line at 776 feet on Figure 5-5 represents the location of the enhanced sign system during the after study.

Table 5-5. Statistical Comparison: North Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Mean Speed (mph)							Significant
		Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	at $\alpha = 0.05$
North	33	17.8	19.0	1.2	1388	0.297	0.49	1.96	NO
	207	33.7	33.4	0.3	1442	0.352	0.24	1.96	NO
	381	40.9	39.9	1.0	1526	0.396	0.58	1.96	NO
	758	48.2	46.3	1.9	1288	0.246	0.58	1.96	NO
	1312	50.2	47.7	2.5	1688	0.414	0.45	1.96	NO

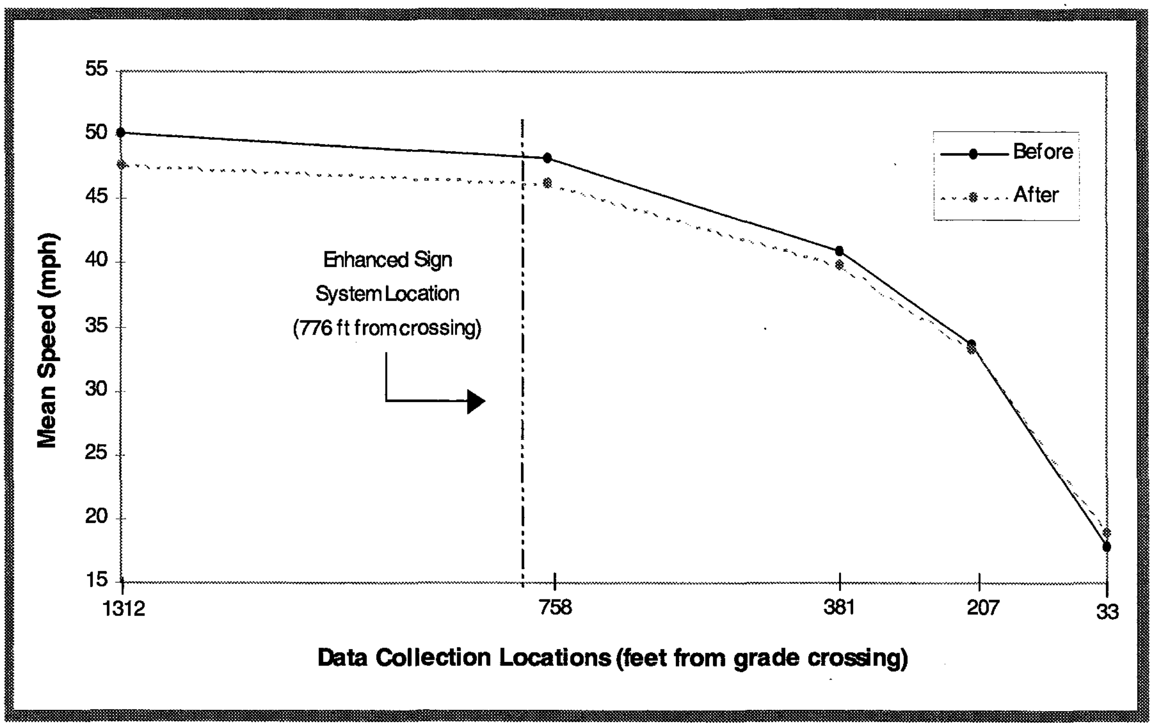


Figure 5-8. Mean Speed Comparison: North Approach to Grade Crossing No. 022116M (Business 78).

Researchers found no significant speed increase or decrease at $\alpha = 0.05$ when comparing the before and after mean speeds at each data collection location on the north approach. Mean speeds were slightly lower at the 207-, 381-, 758- and 1312-feet data collection locations after the enhanced sign system was placed in the field. However, at 33 feet from the crossing the mean speed increased 1.2 miles per hour after the installation of the enhanced sign system. The largest difference in before and after mean speeds, a 2.5 mile per hour decrease, came at the control location 1312 feet from the grade crossing. The second largest difference in before and after mean speeds, a 1.9 mile per hour decrease, came at 758 feet from the grade crossing. The 85th percentile speed was slightly lower after the installation of the enhanced sign system at 381, 758, and 1312 feet. There was virtually no difference between 85th percentile speeds at the data collection location 207 feet from the crossing. A 3.8 mile per hour increase in the 85th percentile speed was seen between the before and after studies at 33 feet. The two-sample t-test does not provide enough evidence to reject the null hypothesis outlined in Equation 1 (Chapter 3). The decreases and increase in mean speed were not statistically significant.

The before and after speed data for the south approach of grade crossing 022116M on Business 78 were also compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 5-6 presents the results of the two-sample t-test for the south approach, and Figure 5-9 presents a graphical representation of the before and after mean speeds along the south approach. Linear interpolation was used to approximate before and after mean speeds between data collection points. The vertical line at 745 feet on Figure 5-6 represents the location of the enhanced sign system during the after study.

Table 5-6. Statistical Comparison: South Approach to Grade Crossing No. 022116M (Business 78).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
South	30	18.6	18.4	0.2	1193	0.32	0.05	1.96	NO
	266	27.8	28.3	0.5	827	0.26	0.29	1.96	NO
	417	34.7	34.3	0.4	834	0.22	0.13	1.96	NO
	554	40.0	38.9	1.1	1009	0.45	0.24	1.96	NO
	1312	42.6	41.2	1.4	805	0.22	0.24	1.96	NO

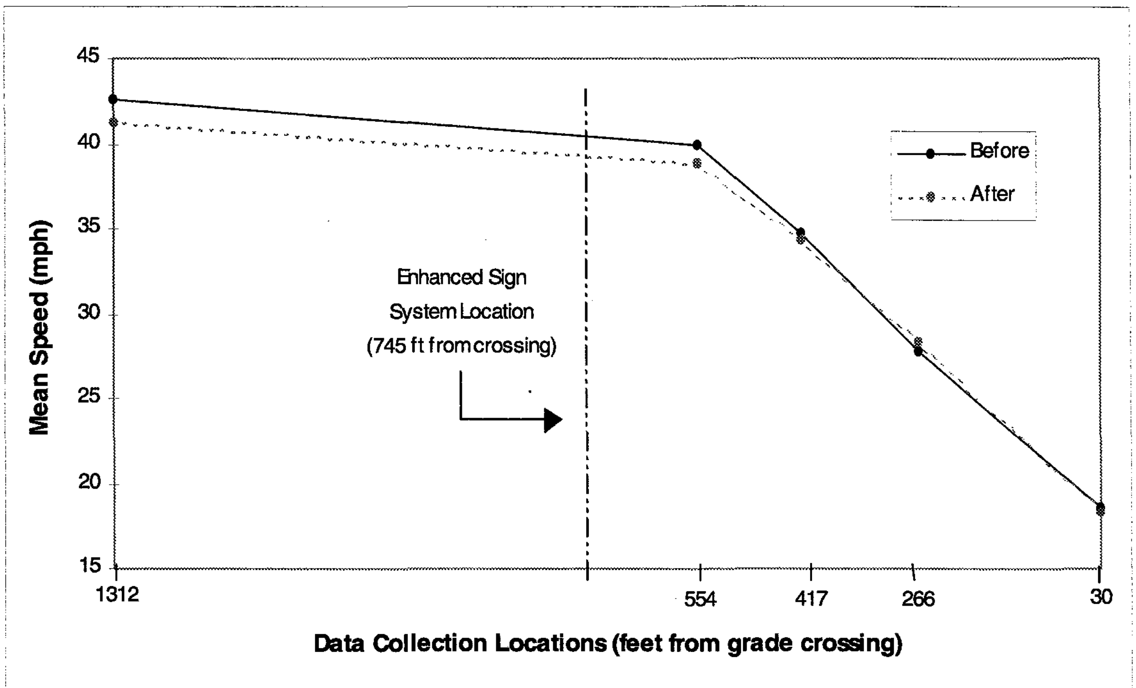


Figure 5-9. Mean Speed Comparison: South Approach to Grade Crossing No. 022116M (Business 78).

No significant speed increase or decrease was found at $\alpha = 0.05$ when comparing the before and after mean speeds at each data collection location on the north approach. Mean speeds were slightly lower at the 30, 417, 554, and 1312 feet data collection locations after the enhanced sign system was placed in the field. However, at 266 feet from the crossing, the mean speed increased 0.5 miles per hour after the installation of the enhanced sign system. The largest difference in before and after mean speeds, a 1.4 mile per hour decrease, came at the control location 1312 feet from the grade crossing. The second largest difference in before and after mean speeds, a 1.1-mile per hour decrease, came at 554 feet from the grade crossing. The 85th percentile speed was slightly lower after the installation of the enhanced sign system at the 554 and 1312 feet data collection locations. The 85th percentile speed was slightly higher after the installation of the enhanced sign system at 30, 266, and 417 feet.

The decreases and increase in mean speed were not statistically significant, using a two-tailed t-test. As with the north approach, the decrease in speed near the sign system cannot be conclusively attributed to the installation of the LOOK FOR TRAIN AT CROSSING sign system with flashing strobes.

Site 6. Grade Crossing No. 022113S in Collin County, Texas

This site on County Road 489 southwest of Copeville, Texas was selected as the second installation site for the LOOK FOR TRAIN AT CROSSING enhanced sign systems with flashing strobes. As shown in Figure 5-10, the grade crossing is located in a long tangent section between two S-curves. The west approach east of the horizontal curves is straight and slopes upward towards the grade crossing. Trees and vegetation along the right-of-way limit the sight distance on the west approach. The east approach west of the horizontal curves is flat and straight and has limited sight distance due to vegetation along the railroad tracks. Several private drives connect to the east and west approaches of CR 489. The posted speed limit for CR 489 is 40 miles per hour.

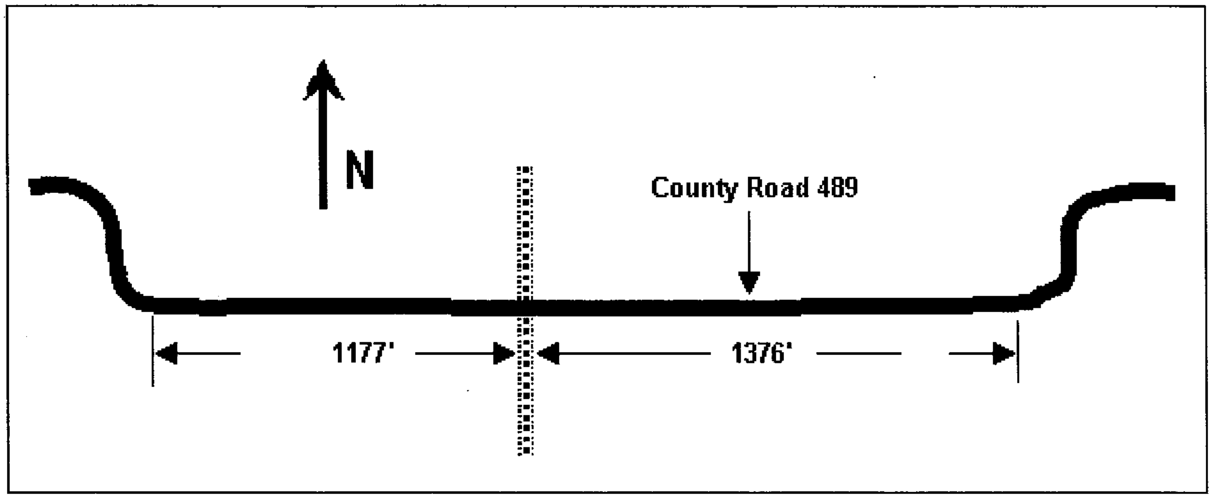


Figure 5-10. County Road 489 in Collin County, Texas.

Sensors were placed on the west approach at 33, 171, 380, 555, and 1312 feet and on the east approach at 33, 207, 380, 555, and 1312 feet to conduct the before speed studies. Each distance was measured from the closest rail to the first sensor in each set. Four feet separated the two sensors in each set. The before study was conducted between June 15 and June 17, 1999, for the east approach and between June 29 and July 2, 1999, for the west approach. Tables 5-7 and 5-8 summarize the data collected during the before study. The data show that vehicles began slowing after they were 380 feet from the grade crossing on the east approach. The largest mean speed decrease on the east approach, 16.1 miles per hour, occurred between 33 and 207 feet from the crossing. On the west approach, a decrease in speed was seen as vehicles passed through the horizontal curves between the fourth and fifth set of sensors. An increase in mean vehicle speed was seen between the third and fourth sensors as vehicles exiting the horizontal curve accelerated. The largest mean speed decrease on the west approach, 12.5 miles per hour, occurred between 33 and 171 feet from the grade crossing.

On September 24, 1999, TxDOT personnel installed a LOOK FOR TRAIN AT CROSSING sign system with a flashing strobe on each approach of the grade crossing. The LOOK FOR TRAIN AT CROSSING sign system was placed 618 feet from the first rail of the crossing on the east approach and at 500 feet from the first rail of the crossing on the west approach (in order to avoid locating the sign in the horizontal curve).

