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16. Abstract This report describes a series of evaluations in which ten traffic control devices were evaluated by a total of 978 participants. The traffic control devices evaluated in the project include one regulatory sign, six warning signs, and three other types of signs. The evaluations included four focus group meetings with a total of 19 participants evaluating ten devices, a driver survey with 747 participants evaluating nine devices, and a follow-up survey with 212 participants evaluating five devices. The four focus group evaluations utilized an open-ended question-and-answer format in which participants were allowed to freely discuss and illustrate their ideas. The driver survey and the follow-up survey utilized a multiple-choice question-and-answer format. This report also describes the findings of each of the evaluations conducted, based on age, gender, ethnicity, and education, as well as recommendations and implementation efforts for each of the ten traffic control devices evaluated. The primary recommendations include: retain the current standard for use, adopt the standard word message sign as the preferred sign over the standard symbol sign, adopt an alternative design which demonstrated an improved comprehension, and/or conduct additional evaluations to further study a particular device in more detail.			
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**MOTORIST UNDERSTANDING OF
ALTERNATIVE DESIGNS FOR TRAFFIC SIGNS**

by

Dale L. Picha
Assistant Research Scientist
Texas Transportation Institute

H. Gene Hawkins, Jr., Ph.D., P.E.
Associate Research Engineer
Texas Transportation Institute

and

Katie N. Womack
Research Scientist
Texas Transportation Institute

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The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

The results of this project are a series of recommendations identifying modifications in the design, the education, and/or the continual evaluation regarding several traffic control devices that were identified as having the potential of being misunderstood by Texas motorists. The implementation of the recommendations provided in this report may be instituted through modifications to TxDOT standards, specifically modifications to the *Texas Manual on Uniform Traffic Control Devices*, and through a modification of driver instruction and driver safety curriculum, with specific emphasis on the particular changes that are implemented as a result of the recommendations.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. This project was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, and is not intended for construction, bidding or permit purposes. The engineer in charge of the project was H. Gene Hawkins, Jr., P.E. #61509.

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- Mr. Bob Musselman, Austin Division, Federal Highway Administration

- Tom Newbern, Traffic Operations Division, Texas Department of Transportation
- Mark Olson, Austin Division, Federal Highway Administration
- Sam Pennartz, San Antonio District, Texas Department of Transportation
- Roger Polson, Public Information Office, Texas Department of Transportation
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SUMMARY

Since the late 1970's, the Texas Transportation Institute (TTI) has conducted several research projects for the Texas Department of Transportation (TxDOT) on driver comprehension of traffic control devices. The first two were completed in 1978 and 1981 and identified many traffic control devices that demonstrated a need or potential for improving driver comprehension. The most recent project, Project 1261- *Assessment and Improvement of Motorist Understanding of Traffic Control Devices*, was initiated in 1990. Over the course of the five-year project period, the researchers conducted seven different evaluations of motorist understanding of traffic control devices. Phase I of the project, which took place during the first four years, was devoted to evaluations of 52 existing traffic control devices. The Phase I evaluations included a statewide survey of over 1,700 drivers, two surveys conducted at the Houston Auto Show, a Spanish language survey, and several focus groups. These activities and the resulting recommendations are described in a previous research report. Phase II, conducted during the fifth year of the project and described in this report, was devoted to the development and evaluation of alternative designs for 10 traffic signs.

Phase II activities included the conduct of several focus groups to identify key issues and potential designs for alternative signs, the development of alternative designs for evaluation, the administration of an initial multi-city survey, and the administration of a follow-up survey.

The focus group evaluations consisted of four focus groups involving 19 participants. These participants evaluated ten traffic signs and provided the research team the groundwork on which to develop between two and seven different feasible, alternative sign designs for each device for further evaluation. Chapter II describes the focus group evaluations and the development of alternative designs and Appendix A contains some of the actual sign designs developed by focus group participants.

The major evaluation effort was the Phase II initial survey. This evaluation utilized a self-administered survey, in English and in Spanish, to evaluate driver comprehension of nine existing traffic signs and their corresponding alternative designs. The survey was administered

at driver licensing stations to a total of 747 participants in seven Texas cities. The results of the Phase II initial survey were then used to develop a smaller follow-up survey on five of the nine signs. This Phase II follow-up survey, which was only in English, was administered to 212 drivers in two Texas cities. Chapter III describes both of the surveys and Appendices B and C contain representations of the two survey instruments that were administered at driver licensing stations.

The results of the evaluations were analyzed to distinguish significant comprehension difficulties among various demographic groups. The primary recommendations for each device were based on these results, and include retaining the current standard design due to adequate comprehension levels, adopting the standard word message sign as the preferred sign over the standard symbol sign, adopting an alternative design which demonstrated an improved comprehension, and/or the conduct of further evaluations in order to better understand driver comprehension difficulties. Secondary recommendations are made on some of the devices, and include using a supplemental plaque and/or increasing driver education/training for that particular device. Table S-1 summarizes the evaluations that were conducted for the ten traffic signs and the resulting recommendations.

Table S-1. Summary of Phase II Evaluations and Recommendations

Signs Evaluated		Phase II Evaluations Conducted			No. of Alt. Evaluated ¹		Recommendations
Device Name	Sign Label	Focus Group	Initial Survey	Follow-Up Survey	Initial Survey	Follow-Up Survey	<ul style="list-style-type: none"> ■ Primary Recommendation ○ Secondary Recommendation
Two-Way Left Turn Only	R3-9b	✓	✓		4		<ul style="list-style-type: none"> ■ Retain current standard ○ Increase education
Two-Way Stop Sign Supplemental Plaque	N/A ²	✓	✓	✓	4	3	<ul style="list-style-type: none"> ■ Conduct additional evaluations ○ To be further addressed in TxDOT Project 0-1374
Lane Reduction Transition	W4-2	✓	✓		8		<ul style="list-style-type: none"> ■ Use standard word message sign³ ■ Adopt alternative word message sign ■ Retain current standard ○ Use supplemental plaque
Narrow Bridge	W5-2a	✓	✓	✓	5	3	<ul style="list-style-type: none"> ■ Use standard word message sign³ ○ Increase education
Slow Down on Wet Road ⁴	W8-5	✓	✓	✓	4	3	<ul style="list-style-type: none"> ■ Adopt alternative design ■ Conduct additional evaluations
Truck Crossing	W11-10	✓	✓	✓	6	3	<ul style="list-style-type: none"> ■ Use standard word message sign³ ■ Retain current standard ○ Use supplemental plaque
School Advance	S1-1	✓	✓	✓	4	3	<ul style="list-style-type: none"> ■ Adopt alternative design for school area ■ Use suppl. plaque for advance crossing ■ Conduct additional evaluations
End School Zone	S5-2	✓					<ul style="list-style-type: none"> ■ Retain current standard
Railroad Advance Warning	W10-1	✓	✓		4		<ul style="list-style-type: none"> ■ Retain current standard ○ Use supplemental plaque
Parallel RR Advance Warning	W10-3	✓	✓		4		<ul style="list-style-type: none"> ■ Retain current standard ■ Adopt alternative design ○ Use supplemental plaque

Notes:

- ¹ Includes the existing standard sign.
- ² There is no standard sign for indicating this condition.
- ³ The standard word message sign is preferred over the standard symbol sign.
- ⁴ This sign is labeled **Slippery When Wet** in the National MUTCD.

CHAPTER I
INTRODUCTION

Traffic control devices are intended to promote safe and uniform operation of motorized and non-motorized traffic using the roadway. As shown in Table I-1, there are three basic types of traffic control devices, which include signs, markings, and signals, as well as several subtypes for each basic type. The most common subtypes of signs can be functionally classified as regulatory signs, warning signs, and guide signs (1). These types of signs use various shapes, colors, symbols, and/or words to relay necessary information to roadway users. Motorists rely on traffic control devices to provide information about traffic laws and regulations to identify potential roadway hazards, and to provide information to help find their desired destinations.

Table I-1. Types of Traffic Control Devices

Basic Type	Description	Most Common Subtypes¹
Signs	Devices mounted on a post or overhead structure which provide road users with information about traffic laws/regulations, potential hazards on or adjacent to the roadway, guidance information to direct road users to destinations, or general information about services and points of interest	Regulatory Signs
		Warning Signs
		Guide Signs
Markings	Devices placed on or adjacent to the roadway which are used to direct road users along an identified path or away from potential hazards.	Pavement Markings
		Object Markers
		Delineators
Signals	Electrically powered devices which are used to control the movement of vehicles and pedestrians at an intersection, to warn road users of potential intersection conflicts, or to identify the proper use of reversible traffic lanes.	Traffic Control Signals
		Pedestrian Signals
		Intersection Beacons
		Lane-Use Control Signals

Note: ¹ Other subtypes may also exist.

COMPREHENSION OF TRAFFIC CONTROL DEVICES

There are many factors that contribute to the effectiveness of traffic control devices, including understandability, recognition time, conspicuity, legibility distance, and learnability. There are also several basic requirements for traffic control devices set forth by the *Texas Manual on Uniform Traffic Control Devices (TMUTCD)* (1), including a requirement that traffic control devices must convey a clear, simple meaning. Traffic control devices serve little purpose if they are misunderstood. Therefore, motorist understanding of traffic control devices is an important element in the overall effectiveness of traffic control devices.

Driver confusion, misunderstanding, and lack of familiarity with traffic control devices may be attributed to several factors, such as the increasing complexity of the driving task in urban areas, the introduction of new traffic control devices from time to time, changes in the use of traffic control devices, and the limited explanation of traffic control devices given in the driver education and licensing process. Two other factors affecting understanding, especially in Texas, are the increasing age of the driver population and the increasing proportion of non-English speaking drivers in the State.

State and local agencies responsible for traffic control devices should consider the factors listed above in providing traffic control devices that motorists can comprehend, as well as avoiding the use of non-standard or non-uniform application of traffic control devices on the roadway. Motorists must be able to read, understand, and learn the meaning of the traffic control devices they encounter while driving, so that they can make proper driving responses.

Several traffic control devices identified in previous and ongoing studies have the potential of being misunderstood by a portion of Texas motorists. Improving the understandability of these devices, either through driver education or traffic control device modification, will result in a safer and more efficient driving environment.

This research project is one of a series of projects on motorist understanding of traffic control devices that TxDOT has sponsored over the years in an effort to provide an effective, efficient, and safe transportation system.

PROJECT OBJECTIVES

In 1990, the Texas Transportation Institute began a TxDOT-sponsored research project on motorist understanding of traffic control devices. The first four years (Phase I) of the project focused upon evaluations of current traffic control devices. The fifth year of the project (Phase II) was conducted to measure and assess how well motorists understand the meaning of alternative designs of several traffic signs evaluated in Phase I. The objectives for Phase II were to:

- Identify traffic control devices which have the potential for driver misunderstanding, as indicated in previous research;
- Evaluate the understanding of these selected devices and conduct a “sign design” process using a small sample of Texas drivers to develop alternative designs for each device;
- Develop feasible alternatives for these devices for further evaluation;
- Measure driver understanding of selected devices, as well as alternatives developed for each, using a diverse sample of Texas drivers;
- Evaluate driver understanding as a function of the following characteristics:
 - ▶ Age;
 - ▶ Sex;
 - ▶ Education;
 - ▶ Ethnic background; and
 - ▶ Geographic region;
- Further develop sign design alternatives and conduct additional evaluations of certain devices in order to refine the assessment of driver understanding; and
- Develop recommendations for improving driver understanding of the selected traffic control devices, based on the results of all evaluations.

RESEARCH APPROACH

A number of research activities were conducted during Phase I of the project, and the results of these activities helped establish the objectives for the Phase II activities. Three reports describe the research activities conducted during Phase I and the results of those activities (2, 3, 4). Because of the importance of Phase I to Phase II activities, a brief summary of Phase I is presented below.

Phase I - Evaluation of Existing Traffic Control Devices

During the first four years of Project 1261, *Assessment and Improvement of Motorist Understanding of Traffic Control Devices*, several evaluation methods were used to assess motorist understanding of a total of 52 different traffic control devices. The major research effort during this time period was a statewide survey conducted during the first two years of research activity. Follow-up surveys and focus group evaluations were conducted during the second and third years of the research project. The activities, results, and recommendations summarized below are described in more detail in three previous research reports (2, 3, 4).

Statewide Survey

The major effort of the research for this project was the development and administration of a statewide survey to assess driver comprehension of 46 traffic control devices. The survey instrument was a 17-minute video administered to 1,745 drivers at driver licensing stations in 12 Texas cities. Two images were shown for each of the 46 devices; the first image was an in-context picture depicting the device and the roadway condition, and the second image was a close-up picture of the device, with four possible comprehension response choices. The development of the initial statewide survey is described in one report (2) and the results are described in a second report (3).

Follow-Up Evaluations

The results of the statewide survey indicated that additional evaluations were necessary for several of the traffic control devices. Therefore, four follow-up evaluations were conducted. These evaluations included two Auto Show surveys, a Spanish language survey, and focus groups. Typically, the devices included in the follow-up evaluations were selected because previous evaluations demonstrated that drivers do not fully understand one or more of the messages conveyed by the devices. One of the follow-up evaluations (the Spanish-language survey) addressed all 46 of the devices included in the statewide survey. A total of 16 traffic control devices were evaluated in the other three follow-up evaluations. Five of the 16 had not been included in the statewide survey. Alternative designs were evaluated for five of the 16 devices. The results of these follow-up evaluations are described in the fourth-year report (4).

1992 Auto Show Survey. The first follow-up evaluation was a survey administered at the 1992 Houston Auto Show. The survey instrument consisted of a close-up image of a traffic control device with a comprehension-type question; eight of the ten questions used a multiple-choice format, one question used a True/False format, and one question was an open-ended question format. Alternative designs were evaluated for four of the ten devices. The survey was administered to 322 participants.

1993 Auto Show Survey. The second follow-up evaluation was conducted for 286 participants at the 1993 Houston Auto Show. The survey instrument was similar to the previous follow-up evaluation, but only five devices were evaluated, and each question was an open-ended format. Each of the participants were asked to explain the meaning of, or appropriate driving response to, the sign.

Spanish Language Survey. In order to assess the relationship between primary language and understanding of traffic control devices, the statewide survey instrument was administered to drivers who spoke Spanish as their primary language. Before administering the Spanish language survey, the survey video was translated to Spanish. The images and the response choices presented in the video, however, remained in English. A Spanish-speaking surveyor administered the survey to 31 drivers in Eagle Pass, Texas, which was one of the cities included in the statewide survey.

1993 Focus Groups. Three focus groups were conducted in order to elicit driver opinions about three different traffic control devices and potential alternative designs or uses of these devices. Ten drivers participated in each of the focus groups, which were held in College Station, Rockport, and Somerville, Texas.

Results and Recommendations

Recommendations for improving motorist understanding of several traffic control devices were made based on the findings of the evaluation surveys and focus group discussions. The recommendations made for the devices typically included one or more of the following: no change, a change in the use of the device, adding a description of the device to the *Texas Drivers Handbook* (TDH) (5), revising the existing TDH description of the device, increasing emphasis in driver education curriculums, development of a public information campaign on traffic control devices (developed as the “Vital Signs” campaign), or conducting additional research during the fifth year to develop alternative designs or uses for the device. These recommendations are provided in the fourth-year research report, *Motorist Understanding of Traffic Control Devices: Study Results and Recommendations* (4).

Phase II - Fifth Year Evaluation of Alternative Traffic Control Devices

The purpose of Phase II was to determine if changes in the design/appearance of selected traffic signs would improve driver comprehension of the signs. During the course of Phase II, three evaluation methods were employed to meet the project objectives previously described. A focus group evaluation process was used to elicit driver input on ten different traffic control devices and measures to improve the comprehension of these devices. An initial survey was conducted to assess driver comprehension of nine of these devices, as well as several alternatives developed for each, and a follow-up survey, on a more limited basis, was used to evaluate five of these devices. Table I-2 indicates the devices that were addressed in each of the three evaluations.

Phase II Focus Group Evaluations

The initial effort of the fifth year was to conduct several focus groups to elicit driver input on ten traffic control devices, nine of which are standard signs listed in the *TMUTCD* (1) and one that is a non-standard supplemental traffic control treatment. These ten devices were recommended from previous research on this project to further evaluate alternatives that could potentially improve motorist comprehension of the device (4). The research team conducted four

Table I-2. Devices Evaluated During Phase II Research

Type of Device	Device Name	Sign Label	Phase II Evaluation		
			Focus Groups	Initial Survey	Follow-Up Survey
Regulatory Signs	Two-Way Left Turn Only	R3-9b	✓	✓	
	Two-Way Stop Sign Supplemental Plaque	N/A ¹	✓	✓	✓
Warning Signs	Lane Reduction Transition	W4-2	✓	✓	
	Narrow Bridge	W5-2a	✓	✓	✓
	Slow Down on Wet Road ²	W8-5	✓	✓	✓
	Truck Crossing	W11-10	✓	✓	✓
School Signs	School Advance Sign	S1-1	✓	✓	✓
	End School Zone Sign	S5-2	✓		
Railroad Signs	Railroad Advance Warning	W10-1	✓	✓	
	Parallel Railroad Advance Warning	W10-3	✓	✓	

Notes: ¹ There is no standard sign for indicating this condition.

² This sign is labeled **Slippery When Wet** in the National MUTCD.

focus group meetings with a total of 19 participants. Three of the meetings were held in College Station, Texas, and one was held in Hearne, Texas. The participants viewed images of ten roadway scenarios. Each scenario corresponded to one of the ten devices evaluated. The device, however, was not visually presented in the scenario, and the participants were asked to illustrate what they considered to be the correct device, and then to develop alternative designs that may improve driver comprehension of that scenario. Chapter II describes the focus group process and the results. Samples of several of the alternative designs illustrated by the participants are presented in Appendix A.

Phase II Initial Driver Survey

As a result of the analysis of the focus group data, several alternative designs were developed for nine of the ten standard devices. The nine devices and the alternatives developed for each, a total of 43 devices, were interpreted by 747 drivers in seven Texas cities. The survey instrument was a multiple-choice questionnaire in which the driver was shown an in-context image and a close-up picture of the device and asked to choose the most correct response to a comprehension-type question. Both English and Spanish versions of the instrument were

developed. The research activities associated with the development of the survey instrument and survey methodology, as well as the results of the survey, are presented in Chapter III of this report. Appendix B contains the images that were presented to survey participants for each device. It also indicates the percentage of drivers who selected each of the response choices.

Phase II Follow-Up Driver Survey

The comprehension results of the initial survey indicated that for a few of the devices, particular design alternatives were more effective than others and necessitated further evaluation. Therefore, a follow-up survey was conducted. Five of the original ten standard devices were evaluated in order to identify the alternative that demonstrated improved comprehension levels. A total of 15 devices, which consisted of three design alternatives for each of the five standard signs, were evaluated by 212 drivers in two Texas cities. The multiple-choice survey instrument was similar in format to the initial survey. Participants were shown an in-context image and close-up picture of each device and were asked to choose the most correct response to a comprehension-type question. The design alternatives for each device were either the same as previously evaluated or consisted of a combination of sign elements from the alternatives in the initial survey. The research activities associated with this follow-up evaluation are described in Chapter III of this report. Appendix C contains the images that were presented to the survey participants for each device as well as the percentage of drivers who selected each of the response choices.

Results and Recommendations

The results of the project evaluations were used to develop recommendations for improving motorist understanding of the ten traffic control devices targeted for improvement. The primary recommendations made for each device include one or more of the following: retain the current standard design due to adequate comprehension levels, adopt the standard word message sign as the preferred sign over the standard symbol sign, adopt an alternative design in order to improve comprehension levels, and/or conduct additional evaluations in order to better understand driver comprehension difficulties and other factors relevant to the use of the device. Chapter IV summarizes the findings and recommendations for each of the devices evaluated in the project.

Implementation Activities

The results of this research aid in the identification of implementation activities that can be instituted by TxDOT in order to improve motorist understanding of ten traffic control devices evaluated. Specific implementation activities, described in Chapter IV, may be instituted through modifications to TxDOT standards, specifically to the *Texas Manual on Uniform Traffic Control Devices*, through a modification of driver instruction and driver safety curriculums, and/or through further research support in the evaluation of the comprehension difficulties associated with particular devices.

Summary

The project recommendations associated with this research are presented in Chapter IV of this report.