The after study was conducted from November 1 to November 4, 1999, on the east approach and from November 11 to November 14, 1999, on the west approach. The setup was the same setup used in the before study. Tables 5-9 and 5-10 summarize the data collected in the after study. The after data again shows that vehicles on the east approach don't begin to slow substantially until they are 380 feet from the grade crossing. The largest mean speed decrease on the east approach, 16.5 miles per hour, occurred between 33 and 207 feet from the crossing, a decrease similar to that recorded during the before study. On the west approach, a decrease in speed was seen as vehicles passed through the horizontal curves between the fourth and fifth set of sensors. An increase in mean vehicle speed was seen between the third and fourth sensors as vehicles exiting the horizontal curve accelerated. The largest mean speed decrease on the west approach, 13 miles per hour, occurred between 33 and 171 feet from the grade crossing. Again, this speed decrease is virtually identical to that in the before study.

Table 5-7. Before Speed Data: East Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	564	17.3	42.0	47.0	5.0	11.3	25.0	7.1	50.0
	207	599	33.4	46.0	52.0	6.0	28.0	39.7	6.0	35.8
	380	590	39.1	46.0	61.0	15.0	32.7	46.5	7.0	48.4
	555	594	40.4	52.0	64.0	12.0	34.2	48.0	7.5	56.0
	1312	606	40.2	55.0	66.0	11.0	34.5	47.1	6.7	45.0

Table 5-8. Before Speed Data: West Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
West	33	790	17.5	44.0	48.0	4.0	11.7	24.5	6.9	48.1
	171	767	30.0	49.0	57.0	8.0	25.1	35.6	5.7	32.4
	380	834	32.8	50.0	62.0	12.0	28.0	39.0	5.3	28.4
	555	860	29.5	33.0	49.0	16.0	25.7	34.4	4.2	17.8
	1312	780	37.0	62.0	69.0	7.0	32.0	43.3	6.1	37.3

Table 5-9. After Speed Data: East Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
East	33	596	17.3	52.0	54.0	2.0	11.9	23.9	6.6	44.0
	207	701	33.8	45.0	55.0	10.0	28.9	40.2	6.0	35.9
	380	404	38.6	48.0	57.0	9.0	32.9	45.9	6.7	44.5
	555	743	39.4	59.0	63.0	4.0	33.9	47.1	7.0	48.3
	1312	772	41.6	54.0	62.0	8.0	36.0	48.0	6.5	42.4

Table 5-10. After Speed Data: West Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
West	33	808	16.1	61.0	65.0	4.0	11.2	21.8	6.3	39.9
	171	792	29.1	38.0	47.0	9.0	24.3	35.1	5.6	31.8
	380	837	31.9	42.0	52.0	10.0	26.6	37.8	5.7	32.8
	555	857	28.7	37.0	49.0	12.0	24.9	33.5	4.4	19.7
	1312	638	36.1	57.0	61.0	4.0	30.8	42.9	6.5	42.2

Figure 5-11 is diagram of the before and after sensor locations and LOOK FOR TRAIN AT CROSSING sign locations. Figure 5-12 illustrates the eastbound approach of CR 489.

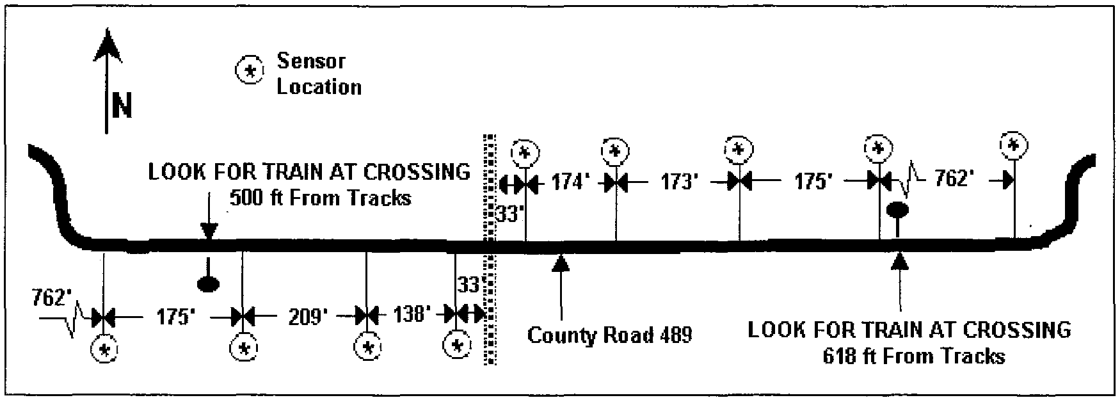


Figure 5-11. Installation Diagram for County Road 489.

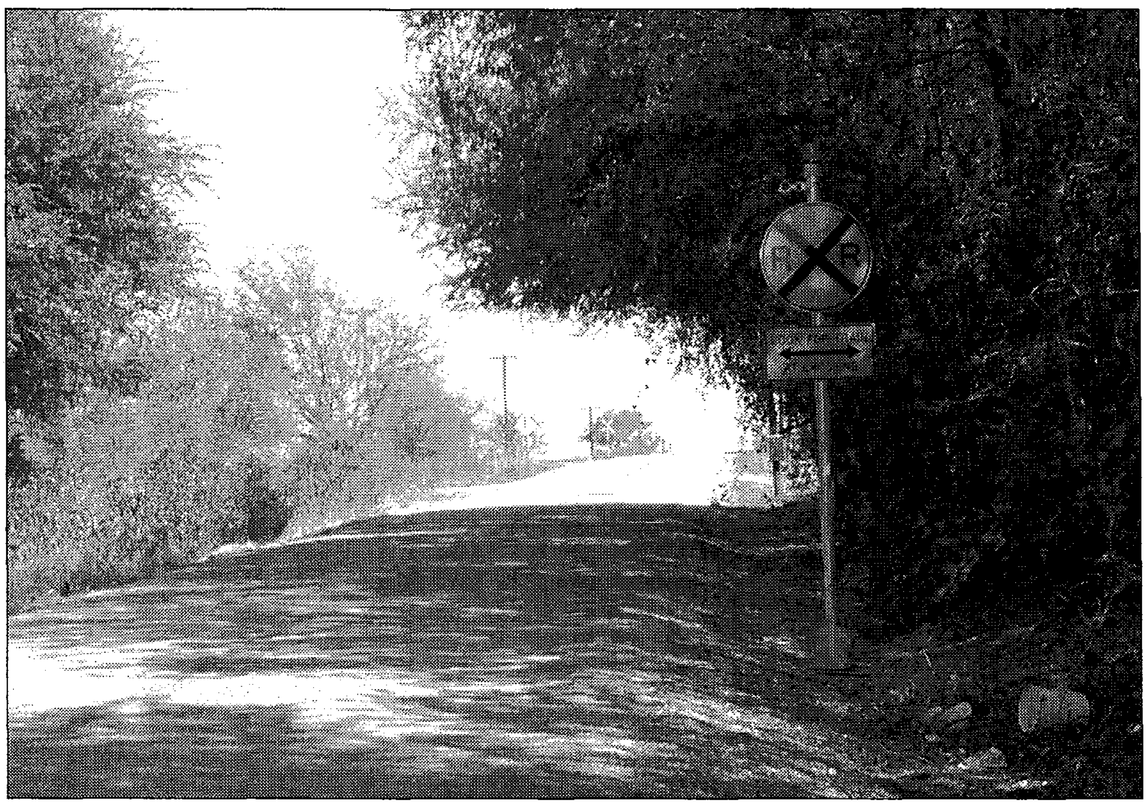


Figure 5-12. Eastbound Approach on County Road 489.

The before and after speed data for the east approach of grade crossing 022113S were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 5-11 presents the results of the two-sample t-test on the east approach, and Figure 5-13 presents a graphical representation of the before and after mean speeds along the east approach. Linear interpolation was used to approximate before and after mean speeds between data collection locations. The vertical line at 618 feet on Figure 5-13 represents the location of the enhanced sign system during the after study.

Table 5-11. Statistical Comparison: East Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
East	33	17.3	17.3	0.0	1120	0.577	0.00	1.96	NO
	207	33.4	33.8	0.4	1267	0.538	0.20	1.96	NO
	380	39.1	38.6	0.5	911	0.448	0.17	1.96	NO
	555	40.4	39.4	1.0	1175	0.627	0.34	1.96	NO
	1312	40.2	41.6	1.4	1261	0.589	0.59	1.96	NO

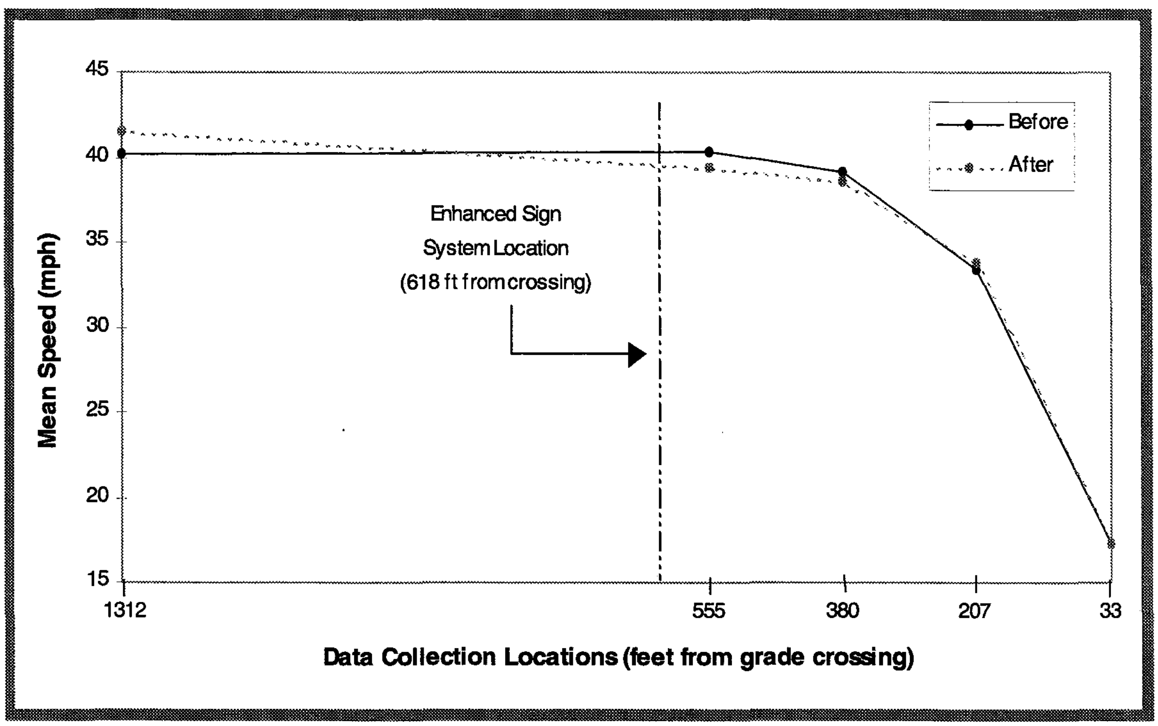
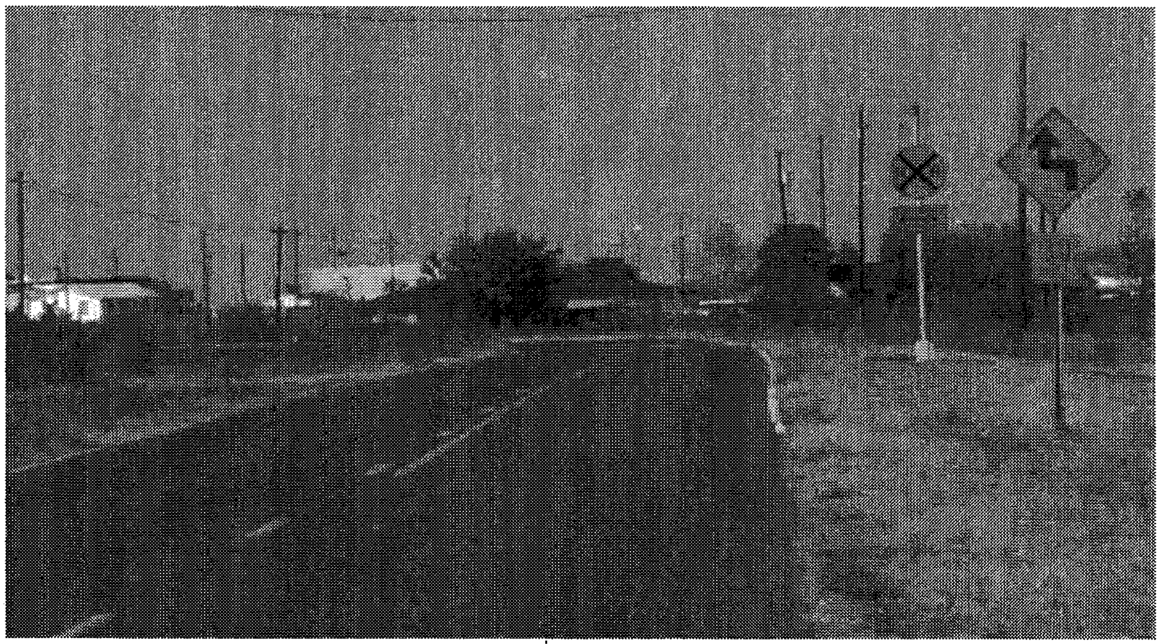


Figure 5-13. Mean Speed Comparison: East Approach to Grade Crossing No. 022113S (CR 489).

Figure 5-14 illustrates the enhanced sign system on the west approach of CR 489. The before and after speed data for the west approach were also compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 5-12 presents the results of the two-sample t-test for the west approach, and Figure 5-15 presents a graphical representation of the before and after mean speeds along the west approach. Linear interpolation was used to approximate before and after mean speeds between data collection points. The vertical line at 500 feet on Figure 5-15 represents the location of the enhanced sign system during the after study.



5-14. Westbound Approach on County Road 489.

Table 5-12. Statistical Comparison – West Approach to Grade Crossing No. 022113S (CR 489).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
West	33	17.5	16.1	1.4	1530.0	0.60	0.63	1.96	NO
	171	30.0	29.1	0.9	1553.0	0.52	0.55	1.96	NO
	380	32.8	31.9	0.9	1637.0	0.43	0.60	1.96	NO
	555	29.5	28.7	0.8	1696.0	0.45	0.88	1.96	NO
	1312	37.0	36.1	0.9	1282.0	0.39	0.42	1.96	NO

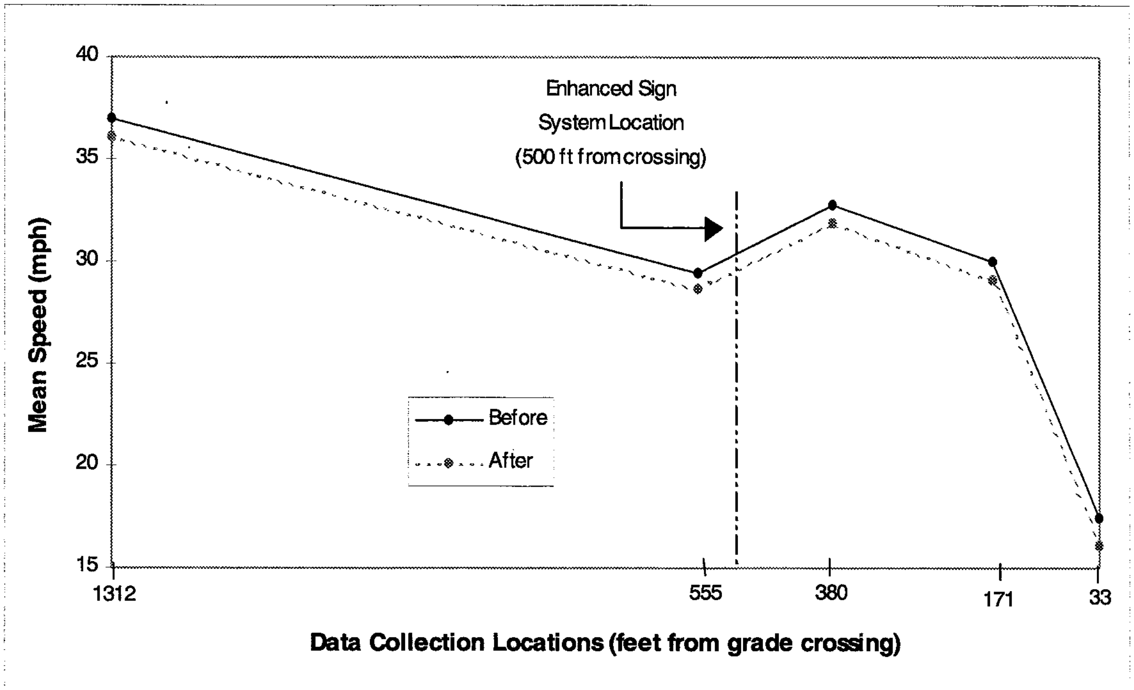


Figure 5-15. Mean Speed Comparison: West Approach to Grade Crossing No. 022113S (CR 489).

Researchers found no significant speed increase or decrease at $\alpha = 0.05$ when comparing the before and after mean speeds at each data collection location on the north approach. Mean speeds were slightly lower along the length of the approach after the enhanced sign system was placed in the field. The largest difference in before and after mean speeds, a 1.4 mile per hour decrease, occurred 33 feet from the grade crossing. The 85th percentile speed was slightly lower at all data collection locations after the installation of the enhanced sign system. Thus, the two-sample t-test does not provide enough evidence to reject the null hypothesis outlined in Equation 1 (Chapter 3). The decreases in mean speeds were not statistically significant.

CHAPTER 6

LOOK FOR TRAIN AT CROSSING ENHANCED SIGN SYSTEMS WITH FLASHING BEACONS

INTRODUCTION

The remaining three study sites for the LOOK FOR TRAIN AT CROSSING enhanced sign systems used LED flashing beacons with the LOOK FOR TRAIN AT CROSSING supplemental sign. The designed sign dimensions for the supplemental sign are shown in Figure 6-1. Other equipment used in the enhanced sign systems included a solar panel and infrared detector as described in Chapter 2.

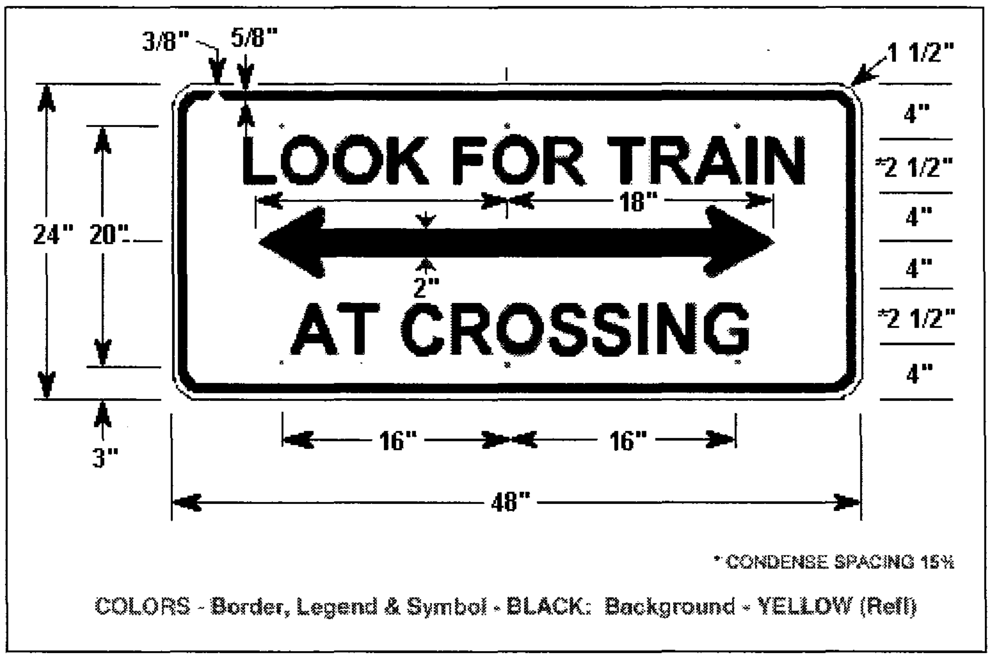


Figure 6-1. LOOK FOR TRAIN AT CROSSING Supplemental Sign Dimensions.

Data Collection Set-up for LOOK FOR TRAIN AT CROSSING Sign System

The location of the railroad advance warning sign (W10-1) was determined by *MUTCD* requirements based on the posted speed or assumed speed of the roadway. The LOOK FOR TRAIN AT CROSSING sign contained 3.94-inch letters and was designed using the 48-inch sign dimensions in Figure 6-1. A ratio of legibility distance to letter height of 7:1 was used assuming 20/20 Snellen vision. This ratio resulted in the equivalent of 226 feet of legibility distance. Drivers with less than 20/20 Snellen vision require shorter legibility distances. However, they would only benefit from the additional observation time provided. Since the LOOK FOR TRAIN AT CROSSING sign system had an unfamiliar flashing strobe, a five-second perception-reaction time was assumed. Another three seconds was allocated for the driver to observe and focus attention on the railroad advance warning sign and LOOK FOR TRAIN AT CROSSING supplemental sign. This provided a travel time of eight seconds from the point at which the vehicle was detected with a long-range passive infrared detector until it arrived at the enhanced sign system. Figure 6-2 illustrates the relevant distances related to the LOOK FOR TRAIN AT CROSSING sign system.

The information in Figure 6-2 was used to create a generic data collection layout for LOOK FOR TRAIN AT CROSSING sign system locations that could be customized to the posted speed of the roadway. As stated previously, the sensors closest to the track and the control sensors furthest from the track remained at 33 and 1312 feet, respectively. However, the remaining three locations varied depending upon the posted speed of the roadway. Each of the remaining three sensor locations was equidistant from the closest downstream sensor. Figure 6-3 illustrates the data collection setup to be used with Figure 6-2 to calculate the required distances for the posted speed of the roadway. It should be noted that these distances were altered by as much as 200 feet at certain locations to account for roadway geometry and existing obstacles.

It should be noted that the supplemental LOOK FOR TRAIN AT CROSSING supplemental signs fabricated and delivered by TxDOT were 36 inches wide rather than 48 inches wide. Time didn't allow for additional signs to be fabricated; therefore, the 36-inch wide signs were used. It is unknown what effect this had on the data.

Posted Speed (mph)	Speed (fps)	Dist. Travel in 8 sec	X (ft)	Y (ft)	Z (ft)	X+Y (ft)	Z+X+Y (ft)
25	37	293	67	226	250	293	543
30	44	352	126	226	325	352	677
35	51	411	185	226	400	411	811
40	59	469	243	226	475	469	944
45	66	528	302	226	550	528	1078
50	73	587	361	226	625	587	1212
55	81	645	419	226	700	645	1345
60	88	704	478	226	775	704	1479
65	95	763	537	226	850	763	1613

Letter height to legibility distance (20/20 vision) = 57.3 ft/in

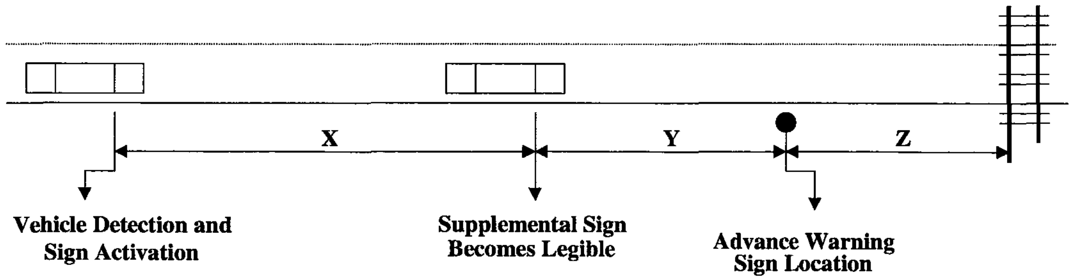


Figure 6-2. LOOK FOR TRAIN AT CROSSING Experimental Setup.

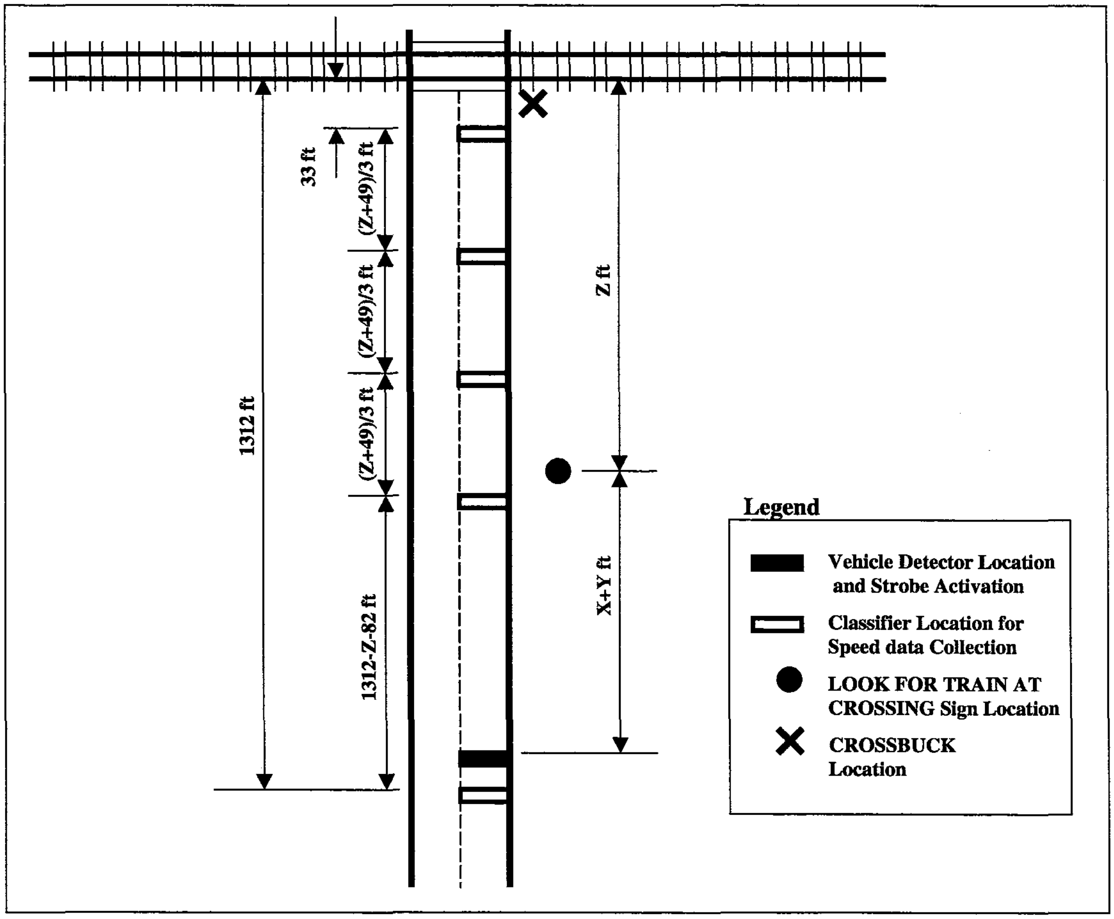


Figure 6-3. LOOK FOR TRAIN AT CROSSING Data Collection Layout.