USE OF METRIC UNITS IN RESEARCH

This report complies with Phase III of TxDOT's metrication policy. All dimensions are presented in metric units with the exception of sign legend illustrations and references to sign legends, which use customary English units. In the conduct of this research, sign legends were presented to drivers in customary English units. The basis for this use is that standard metric sign legends have not been established and the conversion of traffic signs to metric units has been delayed at least until September 1998 by the Federal Highway Administration.

CHAPTER II

**PHASE II FOCUS GROUP EVALUATIONS AND
DEVELOPMENT OF ALTERNATIVE SIGN DESIGNS**

To assess selected devices for further evaluation, a second phase of focus groups was conducted. The primary objectives of the Phase II focus groups were to evaluate the existing design of the selected traffic control devices and to propose design modifications to these devices that would improve comprehension of each device's meaning. These focus groups allowed for detailed discussion of each of the traffic control devices, and focus group participants were allowed to illustrate and discuss improvements to the current devices with the researchers.

METHODOLOGY OF FOCUS GROUP RESEARCH

A focus group is an interactive discussion between a relatively small number of participants that allows for the development of qualitative data. Researchers often use focus groups to generate ideas and creativity among the participants about a particular item of interest, and is usually related to an on-going research project. Previously referred to as focused interviews, focus groups were originally a social scientist's tool for obtaining research data. There has since been a vast usefulness of focus groups among all research disciplines (6).

Focus groups may be useful during any stage of a research project and are particularly useful for exploratory purposes where little information or opinions are known about the topic of interest. For this reason, focus groups are useful during the beginning stages of research and are often followed by other types of studies, such as surveys, that provide a more quantifiable database of a larger sample size of participants. Focus groups are also useful for analyzing large-scale, quantifiable surveys and providing in-depth analysis of survey responses (6, 7).

The many factors that are involved with focus group research lead to many advantages and disadvantages of taking this approach methodology. Table II-1 summarizes these advantages and disadvantages.

Table II-1. Advantages and Disadvantages of Focus Groups

<p>Advantages</p>	<ul style="list-style-type: none"> • Gathers data quickly and at less cost than other research methodologies • Generates hypotheses when little is known • The researcher is able to interact with the subjects directly, providing opportunities for clarification or follow-up questions • The group can build upon each others comments and responses, and possibly tap into data or ideas that would not have been impossible in other research methods • Data can be obtained from children or other illiterate participants • Dramatically reduces the distance between the respondent who produces the research information and the client who uses it
<p>Disadvantages</p>	<ul style="list-style-type: none"> • Small numbers or respondents limit the generalization to a large population • Interaction with other respondents and the researcher makes the data dependant on one another and possibly biased to a dominant respondent • The nature of the interaction may lead the researcher to place greater faith in the findings than is actually warranted • Reducing the data, or summarizing the results, is difficult • The moderator may bias the results by knowingly or unknowingly providing cues

Source: References (6, 7)

OBJECTIVE OF PHASE II FOCUS GROUP EVALUATION

During Phase I of Project 1261 - *Assessment and Improvement of Motorist Understanding of Traffic Control Devices* (4), a statewide survey was conducted at several state driver licensing stations, follow-up evaluations were conducted for two consecutive years at the Houston Auto Show, a Spanish language survey was conducted in conjunction with the statewide survey, and three focus groups were conducted. The results of the survey and follow-up evaluations, with additional input from the research team and the technical panel, identified several devices in need of further study and evaluation. The objective of the Phase II focus groups was to discuss these devices to gain an understanding of the key issues associated with each one. The researchers wanted to know if drivers knew and understood the current devices and the key situational elements the devices address, and if they could suggest improved communication methods for conveying the intended message of a device.

FOCUS GROUP ADMINISTRATION

A total of four focus group meetings were held, and a total of 19 drivers of different driving backgrounds participated in these four groups. Two members of the research team served as the meeting coordinators. Each meeting was divided into two sessions, each lasting

approximately one hour. The first session, the visual demonstration session, allowed each participant to recall ten current sign designs, and allowed time for each participant to individually create alternative signs that would be an improvement over the current signing practice. The second session, the discussion session, was an interactive session in which each participant was invited to share ideas regarding improvements for each of the ten devices.

Introduction and Explanation of Project Objective

Prior to the first session, the two meeting coordinators began with introductions of each of the participants. A brief explanation was given concerning the project's objective and the objective of the focus group. It was explained that ten different traffic signs and situations had been identified by previous research efforts of the Texas Transportation Institute, and that these ten situations were to be presented to them for their evaluation and discussion. The expectations of the participants during the focus group and the compensatory agreement that was arranged prior to the participant's arrival were also discussed.

Each person then received a packet of material that would be necessary for his or her participation in the focus group. The packet contained a brief overview of the project and its objectives, a consent form, two sample data sheets, two data sheets for each of the ten traffic scenarios, and a demographic information sheet. The two data sheets for each scenario were for illustrating the current sign and for developing an alternative or improved sign design, respectively.

Session I - Visual Demonstration and Written Evaluation

After introductions, the meeting coordinators began the first session with a slide presentation for the research participants to view. The presentation included 12 slides of ten different traffic situations. For each slide, one of the meeting coordinators read a brief, but general, description of the traffic situation and then asked each participant to recollect and illustrate the sign that is currently used for that particular situation shown on the slide. The slides did not show the sign in the picture; the participants had to remember the current signing practice.

Before beginning the actual evaluation, a sample traffic situation was presented to the participants to provide an example of what to expect during this session of the focus group. A sample traffic situation was presented, and in each of the packets, the first of two sample data sheets illustrated what the current sign was for that situation. The second sample sheet illustrated alternative or improved sign designs that were actually developed by other focus groups.

After illustrating or attempting to illustrate the current sign, the participants were asked to continue by developing an alternative sign that would be an improvement over the current sign design. If participants could not remember the current sign, they were asked to place an “X” on the page and to proceed to the next page. Each participant was asked to develop at least one new sign that would be easier to comprehend by the general driving public. In order to identify improved sign symbols, the participants were asked to develop at least one symbol sign (no words) during this process. Participants were encouraged to be creative with their proposed alternatives, but they were not required to participate in the illustrative tasks.

After all ten scenarios were completed, basic demographic data was provided by each participant, and each participant was allowed to take a 10-minute break. During the break, members of the research team prepared for the remaining session. Since the remaining session required dialogue and discussion among the participants and the research team, the meeting coordinators browsed each participants’ proposed alternatives during the break so as to facilitate conversation in the second session.

Session II - Discussion and Oral Evaluation

The second session, coordinated by one member of the research team, involved a “round-table” discussion of each of the ten traffic situations. Each participant was asked to discuss his or her individual improvements to the current sign, and was allowed to debate and dispute the other participants’ ideas and comments. For documentary and summary purposes, each discussion session was audio-recorded. Since each participant was to remain anonymous, the sessions were not video-recorded.

Summary

No formal summary of the meeting was provided for the participants. After the discussion of the tenth and final traffic scenario and each participant's alternative sign design, the meeting concluded. The participants were thanked for their time and effort, and were each compensated \$15.00 for the two hours of participation.

FOCUS GROUP PARTICIPATION

A total of 19 volunteer drivers participated in the four focus groups. Both male and female participants were involved; the age range was from 18 to 91. The participants also represented diverse backgrounds in education level and driving experience. Table II-2 summarizes the demographic data for the four focus groups.

Table II-2. Demographic Data for Phase II Focus Groups

Characteristics		Number
Age	16 to 24	8
	25 to 54	7
	55 to 64	2
	+65	2
Gender	Male	8
	Female	11
Ethnicity	Anglo	17
	Hispanic	1
	African American	0
	Other(American Indian)	1
Education Level	Less Than High School	3
	High School (or Equivalent)	5
	Some College	8
	College Graduate	3
Total		19

SELECTION OF DEVICES FOR EVALUATION

Ten traffic scenarios and the traffic control devices accompanying these scenarios were evaluated by the four focus groups. These signs were chosen from a total of 52 different traffic control devices evaluated by a total of 2,414 Texas drivers in Phase I of the research project. Each device was previously studied in either a statewide survey, a follow-up evaluation survey, a Hispanic driver population group survey, or the Phase I focus groups. The devices chosen for Phase II represented ones that drivers had the most difficulty understanding, ones that the research team and the technical panel identified as probable contributors towards driver confusion, or both. Table II-3 lists the ten traffic control devices selected for Phase II evaluation and the types of evaluations conducted for each device in Phase I.

Table II-3. List of Traffic Control Devices Evaluated and Previous Evaluations

Type of Device	Device Name	Sign Label	Phase I Evaluations			
			Statewide Survey	Auto Shows		Focus Groups
				1992	1993	
Regulatory Signs	Two-Way Left Turn Only	R3-9b	✓	✓		
	Two-Way Supplemental Plaque	N/A ¹	✓ ²	✓ ²		✓ ²
Warning Signs	Lane Reduction Transition	W4-2	✓		✓ ³	✓
	Narrow Bridge	W5-2a	✓			
	Slow Down on Wet Road ⁴	W8-5	✓	✓		✓
	Truck Crossing	W11-10	✓			
School Signs	School Advance	S1-1		✓		
	End School Zone	S5-2	✓ ⁵			
Railroad Signs	Railroad Advance Warning	W10-1	✓	✓		✓
	Parallel RR Advance Warning	W10-3	✓			

Notes: ¹ There is no standard sign for indicating this condition.

² Understanding of the difference between two- and four-way stop controlled intersections studied.

³ Lane Ends Merge Left sign (W9-2) evaluated.

⁴ This sign is labeled **Slippery When Wet** in the National MUTCD.

⁵ Understanding of the end of a School Speed Limit evaluated.

SUMMARY OF FOCUS GROUP RESULTS

A qualitative assessment of the data from the four focus group meetings was conducted to identify reasonable, alternative sign designs developed by the participants. The difficulty that always exists in assessing focus group data is that the data is “subjective” in nature and that it is only from a very small sample size of the general driving population. Therefore, a careful review of the audio recordings and the illustrations was conducted in order to develop a “summary” of alternative sign designs. Three steps were performed in order to accomplish this task, and are listed as follows:

1. Review the audio recordings of each focus group meeting. A summary of each focus group was then prepared that included critiques, comments, and suggestions of the ten traffic control devices that were evaluated. The summary specifically incorporated the issues that pertained to difficulty in comprehending the intended meaning of the device.
2. Evaluate the alternative sign designs of each of the ten traffic control devices that were developed and illustrated by the participants and quantify the frequency in which individual sign elements appeared in the illustrations.
3. Develop alternative sign designs based on a summary of the participants’ comments and illustrations, but more importantly, consistent with the sign elements identified in greater frequencies by the participants.

RESULTS FOR INDIVIDUAL DEVICES

The following is a summary of the focus group discussions and the alternative designs developed. Each section summarizes the comments and suggestions made by the participants for each of the devices, specifically the comprehension difficulties, the elements that appeared in the improved designs, and the alternative signs developed by the research team. The alternative signs presented are either original in format (as developed by the participants), are composite alternatives (developed by the research team which combines the ideas of the focus group participants), or are signs currently being researched or utilized by other agencies that were considered practical alternatives.

Therefore, the alternatives not only represent a result of the focus group meetings, but also efforts by the research team to identify alternative sign designs currently being researched or utilized by other local and state agencies and countries. Several state and national MUTCDs and Sign Manuals were obtained from various state agencies and countries, as well as documented research findings, brochures, and pamphlets. Combining the findings from other MUTCDs with the focus group findings, the research team identified proposed alternatives for further testing.

An important consideration in the development of the proposed designs was that the alternatives incorporate sign features that were considered improvements by the participants in the focus groups. However, because focus group results are not generalizable to the population at large, whether or not these alternatives are improved designs can only be determined through further research efforts.

The results also identified the number of drivers who were able to correctly draw the current sign prior to discussing various alternatives. The interpretation of whether the drawing of the current sign is correct is a subjective evaluation. The researchers considered only the sign legend in determining whether a driver knew the correct sign. Shape was not considered a factor. In order to be considered correct, a driver had to correctly draw a majority of the sign legend elements. Some leeway was provided with respect to proportion and layout if it appeared that the driver recalled the basic aspects of the current sign. Table II-4 summarizes the results of the current sign recall portion of the focus groups. As this table shows, a significant portion of the drivers were not able to draw an image for any of the signs. Even when using a generous interpretation of a correct sign, no more than a third of the drivers were able to correctly draw the image for any of the existing signs. However, a significant portion of the participants were able to draw some key feature of the existing sign, even if the image they drew was incorrect.

Table II-4. Summary of Driver Recall of Current Sign

Device Name	Label	Percent Drawing Each Type of Image for Current Sign						Incorrect, but Drew Key Feature
		No Image	Correct		Incorrect			
			Symbol	Text	Symbol	Text	Symbol & Text	
Two-Way Left Turn Only	R3-9b	42				21	11	26 ¹
Two-Way Supplemental Plaque	N/A	No Existing Sign						
Lane Reduction Transition	W4-2	32	11	11	16	5	5	21 ²
Narrow Bridge	W5-2a	42		32	11		11	5 ³
Slow Down on Wet Road	W8-5	21	21			11	11	37 ⁴
Truck Crossing	W11-10	53	21	5		11	11	
School Advance	S1-1	53	21			11	5	11 ⁵
End School Zone	S5-2	26		16	5	21		32 ⁶
Railroad Advance Warning	W10-1	26	16		26		11	21 ⁷
Parallel RR Advance Warning	W10-3	68	11		11	11		

Descriptions of Key Features:

- ¹Opposing left turn arrows.
- ²Correct symbol but words included.
- ³Constriction symbol with words.
- ⁴Words “slippery when wet.”
- ⁵School speed limit sign.
- ⁶Right words in the wrong order.
- ⁷Crossbuck image

Two-Way Left Turn Only Sign (R3-9b)

Two-way left turn lanes (TWLTLs) are often used in urban areas to provide continual left-turn access to adjacent properties and as a flush median to separate opposing traffic flows. The **Two-Way Left Turn Only** sign (R3-9b) “*should be used in conjunction with the required pavement markings where a lane is reserved for the exclusive use of left turning vehicles in either direction and is not used for passing or overtaking*” (1).

The two-way left turn lane is indicated with yellow pavement markings shown in Figure II-1 and is typically accompanied by the **Two-Way Left Turn Only** sign shown in Figure II-2. This is the post

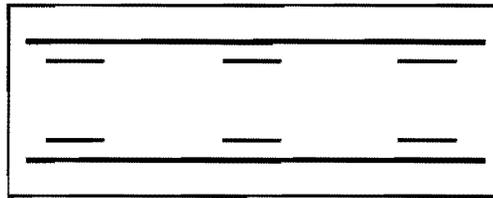


Figure II-1.
Two-Way Left Turn Markings



Figure II-2.
R3-9b Sign

mounted version of the sign. An overhead version (R3-9a) excludes the words **CENTER LANE** from the sign. Both the R3-9b sign and the markings were evaluated in the statewide survey, and R3-9b was further evaluated in the 1992 Auto Show survey (4).

Phase I Recommendations

Results from the first four years of the project indicated that drivers do not have a thorough understanding of “*how two-way left turn lanes should be used*” (4). A comparison of driver comprehension of R3-9b symbolic and word message versions of the sign indicated that one sign was no more significantly effective than the other. Additional research was recommended to evaluate whether an alternative design would better convey the desired message (4). The Phase I recommendations also suggested that driver education/training programs and the *Texas Drivers Handbook* might be revised to address the use of two-way left turn lanes. As a result of these recommendations, this sign was selected for an initial evaluation in the focus groups of Phase II.

Phase II Focus Group Evaluation

In the focus groups, the participants were shown a picture of a five-lane roadway which included a two-way left turn lane. The description explained that the turn-lane in the “middle” of the roadway can be used by traffic going in either direction to make left turns, but could not be used for passing purposes. It was also explained that drivers should be aware of on-coming vehicles. The participants were then asked to illustrate the current sign used to inform drivers that this lane is used only for left-turning vehicles traveling both directions. Once they attempted the current illustration, they were asked to develop and illustrate improved word message or symbol signs that would better convey the desired message. A concerted effort was made by the

moderator to not use the words “center lane” during the description. The use of this phrase would have possibly influenced the participants’ illustrations.

Eight of the 19 drivers were not able to draw any image for the current sign used for this application. Of the remaining 11 drivers, four provided incorrect text, two drew an incorrect combination of symbols and text, and five incorrectly drew head-on left turn arrows. These five drivers probably have some recall of the correct sign, but were not able to draw the arrows correctly.

The operation of a two-way left turn lane (TWLTL) was considered potentially unsafe by many of the participants in the focus groups. The fact that TWLTLs are “two-way” lanes was the foundation for this belief, and it was on this concept that much of the criticism was based. In fact, many of the comments favored the elimination of TWLTLs altogether rather than attempting to improve the current sign (R3-9b). If not eliminated, the minimum improvements should include limiting left-turn access points along the roadway and changing the sign from a rectangular-shaped regulatory sign to a diamond-shaped warning sign, as well as changing the colors from black-on-white to black-on-yellow.

Development of Alternative Designs

Despite criticism in the discussions, however, participants suggested improvements to the current sign to make the device more comprehensible. The illustrative suggestions focused on modifying the word message on the current sign from **CENTER LANE ONLY** to **CENTER LANE TURN ONLY**; nearly 70 percent of the improved signs included the words **ONLY** or **TURN ONLY**. Other high frequency sign elements that appeared in many of the illustrations included “pavement markings” (58 percent) and head-on left turn arrows (63 percent). Figure A-1 in Appendix A presents four typical alternative designs developed by the participants.

The current sign and the three alternatives developed from the focus group input are shown in Figure II-3. Alternatives 2 and 3, both symbol signs, are very similar to the standard sign, the only changes being the addition of **ONLY** to both signs and the addition of the “pavement markings” to one sign. A word message version of the sign was also developed (Alternative 4). This is the original version of this sign as it was originally introduced in the

1970's (8). The word message alternative had been previously tested in one of the Phase I Auto Show surveys and had been found to have a slightly higher comprehension level than the standard sign, and the researchers proposed to test the sign with a more representative sample.

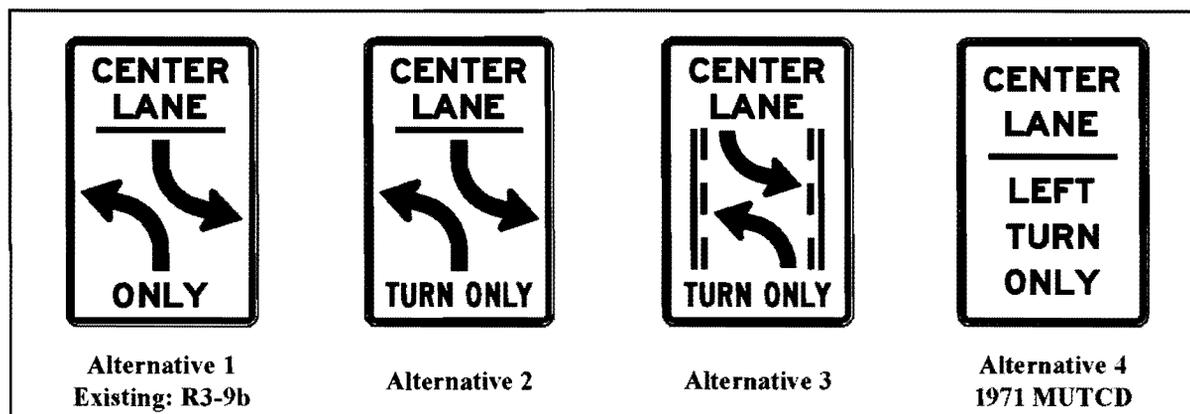


Figure II-3. Alternative Designs for the Two-Way Left Turn Only Sign

Supplemental Sign for Two-Way Stop Controlled Intersections

The **STOP** sign (R1-1) is used to stop traffic on either one or both roadways of an intersection. When used to stop traffic on both roadways, the MUTCD indicates that a supplemental plaque “should” be used below the stop sign. This supplementary plaque uses the legend **4-WAY** (R1-3), **3-WAY** (R1-3), or the **ALL-WAY** (R1-4), depending upon the type of multiway stop controlled condition.