STUDY SITES

As listed in Table 2-2 of Chapter 2, three sites were selected for the LOOK FOR TRAIN AT CROSSING enhanced sign system with LED flashing beacons. The project sites, data collection, and data analysis are included for each site.

Site 7. Grade Crossing No. 024367N in Montgomery County, Texas

Figure 6-4. Train and Grade Crossing on Waukegan Road.

This crossing is located on Waukegan Road in Cut-and-Shoot, Texas. As shown in Figure 6-5, the project site starts in a horizontal curve on the north approach, followed by a long tangent section approaching the grade crossing. The project site also begins in a horizontal curve on the south approach and continues in a slightly offset alignment to the grade crossing. This grade crossing is STOP controlled; it is the only study site that had STOP control at the grade crossing. Sight distance is limited on both approaches by trees and vegetation close to the grade crossing. There are no intersecting roadways within the project study site. However, there is one residential driveway and a future intersecting roadway under development on the south approach to the grade crossing. The posted speed limit on Waukegan Road is 30 mph, and the ADT is 560.

Sensors were placed on the north approach at 20, 146, 290, 398, and 1292 feet and on the south approach at 33, 207, 380, 555, and 1312 feet to collect the before speed data. Each distance was measured from the closest rail to the first sensor in each set, and 10 feet separated the two sensors in each set. The before study was conducted between July 7 and July 15, 1999, for the north approach, and between June 29 and July 2, 1999, for the south approach. Unfortunately, one set of counters provided erroneous results, and the data for the south approach could not be used. Table 6-1 summarizes the data collected on the north approach during the before study. The data show that vehicles began slowing when they were 555 feet from the grade crossing. The largest decreases in mean speed occurred between 207 and 380 feet from the crossing (6.9 mph) and between 33 and 207 feet from the crossing (6.8 mph).

On October 15, 1999, TxDOT personnel installed a LOOK FOR TRAIN AT CROSSING sign system with flashing beacons on each approach of the grade crossing. The LOOK FOR TRAIN AT CROSSING sign system was placed 445 feet from the first rail of the crossing on the north approach and at 500 feet from the first rail of the crossing on the south approach.

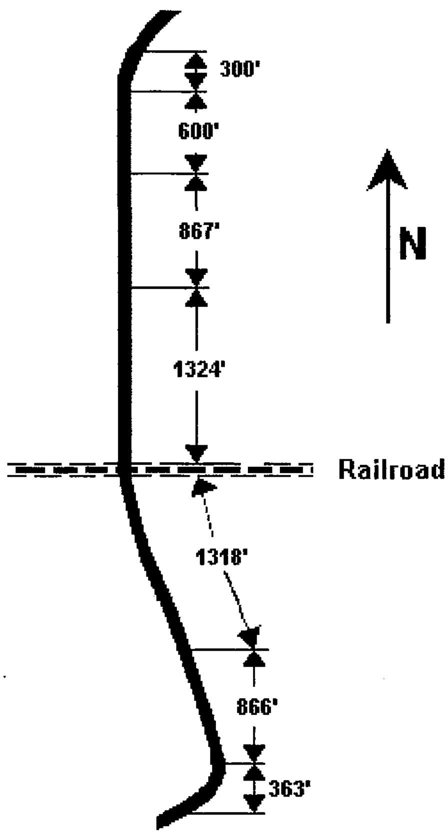


Figure 6-5. Waukegan Road in Montgomery County, Texas.

The after study on the north approach was conducted from November 1 to November 4, 1999. The setup was the same as for the before study. Table 6-2 summarizes the data collected in the after study. The after data again show that vehicles on the north approach don't begin to slow substantially until they are 380 feet from the grade crossing. The largest mean speed decrease on the north approach, 11.5 miles per hour, occurred between 33 and 207 feet from the crossing. This decrease is similar to that recorded during the before study.

Figure 6-6 is diagram of the before and after sensor locations and LOOK FOR TRAIN AT CROSSING sign locations. Figures 6-7 and 6-8 illustrate the north and south approaches to the grade crossing on Waukegan Road.

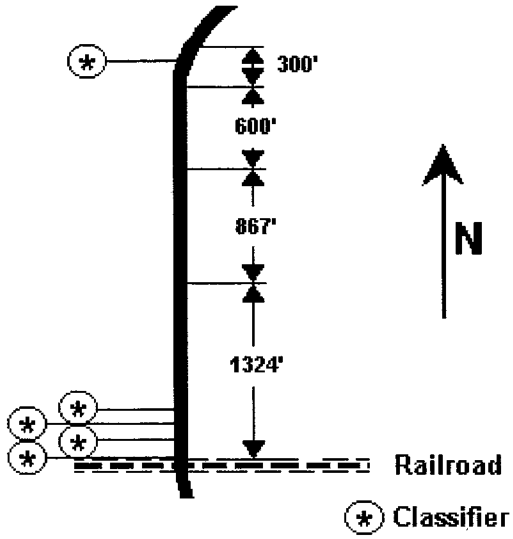


Figure 6-6. Classifier Installation Diagram for Waukegan Road.

Table 6-1. Before Speed Data: North Approach to Grade Crossing No. 024367N (Waukegan Road).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
North	20	136	23.9	58.6	64.1	5.5	16.5	32.5	7.9	62.8
	146	1283	30.7	56.6	61.4	4.8	26.9	35.7	5.0	24.9
	280	1527	37.6	51.2	65.5	14.3	32.6	43.3	5.4	28.7
	398	1433	41.0	57.2	63.4	6.2	35.3	47.4	6.1	37.3
	1292	1292	40.6	55.9	69.6	13.7	30.9	49.5	8.5	71.4

Table 6-2. After Speed Data: North Approach to Grade Crossing No. 024367N (Waukegan Road).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph)						Standard Deviation	Sample Variance
			Mean	Range	High	Low	15th Percentile	85th Percentile		
North	20	3170	11.7	62.8	66.2	3.4	7.5	16.3	4.9	23.9
	146	3141	23.2	58.7	62.1	3.4	11.4	33.1	9.3	87.2
	280	1151	30.8	64.8	68.9	4.3	17.3	43.0	11.4	130.1
	398	1297	35.7	43.7	58.0	14.3	29.9	42.0	6.0	35.5
	1292	2362	38.7	72.2	76.3	4.1	28.0	48.8	9.7	93.3

Figure 6-7. North Approach on Waukegan Road.

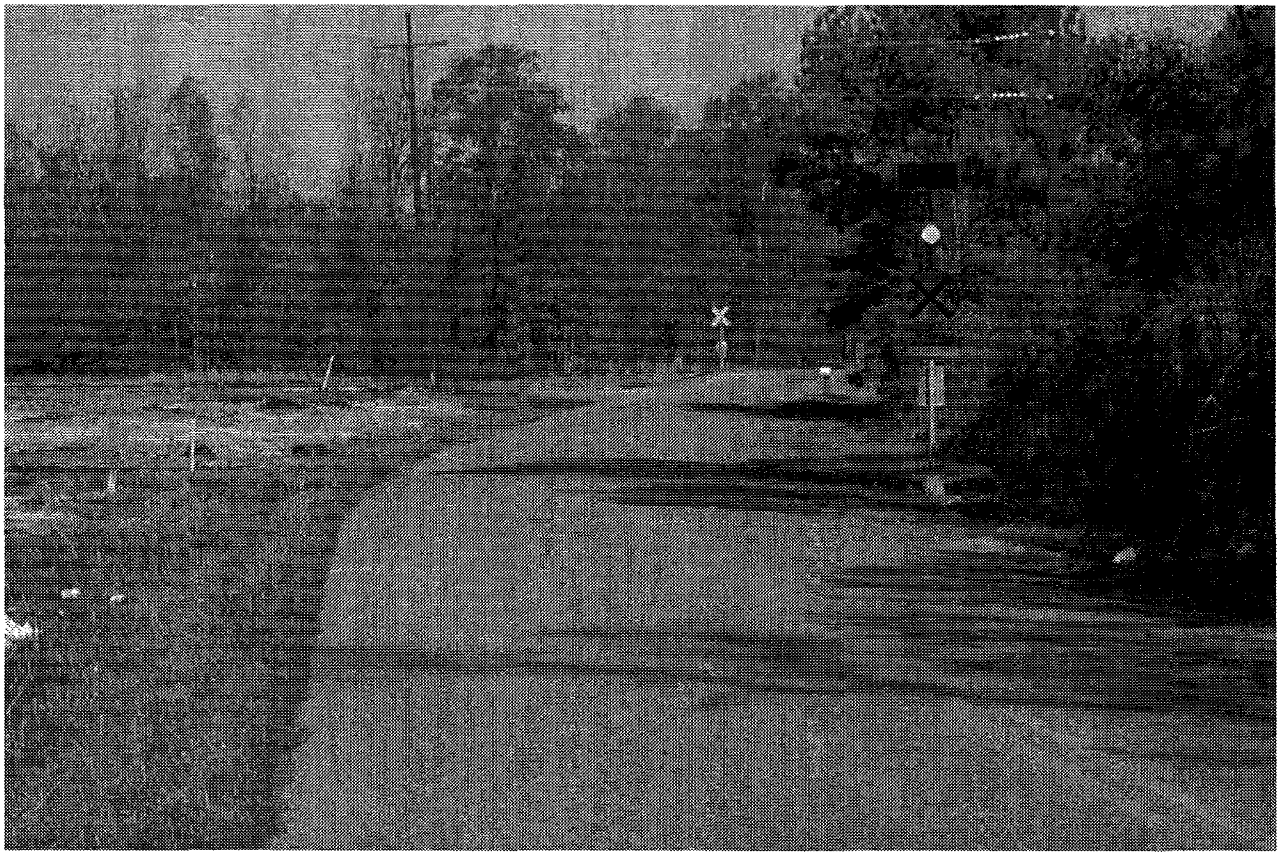


Figure 6-8. South Approach on Waukegan Road.

Researchers compared the before and after speed data for the north approach on Waukegan Road using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 6-3 presents the results of the two-sample t-test for the north approach, and Figure 6-9 presents a graphical representation of the before and after mean speeds along the north approach. Linear interpolation was used to approximate before and after mean speeds between data collection points. The vertical line at 445 feet on Figure 6-9 represents the location of the enhanced sign system during the after study.

Significant speed decreases were found at $\alpha = 0.05$ for three of the before and after mean speeds collection locations on the north approach. The significant decreases were at 20 feet from the crossing and 146 feet from the crossing (the two locations closest to the crossing) and at 398 feet from the crossing. The largest difference in before and after mean speeds, a 12.2-mile per hour decrease, was at 20 feet from the crossing. The 85^{th} percentile speed was slightly lower after the installation of the enhanced sign system.

The two-sample t-test provides enough evidence to reject the null hypothesis outlined in Equation 1 for the data collection points at 20, 146, and 398 feet from the crossing (the enhanced sign system was located 445 feet from the crossing). The before and after speed study results at this location are encouraging. Researchers hypothesized that drivers would slow on the approach near the location of the enhanced sign system with no change of speed at the crossing. However, drivers slowed near the location of the enhanced sign system as well as at the two sensor locations closest to the railroad tracks. As noted previously, STOP signs are installed at this crossing; however, the decrease in speed at the two sensor locations closest to the railroad tracks is statistically significant even with the presence of the STOP signs. This indicates that the presence of the enhanced sign system contributed to reduced speeds at this crossing.

Table 6-3. Statistical Comparison: North Approach to Grade Crossing 024367N (Waukegan Road).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at $\alpha = 0.05$
North	20	23.9	11.7	12.2	504	0.994	2.26	1.96	YES
	146	30.7	23.2	7.5	1187	0.166	4.40	1.96	YES
	280	37.6	30.8	6.8	1175	0.035	1.74	1.96	NO
	398	41.0	35.7	5.3	1228	0.500	3.80	1.96	YES
	1292	40.6	38.7	1.9	896	0.517	0.69	1.96	NO

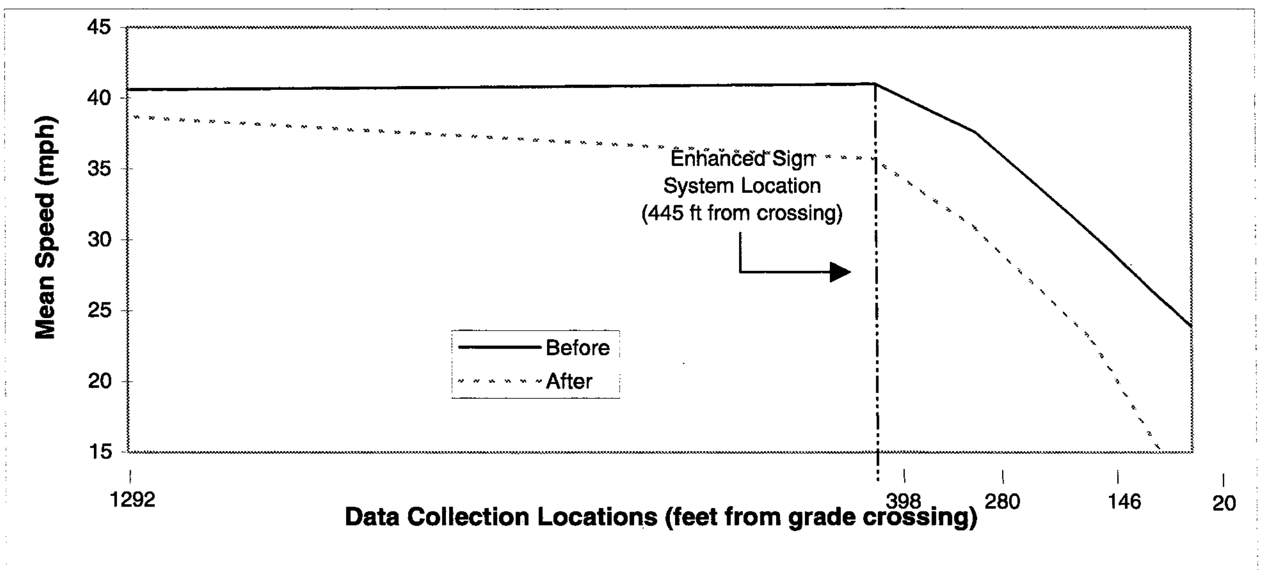


Figure 6-9. Mean Speed Comparison: North Approach to Grade Crossing 024367N (Waukegan Road).

Site 8. Grade Crossing 024369C in Montgomery County, Texas

Grade crossing 024369C on Timberswitch Road near Cut-N-Shoot was selected as the second site for the LOOK FOR TRAIN AT CROSSING sign with a flashing beacon. Timberswitch is a very rural, nonpaved roadway with an ADT of 100. It was specifically selected to test the sensor technology for unpaved roadways, since typical roadway loops are not practical for unpaved roadways. Timberswitch has several mild horizontal curves approaching the grade crossing from both the north and the south as shown in Figure 6-10. There was no posted speed limit.

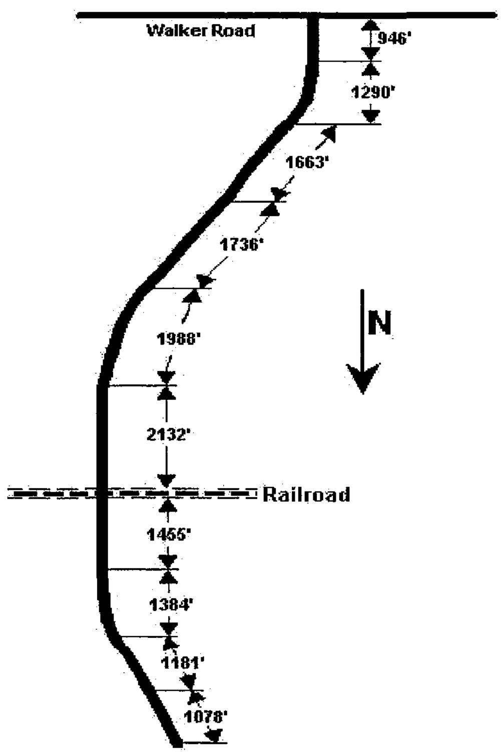


Figure 6-10. Timberswitch Road in Montgomery County, Texas.

Sensors were placed at 33, 158, 283, 408, and 1312 feet on both approach(es) to collect before speed data. Each distance was measured from the closest rail to the first sensor in each set, and sensors were spaced at 10 feet apart in each set. The before study was conducted between July 16 and July 23, 1999.

TxDOT personnel installed LOOK FOR TRAIN AT CROSSING enhanced sign systems with flashing beacons on October 15, 1999 (see Figure 6-11).

Unfortunately, an after study could not be conducted at this site due to vandalism: the flashing beacons were shot and replaced; the flashing beacons were shot again; and the detectors were shot and destroyed before enough time had elapsed to conduct an after study. Figures 6-12 and 6-13 illustrate the damaged beacon and detector, respectively. Since the after data could not be collected, the before data is not included in this report.

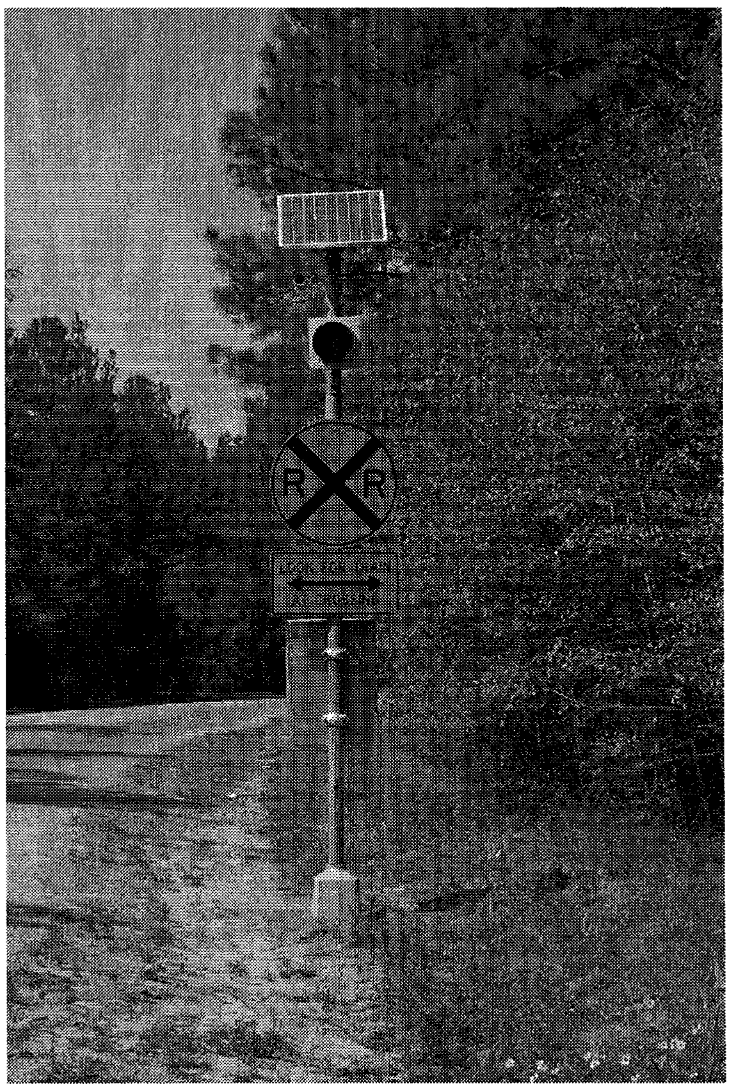


Figure 6-11. LOOK FOR TRAIN AT CROSSING System on Timberswitch Road.

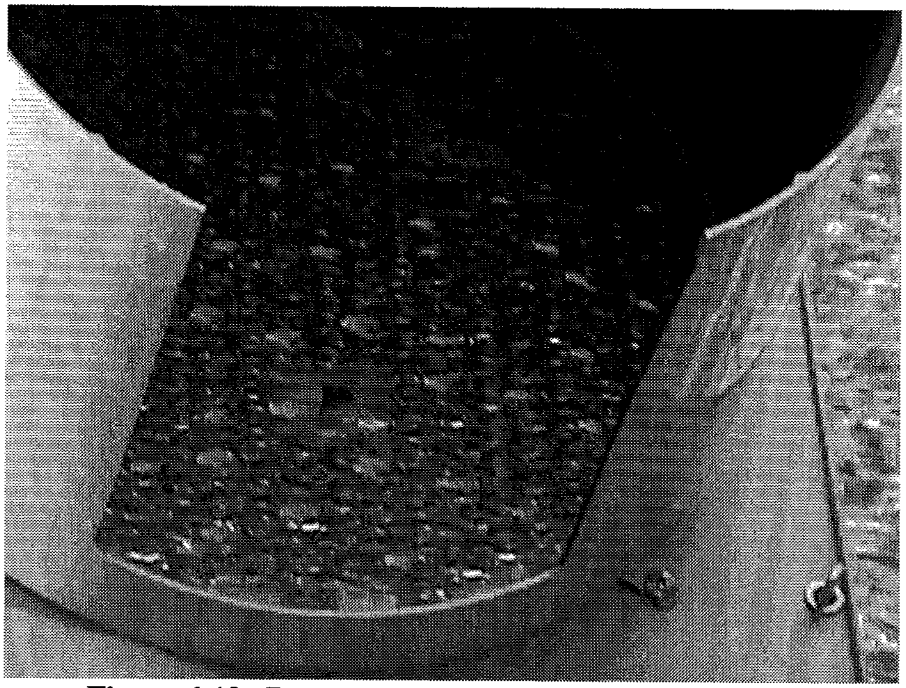


Figure 6-12. Damaged Beacon on Timberswitch Road.

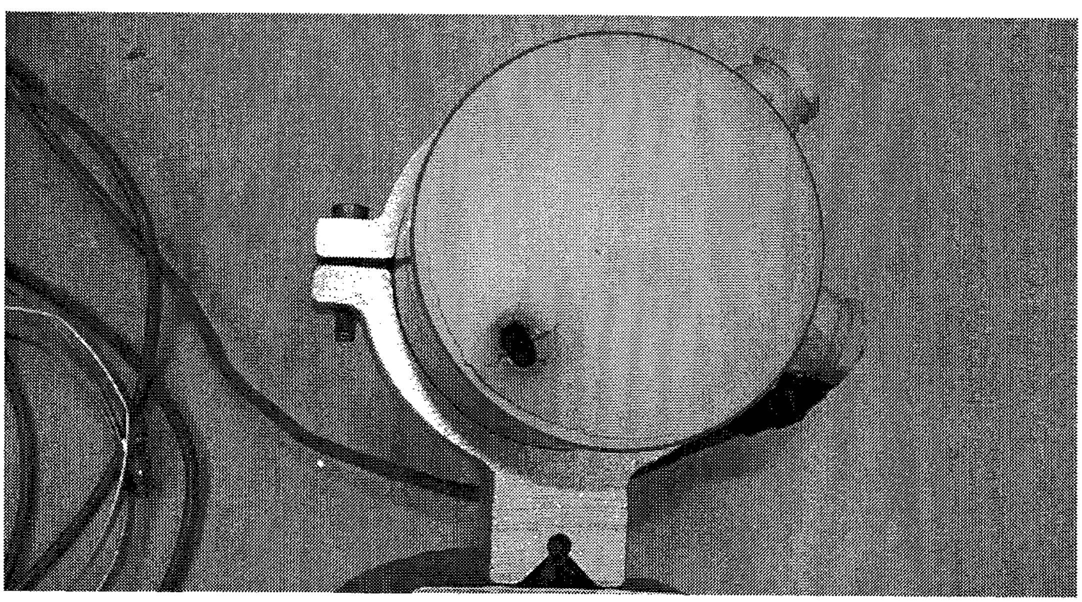


Figure 6-13. Damaged Sensor on Timberswitch Road.

Site 9. Grade Crossing 755763X in Polk County, Texas

The final site selected for the LOOK FOR TRAIN AT CROSSING enhanced sign system with flashing beacons was on Marston Road north of Livingston, Texas. The crossing is located in a tangent section with no adverse grade on either approach, as shown in Figure 6-14. Trees on both approaches restricted the sight distance. ADT on the roadway was 170, and there was no posted speed limit. A 30-mph speed limit was assumed.