The potential for confusion exists when an intersection is signed in such a manner that one or more approaches to the intersection are required to stop, while one or more approaches are not required to stop. A typical scenario is a four-way, 90-degree intersection in which two approaches (e.g., minor roadway) are required to stop and two approaches (e.g., major roadway) are not required to stop. A scenario such as this is not considered a “multiway” stop. Therefore, no specific warrants or signs are specified for a “two-way” stop controlled intersection. However, a lack of understanding of the two-way stop condition could lead a driver on the minor road to enter the intersection under the assumption that an approaching vehicle on the major street will stop, when, in fact, it doesn't. Some state and local agencies have become concerned with this possible scenario and have developed word and symbol signs to warn motorists on the minor road that the major street traffic does not stop.

The California Department of Transportation (Caltrans) developed a supplemental word and symbol sign in their state MUTCD (9), which is mounted on the same post and immediately below the **STOP** sign. This **CROSS TRAFFIC DOES NOT STOP** sign (SW1), depicted in Figure II-4, “*may be used to supplement standard signs and markings that have not proven effective at problem intersections where the minor road is STOP sign controlled*” and where the accident history indicates that “*motorists on the minor road, after stopping, assume that traffic on the major road will also stop*” (9). It is also used (“*may*” condition) for a limited time at intersections that have been converted from a four-way stop to a two-way stop control (9).

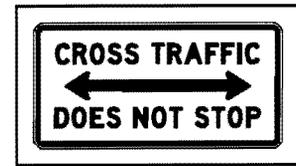


Figure II-4.
California Plaque
for Two-Way Stop

The Minnesota Department of Transportation (MnDOT) developed a slightly different alternative for a two-way stop controlled intersection. The **CROSS TRAFFIC DOES NOT STOP** sign (R1-X2), depicted in Figure II-5, is a word message sign used to warn drivers of the cross-traffic operations. It is intended for use “*at those intersections where geometric, topographic or other conditions exist and motorists approaching a STOP sign may expect cross traffic to stop*” (10). Furthermore, the use of the sign “*shall*” be limited to intersections where driver expectations or an engineering study “*indicate a need*” (10). MnDOT also installs this sign on the same post and immediately below the **STOP** sign.



Figure II-5.
Minnesota Plaque
for Two-Way Stop

Other state agencies, as well, have addressed the two-way, stop controlled intersection in their respective state MUTCDs or standard sign manuals. The Illinois Department of Transportation uses the same **CROSS TRAFFIC DOES NOT STOP** sign (R1-I100) as MnDOT (11). The Pennsylvania Department of Transportation uses a word message sign (R1-1B) with the legend **OPPOSING TRAFFIC DOES NOT STOP**. This sign, depicted in Figure II-6, is used when “*opposing...traffic does not have to stop*” (12). Wisconsin uses word message signs (R1-52(A,R,L)) with the legends



Figure II-6.
Pennsylvania
Plaque for
Stop Control

TRAFFIC ON (INTERSECTED HIGHWAY) DOES NOT STOP, **ONCOMING TRAFFIC DOES NOT STOP**, or **TRAFFIC FROM RIGHT (LEFT) DOES NOT STOP** (13). These supplemental word message signs are used “*sparingly*,” usually at locations where motorists “*believe the intersection may be a 4-way*” stop controlled intersection. (13).

Phase I Recommendations

Phase I of the project conducted a limited evaluation of a **2-WAY** supplemental plaque used with a **STOP** sign in the first Auto Show survey and in the Phase I focus groups. The plaque was evaluated with the use of flashing beacons at an intersection. The evaluations indicated that the use of the **2-WAY** plaque may slightly increase understanding of right-of-way assignments at an intersection. Furthermore, the consensus of the focus group participants was that the **2-WAY** plaque below a **STOP** sign was sufficient to convey the message that intersection traffic would not stop (4). The use of the plaque, however, was evaluated also with the use of intersection control beacons. Because flashing beacons are impractical to use at all two-way stop controlled intersections, the use of a supplemental plaque was selected for additional evaluation in Phase II to assess motorist understanding of this device at intersections without flashing beacons.

Phase II Focus Group Evaluation

Participants in the focus group were shown a picture of a four-legged intersection; one approach was a one-way frontage road, controlled by a **STOP** sign. The cross-street movement was not controlled in either direction. The moderator explained that at some intersections, the traffic may be required to stop on one or both of the roads (i.e., two of the four approaches). If **STOP** signs are used only on two approaches of the same road, then drivers on that road may require a warning that the traffic on the other two approaches is not required to stop.

Even though a current sign does not exist in the National MUTCD (14) but does in several state MUTCDs, the participants were asked to illustrate the current sign used to warn drivers that cross-street traffic is not stop controlled. They were then asked to illustrate alternative word message and symbol signs that would improve motorist understanding of the device.

Asking the participants to draw a current sign was somewhat of a “trick” question; it came as no surprise that 11 of the 19 focus group participants were not able to identify a sign used to distinguish a two-way stop from a four-way stop. Of the remaining eight drivers, three

drew some form of a two-way plaque, two drew a form of one-way plaque, two drew a **STOP** sign alone with no plaque, and one drew a plaque with the legend “cross traffic does not stop.”

A difference of opinion existed among the focus group participants about the use of a supplemental sign at two-way stop controlled intersections. A few of the participants believed that the **STOP** sign alone is adequate and that the driver should be responsible for determining when the intersection is safe for crossing. On the other hand, several participants illustrated alternative supplemental plaques to be installed either below the **STOP** sign or in advance of the **STOP** sign in order to convey the meaning that the cross-street traffic is not required to stop.

Development of Alternative Designs

The sign elements that appeared the most frequently in the improved designs were: 1) a plan view of the roadway (40 percent) depicting approaching traffic stopping and cross street traffic continuing through the intersection; and 2) a horizontal, double-headed arrow (35 percent), which is intended to show that the cross traffic is a continuous movement and does not stop. Because of the inherent difficulties in depicting a legible representation of a roadway on a sign, this element was eliminated from further consideration. Other elements, however, that appeared in the illustrations and were considered feasible for further testing included the word messages **2-WAY** (22 percent) and **CROSS TRAFFIC** (17 percent). Figure A-2 in Appendix A illustrates some of the treatments suggested by the focus group participants.

In conjunction with the focus group meetings, several state MUTCDs and Sign Manuals were reviewed to identify existing alternative signs in use at two-way stop controlled intersections in the respective states. The alternative designs developed as a result of the focus groups, as well as similar designs in other state MUTCDs and Sign Manuals, are depicted in Figure II-7. The alternative designs include the California and Minnesota supplemental plaques and a **2-WAY** supplemental plaque.

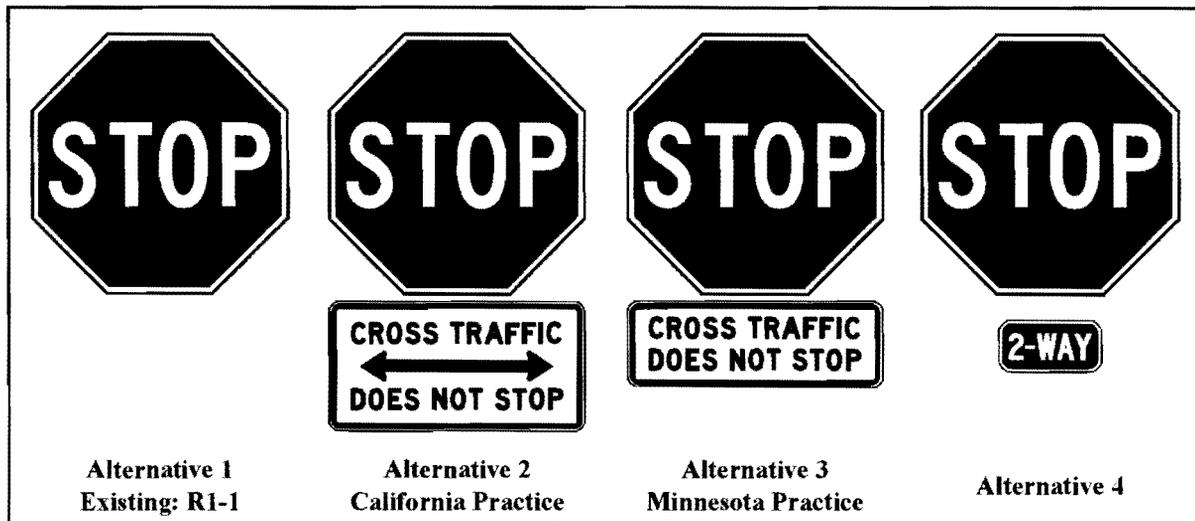


Figure II-7. Alternative Designs for the Two-Way Stop Controlled Intersection Sign

Lane Reduction Transition Sign (W4-2)

There are three different signs that are used to indicate a reduction in the number of lanes in the direction of travel on a multilane highway. These signs are illustrated in

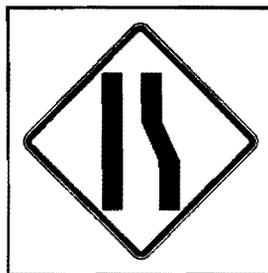


Figure II-8.
W4-2 Sign



Figure II-9.
W9-1 Sign



Figure II-10.
W9-2 Sign

Figures II-8, II-9, and II-10. The word message signs are used to supplement the symbol sign. These signs can also be used with orange backgrounds in maintenance and construction areas to warn drivers of a reduction in the number of lanes (1).

Although the symbol sign (W4-2) is the primary sign used on roadways, all three signs were evaluated in the Phase I evaluations. The symbol sign (W4-2) was selected for evaluation due to several previous studies which indicated that drivers do not understand the intended meaning of the sign. The word message signs (W9-1 and W9-2) were selected for evaluation due to a lack of previous research on these signs and their role in supplementing the symbol sign. The **Lane Reduction Transition** symbol sign (W4-2) and the **LANE ENDS MERGE LEFT (RIGHT)** sign (W9-1) were evaluated in the statewide survey. The **LANE ENDS MERGE**

LEFT sign (W9-1) was also evaluated in the 1993 Auto Show survey. All three signs and some alternative sign designs for the symbol sign were evaluated in the Phase I focus groups (4).

Phase I Recommendations

The results of the statewide survey indicated that less than two-thirds of the drivers selected the correct meaning of the **Lane Reduction Transition** sign, which was “*fewer lanes ahead*” (4). Approximately the same percentage of drivers responded correctly to the **LANE ENDS MERGE LEFT** sign. The responses of the remaining drivers indicated that there was some level of uncertainty about maneuvering the vehicle from the lane they are in to the lane they should be in ahead. This uncertainty over driving response as a function of lane position led the research team to include this sign in the 1993 Auto Show survey (4).

The results of the Auto Show survey found that a majority of drivers chose the correct response on the survey with respect to their lane assignment ahead. The research team previously believed that the word **MERGE** was a contributing factor to driver confusion of the **LANE ENDS MERGE LEFT** sign; however, over 90 percent of the drivers participating in the survey correctly identified the meaning of the word.

During the Phase I focus groups, participants were shown two alternative symbol signs as well as the current **Lane Reduction Transition** sign (W4-2). These three signs are presented in Figure II-11. The results indicated that the participants preferred the current symbol sign over the alternative designs even though some participants did not fully understand the meaning of the standard sign. Because of this, and because a majority of the participants understood the meaning of the word message signs, the research team found it necessary to recommend further research into alternative sign designs for the current symbol sign (4).



Figure II-11. Lane Reduction Transition Sign and Alternatives Evaluated in Phase I Focus Groups

Phase II Focus Group Evaluation

The participants in the focus group were shown a scenario of a two-lane roadway that reduced to one lane ahead. The description of the traffic scenario explained that there are two lanes in the direction of travel, but at some distance ahead, one of the lanes would end and traffic would have to move over to the lane that continued. The moderator also pointed out that if a motorist were to continue driving in the lane that ended, he or she may drive off of the road or *“find themselves trapped without enough space to move over to the continuing lane.”*

The participants were then asked to illustrate the current sign that is used in this type of traffic condition, and to then develop alternative word message or symbol signs that may improve motorist understanding of the device. The moderator avoided the use of the phrases “lane ends” and “merge left (right)” during the explanation in order to avoid influencing the participants.

Four of the 19 participants were able to correctly draw the sign symbol or the word messages (**LANE ENDS MERGE LEFT**, **RIGHT LANE ENDS**). Another four drivers were able to draw a correct symbol, but also included words with the symbol. This indicates that almost half of the drivers have some recall of the symbol used for a lane ending situation. One-third of the drivers were not able to draw any image for this sign.

Many of the focus group participants indicated during the discussion that the current **Lane Reduction Transition** symbol sign (W4-2) does not convey a clear meaning as to what maneuver is expected and when the motorist should expect such a maneuver. The participants

further believed that the current sign does not provide sufficient information as to how many lanes are reduced (i.e., how many lanes end) and how many lanes continue as through-lanes.

Development of Alternative Designs

In the focus group illustrations the “pavement marking” symbol (61 percent) and the word message **LANE ENDS** (36 percent) were the elements with the highest frequency of occurrence. Other elements, such the word message **MERGE** or **500 FEET** (or appropriate distance), as well as an arrow symbol, occurred in approximately 25 percent of the illustrations. Figure A-3 in Appendix A presents four typical alternative designs prepared by the focus group participants. Figures II-12 and II-13 present the alternative designs developed as a result of the focus groups, as well as signs used by other agencies. These alternatives can be roughly grouped into two types — symbolic and word message. The three symbolic alternatives all use some form of “pavement marking” within the symbol. Alternative 2 is the original version of the sign as it was introduced in the 1961 MUTCD (15). Alternative 3 is the Canadian version of this sign (16). Alternative 4 was recently recommended in an FHWA research report (17) on driver understanding of symbol signs. This sign includes both the lane striping and an arrow indicating the need to change lanes.

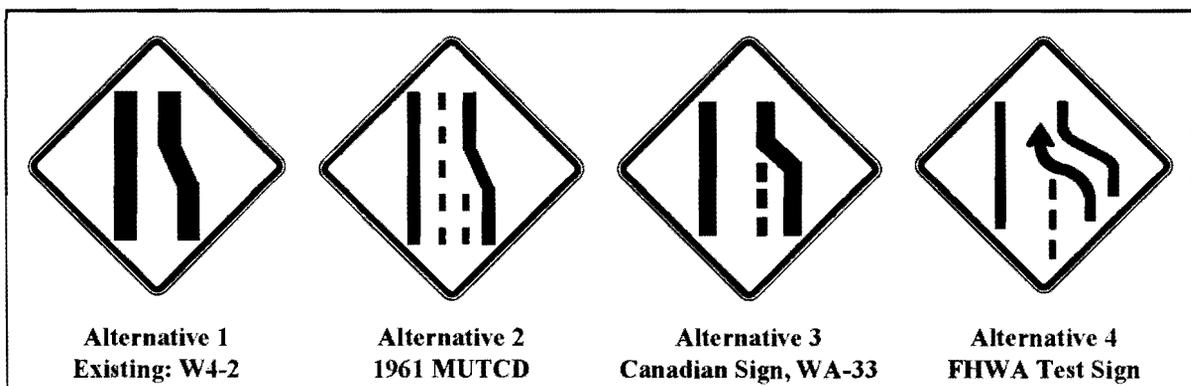


Figure II-12. Symbolic Alternative Designs for the Lane Reduction Transition Sign

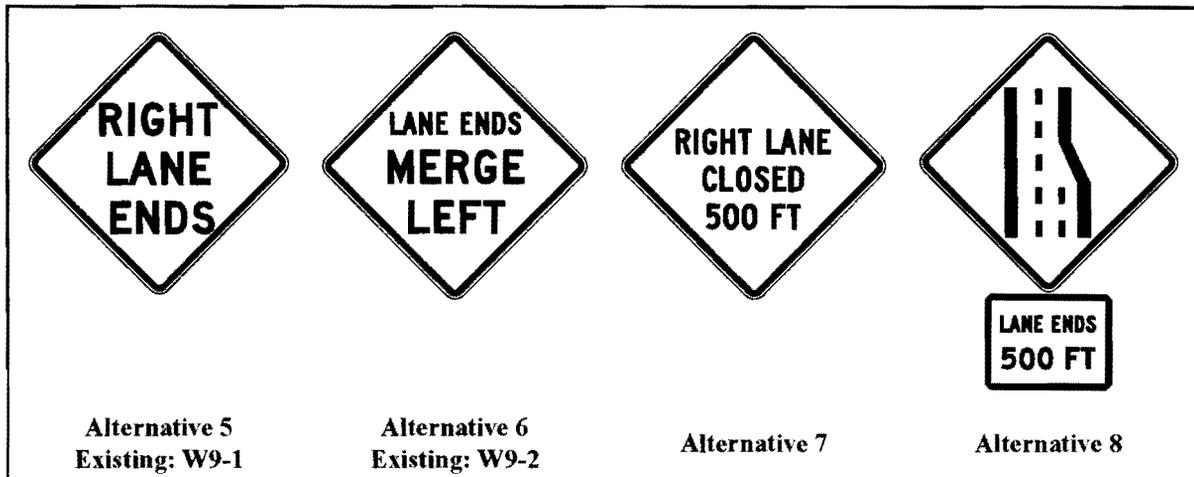


Figure II-13. Word Message Alternative Designs for the Lane Reduction Transition Sign

The word message signs include two current standard signs (W9-1 and W9-2) and two alternative signs. Alternative 7 was taken from the construction and maintenance operations part of the MUTCD. The legend is identical to that used in work zones to indicate a lane closure, but the sign background color has been changed from orange to yellow. The final alternative (Alternative 8) combines an educational plaque with the Alternative 2 sign. More alternatives were developed for this sign than for any other sign in the evaluation.

Narrow Bridge Sign (W5-2a)

The **NARROW BRIDGE** word message sign (W5-2) and the **Narrow Bridge** symbol sign (W5-2a) are intended for use *“in advance of a bridge or culvert having a clear two-way roadway width of 16 to 18 feet or any bridge or culvert having a roadway clearance less than the width of the approach pavement”*

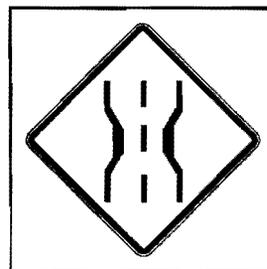


Figure II-14.
W5-2a Sign

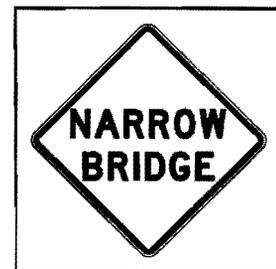


Figure II-15.
W5-2 Sign

(1). Additional pavement markings, delineators, and object markers should be used on or near the structure, where appropriate, to provide further protection for the motorist. Both signs are shown in Figures II-14 and II-15.

The symbol sign (W5-2a) was evaluated in the Phase I statewide survey in order to assess driver interpretation of the number of lanes on the bridge and passing restrictions on the bridge.

The issue raised by the research team was that the stripe in the symbol implied that passing was permitted on the bridge. Furthermore, the sign description in the *Texas Drivers Handbook* implies that the bridge only has two lanes and that drivers should approach with caution (5).

Phase I Recommendations

The results of the statewide survey indicated that over 80 percent of the respondents selected the correct response for the symbol sign. The findings did not identify any major sources of driver confusion for this sign with respect to passing restrictions or the presence of a one-lane bridge. Concerns addressed in other research studies (18, 19, 20, 21), however, suggested that the sign should be further evaluated and that the *Texas Drivers Handbook* should be changed to reflect all of the possible uses of the sign (4).

Phase II Focus Group Evaluation

The participants in the focus group were shown a picture of a bridge with a discontinuous shoulder that terminated at the bridge approach. The explanation indicated that newer bridges typically have similar roadway widths on the bridge as on the approach, but on older bridges, the traffic lanes may be narrower and/or shoulders may not be present. It was also noted that if a driver does not notice the reduced roadway width ahead, serious consequences may be suffered, such as a collision with the bridge abutment.

The participants were then asked to illustrate the current sign that is used in this type of traffic condition, and to develop alternative word message or symbol signs that may improve motorist understanding of the device. The moderator avoided using the phrases “narrower traffic lanes” and “narrow shoulders” during the explanation in order to avoid introducing any biases for the participants.

Six of the 19 drivers were able to correctly draw the sign by using the words **NARROW BRIDGE**. Four drew incorrect symbols or words and another eight were not able to draw any image at all. Many of the participants indicated that the primary misunderstanding of the **Narrow Bridge** symbol sign (W5-2a) was the fact that the sign represents a narrow “roadway,” not a narrow “bridge.” In other words, the sign does not convey a clear meaning that a bridge

ahead has a narrower roadway width. In fact, a few of the participants indicated that the sign could signify construction activity ahead, and that the roadway width could be narrower within this activity.