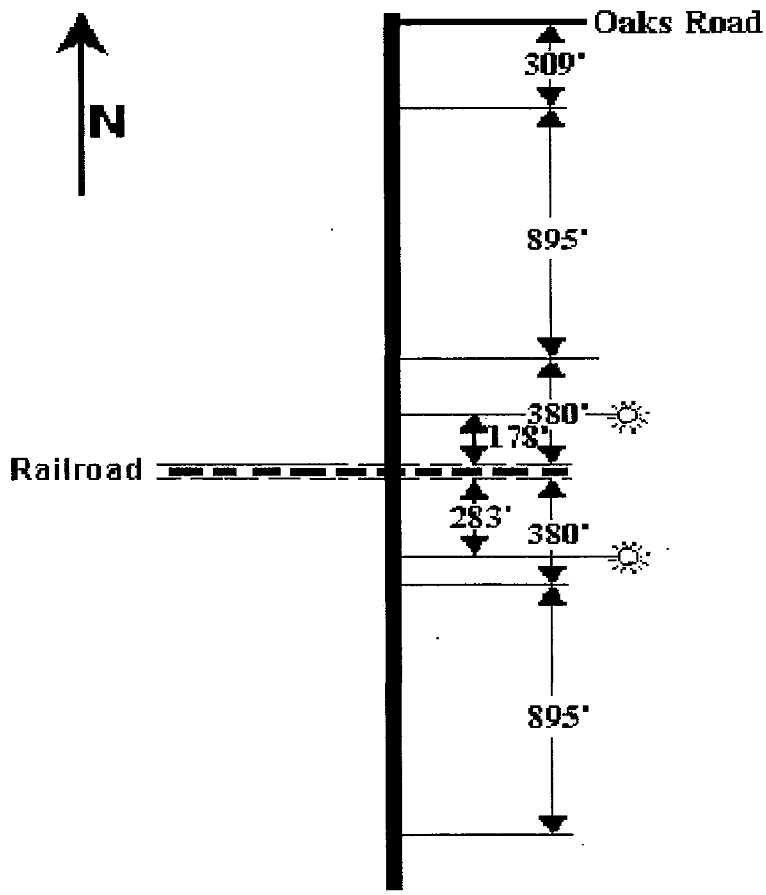


Figure 6-14. Marston Road in Polk County, Texas.

Sensors were installed at 32, 150, 270, 380, and 1275 feet on both the north and south approaches to the crossing in order to collect before speed data (see Figure 6-15). Each distance was measured from the closest rail to the first sensor in each set, and the sensors in each set were spaced at 10 feet apart. The original before study was conducted between July 28 and August 5, 1999. Due to problems with the data, a second before study was conducted between September 6 and September 13, 1999. Data were collected only on the south approach—the north approach led to a dead end, and volumes were so long that it was not feasible to collect data on this approach. Table 6-4 summarizes the before data on the south approach. The data indicate that mean speeds decrease most between 32 and 150 feet from the crossing (by 8.3 mph) and between 150 and 270 feet from the crossing (by 7.7 mph).

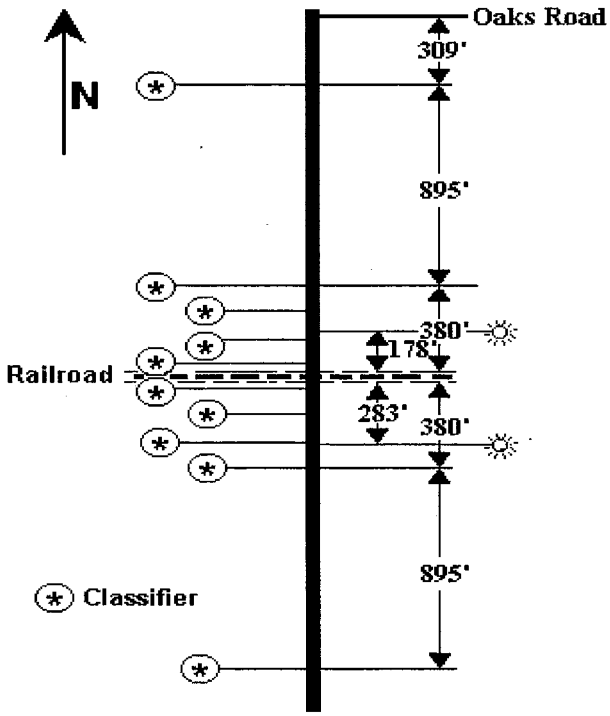


Figure 6-15. Classifier Installation Diagram for Marston Road.

TxDOT personnel installed the LOOK FOR TRAINS AT CROSSING enhanced sign systems with flashing beacons on Marston Road on October 28, 1999. The LOOK FOR TRAINS AT CROSSING sign system was placed at 274 feet from the crossing on the south approach, and at 165 feet from the crossing on the north approach. The sign system on the north approach was inadvertently placed closer to the crossing than desired due to field errors.

The after speed study was conducted between December 10 and December 17, 1999. The same setup was used as the before speed study. Table 6-5 lists the results of the after study, indicating that the greatest decrease in speed occurred at the same locations as in the before study. Mean speeds decreased most between 32 and 150 feet from the crossing (by 8.1 mph) and between 150 and 270 feet from the crossing (by 7.4 mph).

Table 6-4. Before Speed Data: South Approach to Crossing No. 755763X (Marston Road).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	32	547	13.8	51.1	55.2	4.1	9.2	19.3	5.7	33.0
	150	873	22.1	37.3	40.9	3.6	17.5	28.0	5.0	24.9
	270	882	29.8	42.3	49.8	7.5	25.0	35.8	5.7	32.4
	380	427	34.0	41.5	51.1	9.6	28.1	41.4	6.7	44.6
	1275	1312	34.5	57.2	63.4	6.2	27.8	42.2	7.4	54.3

Table 6-5. After Speed Data: South Approach to Crossing No. 755763X (Marston Road).

Approach and Location from Crossing (feet)		Number of Observations	Speeds (mph) Mean	Range	High	Low	15th Percentile	85th Percentile	Standard Deviation	Sample Variance
South	32	532	12.6	34.8	38.9	4.1	8.6	17.0	4.6	21.4
	150	357	20.7	47.7	52.5	4.8	16.1	25.7	5.9	34.4
	270	703	28.1	41.5	46.3	4.8	22.9	33.9	6.0	35.8
	380	205	31.9	46.4	49.8	3.4	25.6	38.5	7.3	53
	1275	732	34.0	55.9	66.8	10.9	26.2	42.3	8.2	67.9

The before and after speed data for the south approach of grade crossing 755763X on Marston Road were compared using the two-sample t-test (Equations 1 through 8 in Chapter 3). Table 6-6 presents the results of the two-sample t-test for the x-approach, and Figure 6-16 is a graphical representation of the before and after mean speeds along the south approach. Linear interpolation was used to approximate before and after mean speeds between data collection points. The vertical line at 283 feet on Figure 6-16 represents the location of the enhanced sign system during the after study. No significant speed increase or decrease was found at X=0.05 when comparing the before and after mean speeds at each data collection location on the south approach.

Table 6-6. Statistical Comparison: South Approach to Grade Crossing 755763X (Marston Road).

Approach and Location from Crossing (feet)		Mean Speed (mph) Before	After	Difference	*df*	*c*	*t'*	$t_{.025}$	Significant at α = 0.05
South	32	13.8	12.6	1.2	1068	0.698	0.71	1.96	NO
	150	22.1	20.7	1.4	1682	0.176	0.70	1.96	NO
	270	29.8	28.1	1.7	1731	0.395	0.98	1.96	NO
	380	34.0	31.9	2.1	347	0.3	0.5	1.96	NO
	1275	34.5	34.0	0.5	1423	0.263	0.17	1.96	NO

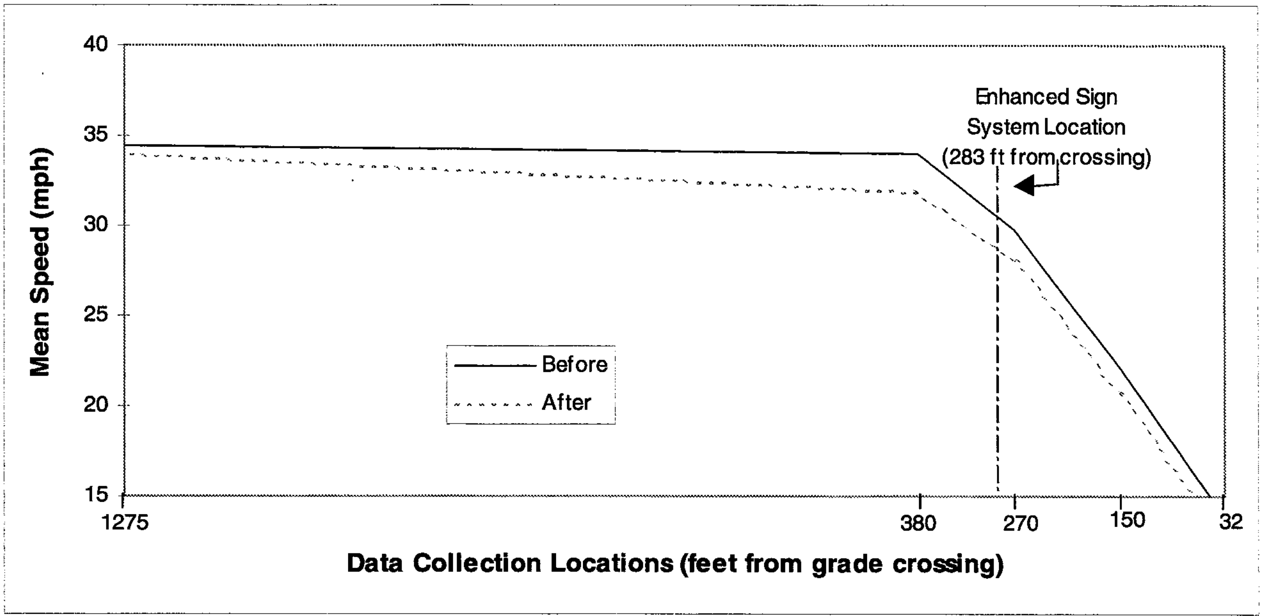


Figure 6-16. Mean Speed Comparison: South Approach to Grade Crossing 755763X (Marston Road).

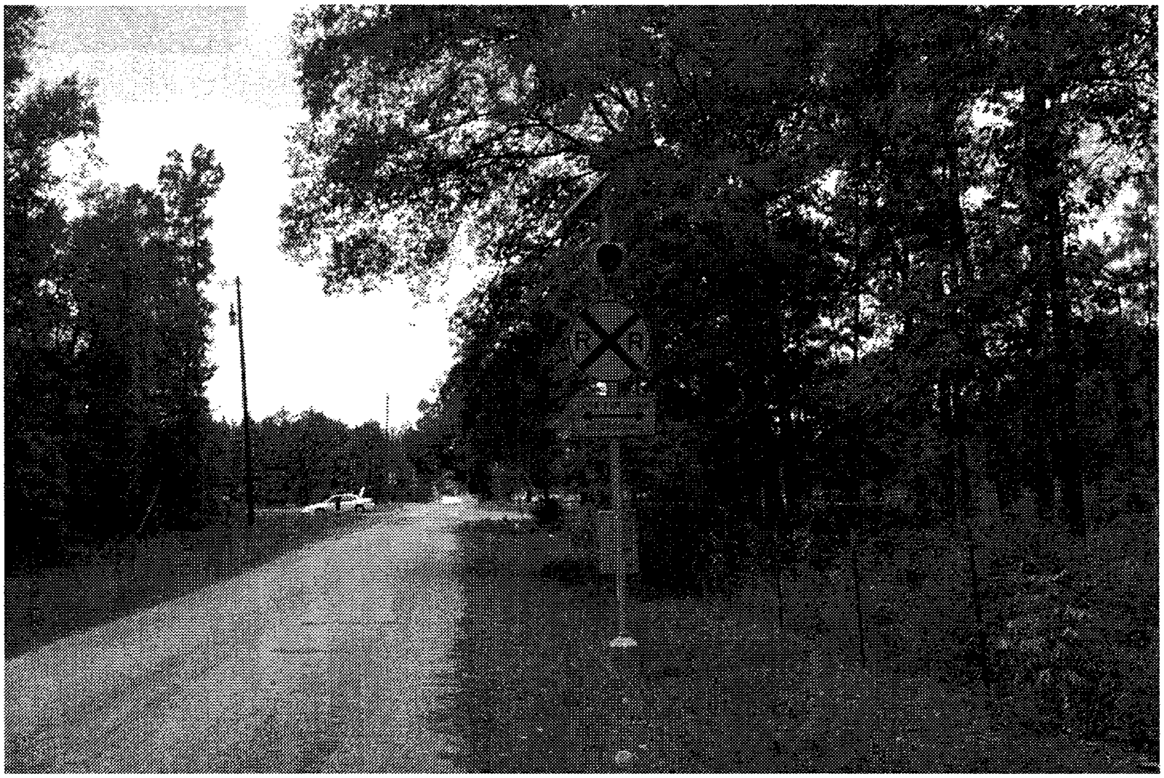


Figure 6-17. North Approach to Crossing on Marston Road.