Development of Alternative Designs

In the illustrative recommendations, the two elements with the highest frequency of occurrence were the “pavement markings” (78 percent) and the “constriction” symbol (74 percent), which is on the current sign. In order to convey a “narrow bridge” theme in the sign, the word message **NARROW BRIDGE** appeared in approximately 60 percent of the drawings. Other elements, such as the word message **SHOULDER ENDS** and a “river” or “stream” symbol, appeared in a smaller percentage of the illustrations. Figure A-4 in Appendix A presents four of the drawings prepared by the drivers in the focus groups. The researchers used the information gained from these sketches to prepare the proposed improvements illustrated Figures II-16 and II-17. The ones presented in Figure II-16 are both existing signs (1). Figure II-17 contains the new alternatives developed for survey evaluation. The word message version of the sign was included as an alternative because of the high proportion of focus group participants who presented it in their sketch of the current sign. Alternative 3 is the Canadian version of the **Narrow Bridge** sign (16). The Canadian sign does not use any “lane striping” and the “constriction” symbol is slightly different from that used in the U.S. sign. Alternative 4 shows a “water stream” crossing below the bridge and Alternative 5 combines the “constriction” symbol and the word message.

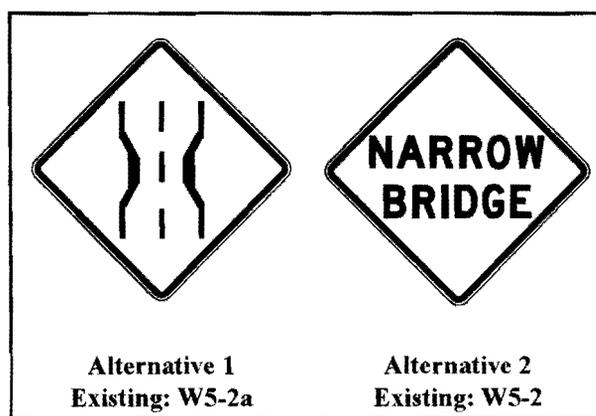


Figure II-16. Current Designs for the Narrow Bridge Sign

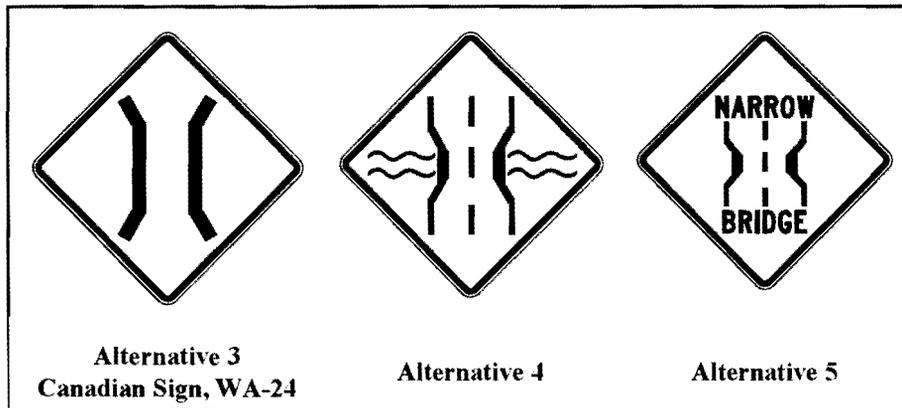


Figure II-17. Alternative Designs for the Narrow Bridge Sign

A large percentage of the illustrations suggest that the dashed “pavement markings” should remain a part of the current symbol sign. According to the participants, the primary justification for illustrating the “pavement markings” was that it represents a centerline between a two-lane, two-way roadway on the bridge. The fact that it represents a two-lane, two-way roadway may diminish previous concerns that the dashed “centerline” would be misinterpreted to indicate that *passing* was permitted on the narrow roadway. The participants in the four focus groups did not express this concern.

Slow Down on Wet Road Sign (W8-5)

The **Slow Down on Wet Road** sign (W8-5) is intended for use to warn of a condition where the highway surface is extraordinarily “*slippery when wet*” (1). In fact, the National MUTCD refers to the name of the sign as **Slippery When Wet** (14). It should be located at the beginning or advance of a “slippery” pavement condition and at intervals along the section to warn drivers of the pavement condition. The sign is shown in Figure II-18.



**Figure II-18.
W8-5 Sign**

During the Phase I evaluations, the sign was evaluated in the statewide survey, the 1992 Auto Show survey, and the focus group surveys. Previous research studies indicated that some drivers associated this sign with the presence of curves on the road (3, 18, 19, 22, 23,) or that drivers believed that slippery conditions existed at all times, not just during wet weather

conditions (18, 19, 20, 23). The focus of the Phase I statewide survey was to evaluate not only this, but to determine if drivers associated this sign with an out-of-control vehicle (4).

The **Slow Down on Wet Road** sign and two alternative designs were evaluated at the 1992 Auto Show. One of the alternative signs included the standard sign with the addition of a **SLOW DOWN ON WET ROAD** plaque underneath the symbol sign, and the second sign was a word message sign with the legend **SLOW DOWN ON WET ROAD** (4). This second alternative is used in Texas as an alternative to the symbol sign



Figure II-19.
W8-5 Sign with
Educ. Plaque



Figure II-20.
Word Message
Alternative Sign
for W8-5

(1). The two alternatives evaluated in the 1992 Auto Show survey are shown in Figures II-19 and II-20.

The standard symbol sign, the **SLOW DOWN ON WET ROAD** word message sign, and a third alternative were evaluated in the focus group surveys. This third alternative sign, shown in Figure II-21, added “raindrops” and a horizontal line to the standard symbol sign. The “raindrops” were intended to reinforce the wet weather message of the sign and the horizontal line was intended to eliminate the confusion with a “winding road” (4).



Figure II-21.
Alternative Symbol
Sign for W8-5

Phase I Recommendations

The results of the statewide survey, the Auto Show evaluation and focus group evaluations indicated many drivers did not fully comprehend the meaning of the standard **Slow Down on Wet Road** symbol sign. The main misconception was the failure by the participants to identify this sign with wet weather implications. The **SLOW DOWN ON WET ROAD** word message sign was better understood than the standard symbol sign, but the language issue associated with the word message was not evaluated. Focus group participants, however, preferred the standard symbol sign (4).

Phase II Focus Group Evaluation

The participants in the focus group were shown a picture of a wet roadway with the explanation that when water accumulates on a roadway due to rain, the section of roadway ahead may become more slick than what might be expected by the motorist. This type of condition requires motorists to reduce their speed to minimize the likelihood of losing control of the vehicle and having an accident.

The participants were then asked to illustrate the current sign that is used in this type of traffic condition when the pavement is wet, and to develop an alternative word message or symbol sign they thought would improve motorist understanding of the device. The moderator avoided the use of the phrases “slippery when wet” and “slippery roadway” during the explanation in order to avoid introducing any biases for the participants.

Four focus group participants were able to correctly draw the symbol version of the sign, four were not able to draw any image, and four drew incorrect images or words. The remaining seven participants used the words **SLIPPERY WHEN WET** alone or in combination with a symbol. This trend appears to indicate that drivers still recall that term, even though it should no longer be used in signs in Texas.

The primary misunderstanding of the **Slow Down on Wet Road** symbol sign, also known as the **Slippery When Wet** sign (14), was the *distance* in which a motorist should expect slick pavement conditions. An operational concern exists if a motorist has the impression that slick conditions only exists for a short segment of the roadway and the motorist does not exercise caution for the extended portion of the slick pavement. Furthermore, a few of the participants believed that the current symbol sign does not achieve the message of emphasizing a slick pavement only during wet weather conditions. Their belief was that motorists may be misled to believe that slick conditions exist at all times.

Development of Alternative Designs

To improve the current symbol sign (W8-5), many of the participants recommended the addition of a word message on the sign or on a supplementary plaque. Word messages with the

words **WET** (79 percent), **SLIPPERY** (32 percent), or **SLICK** (29 percent) occurred the most frequently in the sign illustrations. The “tire mark” symbol used on the current sign occurred in nearly 50 percent of the drawings. Other symbolic improvements included a plan or profile of the roadway (32 percent), a profile of a vehicle (25 percent), and the addition of “raindrops” (21 percent) on the sign. Figure A-5 in Appendix A presents a sample of the designs prepared by the focus group participants. The alternatives developed for further evaluation are illustrated in Figure II-22. Alternative 2 adds “raindrops” and a horizontal line to the standard sign. Alternatives 3 and 4 use “tire marks” that were modified to reduce potential confusion with the roadway’s geometric alignment. Alternative 3 is the German version of this sign and Alternative 4 is the Swiss version of the sign.

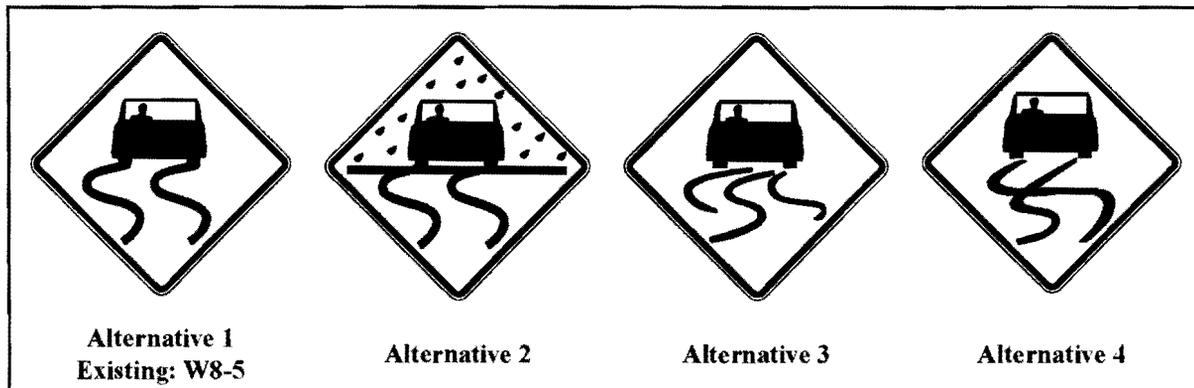


Figure II-22. Alternative Designs for the Slow Down on Wet Road Sign

Truck Crossing Sign (W11-10)

The **Truck Crossing** sign (W11-10), shown in Figure II-23 , is one of several signs included in the **Advance Crossing** series (W11) of warning signs. This sign is used to alert motorists of unexpected truck entries in the roadway ahead, either random or confined entries. The sign may be supplemented with a distance plaque if the crossings are confined to one location (1).



**Figure II-23.
W11-10 Sign**

The sign was chosen for evaluation in the statewide survey. It was selected in order to determine how motorists interpret the message conveyed by the symbol

sign. Some drivers may believe that the sign only warns of the presence of trucks in the roadway ahead, but not an advance warning of a truck crossing or entry ahead (4).

Phase I Recommendations

The results of the statewide survey indicated that a majority of drivers understand that trucks may be present in the roadway, but the message of “trucks crossing ahead” is not fully communicated with the current symbol sign. Further evaluations were recommended in order to study the driver comprehension improvements of adding a supplementary word message plaque. The plaque would contain a legend such as **NEXT 5 MILES**.

Phase II Focus Group Evaluation

The participants in the focus group were told that when driving on a roadway that is heavily used by trucks, conflicts may arise due to trucks attempting to enter or cross the roadway, especially from unexpected locations. The moderator explained that because trucks have reduced acceleration and braking capabilities and because they may enter the roadway unexpectedly over several miles, drivers must be warned that trucks could interfere with normal driving tasks. The participants were also told that a collision could result if drivers are not aware of the presence of trucks.

The participants were then asked to illustrate the current sign that is used to warn drivers of the potential of large trucks using and entering the roadway. They were also asked to illustrate one or more alternative signs, incorporating word messages and symbols, that may improve motorist understanding of the device.

When asked to draw the current sign, the majority of participants either drew nothing (10 drivers) or drew the correct symbol or word message version of the sign (5 drivers). The remaining four drivers drew the sign incorrectly. Of the nine participants that drew a sign, six drew some form of a “truck” in the sign (four of them correctly). The illustrative sessions also indicated that the truck symbol used on the current sign adequately signifies the existence of trucks. When asked to illustrate an improved sign, nearly 80 percent of drawings included the truck symbol.

Some of the participants, however, believed that even though the truck symbol signifies the existence of trucks, the symbol does not convey whether the trucks are “on” the roadway or “crossing” the roadway. A potential improvement to the current sign was evident by the large percentage (83 percent) of illustrations that included both a symbol and a supplemental word message on the sign face. Of the 19 signs that depicted both words and symbols, the legend **CAUTION**, **WARNING**, or **BEWARE** was used on nine of the designs and 13 of the designs included the word **TRUCK**.

Development of Alternative Designs

To help convey the meaning of a truck crossing, nearly 50 percent of the improved illustrations included a plan view of the roadway, which usually depicted a truck entering an intersection. Further improvements to convey the meaning of a truck crossing included the addition of a distance message, either indicating a specific location of a truck crossing (**500 FEET**) or a section of roadway with numerous truck crossings (**NEXT 5 MILES**). Figure A-6 in Appendix A illustrates four examples of the sketches drawn by focus group participants for the truck crossing sign. These and other alternatives that were developed as a result of the focus groups are depicted in Figures II-24 and II-25. Alternative 2 is the existing word message version of the sign (W8-6). Alternatives 3 and 4 combine the standard symbol sign (W11-10) with a supplemental distance plaque. One plaque indicates the distance to a specific crossing (**500 FEET**) and the other indicates the length of roadway over which crossings are present (**NEXT 5 MILES**). Alternative 5 combines both the symbol and word message in a single sign. Finally, Alternative 6 is the Canadian version of this sign, which includes some of the key features (“truck,” “road,” and “motion”) identified by focus group participants as desirable (16).

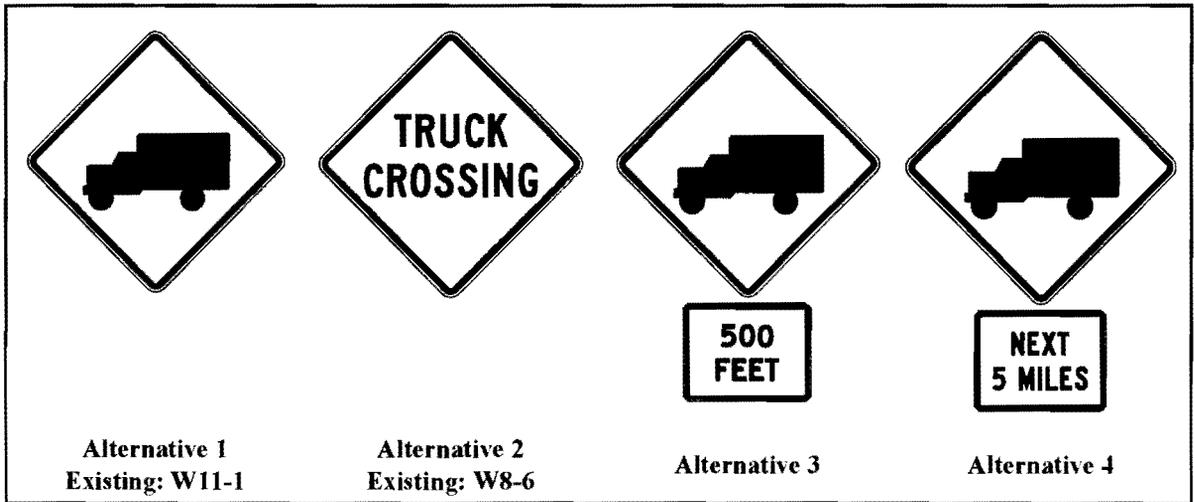


Figure II-24. Alternative Designs for the Advance Truck Crossing Sign

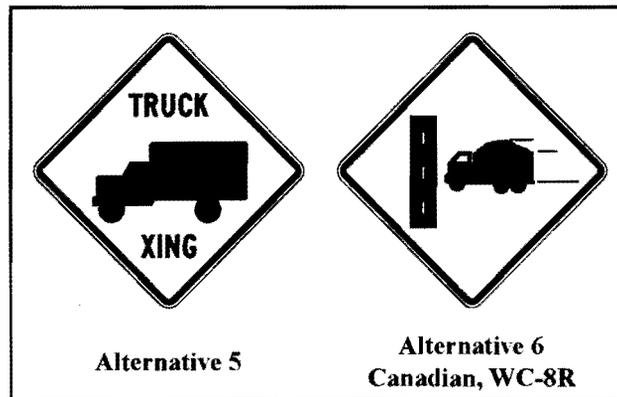


Figure II-25. Alternative Designs for the Advance Truck Crossing Sign

School Advance Sign (S1-1)

The **School Advance** sign (S1-1), shown in Figure II-26 , can be used for three different purposes. It is required, or “*shall be used,*” in advance of any installation of the **School Crossing** sign (S2-1) (1). This is one of the few conditions in the MUTCD where the use of a warning sign is required. The other two purposes for this sign are in advance of any established school crossing not adjacent to a school ground and in advance of locations where school buildings or grounds are adjacent to the highway. The **School Advance** sign is one of only two signs in the MUTCD which uses a pentagon shape with parallel vertical sides. The sign is erected “not less



Figure II-26.
S1-1 Sign

than 45 meters nor more than 210 meters in advance of the school grounds or school crossing” (1).

The sign was chosen for evaluation in the 1992 Auto Show survey due to previous research efforts which indicated difficulties in driver comprehension of the device. In several studies, the similarities between this sign and the **School Crossing** sign (S2-1) were identified as sources of driver confusion (18, 22, 23). Other studies showed that drivers have difficulty distinguishing between the school children in these signs and the pedestrian in the **Advance Crossing** and **Crossing** signs (18, 20, 21, 23, 24). Still another source of potential confusion is the multiple messages that the sign is intended to communicate, depending upon the circumstances in which it is used.

Phase I Recommendations

An alternative sign design, shown in Figure II-27, was evaluated during the 1992 Auto Show survey. The intent was to determine if this sign was more effective than the standard S1-1 sign in communicating the advance warning of a school crossing. The results of the survey indicated that it was more effective, but that additional evaluations should be conducted to determine the extent, if any, of driver confusion of the school crossing signs (standard S1-1 and alternative design) with pedestrian crossing signs. Further recommendations included modifying the language in the *Texas Drivers Handbook*, if the alternative was not selected for implementation, to indicate that the standard sign may be used in advance of a school crossing (4).



**Figure II-27.
Alternative School
Crossing Sign**

Phase II Focus Group Evaluation

The participants in the focus groups were shown a picture taken approximately 15 meters in advance of a school crossing, which showed the pavement markings for the school crossing and the pentagon-shaped **School Crossing** sign (S2-1). The participants were told that school crossings require special treatment because of the hazards that are presented when children

attempt to cross the roadway. A driver unaware of the crossing may not have adequate time to stop or slow down if children enter the roadway unexpectedly.

The participants were then asked to illustrate the current sign that is used in advance of this type of scenario to warn motorists that they are approaching a school crossing. They were also asked to illustrate one or more alternative word message or symbol signs that would improve motorist understanding of the device. The moderator emphasized that the sign is used in advance of the crossing, and more specifically, several hundred feet from the crossing.

Half of the focus group participants (10) were not able to recall the sign used to provide advance warning of a school crossing. Four drivers drew a pair of schoolchildren/pedestrians. The presence or lack of a crosswalk in a sign was not considered in determining the correctness of the sign image. Worth noting is the fact that, of the four drivers that drew the sign correctly, three of them used the correct sign shape (a pentagon).

Development of Alternative Designs

There was a strong indication from the focus group data that the participants understood the meaning of the current sign. Over 50 percent of the improved designs included the pedestrian symbol used on the current sign. Further improvements included the addition of a word message such as **CROSSING** (70 percent), **SCHOOL** (65 percent), **AHEAD** (40 percent), or a combination of these three words. Figure A-7 of Appendix A provides examples of alternative designs suggested by some of the focus group participants. The improved sign designs, developed as a result of the focus group meetings and practical alternatives developed by the research team, are depicted in Figure II-28. Alternative 2 is the standard **School Advance** sign with a **SCHOOL** supplemental plaque below the sign. Alternative 3 is the same as the alternative tested in the 1992 Auto Show survey. Alternative 4 uses a supplemental distance plaque to provide an advance warning of the school crossing. Both signs in Alternatives 3 and 4 include the “crosswalk” symbol within the sign.

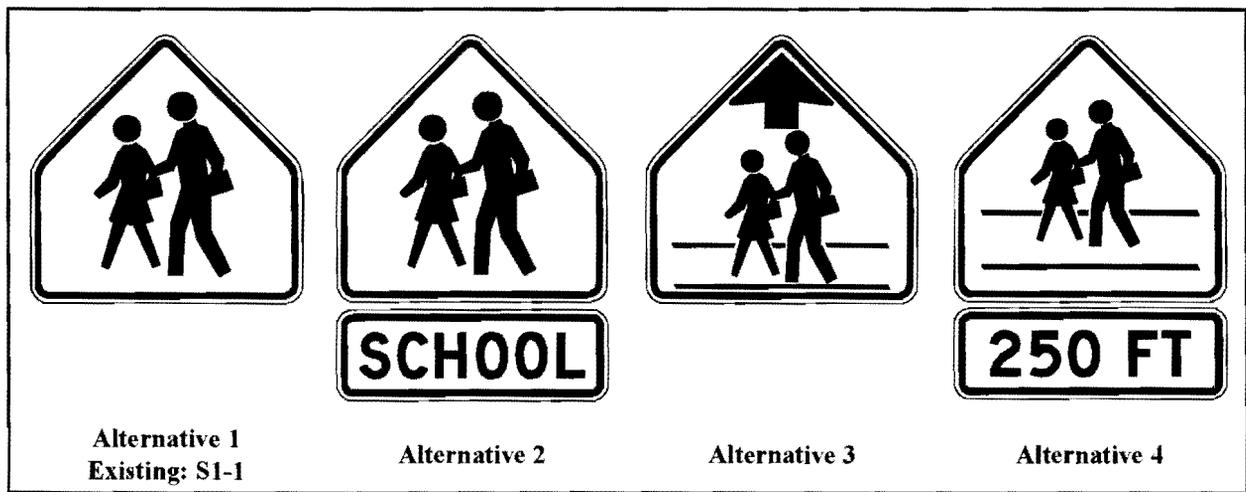


Figure II-28. Alternative Designs for the School Advance Sign

End School Zone Sign (S5-2)

The **END SCHOOL ZONE** sign (S5-2), shown in Figure II-29, or a standard **SPEED LIMIT** sign (R2-1) showing the speed limit for that section of the highway, is required to mark the end of an authorized or posted school speed zone (14).

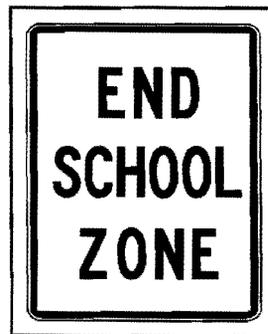


Figure II-29.
S5-2 Sign



Figure II-30.
S5-1 Sign

Previous research activities did not evaluate the **END SCHOOL ZONE** sign, but did evaluate the **SCHOOL SPEED LIMIT** sign (S5-1), shown in Figure II-30, which is used in the vicinity of schools to reduce vehicular speeds at times when children may be present in or near the roadway.

In the statewide survey, participants were asked to identify the point where they could resume their normal speed after passing the sign shown in Figure II-30 (4).

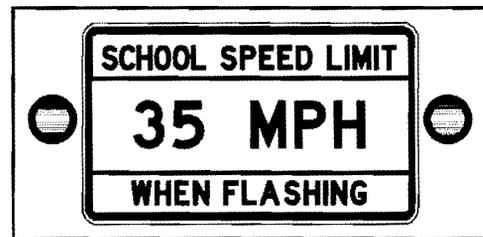
Phase I Recommendations

The statewide survey results indicated that approximately 20 percent of the participants did not know that a standard **SPEED LIMIT** sign could be used to mark the end of a school

speed zone. One alternative would be to use the **END SCHOOL ZONE** sign instead of the **SPEED LIMIT** sign to mark the end of the speed zone. In order for this to be implemented, however, additional evaluation was recommended in the fourth year report to determine if the sign was more effective than the **SPEED LIMIT** sign (4).

Phase II Focus Group Evaluation

Participants in the focus group were shown two different signs that are used to warn drivers to reduce vehicular speeds and that children may be present in or near the roadway. The first sign was an overhead word message sign, similar to the one depicted in Figure II-31, accompanied by two horizontally aligned **Speed Limit Sign Beacons**. The second sign was a picture of the standard **SCHOOL SPEED LIMIT** sign (S5-1), shown in Figure II-30. The participants were told that both signs are used during times when schools are starting and ending for the day, and that speed limits may be reduced near the school grounds. The moderator further explained the potential hazards of school zones, including the fact that motorists usually begin to increase speeds after passing the school grounds, even though children may still be present in or near the roadway.



**Figure II-31.
Overhead Sign Used to Warn
Drivers to Reduce Speeds**

The participants were then asked to illustrate the current sign that is used to inform motorists that the school speed limit has terminated and that the speed limit for that section of highway may be resumed. They were also asked to illustrate alternative word message and symbol signs that would improve the motorists' understanding of the device.

Three of the 19 participants were able to draw the sign correctly, while another six presented the proper words (**END**, **SCHOOL**, and **ZONE**) in a different order or slightly different form. Five participants were not able to present any image and five drew an incorrect sign.

Development of Alternative Designs

In the discussion session, many of the participants understood that they could resume to a normal vehicular speed after traveling through a school zone. All of the participants indicated a strong preference for the use of the **END SCHOOL ZONE** (S5-2) sign, either alone or in combination with a **SPEED LIMIT** (R2-1) sign. Furthermore, they were not able to suggest many alternatives to the sign other than a sign with the legend **RESUME SPEED**. As a result of this consensus of opinion, the researchers determined that it was not necessary to test alternative versions of this sign.

Railroad Advance Warning Sign (W10-1)

The circular advance warning sign, depicted in Figure II-32, is used when the railroad grade crossing is on the same roadway as the motorist. It is generally placed 225 meters or more in advance of a crossing in rural areas and 75 meters in urban areas unless lower speeds are prevalent (14). This sign was chosen for evaluation in the statewide survey on the basis that in previous research studies, drivers could not distinguish between the circular advance sign and the **Crossbuck** sign (R15-1) used at the crossing (4).

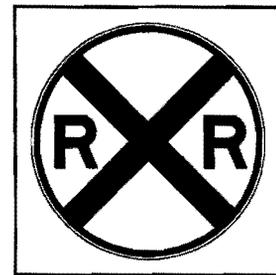


Figure II-32.
W10-1 Sign

Phase I Recommendations

Most drivers in the statewide survey accurately associated the circular **Railroad Advance Warning** sign (W10-1) with an advance warning of a railroad crossing. The statewide survey, however, did not address if drivers notice this sign near a crossing. Also, because all of the response choices in the survey contained a reference to a “railroad crossing,” the survey did not address if this sign could be confused with an issue other than a railroad crossing. Therefore, it was selected for additional evaluation in Phase II.

Phase II Focus Group Evaluation

For the focus group evaluations of the circular **Railroad Advance Warning** sign (W10-1), participants were shown a picture of an approach to a railroad grade crossing. The explanation described the consequences of failing to yield the right-of-way to a crossing train, including serious injury or a fatality to the motorist. The participants were asked to illustrate the current sign used in advance of the crossing, and to illustrate alternative word message or symbol signs that would improve motorist understanding of the device.

Five of the focus group participants were not able to draw any image for the sign that is used in this situation. Three drivers were able to correctly draw the railroad “**X**” with an “**R**” in each opposing quadrant. Seven participants drew incorrect symbols or words, while four participants drew an incorrect image that included the railroad “**X**.”

Many of the participants in the four focus groups expressed concern about the potential hazards of railroad grade crossings. In order to minimize these hazards, many of the comments and illustrations focused on making the advance sign more conspicuous and ultimately making the driver more aware of the grade crossing.

A general misunderstanding interpreted from the discussion sessions, but not noticeably demonstrated in the illustrative sessions, was that the current sign does not convey an “advance” theme and should be supplemented with words or redesigned in order to convey such a meaning. While approximately 35 percent of the drawings included a word message referencing the word **TRAIN** or the “**X**” symbol (the symbol that appears on the current sign), only four of the 25 (16 percent) illustrations for an improved railroad advance warning sign included a distance legend such as **500 FEET**.

Development of Alternative Designs

Another high frequency sign element that appeared in several sign illustrations (28 percent) was a symbol of a train. Most of the symbol designs represented the shape of a traditional steam locomotive. Furthermore, during the discussion session of one focus group meeting, the participants indicated that the steam locomotive icon is preferable over a more

contemporary design because it conveys a clearer understanding of the existence (or potential existence) of a train. Figure A-8 in Appendix A presents four examples of alternative signs suggested by the focus group participants. The proposed alternatives developed by the focus groups are illustrated in Figure II-33. Alternatives 2 and 4 present a distance with the sign. Alternatives 3 and 4 present an icon of a steam locomotive. This icon is being field evaluated in a separate TTI project (25).

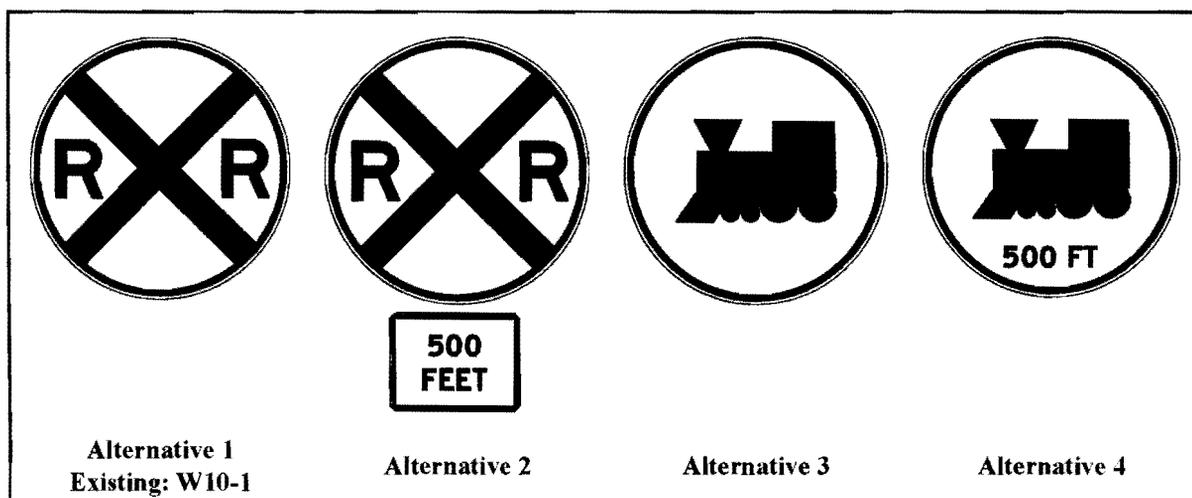


Figure II-33. Alternative Designs for the Railroad Advance Warning Sign

Parallel Railroad Advance Warning Sign (W10-3)

The diamond-shaped advance warning sign, depicted in Figure II-34, is used when the railroad grade crossing is on a roadway perpendicular to the main roadway the motorist is on and within 30 meters of that roadway (14). The railroad tracks are parallel to the main roadway, and if the distance exceeds 30 meters, the diamond-shaped sign would not be necessary (14). There are three different versions of this sign which are used to indicate different types of intersection configurations. Because of the lack of research on motorist understanding of these three signs, the W10-3 sign was chosen for evaluation in the statewide survey to determine if motorists associated this sign with a railroad crossing on a parallel roadway (4).

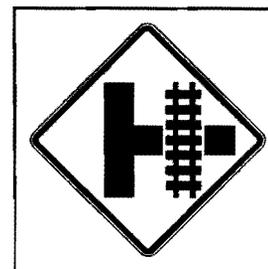


Figure II-34. W10-3 Sign

Phase I Recommendations

The survey results for the diamond-shaped **Parallel Railroad Advance Warning** sign (W10-3) indicated that drivers exhibited some confusion over the orientation of the roadway on the sign. These results, combined with the fact that the sign is not presented in the *Texas Drivers Handbook* and with the lack of previous research on the diamond-shaped signs (W10-2, W10-3, and W10-4), established that further evaluations were necessary to determine if an alternative legend could be more effective in communicating the desired message (4).

Phase II Focus Group Evaluation

Participants were shown two pictures of an intersection, both from the perspective of a driver approaching on the main street, with a railroad crossing on the minor street and with the railroad tracks extending parallel to the main street. The railroad tracks were offset approximately 15 meters from the main roadway. The first picture was taken approximately 150 meters from the intersection (and crossing), and the second picture was taken at approximately 15 meters from the intersection. The explanation to the participants indicated that many roadways are built parallel to railroad tracks and at times, at the intersection, there is not enough distance to provide turning motorists with advance warning of the crossing. The participants were asked to illustrate the current sign and to illustrate an improved design, incorporating word messages and symbols, that would improve motorist understanding of the sign and situation.

Over two-thirds of the participants were not able to draw any image for this sign. This is the highest “no image” percentage among all ten signs evaluated in the focus groups. Two drivers were able to recall the correct image for this sign, and another four presented incorrect images.

Development of Alternative Designs

A general improvement to the current sign (W10-3), interpreted from the focus group sessions, was to enhance the conspicuity of the sign and to make drivers more aware of the potential hazard that exists at the intersection. During the illustrative sessions, the participants were asked to draw improved designs. Over 50 percent of these illustrations included the “picket

fence” track symbol, the same element used on the current sign. To enhance the conspicuity of the sign, an “arrow” symbol appeared in a similar percentage of the illustrations (46 percent). This arrow symbol was included on the sign face on all but one of the sign designs and was typically shown as a bent arrow indicating that the crossing was ahead and to the right of the driver.

The illustrative data also suggested that in order for a driver to fully understand the geometric conditions at the intersection (i.e., parallel tracks within a close proximity to the traveling roadway), the sign should suggest a “parallel” roadway-track theme. Nearly 80 percent of the illustrations that included the “picket fence” symbol also depicted a parallel roadway or parallel arrow indicating the direction of travel. Figure A-9 in Appendix A provides a typical indication of the frequency of the parallel roadway/railroad concept sketched by most participants. While the current sign depicts this scenario, a modification was made by placing a “bent arrow” inside the roadway symbol. Two remaining alternatives include the **Railroad Advance Warning** sign (W10-1) with the addition of an “arrow” plaque and a “bent arrow” plaque. These proposed alternatives are depicted in Figure II-35.

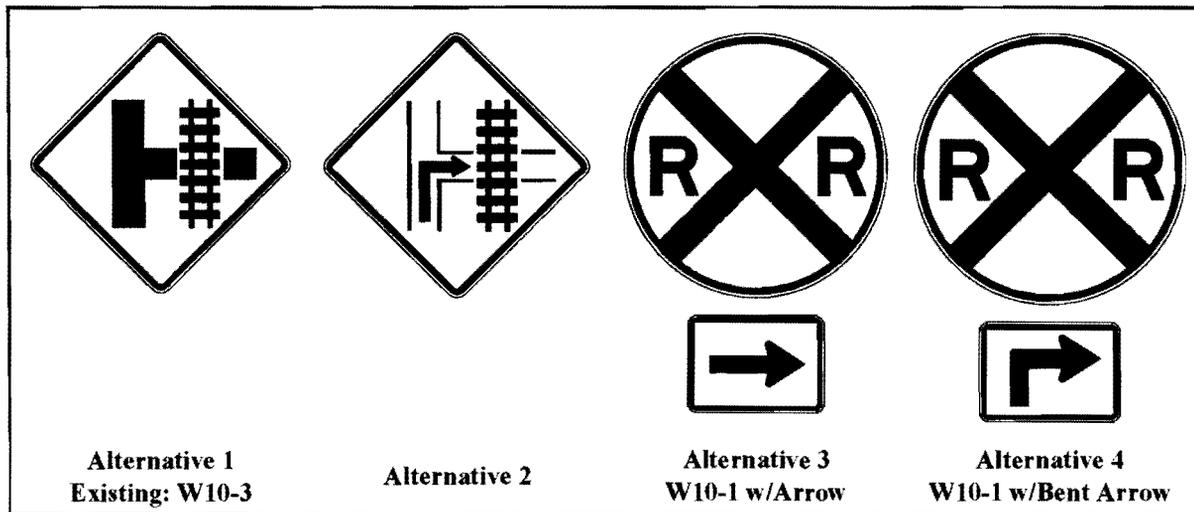


Figure II-35. Alternative Designs for the Parallel Railroad Advance Warning Sign

SUMMARY OF FOCUS GROUPS AND OF ALTERNATIVE DEVELOPMENT

A series of four focus groups involving a total of 19 drivers were conducted to identify key issues associated with ten traffic signing/control situations. In conducting the focus groups,

the researchers were seeking to identify driver understanding and recall of existing traffic signs, key concepts that drivers felt were important for individual signs to convey, and layperson input on possible alternative sign designs that might be more effective at communicating the desired message to drivers.

The focus groups produced some valuable information about the 10 signs presented to the groups. An average of 40 percent of the participants were not able to recall any sign when asked to draw a sketch of the current sign used for a particular traffic situation. An average of 18 percent were able to draw a correct symbol or word message for these signs. These results indicate that drivers have some difficulty recalling specific signs. This information, however, should be interpreted carefully, as it provides no indication of driver understanding of traffic control devices. There is a significant difference between a driver recalling the appearance of a sign for a particular situation and recalling the meaning of a sign being presented to the driver.

The most valuable aspect of the focus groups related to the development of potential alternative designs for the selected signs. Each participant sketched numerous designs for all ten signs, and the sketches were analyzed to identify common themes. This information was then used by the researchers to prepare alternative designs for further evaluation. Alternatives were developed for all ten devices, except for the **END SCHOOL ZONE** sign (S5-2). These alternative designs were evaluated in an expanded survey, which is described in the next chapter.

CHAPTER III

PHASE II SURVEY EVALUATIONS

The primary task of the Phase II evaluation was a driver survey given to 747 drivers in seven Texas cities. The survey was intended to evaluate alternative designs for nine different traffic control devices, which included four warning signs, two regulatory signs, and three other types of signs. A follow-up survey was given to 212 drivers in two Texas cities and evaluated alternative designs for three warning signs and two other types of signs. The activities associated with each survey included four major efforts: 1) development of the survey instrument; 2) administration of the survey; 3) analysis of the survey results; and 4) development of recommendations for each device. This chapter describes these research activities associated with both of the Phase II surveys.

PHASE II INITIAL SURVEY

The development of the initial survey instrument began at the conclusion of the Phase II focus groups. The results of the focus group “data” were qualitatively and quantitatively analyzed to identify practical sign designs that could be further evaluated in a driver survey. Once the devices were identified, the research team selected a format for the survey, evaluated the effectiveness of the survey instrument through a limited pilot study, developed a plan for administering the survey, and once administered, analyzed the results and identified potential devices needing further evaluation.

Identification and Development of Alternative Sign Designs

A total of ten traffic control devices were identified in the Phase I evaluations as demonstrating the potential for motorist misunderstanding of the device. These ten devices were evaluated in the Phase II focus groups in order to elicit driver opinion for potential improvement to the devices’ design and use.

As a result of the focus group evaluations, nine of the ten devices were chosen for evaluation in the Phase II initial survey. The one device not chosen for the initial survey was found to have a limited number of practical alternative sign designs worthy of further evaluation. Several alternative designs, however, were developed for each of the other nine devices. The designs were developed as a direct result of the illustrations provided by the focus group participants, as well as through a review of previous and on-going research activities and other state practices. A sample of these illustrations for each device is provided in Appendix A.

Survey Format

Once the alternative sign designs were identified and/or developed, questions, responses, and graphics were developed for each device. The survey instrument was presented in a three-ring binder and consisted of several multiple-choice questions for the participants to answer. The survey instrument contained an in-context picture of a traffic control device that was depicted on the top of the left page. This image was an actual photograph depicting a roadway condition, but modified by a computer graphics software program to display the device being tested. Below this image on the same page was a close-up view of the same device, created by the same software program. On the top of the facing page, a multiple-choice question was presented. The participants recorded their response choices on a separate answer sheet.