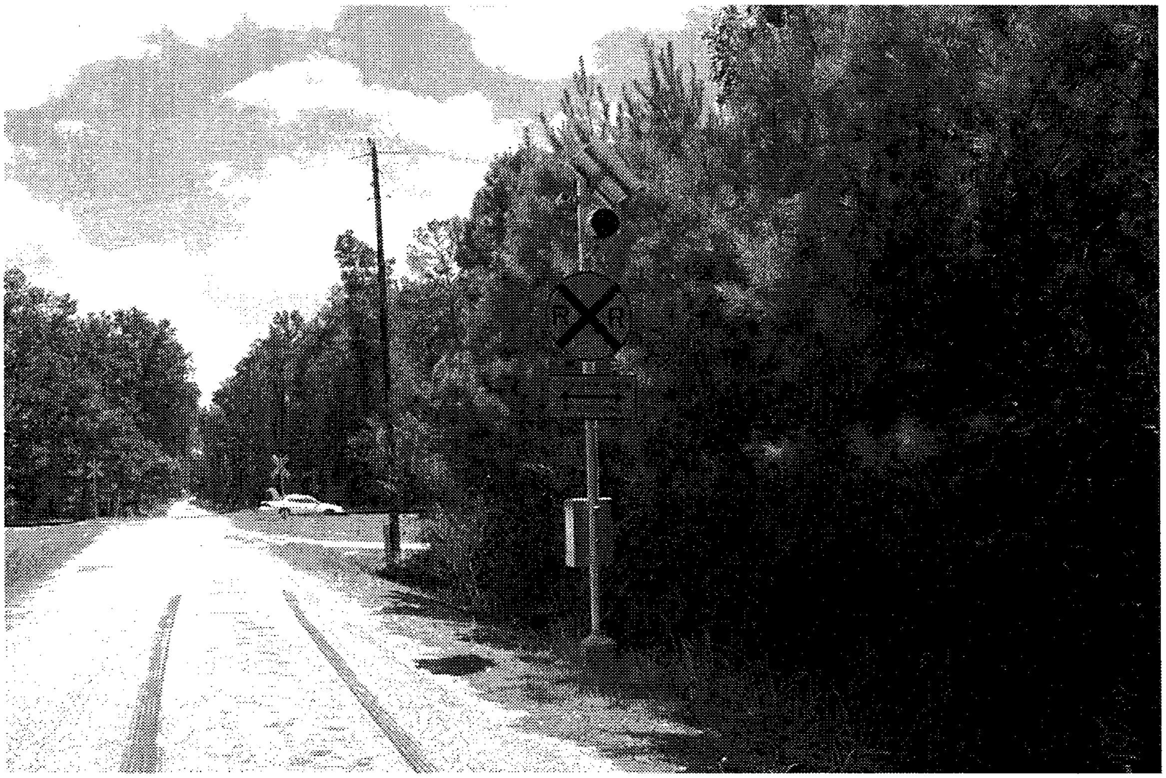


Figure 6-18. South Approach to Crossing on Marston Road.

CHAPTER 7

ON-SITE SURVEYS

SURVEY DESIGN

Researchers conducted on-site surveys at the four study sites with LOOK FOR TRAIN AT CROSSING enhanced sign systems with flashing strobes and with flashing beacons. The purpose of the surveys was to record the perceptions of the drivers traveling through the project sites, including the enhanced sign system and railroad crossing. Table 7-1 lists the four study sites where on-site surveys were conducted. (Site numbers stay consistent as they have through the previous chapters.)

Table 7-1. Locations of On-Site Surveys.

	Site Number	County / Nearest City or Town	Road	Crossing Number	TxDOT District
LOOK FOR TRAINS Sign (with Strobe)	5	Collin / Copeville	State Highway 78 Business Loop	022116M	Dallas
	6	Collin / Copeville	County Road 489	022113S	Dallas
LOOK FOR TRAINS Sign (with Beacon)	7	Montgomery / Cut-N-Shoot	Waukegan Road	024367N	Houston
	9	Polka / Livingston	Marston Road	755763X	Lufkin

TTI personnel conducted all surveys. Standard safety vests and flags were used, and an official TTI vehicle was parked adjacent to the site to add identification. TTI researchers near the grade crossing approached drivers who had slowed down or stopped prior to or after the grade crossing. Drivers were asked if they were willing to answer some questions about the grade crossing that they had just crossed or were about to cross. Most drivers were receptive to answering questions because they lived in the vicinity and had an interest in safety at the crossing.

Those drivers who agreed to participate were asked to respond to a series of questions as shown in Figure 7-1. Drivers were first asked if they had noticed anything new or different about the grade crossing that they had not seen at other crossings. If drivers answered yes, they were asked to describe what they had noticed that was new or different. Drivers who did not mention a flashing light were then asked if they had noticed a yellow flashing light. Drivers were asked what they thought the flashing light meant. Drivers who did not mention a supplemental sign were told that there was an additional sign under the railroad warning sign and were asked to try to recall what the sign said. Other questions included the frequency of travel over the railroad crossing and demographic data including age, gender, and home zip code to determine how many drivers lived close to the crossing.

Surveys were conducted after the devices had been in place at least 30 days. A pilot survey was conducted on Waukegan Road in Cut-N-Shoot with 20 drivers to ensure that the appropriate information was obtained in the survey. The survey questions were then revised slightly to improve their flow. Surveys were then conducted on Waukegan Road in Cut-and-Shoot; on Business 78 and on County Road 489, both near Copeville; and on Marston Road in Livingston.

SURVEY RESULTS

The survey results are summarized in Table 7-2 and are discussed in the following pages. Sixty surveys were completed at each of the first three sites (Waukegan Road, Business 78, and on CR 489), and 40 surveys were completed on Marston Road. The number of surveys on Marston Road was lower due to the lower average daily traffic on the roadway and to the high number of repeat drivers. Therefore, researchers conducted 220 surveys.

Texas Transportation Institute | **Project 1881**

Date: __________ | Researcher:________
Site #:__________ | Participant #:_______

Highway-Railroad Grade Crossing Driver Survey on Location

This survey is being conducted by the Texas Transportation Institute, which is part of the Texas A&M University System, to obtain your opinion of a new highway-railroad crossing technique. Do you have a few minutes to answer some questions for us? All the information you provide will remain strictly confidential.

1. **Did you notice anything new or different at the railroad crossing you just passed that you normally do not see at other railroad crossings?** NO ❑ YES ❑
   If no: skip to Question 9 and then to 11.
   If yes: **Can you explain what you saw that was different?** If they answer a sign, go to Question 3 and ask if they noticed anything else.

2. **Did you notice a sign placed below the railroad warning light?** NO ❑ YES ❑
   If yes: **Can you recall what the sign said?** NO ❑ YES ❑
   If yes: **What?**

3. **When did you first notice the flashing light and sign?** ______________________________

4. **What do you think the flashing light and sign mean?** ______________________________

5. **Upon approaching the flashing light and sign, what driving action did you take, if any** ? __________
   ____

6. **Was there anything that you particularly liked or didn't like about this light and sign?** NO ❑ YES ❑
   Is so, please explain.______________________________

7. **Have you observed the use of this light and sign at night?** NO ❑ YES ❑

8. **Is there anything that you particularly liked or didn't like about using it at night? NO** ❑ **YES** ❑
   If so, please explain. ______________________________

9. **How often do you travel over this railroad crossing?**

10. **What is your overall opinion of this flashing light and sign?**

11. **Do you have any suggestions that you feel could increase the safety of motorists at railroad crossings?**
    If so, please explain. ______________________________

12. **Gender:** ❑ Male ❑ Female

13. **Age:** ❑ 16-25 ❑ 26-55 ❑ Over 55

14. **Your Zip Code:** __________

Comments:
____
____

Thank you for your cooperation!

Figure 7-1. On-Site Survey Questions.

Table 7-2. Summary of Survey Responses.

Type of Flashing Light	STROBE		LED BEACON	
Survey Location	SITE 5 Business 78	SITE 6 CR 489	SITE 7 Waukegan Road	SITE 9 Marston Road
1. Did you notice anything new or different at the railroad crossing you just passed that you normally do not see at other RR crossings?				
Yes	51	48	56	39
No	9	12	3	1
No response	0	0	1	0
Total:	**60**	**60**	**60**	**40**
Can you explain what you saw that was different?				
Light	44	30	41	35
Light and Sign	4	15	10	1
Sign	2	0	2	0
2. Did you notice a sign placed below the railroad warning sign?				
Yes	41	42	41	36
No	15	13	17	4
No response	4	5	2	0
Can you recall what the sign said?				
Can't recall	13	13	10	10
Railroad crossing: look both ways	2	1	4	7
Look or watch for trains	12	10	8	3
Warning—train coming	0	0	1	2
Something about railroad crossing	13	16	19	10
Stop and look	1	0	0	0
Look for cars at tracks	0	1	1	0
Caution	0	0	0	2
Trains	0	0	1	0
New sign and light	0	0	1	0
Dangerous crossing	0	0	0	1
3. When did you first notice the flashing light and sign?				
When installed	25	15	17	18
Today	4	5	5	3
1 to 3 weeks	5	12	18	10
More than one month	18	18	15	8
Don't remember	0	10	1	1
No response	8	0	4	0

Table 7-2. Summary of Survey Responses (continued).

Type of Flashing Light	STROBE		LED BEACON	
Survey Location	SITE 5 Business 78	SITE 6 CR 489	SITE 7 Waukegan Road	SITE 9 Marston Road
4. What do you think the flashing light and sign mean?				
Crossing ahead	16	11	11	8
Crossing ahead, slow down	1	2	5	3
Crossing ahead, caution	23	20	25	18
Crossing ahead, stop	1	0	4	0
Crossing ahead, slow down and caution	2	8	5	2
Crossing ahead, look both ways	0	0	2	3
Crossing ahead, stop and caution	0	1	3	0
Crossing ahead, slow down, caution and look both ways	5	3	0	2
When lights flashing, train is coming	1	3	0	2
When cars are coming	1	0	0	0
Already known	0	0	1	0
Not sure	1	2	0	1
No responses	9	10	4	1
5. Upon approaching the flashing light and sign, what driving action did you take, if any?				
Slow down	23	15	25	12
Stopped and looked both ways	7	4	5	7
Stopped	2	3	4	1
Slow down and stop	1	0	3	2
Look for train	1	2	1	6
Caution	1	2	0	2
Listen for train	0	1	0	0
Nothing different	0	20	19	8
No response	10	13	3	1

Table 7-2. Summary of On-Site Survey Responses (continued).

Type of Flashing Light	STROBE		LED BEACON	
Survey Location	**SITE 5** Business 78	**SITE 6** CR 489	**SITE 7** Waukegan Road	**SITE 9** Marston Road
6. Was there anything that you particularly liked or didn't like about this light and sign?				
Positive	**30**	**32**	**50**	**24**
Warns drivers	8	6	13	4
Far back enough to slow down	1	0	3	0
Like lights	3	2	2	0
Safety	0	0	1	0
Sensing unit	0	0	3	3
Noticeable	0	0	7	1
Its fine	18	24	20	16
Negative	**21**	**17**	**5**	**14**
Can't see flashing lights during day	3	0	0	0
Not big or bright enough	2	2	0	0
Not sure if train is coming	1	1	0	0
Needs arm rails or gates	1	3	0	4
Should flash when train is coming	2	0	1	0
Doesn't always work	7	6	2	7
Change to human activated	1	0	1	0
To far away	3	2	0	1
Not good enough	1	3	1	2
No response	**9**	**10**	**4**	**2**
7. Have you observed the use of this light and sign at night?				
Yes	31	33	38	26
No	21	17	18	13
No response	08	10	04	01

Table 7-2. Summary of On-Site Survey Responses (continued).

Type of Flashing Light	STROBE		LED BEACON	
Survey Location	**SITE 5** Business 78	**SITE 6** CR 489	**SITE 7** Waukegan Road	**SITE 9** Marston Road
8. Was there anything you particularly liked or didn't like about using it at night?				
Positive	**32**	**25**	**41**	**27**
Helps unfamiliar people at night	0	0	4	1
Warning & attention	5	5	5	3
Bright flashing lights	5	5	7	2
Sensing units	0	1	2	0
Safety	0	0	1	0
Far enough to slow down	0	0	2	0
It's fine	22	14	20	21
Negative	**10**	**13**	**4**	**8**
If weather is bad you can't see the lights	0	0	1	0
Doesn't always work	8	4	2	5
Can't read signs	0	3	1	1
Confusion of meaning	0	2	0	2
Lights too high	1	1	0	0
Needs arms with lights	1	0	0	0
To far away	0	1	0	0
Not bright enough	0	1	0	0
Not good enough	0	1	0	0
No response	**18**	**22**	**15**	**5**
9. How often do you travel over this railroad crossing?				
First or second time	5	2	3	2
Once a day	11	7	10	5
Once a week	2	2	3	3
Once a month	6	4	4	0
Once a year	0	1	1	0
Two to three year	2	3	2	2
Few times a year	2	2	5	0
Two to five times a day	25	24	21	17
More than five times a day	2	3	0	6
Two to five times a week	3	8	9	3
More than five times a week	0	1	1	2
Several times a month	2	1	1	0
Never	0	1	0	0
No responses	0	1	0	0
Total:	**60**	**60**	**60**	**40**

Table 7-2. Summary of On-Site Survey Responses (continued).