Four different versions of the survey instrument were prepared. The first version, Set A, contained only standard traffic control devices, the same ones identified in the Phase I evaluations as ones requiring further evaluation of alternative designs. The second, third, and fourth versions of the survey (Sets B, C, and D, respectively) consisted of alternative sign designs developed as a direct result of the Phase II focus group evaluations. A Spanish language survey was also developed for each of the four survey sets and administered to non-English speaking participants with the aid of a translator. A more descriptive summary of the survey instrument is presented in Appendix B. Table III-1 illustrates the standard and alternative devices evaluated, including the order in which they were presented in each of the survey sets.

Table III-1. Organization of the Phase II Initial Survey

	Set A Standard Sign	Set B Alternative	Set C Alternative	Set D Alternative
Question 1				
Question 2				
Question 3				
Question 4				
Question 5				
Question 6				
Question 7				
Question 8				
Question 9				
Question 10				
Question 11				N/A ¹

Note: ¹ Survey Set D contained only ten questions.

Survey Evaluation

The first draft of the Phase II initial survey was pilot-tested at the Department of Public Safety Driver Licensing (DL) Office in Bryan, Texas, with 100 participants. Only minor modifications were made to the survey questions and responses to provide a more effective survey instrument that could be administered on a larger scale.

Survey Administration

Establishment of the sampling plan involved selecting geographic areas of interest. In order to obtain a representative sample of age, gender, and ethnicity, two rural cities with a population of under 50,000 each (Lufkin and Beeville) and five urban cities with a population of over 50,000 each (Bryan, Temple, Houston, Amarillo, and El Paso) were selected. These areas also represented geographically diverse regions of Texas. The Phase II initial survey was conducted at Department of Public Safety DL stations in these seven cities.

PHASE II FOLLOW-UP SURVEY

At the conclusion of the initial survey, the results were analyzed to determine what, if any, devices should be further evaluated through a follow-up survey. The Phase II initial survey provided useful information regarding motorist understanding of all nine devices evaluated. Because of the numerous alternative designs, however, this survey was not sufficient to answer all questions regarding motorist comprehension of all devices. Therefore, a follow-up survey was conducted to evaluate specific sign designs or sign elements that the researchers believed were not adequately addressed in the initial survey. The follow-up survey was also used as a confirmatory survey instrument, one that could confirm comprehension results obtained in the initial survey.

Identification and Development of Alternative Sign Designs

The objective of the Phase II follow-up survey was to assess motorist comprehension of particular sign alternatives. A total of five traffic control devices were identified for further evaluation. Three alternatives were developed for each device, which included a combination

of signs, sign elements (i.e., words or symbols), or supplemental plaques previously evaluated in the Phase II initial survey.

Survey Format

The format of the Phase II follow-up survey closely resembled that of the Phase II initial survey. For the five devices chosen, the same questions and response choices presented in the initial survey were used in the follow-up survey for each respective device; only the design of the alternative was changed. The follow-up survey instrument was also presented in a three-ring binder and contained a similar in-context picture of the device, a close-up view of the device, and the corresponding multiple-choice question and response choices.

The follow-up survey instrument consisted of three different versions, with a different alternative in each set. A Spanish language version of the follow-up survey instrument was not developed for administration. A more descriptive summary of the follow-up survey is presented in Appendix C, including the in-context and close-up images, the multiple-choice questions, the response choices, and the percentage of respondents who chose each answer. Table III-2 illustrates the organization of the follow-up survey.

Survey Evaluation

Because of the close similarities in format to the initial survey, the Phase II follow-up survey was not formally pilot tested before being administered.

Table III-2. Organization of the Phase II Follow-Up Survey

	Set A Alternative	Set B Alternative	Set C Alternative
Question 1			
Question 2			
Question 3			
Question 4			
Question 5			

Survey Administration

Two cities previously selected for the Phase II initial survey were again chosen for the follow-up survey. For the signs chosen for this follow-up survey, the overall mean correct response rates from the initial survey were compared to the mean correct response rates for each individual city that was surveyed. A precision of ± 15 percent was used to compare individual rates to the overall rates. This value is based on a 90 percent confidence interval and sample size of 30, which was the average number of respondents for each sign tested in each city (see discussion in **Statistical Significance Test** on Page III-8). Individual mean response rates that exceeded ± 15 percent of the overall response rates were recorded. The two cities with the lowest number of occurrences exceeding the ± 15 percent threshold were chosen for the follow-up survey.

The results indicated that the cities of Lufkin and Amarillo, with a population of less than 50,000 and over 50,000, respectively, were the two sites that demonstrated the lowest overall variance. The Phase II follow-up survey was conducted at Department of Public Safety DL stations in these two cities.

DEMOGRAPHICS OF THE PHASE II SURVEYS

In order to account for the differences in demographic characteristics in the data analysis, seven questions at the end of each the Phase II surveys asked respondents to provide the following information:

- age;
- gender;
- ethnic background;
- education level;
- number of years driving a vehicle (driving experience);
- type of vehicle driven on a regular basis; and
- size of city in which respondent resides.

Table III-3 summarizes the demographic characteristics of both Phase II survey samples, as well as the statewide characteristics for the general population and driving population for some categories. A majority of the motorists that were surveyed in both evaluations were Anglos between the ages of 25 and 54, a close representation of the Texas driving population.

Table III-3. Demographic Characteristics of Phase II Survey Evaluations

Characteristics		Initial Survey		Follow-Up Survey		Texas Population	
		Number	Percent	Number	Percent	General	Driving
Gender	Male	380	51.3	110	51.9	49.3	51.5
	Female	360	48.7	102	48.1	50.7	48.5
Age	16 to 24	214	28.9	79	37.3	18.9	15.2
	25 to 54	442	59.7	110	51.9	57.4	62.4
	55 to 64	54	7.3	12	5.7	10.2	10.4
	65+	31	4.2	11	5.2	13.6	12.0
Ethnicity	African American (Black)	79	10.7	13	6.1	11.6	—
	Anglos (White)	449	60.6	173	81.6	60.6	—
	Hispanic	178	24.0	18	8.5	25.6	—
	Other	35	4.7	8	3.8	2.2	—
Education Level	Less Than High School	82	11.3	34	16.1	28.1	—
	High School (or Equivalent)	231	31.7	76	36.0	25.9	—
	Some College	240	32.9	63	29.9	27.8	—
	College Graduate	175	24.0	38	18.0	18.1	—
Total¹		747	100.0	212	100.0	100.0	—

Note: ¹ Individual totals may not reflect the overall total. A few participants chose not to answer some or all of the demographic questions.

EVALUATION OF PHASE II SURVEY RESULTS

In order to analyze the survey data, several limitations must be understood and considered before evaluating the survey results, particularly the location of survey administration, the format of the survey, and the difference between driver comprehension and driver behavior. The two surveys were administered at DL stations around the state, and patrons of these stations, although ideally representative of the driving population, may be more prepared to answer comprehension-type questions of traffic control devices than the “average” driver, especially if they are prepared to take written or driving examinations for a driver’s or commercial license. The survey format also lends itself to potential limitations. In-context images of the traffic control devices do not adequately represent what a driver would visualize in a driving environment. Therefore, comprehension of a traffic control device, or lack of comprehension, does not necessarily correlate to the actual driving response a person may make with respect to that device.

Statistical Significance Test

The standard normal *z-test* was used in order to statistically analyze the Phase II survey data. This test is typically used for analyzing survey results in order to determine if two response percentages are statistically significant. The primary assumption of the *z-test* is that the sample population *approximates* the actual driving population and a normal distribution is used to characterize the sample population. There is an increase in confidence of the test statistic as the sample size increases. The typical confidence level used for this test is 90 percent ($\alpha = 0.10$), but if the findings indicate a significant difference in response percentages at a 90 percent confidence level, it does not necessarily imply that a large or unacceptable difference exists. It simply means that there is *evidence* to suggest that a difference exists. The precision of the results was also considered during the evaluation of the survey data. Precision is calculated based on assumptions of the binomial distribution, the response percentage, the confidence level, and the sample size, with increased precision as the response percentage and the sample size increase. Precision is calculated using the following equation:

$$\bar{x} = z_{\alpha/2} \sigma_{\pi} \quad (1)$$

where: \bar{x} = level of precision, expressed as a percentage;
 $z_{\alpha/2}$ = Standard normal deviate at a $(1-\alpha/2)$ confidence interval;
 α = Indication of confidence interval and Type I error; and
 σ_{π} = sample standard deviation.

The sample standard deviation can be calculated using the following formula:

$$\sigma_{\pi} = \sqrt{\frac{\pi(1-\pi)}{n}} \quad (2)$$

where: π = proportion of correct response, expressed as a percentage; and
 n = sample size.

For example, assuming a 50 percent correct response rate ($\pi=0.50$), a sample size of 200 ($n=200$), and a 90 percent confidence interval ($\alpha = 0.10$, $Z_{\alpha/2} = 1.645$), the following equation can be used to determine the level of precision that can be assumed:

$$\bar{x} = Z_{\alpha/2} \sigma_{\pi} = 1.645 \sqrt{\frac{0.5(1-0.5)}{200}} = \pm 5.8 \text{ percent} \quad (3)$$

For both of the Phase II surveys, an overall precision estimate can be determined based on the sample size of each survey, assuming a 90 percent confidence interval and a range of correct response rates. General levels of precision for each survey are presented in Table III-4. Furthermore, a table of results for each device evaluated indicates the precision level for each sign alternative (see “Results and Recommendations” section of this chapter).

Table III-4. Level of Precision for Phase II Surveys (C.I.=90%)

Correct Response Rate, π	Phase II Evaluation	
	Initial Survey, n=187 ¹	Follow-Up Survey, n=71 ²
0.50	±6.0%	±9.8%
0.60 or 0.40	±5.8%	±9.6%
0.70 or 0.30	±5.5%	±8.9%
0.80 or 0.20	±4.8%	±7.8%
0.90 or 0.10	±3.6%	±5.9%

Notes: ¹ Indicates average size of four survey sets.

² Indicates average size of three survey sets.

PHASE II RESULTS AND RECOMMENDATIONS

The Phase II initial survey was administered to a total of 747 drivers in seven Texas cities. Following the administration of this survey, the data was analyzed to determine what, if any, traffic control devices would be evaluated through a follow-up survey. The analysis included an evaluation of the survey data, particularly the average response rates, for each of the nine traffic control devices and their alternatives. Five of the devices were chosen for further evaluation in the Phase II follow-up survey, which was administered to 212 drivers in two Texas cities. Based on one or both of the Phase II survey evaluations, the results and recommendations for each device are summarized in this section.

Two-Way Left Turn Only Sign (R3-9b)

The **Two-Way Left Turn Only** sign (R3-9b) and three alternatives, all presented in Figure III-1, were evaluated with a multiple-choice question in which two of the six response choices were correct answers. One of the response choices was included to evaluate driver use of two-way left turn lanes (TWLTLs). This response was intended to identify driver use of the lane for storage when turning onto or crossing the street with the TWLTL. The use of the lane for storage is not addressed in the driving laws; therefore, the response cannot be classified as correct or incorrect. The question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative is presented in Table III-5.

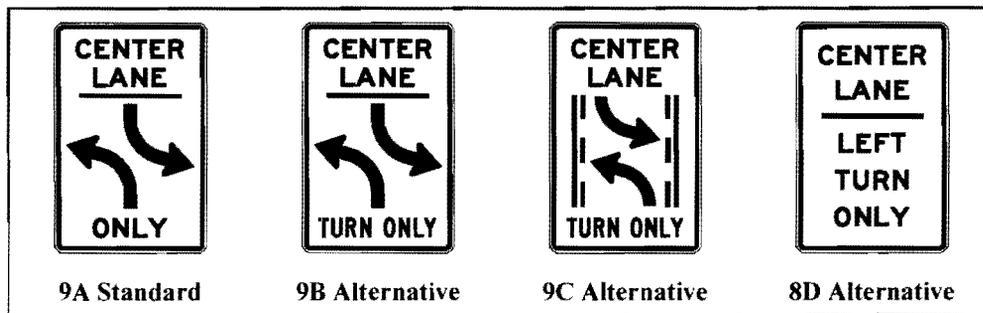


Figure III-1. Two-Way Left Turn Only Sign Alternatives Evaluated in Phase II Initial Survey

Table III-5. Phase II Initial Survey Results (Percent) for Two-Way Left Turn Only Alternatives

SIGN ALTERNATIVE				QUESTION AND RESPONSES
9A	9B	9C	8D	
				Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
2.8	1.0	4.2	3.2	The center lane can be used for passing and overtaking other vehicles.
17.6	22.3	22.1	18.6	<i>Drivers in the center lane should be aware of head-on traffic.</i>
2.3	3.1	6.3	3.7	You cannot drive in this area for any reason.
81.8	86.5	84.2	78.2	<i>The center lane can be used for making left turns in either direction.</i>
30.7	31.1	34.7	32.4	The center lane can be used as a waiting area when turning onto/crossing the road.
0.6	1.0	2.1	1.6	The center lane can be used as a parking area for businesses along the road.
2.8	2.6	2.1	3.7	I'm not sure what this sign means.
176	193	190	188	Sample Size
±4.8	±4.0	±4.4	±5.0	Precision of responses (90 percent confidence interval)

Results of Phase II Initial Survey

Based on the survey results, no alternative appeared to be statistically better than the others. The standard sign (R3-9b, Alternative 9A) appears to be adequately understood, with approximately 80 percent of the respondents choosing the answer “The center lane can be used for making left turns in either direction.” There is no statistically significant difference, however, between the remaining alternatives with respect to the same response. A small, but meaningful, percentage (approximately 20 percent) of the participants were aware of the hazards of on-coming, or “head-on” traffic in the center lane. Approximately 30 percent of the

respondents indicated that using the two-way left turn lane for storage is an appropriate use of the lane. The **Two-Way Left Turn Only** sign was not recommended for further survey evaluation.

Recommendations for Two-Way Left Turn Only Sign

The survey results indicated that, although the primary sign message was understood by approximately 80 percent of the respondents, other aspects of TWLTLs are not fully understood by portions of the driving population. In particular, only a small percentage of respondents (approximately 20 percent) selected the response identifying the potential for head-on traffic in the lane. The results indicated that there was no statistically significant difference in driver understanding of the four signs evaluated. The results also indicated that approximately 30 percent (± 5 percent) of the driving population believe it was acceptable to use the lane for storage purposes (stopping in the lane and waiting) when turning onto or crossing the road with the two-way left turn lane.

Based on these results, the standard sign (R3-9b) should continue to be used as the ground mounted sign for two-way left turn lanes. The use of the lane for storage purposes should also be clarified. If it is not intended for this purpose, then additional educational efforts should be made to inform drivers of appropriate driving practices.

Stop Sign (R1-1)

Various treatments for distinguishing two-way stop controlled intersections from four-way stop controlled intersections were evaluated in both the initial and follow-up surveys. In the initial survey, a standard **STOP** sign (R1-1) alone was compared to **STOP** signs with three different supplemental plaques. Figure III-2 illustrates the various sign alternatives evaluated in the initial survey, and Table III-6 presents the question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative. Alternatives 5B and 5C used a black on white supplemental plaque, while Alternative 5D used a white on red supplemental plaque.

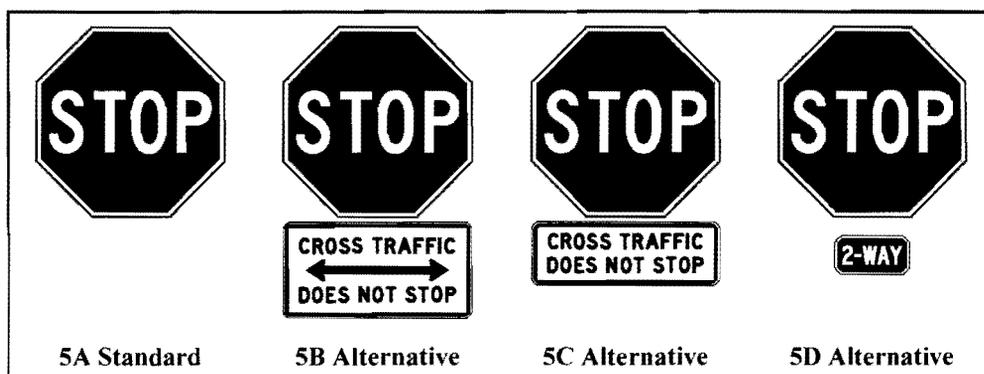


Figure III-2. Two-Way Supplemental Stop Sign Alternatives Evaluated in Phase II Initial Survey

Table III-6. Phase II Initial Survey Results (Percent) for Stop Sign Supplemental Alternatives

SIGN ALTERNATIVE				QUESTION AND RESPONSES
5A	5B	5C	5D	
				What is this sign telling you? Circle ONE answer.
3.3	3.3	4.2	1.2	You do not have to stop because you are crossing the intersection. Traffic from all directions must stop at the intersection. Traffic from the right or left may not slow down or stop at the intersection. I am not sure what this sign means.
37.0	12.5	7.1	25.2	
56.5	83.3	87.5	68.3	
3.3	0.8	1.2	5.4	
154	120	168	167	Sample Size
±6.6	±5.6	±4.2	±5.9	Precision of responses (90 percent confidence interval)

Results of Phase II Initial Survey

The initial survey results for just a **STOP** sign indicated that only about half of the respondents (57 percent) recognized that traffic on the intersecting road may not have to stop, while over a third (37 percent) expected traffic to stop. The **CROSS TRAFFIC DOES NOT STOP** plaques exhibited a statistically significant increase in the response rate for the correct answer over just the **STOP** sign, with correct response rates of 83 and 88 percent. The **2-WAY** plaque demonstrated a statistically significant increase (25 percent) to the “all directions must stop” response, likely due to this plaque’s similarity (i.e., shape and color) to the multi-way plaques in the MUTCD and possible confusion over the “two-way” meaning of the legend. Also of interest were the rates for the “you do not have to stop” response; three of the alternatives had response rates between 3.3 and 4.2 percent.

The wide variety of supplemental plaques used for this application indicated the need for further evaluation in the follow-up survey to assess color and wording impacts.

Results of Phase II Follow-Up Survey

Three alternatives were evaluated in the follow-up survey. They are illustrated in Figure III-3. Alternatives 2A and 2B were identical except that the plaque in 2A had a yellow background and the one in 2B had a white background. The legend used the term **CROSS STREET** instead of the **CROSS TRAFFIC** used in the initial survey. The third alternative was the same as the one in the initial survey. The question, responses, response rates, and sample sizes are shown in Table III-7.

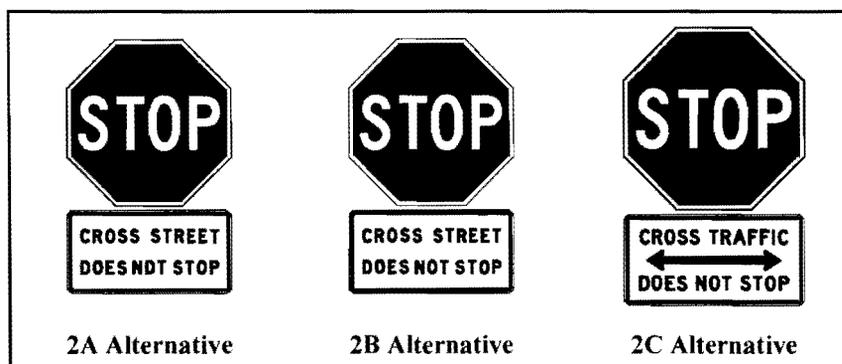


Figure III-3. Two-Way Supplemental Stop Sign Alternatives Evaluated in Phase II Follow-Up Survey

Table III-7. Phase II Follow-Up Results (Percent) for Stop Sign Supplemental Alternatives

SIGN ALTERNATIVE			QUESTION AND RESPONSES
2A	2B	2C	
			What is this sign telling you? Circle ONE answer.
0.0	7.1	2.9	You do not have to stop because you are crossing the intersection.
9.9	10.0	2.9	Traffic from all directions must stop at the intersection.
84.5	81.4	91.4	Traffic from the right or left may not slow down or stop at the intersection.
5.6	1.4	2.9	I am not sure what this sign means.
71	70	70	Sample Size
±7.1	±7.7	±5.5	Precision of responses (90 percent confidence interval)

There was little statistical difference between the initial and follow-up survey responses to the supplemental plaque with an arrow. Only the second response in the follow-up survey was statistically different than the second response in the initial survey, at a 90 percent confidence level. Changing the wording or color of the plaques without the arrow did not have a statistically significant impact (at 90 percent confidence level) on the response rates either. There was no statistical difference in the correct response rates for all three alternatives in the follow-up survey; nor was there a statistically significant difference in the rates for the “all traffic must stop” response.

Recommendations for Stop Sign

It was not clear from the survey results which of the treatments was most effective at distinguishing the two-way nature of some stop controlled intersections. The arrow plaque had the highest understanding in the follow-up survey, but not the initial survey. Color and wording did not seem to have any impact on comprehension.

The use of **STOP** signs at intersections is very important and many of the issues related to this application were not evaluated in either of the surveys. Before any comprehensive recommendations can be made, it is necessary to evaluate factors such as comprehension, target value, and driver behavior. At a minimum, field studies of alternative treatments should be conducted before any recommendations are offered. These issues will be evaluated in a separate TxDOT research project (0-1374) being conducted by TTI (26).

Lane Reduction Transition Sign (W4-2)

The **Lane Reduction Transition** sign (W4-2) and seven alternatives were evaluated with a multiple-choice question in which only one of the six response choices was the correct answer. All of the signs used a black legend on a yellow background. Figure III-4 presents the symbolic and word message versions of the sign evaluated in the survey. The question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative is presented in Tables III-8 and III-9.

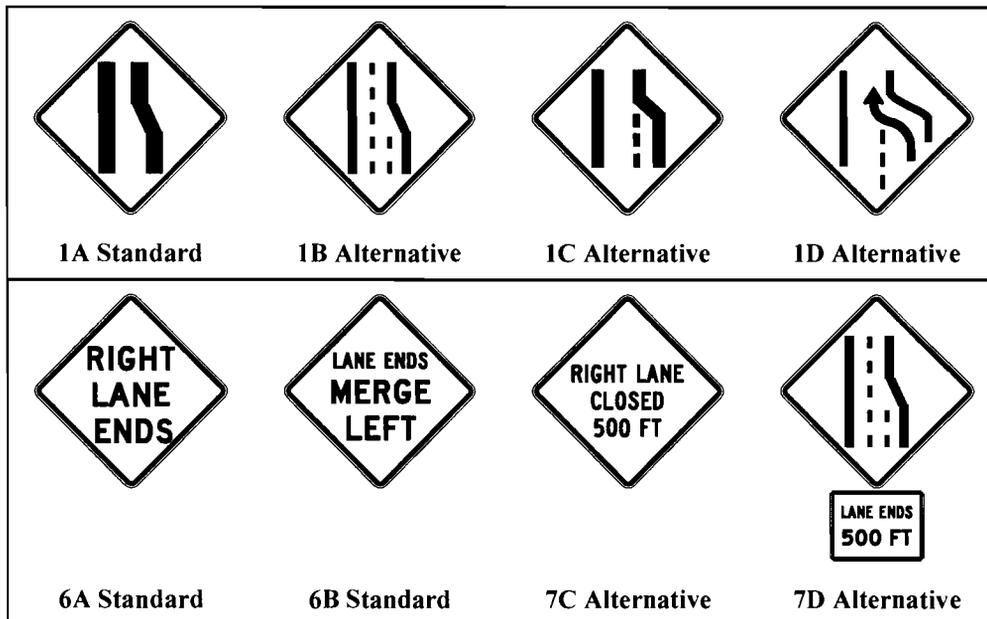


Figure III-4. Lane Reduction Transition Symbol and Word Alternatives Evaluated in Phase II Initial Survey

Results of Phase II Initial Survey

The question for these sign alternatives required the respondents to choose a single, correct response. The survey results indicated that the correct response rates for the symbol signs (Alternatives 1A, 1B, 1C, 1D, and 7D) varied between 71 and 78 percent. The current standard sign, the symbolic **Lane Reduction Transition** sign (W4-2, Alternative 1A), had a correct response rate of 72 percent. The other symbol alternatives (1B, 1C, and 1D) were understood equally as well as Alternative 1A at a 90 percent level of confidence. The best understood of these signs is Alternative 1B, at 78 percent. However, this response rate is not statistically different than those for the other symbol signs. It is worth noting that Alternative 1B was the original version of this sign when it was added to the MUTCD in the 1961 edition (15). However, the “lane markings” in this particular sign may not be practical for legibility reasons. Alternatives 1B and 7D are the same sign, except for the addition of an educational distance plaque below the 7D sign. The difference between the correct response rates of these two signs is not statistically significant at a 95 percent level of confidence.

**Table III-8. Phase II Initial Survey Results (Percent)
for Symbolic Lane Reduction Transition Alternatives**

SIGN ALTERNATIVE				QUESTION AND RESPONSES
1A	1B	1C	1D	
				What is the most correct meaning of this sign? Circle only ONE answer.
71.6	78.2	70.9	71.3	<i>The lane ends and traffic in the right lane should move into the left lane.</i>
7.4	6.2	5.8	6.4	The lane ends and traffic in the left lane should move into the right lane.
5.7	2.6	8.5	2.1	The median between opposing traffic will end.
4.6	3.1	4.8	11.2	There is a single lane ahead for both directions of traffic.
9.7	8.3	4.8	4.3	The lane you are in will become narrower.
1.1	1.6	5.3	4.8	I am not sure what this sign means.
176	193	189	188	Sample Size
±5.6	±4.9	±5.4	±5.4	Precision of responses (90 percent confidence interval)

**Table III-9. Phase II Initial Survey Results (Percent)
for Word Message Lane Reduction Transition Alternatives**

SIGN ALTERNATIVE				QUESTION AND RESPONSES
6A	6B	7C	7D	
				What is the most correct meaning of this sign? Circle only ONE answer.
81.0	66.7	84.1	76.3	<i>The lane ends and traffic in the right lane should move into the left lane.</i>
3.5	10.4	4.8	2.7	The lane ends and traffic in the left lane should move into the right lane.
8.6	14.6	1.1	4.8	The median between opposing traffic will end.
4.6	4.7	5.8	7.5	There is a single lane ahead for both directions of traffic.
2.3	2.6	2.1	8.1	The lane you are in will become narrower.
0.0	1.0	2.1	0.5	I am not sure what this sign means.
174	192	189	186	Sample Size
±4.9	±5.6	±4.4	±5.1	Precision of responses (90 percent confidence interval)

In comparison to the symbol signs, two of the three word message signs, the **RIGHT LANE CLOSED 500 FT** (CW20-5, Alternative 7C) and the **RIGHT LANE ENDS** (W9-1, Alternative 6A), had higher correct response rates of 84 and 81 percent, respectively. “**RIGHT LANE CLOSED 500 FT**” is the legend used in a standard construction warning sign with an orange background. The sign was shown with a yellow background in this survey. Using a legend with the word **CLOSED** or **END** may provide an “urgency” that emphasizes the need for a driver to change lanes. The other word message sign, **LANE ENDS MERGE LEFT** (W9-

2, Alternative 6B) had a correct response rate of 67 percent, which is lower than the response rates for all of the symbolic signs. The difference in response rates between the standard sign (W4-2) and the two word message signs (CW20-5 and W9-1) is statistically significant at a 95 percent confidence level.

The survey results indicated that the word message signs may be more effective at informing drivers of a lane reduction. Comprehension of word message signs, however, among portions of the population that do not speak English as their primary language is a concern. Table III-10 compares the overall survey results for the standard symbol sign (W4-2, Alternative 1A) and the three word message signs (Alternatives 6A, 6B, and 7C) with several groups that may represent drivers who primarily speak Spanish. The *Spanish* survey group represents respondents who completed the Spanish language version of the survey. The *Hispanic* survey represents those respondents who checked the Hispanic category under ethnic background. The *El Paso* survey represents the results for the surveys administered in El Paso, a city with a large Spanish-speaking population.

For all four groups shown in Table III-10, the order of the correct response rates is similar. The **RIGHT LANE CLOSED 500 FT** sign (7C) always has the highest correct comprehension level, followed by the **RIGHT LANE ENDS** sign (6A); the standard symbol sign (1A) and the **LANE ENDS MERGE LEFT** sign (6B) have the lowest comprehension. For the word message signs 6A and 7C, the correct response rates among the Spanish speaking population groups are slightly lower, but are not statistically significant. For the symbol sign however, the correct response rates for the Spanish speaking population are much lower than the overall survey correct response and are statistically significant at a 90 percent level for both the Spanish Language and Hispanic Background groups.

The distance **500 FT** and the word **CLOSED**, which translates to the Spanish word *cerrado*, may improve the comprehension of the **RIGHT LANE CLOSED 500 FT** sign with the Hispanic driving population. “*Cerrado*” and “*abierto*” (and “closed” and “open”) are two words frequently seen and recognized by Hispanic drivers (i.e., tourists) on many restaurants, hotels, and automotive service stations, which may have led to the improved comprehension of the **RIGHT LANE CLOSED 500 FT** sign legend amongst the *Hispanic* and *El Paso* survey participants.

Table III-10. Survey Results (Percent) Among Spanish Language Groups for Lane Reduction Transition Alternatives

Overall Survey				Spanish Language Version				Hispanic Background				El Paso Location				QUESTION AND RESPONSES
1A	6A	6B	7C	1A	6A	6B	7C	1A	6A	6B	7C	1A	6A	6B	7C	
																
71.6	81.0	66.7	84.1	55.6	66.7	33.3	72.7	55.8	76.7	53.3	80.5	62.2	75.7	72.5	86.5	<i>The lane ends and traffic in the right lane should move into the left lane.</i>
7.4	3.5	10.4	4.8	11.1	22.2	11.1	9.1	16.3	7.0	11.1	14.6	10.8	8.1	7.5	5.4	The lane ends and traffic in the left lane should move into the right lane.
5.7	8.6	14.6	1.1	11.1	0.0	11.1	9.1	4.6	7.0	8.9	0.0	5.4	2.7	0.0	2.7	The median between opposing traffic will end.
4.6	4.6	4.7	5.8	22.2	11.1	0.0	9.1	7.0	7.0	15.6	0.0	8.1	8.1	12.5	2.7	There is a single lane ahead for both directions of traffic.
9.7	2.3	2.6	2.1	0.0	0.0	22.2	0.0	16.3	2.3	6.7	0.0	13.5	5.4	2.5	0.0	The lane you are in will become narrower.
1.1	0.0	1.0	2.1	0.0	0.0	22.2	0.0	0.0	0.0	4.4	4.9	0.0	0.0	5.0	2.7	I am not sure what this sign means.
176	174	192	189	9	9	9	11	43	43	45	41	37	37	40	37	Sample Size
±5.6	±4.9	±5.6	±4.4	±27.2	±25.8	±25.8	±22.1	±12.5	±10.6	±12.2	±10.2	±13.1	±11.6	±11.6	±9.2	Precision of responses (90% conf. interval)

Recommendations for Lane Reduction Transition Sign

The current standard signing practice for lane reductions is for the symbol sign (W4-2) to be the primary sign. The symbol sign is used for a lane reduction when only one sign is used. The **LANE ENDS MERGE LEFT** sign (W9-2) is used to supplement the symbol sign. The **RIGHT LANE ENDS** sign (W9-1) supplements either the symbol or the other word message sign. When all three signs are used, a driver approaching a lane reduction would see the **RIGHT LANE ENDS** sign first, followed by the **LANE ENDS MERGE LEFT**, and ending with the symbol sign.

Based on the survey results, the two word message signs, **RIGHT LANE ENDS 500 FT** (CW20-5 with a yellow background) and **RIGHT LANE ENDS** (W9-1), are both understood by more drivers than the current standard **Lane Reduction Transition** symbol sign (W4-2), especially when Hispanic or non-English speaking drivers were involved. The Texas MUTCD should allow either of the two word message signs to be used as the primary warning sign for a lane reduction instead of the standard symbol sign. When only one sign is installed, the MUTCD should allow one of these word message signs to be used. When more than one sign is used, the symbol sign should be used to supplement the word message sign. The **RIGHT LANE CLOSED 500 FT** sign should be added to the Texas MUTCD as a general warning sign (Chapter 2C) with a yellow background. The MUTCD language for this sign should provide an option that allows the distance to be displayed in a supplemental plaque instead of in the sign legend.

Narrow Bridge Sign (W5-2a)

The **Narrow Bridge** sign was evaluated in both the initial and follow-up surveys. The initial survey evaluated the standard symbol sign (W5-2a, Alternative 10A), the standard word message sign (W5-2), and three symbolic alternatives with a multiple-choice question in which two of the seven response choices were correct. All five signs are presented in Figure III-5. The question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative is presented in Table III-11.

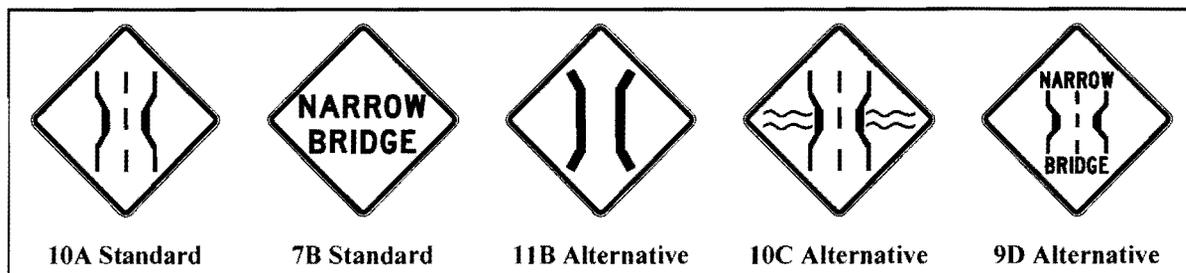


Figure III-5. Narrow Bridge Sign Alternatives Evaluated in Phase II Initial Survey

Table III-11. Phase II Initial Survey Results (Percent) for Narrow Bridge Sign Alternatives

SIGN ALTERNATIVE					QUESTIONS AND RESPONSE
10A	7B	11B	10C	9D	
					Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
2.8	2.1	1.0	3.7	1.6	You will go under an overpass ahead.
34.1	29.5	31.1	23.7	30.3	The shoulder may get narrower or end.
6.8	13.5	11.9	4.7	12.8	You will have to share your lane with traffic from other direction.
6.8	1.0	5.2	1.6	0.5	You are about to enter a tunnel.
52.8	59.1	54.4	39.5	67.0	The lane you are in may get narrower.
34.1	70.5	24.9	63.7	74.5	There is a bridge ahead. ¹
6.8	1.6	16.1	12.6	2.1	I am not sure what this sign means.
176	193	193	190	188	Sample Size
±6.2	±5.8	±5.9	±5.8	±5.6	Precision of responses (90 percent confidence interval)

Note: ¹ Partially correct answer.

Results of Phase II Initial Survey

The survey question was intended to evaluate drivers' understanding of the detailed message of the **Narrow Bridge** sign. Therefore, the response "there is a bridge ahead" is not completely correct if the respondent chose only this, as the sign is used to indicate that the roadway pavement width is narrower at the bridge. The sign is not used simply to indicate the presence of a bridge. Drivers that selected the "bridge ahead" response without also selecting the narrow lane/shoulder did not fully grasp each intended meaning for this sign. This question attempted to determine if drivers associate a "narrow bridge" with a change in the shoulder width or a change in the lane width. From the survey results, approximately 40 percent who chose the

“bridge ahead” response also chose either the “narrow shoulder” or “narrow lane” response as well.

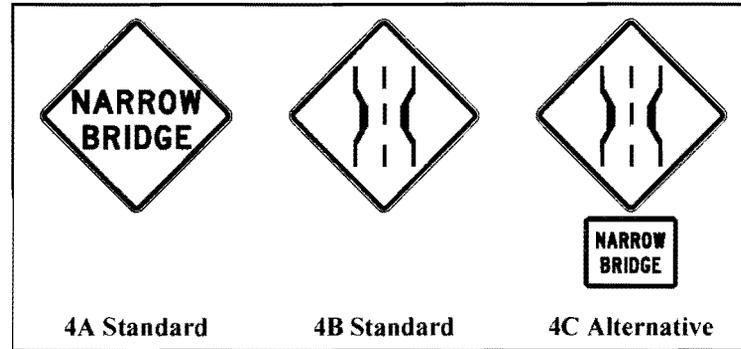
Based on the results presented in Table III-11, each sign demonstrated different strengths. The standard symbol sign (Alternative 10A) was associated more with a narrow lane (53 percent) than a shoulder getting narrower or ending (34 percent). Only about one-third (34 percent) of the respondents associated the sign with a bridge, and only about 15 percent associated a “bridge ahead” with either the “narrow shoulder” or “narrow lane” response. The standard word message sign (7B) had a much stronger association with a bridge (71 percent) and similar associations with a narrow lane (59 percent) and a narrow shoulder (30 percent). Furthermore, nearly half (47 percent) of the respondents associated “bridge ahead” with “narrow shoulder/narrow lane.”

For all signs except Alternative 10C, there was no statistically significant difference (at 90 percent confidence level) in the response rates for the “shoulder narrows/ends” response. There was no statistical difference between Alternatives 10A, 7B, and 11B in the response rates for the “narrow lane” response. The two signs with the words “narrow bridge” had the highest association with a bridge. The Canadian sign (Alternative 11B) had a high percentage of “I am not sure what this sign means” and a low association (14 percent) with a “bridge ahead” and “narrow shoulder/narrow lane”; therefore, this sign would not be practical to implement. Alternative 9D, with both a word and a symbolic legend, was the most effective at conveying the bridge message portion of the sign. Also, nearly 60 percent of the respondents associated this sign with a “bridge ahead” and “narrow shoulder/narrow lane.” This sign, however, may not be practical to implement due to the lower legibility of the small letter height. Due to the increased comprehension of this sign, and concern over driver understanding of the narrow shoulder/lane message, this device was included in the follow-up survey.

Results of Phase II Follow-Up Survey

Three signs were evaluated in the follow-up survey: the standard symbol sign alone, the standard word message sign, and the standard symbol sign with an educational plaque. These signs are illustrated in Figure III-6. The responses were the same as in the initial survey, except that the “bridge ahead” response was not included. The question, the responses, the percentage

of total participants choosing each response, and the sample size for each device is presented in Table III-12.



**Figure III-6. Narrow Bridge Sign Alternatives
Evaluated in Phase II Follow-Up Survey**

**Table III-12. Phase II Follow-Up Survey Results (Percent)
for Narrow Bridge Sign Alternatives**

SIGN ALTERNATIVE			QUESTION AND RESPONSES
4A	4B	4C	
			Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
6.9	5.7	2.9	You will go under an overpass ahead.
55.6	48.6	54.3	<i>The shoulder may get narrower or end.</i>
18.1	7.1	15.7	You will have to share your lane with traffic from the other direction.
0.0	2.9	1.4	You are about to enter a tunnel.
83.3	85.7	88.6	<i>The lane you are in may get narrower.</i>
0.0	1.4	4.3	I am not sure what this sign means.
72	70	70	Sample Size
±7.2	±6.9	±6.2	Precision of responses (90 percent confidence interval)

The response rates for the “narrow/ending shoulder” answer are equivalent at 90 percent level of confidence for all three devices, as are the response rates for the “narrow lane” answer. Worth noting is that at a 99 percent level of confidence, the response rates for “narrow/ending shoulder” are statistically significant than the response rates for “narrow lane.” Only about 50 percent of the respondents associated these alternatives with a “narrow/ending shoulder,” while over 85 percent associated the alternatives with a “narrow lane.” The word message sign (Alternative 4A) had the highest understanding of the “narrow/ending shoulder,” while the

symbol sign with the educational plaque (Alternative 4C) demonstrated the highest understanding of the “narrow lane” concept.

Recommendations for Narrow Bridge Sign

Based on the survey results, it does not appear as if any of the proposed alternative signs is any more effective than the existing standard signs. There was little statistically significant differences in the response rates for both the symbol (W5-2a) and word message (W5-2) signs. The results give a strong indication that drivers associate a narrow bridge condition more with a narrow lane than shoulders becoming narrow or ending.

Based on the survey results, the word message sign may be more effective than the symbol sign and the use of an educational plaque does not provide any significant improvement in comprehension. Table III-13 presents a comparison of comprehension of the symbol and word message signs in the initial survey among groups that speak Spanish as their primary language.