Type of Flashing Light	STROBE		LED BEACON	
Survey Location	**SITE 5** Business 78	**SITE 6** CR 489	**SITE 7** Waukegan Road	**SITE 9** Marston Road
10. What is your overall opinion of this flashing light and sign?				
Positive	**27**	**26**	**39**	**27**
Advanced warnings	2	2	5	3
Stop signs help	1	0	1	0
Great safety	0	0	3	2
Increase awareness	3	0	1	4
Helps unfamiliar people with area	3	3	1	0
Lights help	1	0	0	0
Great idea	17	21	28	18
Negative	**22**	**21**	**5**	**11**
Need arms and gates	3	6	3	3
People don't pay attention to signs or lights	1	0	1	0
Need blinking lights	0	1	1	1
Need to add strips	1	0	0	0
Bigger and Brighter lights and signs	3	1	0	2
Need lights at track	1	0	0	0
Should flash only when train is coming	3	0	0	2
Too high	1	0	0	0
Doesn't always work	2	4	0	3
Confusion of meaning	0	2	0	0
Bad idea	7	9	0	0
No response	**11**	**11**	**16**	**1**
11. Do you have any suggestions that you feel could increase the safety of motorists at railroad crossings?				
Arms or gates with lights	22	25	24	16
Red light with train is coming	3	3	2	3
Add a dip, bump or fine surface to the road	3	1	2	0
Install surrounding light to help visualization at night	3	0	3	0
Consistent functioning equipment	0	0	1	0
Add clear, bright markings	1	1	1	0
Install signs further away from the RR	1	2	3	2
Remove items that block vision of the RR	6	5	1	4
Install equipment where high travel occurs	0	0	1	0
Educate	1	2	2	1
Build an overpass or underpass	1	0	0	1
Install stop signs & lights closer to the RR	7	3	0	3
Trains should blow their horns	0	0	0	1
Eliminate a few train routes	1	0	0	0
No suggestion	5	9	9	7
No response	6	9	11	2

Table 7-2. Summary of On-Site Survey Responses (continued).

Type of Flashing Light	STROBE		LED BEACON	
	SITE 5 Business 78	**SITE 6** CR 489	**SITE 7** Waukegan Road	**SITE 9** Marston Road
12. Gender				
Male	37	34	36	31
Female	19	26	23	9
No response	4	0	1	0
13. Age				
16-25 years	8	6	9	6
26-55 years.	34	43	39	26
Over 55	16	11	11	8
No response	2	0	1	0
14. Zip Code				
In same county	40 of 58	51 of 60	52 of 58	35 of 40
In adjoining county	9	7	3	1

The responses to the questions are summarized on the following pages.

Question 1. Did you notice anything new or different at the railroad crossing you just passed that you normally don't see at railroad crossings?

Eighty-eight percent of the drivers at all four sites (from 80 to 98 percent at each site) had noticed something different at the railroad crossing where they were surveyed.

Can you explain what you saw that was different?

Eighty-two percent of the drivers surveyed (67 to 97 percent at each site) noticed the flashing light, while 16 percent (3 to 33 percent at each site) noticed the flashing light and a sign.

Question 2. Did you notice a sign placed below the railroad warning light?

Seventy-three percent of the drivers surveyed at all four sites (68 to 90 percent at each site) had noticed the sign placed below the flashing strobe or beacon.

Can you recall what the sign said?

The most common three answers (by all respondents at all sites) were:

- something about a railroad crossing (36 percent),
- can't recall (28 percent), and
- look or watch for trains (20 percent).

Question 3. When did you first notice the flashing light and sign?

Drivers noticed the flashing light and sign:

- when they were first installed (34 percent of the drivers surveyed all four sites; 25 to 45 percent at each site);
- more than one month ago (27 percent at all four sites; 13 to 30 percent at each site); and
- one to three weeks ago (20 percent at all four sites; 8 to 30 percent at each site).

Question 4. What do you think the flashing light and sign mean?

The responses indicated that the flashing light and sign meant:

- both that a crossing is ahead and some type of driving action such as slow down, caution, stop, slow down and use caution, look both ways, stop and use caution (63 percent of the drivers surveyed at all four sites; 53 to 73 percent at each site);
- there is a crossing ahead (21 percent of the drivers surveyed at all four sites; 18 to 27 percent at each site); and
- a train was coming when the lights were flashing (5 percent from all four sites; 0 to 5 percent at each site).

The possibility that drivers would interpret the flashing lights to mean that a train was approaching was a concern at the start of the project.

Question 5. Upon approaching the flashing light and sign, what driving action did you take, if any?

Drivers indicated that they:

- slowed down when they saw the light and sign (34 percent of the drivers surveyed at all four sites; 25 to 42 percent at each site);
- did nothing different their from normal behavior (21 percent at all four sites; 0 to 33 percent at each site);
- stopped and looked both ways (10 percent at all four sites; 7 to 18 percent at each site);
- stopped (5 percent at all four sites; 3 to 7 percent at each site);
- looked for a train (5 percent at all four sites; 2 to 15 percent at each site);
- slowed down and stopped (3 percent at all four sites; 0 to 5 percent at each site); and
- used caution (2 percent at all four sites; 2 to 5 percent at each site).

Question 6. Was there anything that you particularly liked or didn't like about this light and sign?

Overall, 62 percent of the total responses for all four sites were positive. The most common positive responses were that:

- the sign system is fine (35 percent of the overall responses at all four sites; 30 to 40 percent at each site); and
- the sign and light warn drivers (14 percent of overall responses at all four sites; 10 to 22 percent at each site).

Twenty-six percent of the total responses for all four sites were negative. The most common negative responses were that:

- the light doesn't always work (10 percent of overall responses at all four sites; 3 to 18 percent of responses at each site);

- rails or gates are needed (4 percent of responses at all four sites; 2 to 10 percent of responses at each site); and
- the system is not good enough (3 percent of responses at all four sites; 2 to 5 percent of responses at each site).

Question 7. Have you observed the use of this light and sign at night?

Fifty-eight percent of the total respondents at all four sites (52 to 65 percent of respondents at each site) stated they had seen the light and sign at night. Thirty-one percent of the respondents at all four sites (28 to 53 percent of respondents at each site) had not seen the light and sign at night.

Question 8. Is there anything you particularly liked or didn't like about using it at night?

Fifty-seven percent of the overall responses for all four sites were positive (42 to 68 percent at each site). The most common response was that it was fine or satisfactory (35 percent of responses at all four sites; 23 to 53 percent of responses at each site).

Sixteen percent of the overall responses for all four sites were negative (7 to 22 percent at each site). The most common response was that the flashing light doesn't always work.

Question 9. How often do you travel over this railroad crossing?

The most common responses were:

- two to five times per day (40 percent of responses at all four sites; 35 to 43 percent of responses at each site);
- once per day (15 percent of responses at all four sites; 12 to 18 percent of responses at each site); and
- two to five times per week (10 percent of responses at all four sites; 5 to 15 percent of responses at each site).

These responses indicate that the majority of drivers are very familiar with the grade crossings.

Question 10. What is your overall opinion of this flashing light and sign?

Fifty-four percent of the overall responses for all four sites were positive (43 to 68 percent of the responses at each site). The most common response was that it was a great idea (38 percent of the overall responses for all four sites; 28 to 47 percent of responses at each site).

Twenty-seven percent of the overall responses for all four sites were negative (8 to 37 of the responses at each site). The most common negative responses were that:

- it is a bad idea (7 percent of the overall responses for all four sites; 0 to 15 percent of responses at each site);
- gate arms are needed (7 percent of the overall responses for all four sites; 5 to 10 percent of the responses at each site); and
- the system doesn't always work (4 percent of the overall responses for all four sites; 0 to 8 percent of the responses at each site).

Question 11. Do you have any suggestions that you feel could increase the safety of motorists at railroad crossings?

The most common responses were to:

- add gates and lights to the grade crossings (40 percent of the overall responses; 37 to 42 percent of the responses at each site);
- remove items that block the sight distance of the railroad tracks (7 percent of the overall responses for all four sites; 2 to 10 percent of responses at each site); and
- install stop signs and lights closer to the railroad tracks (6 percent of the overall responses for all four sites; 0 to 12 percent of the responses at each site).

Question 12. Gender: gender of the survey respondents was recorded.

Sixty-three percent of the respondents at all four sites were males (57 to 78 percent of the respondents at each site), and 37 percent of the respondents at all four sites were female (23 to 43 percent of the respondents at each site).

Question 13. Age: respondents were asked which of the following age groups they were in—16-25 years, 26-55 years, or over 55 years.

The age group representation was:

- 26 to 55 year-old age group—65 percent of the total respondents at all four sites (57 to 72 percent of respondents at each site);
- over 55 year-old age group—21 percent of the total respondents for all four sites (20 to 27 percent of the respondents at each site); and
- 15 to 25 year-old age group—13 percent of the total respondents at all four sites (13 to 15 percent of respondents at each site).

Question 14. Zip Code: respondents were asked for their zip codes in order to determine if they were local, from a nearby county, or from farther away.

Table 7-3 lists the responses. As the researchers had hypothesized, high percentages of the drivers were from the same county.

Table 7-3. Responses for Survey Question 14.

Site	Percentage of Respondents in Same County	Percentage of Respondents from Adjoining Counties
Site 7 (Waukegan Road in Montgomery County)	91	5
Site 9 (Marston Road in Polk County)	88	3
Site 5 (Business 78 in Collin County)	69	16
Site 6 (CR 489 in Collin County)	85	12

DISCUSSION OF RESULTS

Based on the survey responses, both of the LOOK FOR TRAIN AT CROSSING enhanced sign systems appeared to be effective in gaining the attention of drivers. Ninety-eight percent of the drivers surveyed had noticed something new or different at the two crossings with flashing beacons, and 80 to 85 percent of the drivers surveyed had noticed something new or different at the two crossings with flashing strobes. A high percentage of drivers (from 69 to 91 percent) resided in the county where the grade crossing was located.

Drivers who had seen the enhanced sign systems with the flashing beacons made fewer negative responses about the systems not working correctly than the drivers who had seen the enhanced sign systems with flashing strobes.

Most of the drivers stated they were very familiar with the crossings and were concerned about safety. Many drivers stated that they would prefer a system of gates and flashing lights, but most thought an enhanced system was beneficial as a temporary measure. Many expressed a definite need for some type of warning at the crossing.

CHAPTER 8
SUMMARY AND RECOMMENDATIONS

SUMMARY

The project objective was to determine the effectiveness of two previously developed enhanced sign systems at passive highway-railroad grade crossings. Railroad warning signs do not require drivers to slow upon approaching a grade crossing. However, it was believed that an effective enhanced sign system would result in a speed reduction on the approach near the location of the enhanced sign system with no significant reduction in speed at the grade crossing.

The results indicate that the YIELD TO TRAINS enhanced sign system did not have a statistical effect on the mean approach speed. Only one mean speed on one approach of the three project sites showed a statistically significant change (increase). There was no apparent reason for this slight increase.

The results of the LOOK FOR TRAIN AT CROSSING enhanced sign systems varied more. One study site (out of five) experienced statistically significant decreases in speed at three of the classifier locations on one approach. This grade crossing is STOP controlled; the effects of the STOP signs on the study are unclear. However, the STOP signs were in place for the before study, and the conditions at the site were unchanged during the before and after speed studies. No significant increases or decreases in speed were found at the other four locations.

The study results also indicate that neither of the enhanced sign systems harmed the drivers or negatively influenced their approach speeds to the grade crossings. For the LOOK FOR TRAIN AT CROSSING enhanced sign system, this was verified by the results of on-site surveys: 54 percent of the survey participants stated that they believed the LOOK FOR TRAIN AT CROSSING enhanced sign system was a good idea. Additionally, 90 percent of survey respondents at the four sites surveyed noticed the flashing lights at the approaches to the railroad-highway grade crossings.

RECOMMENDATIONS

YIELD TO TRAINS Enhanced Sign System

The YIELD TO TRAINS enhanced sign system did not produce a speed reduction at any of the test sites; however, this sign system did not appear to produce any negative results related to driver actions. The results of a previous study and report (TxDOT Project 0-1469, TxDOT Report 1469-2: Enhanced Traffic Control Devices and Railroad Operations for Highway-Railroad Grade Crossings—Second Year Activities) indicated that driver looking behavior may be significantly increased after the implementation of the YIELD TO TRAINS sign system. There is no evidence to suggest that this system would cause a significant decrease in looking behavior. The installation of the YIELD TO TRAINS enhanced sign system is recommended if funds are not available to install any other type of more active device. The device should be used as an interim measure prior to upgrading to more active control.

LOOK FOR TRAIN AT CROSSING Enhanced Sign System

Although before and after speed studies for the LOOK FOR TRAIN AT CROSSING enhanced sign system indicated a speed reduction only on one approach of one study site, on-site interviews indicated that the flashing lights were effective in getting drivers' attention. These results indicate that the LOOK FOR TRAIN AT CROSSING enhanced sign system could be effective as an interim measure prior to upgrading to an active grade crossing. If this enhanced sign system is to be used as an interim measure, it is recommended that:

- Pavement loops should be used rather than infrared sensors (for paved roadways). The infrared sensors were difficult to set to the proper angle, and TxDOT crews are more familiar with pavement loops.
- The LOOK FOR TRAIN AT CROSSING signs should be 48 inches as designed.
- Flashing beacons should be used rather than flashing strobes. The flashing beacons appeared to be more effective in gaining drivers' attention, they were more dependable, and TxDOT crews are more familiar with the installation and maintenance of flashing beacons.

- The system should be used as an interim device until the crossing can be upgraded to active controls.

Other Sign Systems

Results of other current research studies should also be carefully monitored for potential application to passive railroad crossings in Texas.

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