Table III-13. Survey Results (Percent) Among Spanish Language Groups for Narrow Bridge Sign Alternatives

Overall Survey		Spanish Version		Hispanic Background		El Paso Location		QUESTIONS AND RESPONSE
10A	7B	10A	7B	10A	7B	10A	7B	
								Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
2.8	2.1	11.1	11.1	9.3	4.4	5.4	0.0	You will go under an overpass ahead.
34.1	29.5	33.3	11.1	25.6	20.0	29.7	24.4	The shoulder may get narrower or end.
6.8	13.5	11.1	11.1	9.3	13.3	8.1	14.6	You will have to share your lane with traffic from other direction.
6.8	1.0	0.0	0.0	7.0	0.0	0.0	0.0	You are about to enter a tunnel.
52.8	59.1	44.4	11.1	48.8	46.7	54.1	58.5	The lane you are in may get narrower.
34.1	70.5	33.3	44.4	34.9	64.4	27.0	68.3	There is a bridge ahead. ¹
6.8	1.6	0.0	11.1	7.0	4.4	8.1	4.9	I am not sure what this sign means.
176	193	9	9	43	45	37	41	Sample Size
±6.2	±5.8	±27.2	±27.2	±12.5	±11.7	±13.5	±12.0	Precision of responses (90 percent C.I.)

Note: ¹ Partially correct answer.

Based on these results, the current standard **Narrow Bridge** signs, both symbol and word, should continue to be used. The word message version appears slightly better understood (but not statistically significant) among the general population; therefore, it should be the preferred version. In areas with a significant proportion of non-English speaking drivers, the symbol sign may be used as the preferred alternative.

The survey results also indicated that drivers associate these signs more with a reduction in lane width than a shoulder becoming narrower or ending. This indicates the need to emphasize this message to drivers. Options for increasing driver awareness of this message include:

- Clarifying the description of the **Narrow Bridge** sign in the *Texas Drivers Handbook* distributed to drivers by the Texas Department of Public Safety;
- Increasing the emphasis on narrow bridge situations in driver education/training curriculums;
- Including this sign in public information campaigns; and/or
- Using other traffic control devices such as pavement markings or supplemental signs to indicate the change in shoulder condition.

Slow Down on Wet Road Sign (W8-5)

The **Slow Down on Wet Road** sign was evaluated in both the initial and follow-up surveys. Four versions of the sign (presented in Figure III-7) were evaluated in the initial survey with a multiple-choice question. The respondents were allowed to choose more than one response, but only one response was completely correct (“slow down when the road is wet to keep from losing control”). Two other responses (“slow down to keep from losing control” and “watch out for large puddles of water on the road when it is raining”) were not incorrect, but indicated incomplete understanding of the sign’s message. The question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative is presented in Table III-14.

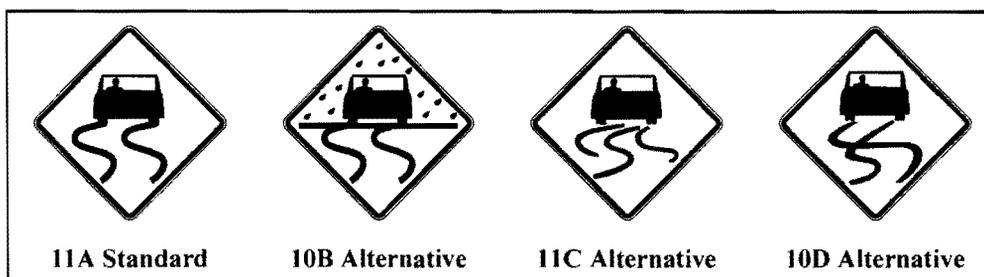


Figure III-7. Slow Down on Wet Road Sign Alternatives
Evaluated in Phase II Initial Survey

Table III-14. Phase II Initial Survey Results (Percent)
for Slow Down on Wet Road Sign Alternatives

SIGN ALTERNATIVE				QUESTION AND RESPONSES
11A	10B	11C	10D	
				Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
37.5	16.1	18.4	19.7	Be prepared for several curves in the road ahead.
7.4	5.2	8.4	9.6	Watch out for cars that are out-of-control.
35.8	26.4	34.2	49.5	Slow down to keep from losing control. ¹
4.0	2.6	2.1	3.7	Be prepared for potholes in the road that might cause you to lose control.
62.5	90.7	72.1	67.6	<i>Slow down when the road is wet to keep from losing control.</i>
5.7	17.6	15.3	9.6	Watch out for large puddles of water on the road when it is raining. ¹
2.3	0.5	5.3	4.3	I am not sure what this sign means.
176	193	190	188	Sample Size
±6.0	±3.4	±5.4	±5.6	Precision of responses (90 percent confidence interval)

Note: ¹ Partially correct answer.

Results of Phase II Initial Survey

There were statistically significant differences in the percentage of respondents that selected the most correct response for the different signs (63 to 91 percent). The sign with the best apparent overall understanding was the sign with the “raindrops” (10B). However, the “tire marks” in Alternatives 11C and 10D (the European versions of this sign) also demonstrated increased comprehension levels (not statistically significant) over the current sign used in Texas. The “raindrops” shown in Alternative 10B show a statistically significant increase in comprehension of “slowing down when the road is wet to keep from losing control” over the other three alternatives, but the “tire marks” in Alternative 10D exhibit a higher percentage of “slowing down to keep from losing control.”

The standard sign (Alternative 11A) had the lowest percentage for the correct response and the highest percentage selecting the “curves in road” response. This area of misunderstanding has been associated with this sign in several previous studies (18, 19, 20, 23). The standard sign also had the lowest percentage of drivers selecting the other response that included water on the road (“watch out for large puddles when raining”).

The results indicated that the “raindrops” and horizontal line in Alternative 10B, along with the “tire marks” in Alternatives 11C and 10D, might have a positive impact on comprehension, but the initial survey did not address all of the combinations of these elements. Therefore, two additional signs were developed for evaluation in the follow-up survey.

Results of Phase II Follow-Up Survey

The three signs evaluated in the follow-up survey are shown in Figure III-8. The Set C alternative was the same as the sign in the initial survey. The Set B alternative was developed by taking the horizontal line out of the Set C Alternative. The Set A alternative was developed by adding “raindrops” to Alternative 10D sign from the initial survey. The question and responses in the follow-up survey were the same as those in the initial survey. The results of the follow-up survey question are presented in Table III-15.



Figure III-8. Slow Down on Wet Road Alternatives Evaluated in Phase II Follow-Up Survey

**Table III-15. Phase II Follow-Up Survey Results (Percent)
for Slow Down on Wet Road Sign Alternatives**

SIGN ALTERNATIVE			QUESTION AND RESPONSES
5A	5B	5C	
			Which of the following responses apply when you see this sign? You may circle MORE THAN ONE answer.
8.3	11.4	14.3	Be prepared for several curves in the road ahead.
5.6	7.1	11.4	Watch out for cars that are out-of-control.
31.9	21.4	27.1	Slow down to keep from losing control. ¹
4.2	0.0	1.4	Be prepared for potholes in the road that might cause you to lose control.
91.7	95.7	91.4	<i>Slow down when the road is wet to keep from losing control.</i>
23.6	17.1	14.3	Watch out for large puddles of water on the road when it is raining. ¹
0.0	0.0	0.0	I am not sure what this sign means.
72	70	70	Sample Size
±5.3	±4.0	±5.5	Precision of responses (90 percent confidence interval)

Note: ¹ Partially correct answer.

There is no statistically significant differences in the response percentage for Alternatives 5B and 5C at a 99 percent level of confidence. This implies that the horizontal line in Alternatives 10B and 5C does not have any appreciable impact on comprehension of the sign's message. Alternative 5A, with the crossing "tire marks" and "raindrops," had a correct response rate that was not statistically different from the other alternatives. It also had a significantly lower percentage selecting the "curves ahead" response and higher percentages selecting the "slow down to keep from losing control" and "watch for large puddles when raining" responses.

Recommendations for Slow Down on Wet Road Sign

The results of the two evaluations of alternatives for the **Slow Down on Wet Road** sign indicated that understanding of the sign can be improved by adding "raindrops" and changing the design of the "tire marks." Alternative 5A, as shown in Figure III-8, should replace the current standard sign, based on comprehension results of both the initial and follow-up surveys. In the initial survey, the "tire marks" exhibited a higher percentage of "slow down to keep from losing control" and the "raindrops" exhibited a higher percentage of "slow down when the road is wet to keep from losing control." Alternative 5A also exhibited the highest percentage selecting the "slow down to keep from losing control" response and the lowest percentage

selecting the “curves in the road” response. The last factor is particularly significant, as a common misinterpretation of the standard sign is “winding road.”

Prior to implementation, however, evaluations should be conducted of the legibility of the “raindrops” in the proposed sign. This is necessary to determine the optimal size of the “raindrops.” Even if the “raindrops” prove to have limited legibility, the comprehension results of using the revised “tire mark” pattern indicated that the “tire marks” in the current standard sign should be changed.

Truck Crossing Sign (W11-10)

Various designs of the **Truck Crossing** sign were evaluated in both the initial and follow-up surveys. In the initial survey, six versions of the **Truck Crossing** sign were evaluated with a multiple choice question. The six versions included the standard symbol sign (W11-10, 2A), the standard word message sign (W8-6, 7A), the standard symbol sign with distance plaques, the Canadian version of the sign (Alternative 8C), and a combination symbol/word message sign (Alternative 2D). Figure III-9 illustrates these alternatives and Table III-16 presents the question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each of the alternatives.

Results of Phase II Initial Survey

An examination of the survey results in Table III-16 indicated that none of the sign alternatives were very well understood. The percentages for all responses for all signs were each less than 55 percent. The lack of understanding demonstrated by the survey results does not mean that drivers do not associate these signs with trucks; it merely indicates that drivers do not associate the sign with the presence of a truck crossing. A result worth noting is that the Canadian version of the sign (Alternative 8C), which possessed most of the features the focus group participants felt were important, had the highest “not sure” response rate of all survey questions. Two of the response choices were very similar and were in fact related. The response “trucks may be entering or crossing the road at a single location a short distance ahead” was actually a subset of the response “trucks may be entering or crossing the road at one or several locations on the following section of roadway.” The “single location” response was incorrect

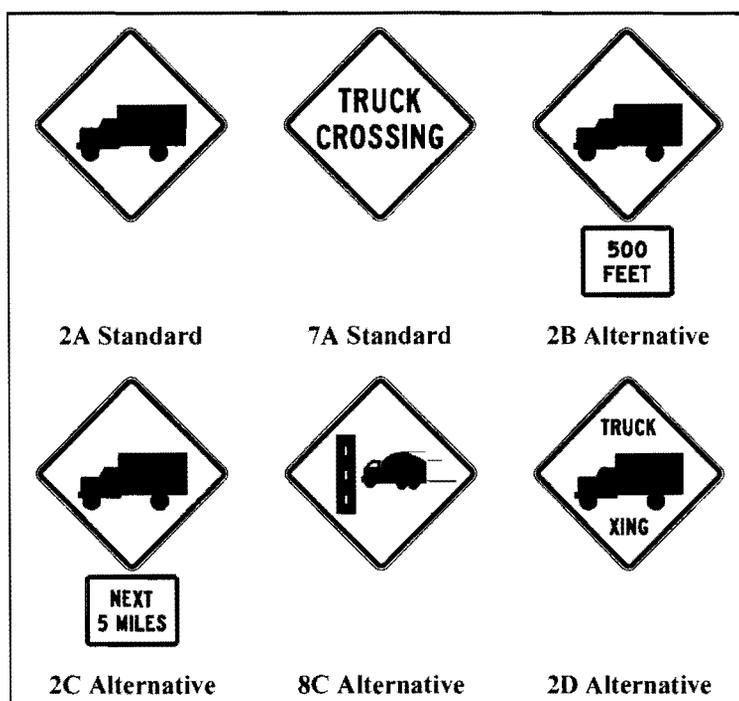


Figure III-9. Advance Truck Crossing Sign Alternatives Evaluated in Phase II Initial Survey

Table III-16. Phase II Initial Survey Results (Percent) for Advance Truck Crossing Alternatives

SIGN ALTERNATIVE						QUESTION AND RESPONSES
2A	7A	2B	2C	8C	2D	
						What is the most correct meaning of this sign? Circle only ONE answer.
26.7 33.0	6.9 33.7	6.8 29.8	16.9 54.5	6.8 30.0	10.1 41.5	This is a warning that this roadway is heavily used by trucks. <i>Trucks may be entering or crossing the road at one or several locations on the following section of roadway.</i>
11.9 21.0	4.0 49.7	9.4 48.2	16.9 9.5	3.2 28.4	7.5 38.8	Be prepared for slow moving trucks using the roadway. <i>Trucks may be entering or crossing the road at a single location a short distance ahead.¹</i>
1.7 5.7	4.0 1.7	0.5 5.2	0.0 2.1	3.7 27.9	0.0 2.1	No cars allowed on this section of the road, only large trucks. I am not sure what this sign means.
176	175	191	189	190	188	Sample Size
±5.8	±5.9	±5.4	±6.0	±5.5	±5.9	Precision of responses (90 percent confidence interval)

Note: ¹ Correct response for Alternative 2B only.

only for the sign alternative with a distance plaque indicating a length of roadway (Alternative 2C). When these two response rates were added together for all sign alternatives except 2C, the response rates were over 50 percent, and the standard word message sign (Alternative 7A) had a response rate of 83 percent. Alternative 2D, with the word message combined with the symbol, also had a combined response rate of over 80 percent. The increased comprehension of the word message, plus uncertainty over comprehension of the distance plaques, led to additional evaluation of this sign in the follow-up survey.

Results of Phase II Follow-Up Survey

The follow-up survey evaluated the three alternatives shown in Figure III-10. All three signs are existing standard signs. The standard symbol sign was shown with an educational plaque (W11-10, 1A). The existing standard word message sign was combined with two different distance plaques — one that showed the distance to a single crossing (W8-6, 1B) and one that showed a length of highway over which crossings are present (W8-6, 1C). The question and responses were the same as those of the initial survey. Table III-17 presents the results of the follow-up evaluation.

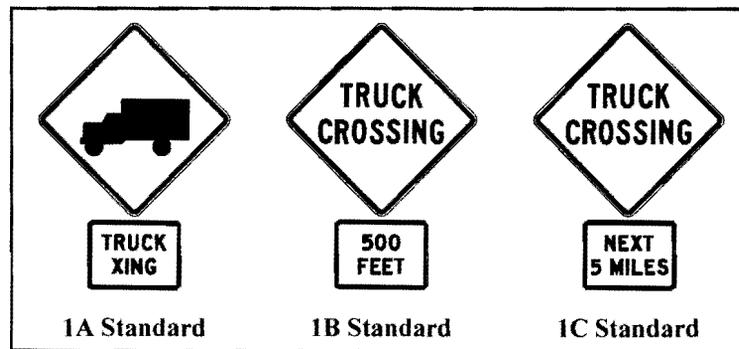


Figure III-10. Advance Truck Crossing Sign Alternatives Evaluated in Phase II Follow-Up Survey

**Table III-17. Phase II Follow-Up Survey Results (Percent)
for Advance Truck Crossing Alternatives**

SIGN ALTERNATIVE			QUESTION AND RESPONSES
1A	1B	1C	
			What is the most correct meaning of this sign? Circle only ONE answer.
9.7 23.6	0.0 30.0	2.9 68.6	This is a warning that this roadway is heavily used by trucks. <i>Trucks may be entering or crossing the road at one or several locations on the following section of roadway.</i>
4.2 61.1	7.1 62.9	1.4 25.7	Be prepared for slow moving trucks using the roadway. <i>Trucks may be entering or crossing the road at a single location a short distance ahead.</i> ¹
0.0 1.4	0.0 0.0	0.0 1.4	No cars are allowed on this section of the road, only large trucks. I am not sure what this sign means.
72	70	70	Sample Size
±8.2	±9.0	±9.1	Precision of responses (90 percent confidence interval)

Note: ¹ Correct response for Alternative 1B only.

The results of the follow-up survey indicated that two of the alternatives (1B and 1C) demonstrated slightly improved comprehension levels over the alternatives evaluated in the initial survey. These two alternatives demonstrated correct comprehension rates between 60 and 70 percent. There is still some uncertainty among the respondents as to whether the alternatives represent a single truck crossing or multiple crossings. Only 24 percent of the respondents chose the correct “multiple crossing” response for Alternative 1A, while over 60 percent chose the “single crossing” response. When the “single crossing” and “multiple crossing” response rates are added, comprehension levels are between 85 and 94 percent.

Recommendations for Truck Crossing Sign

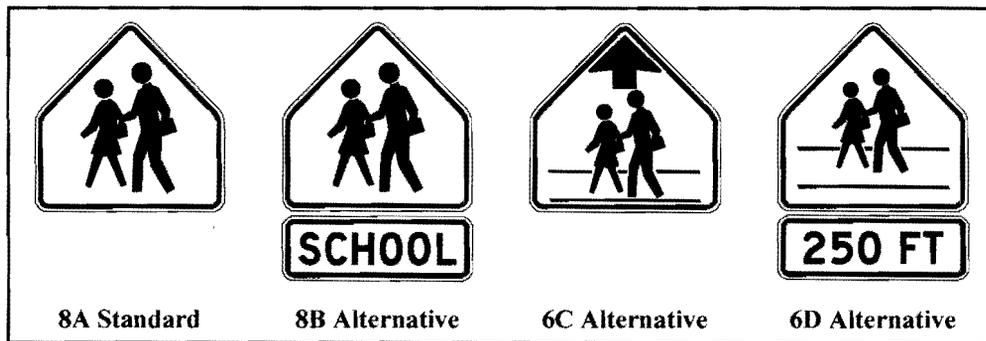
The results of the evaluations of these sign alternatives in the two surveys indicated that the alternatives evaluated in the follow-up survey are better understood than those evaluated in the initial survey. The word message signs appear to have slightly higher comprehension levels, but these differences are not statistically significant at a 90 percent level of confidence.

Based on these results, the existing standard signs should continue to be used. If the symbol sign is used for a single truck crossing, it should be accompanied by the **TRUCK XING**

educational plaque. However, if the word message sign is used for a single crossing, it should be accompanied by a distance plaque. If the sign is intended for multiple crossings, the word message or symbol sign can be used, but it should be accompanied by a **NEXT 3 MILES** (or appropriate distance) plaque.

School Advance Sign (S1-1)

The **School Advance** sign (S1-1) was evaluated in the initial survey due to concern over the dual uses of this sign. Four versions of the sign were evaluated with a multiple choice question which had either one or two correct responses, depending upon which sign alternative was presented. Figure III-11 illustrates the four alternatives, and Table III-18 presents the question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative.



**Figure III-11. School Advance Sign Alternatives
Evaluated in Phase II Initial Survey**

**Table III-18. Phase II Initial Survey Results (Percent)
for School Advance Alternatives**

SIGN ALTERNATIVE				QUESTION AND RESPONSES
8A	8B	6C	6D	
				Please circle <u>ANY</u> of the following responses that apply when you see this sign. You may circle <u>MORE THAN ONE</u> answer.
32.4 36.9 49.4 45.5 0.6	67.9 26.9 21.8 68.4 0.0	9.4 10.6 45.0 34.4 0.6	6.0 8.1 52.4 33.0 0.5	
176	193	180	185	Sample Size
±6.2	±5.5	±5.8	±5.7	Precision of responses (90 percent confidence interval)

Notes: ¹ Correct response for Alternatives 8A and 8B only.

² Correct response for all signs.

Results for Phase II Initial Survey

For the standard sign (S1-1), the survey results indicated that about 32 percent associated this sign with a school area and 46 percent associate it with advance warning of a school crossing. Worth noting is the fact that another 86 percent of the respondents selected the two responses that associate this alternative with pedestrian issues. These results confirm findings of previous studies that indicated drivers had difficulty distinguishing between school crossing signs and pedestrian crossing signs. When the **SCHOOL** plaque was added below the sign in Alternative 8B, association of the school message increased significantly, but almost 50 percent of respondents selected the two responses that associate this alternative with pedestrian issues.

The other two sign alternatives (6C and 6D) were intended to determine if the advance crossing message of the sign could be conveyed more effectively. Each alternative included a “crosswalk” in the legend. These two alternatives demonstrated equal understanding of the advance crossing message (approximately 34 percent), but continued to produce confusion with pedestrian crossing signs. These alternatives were effective at reducing confusion over the dual meaning of the **School Advance** sign, as less than 10 percent for each sign selected the “school area ahead” response.

The initial survey results indicated that the **SCHOOL** plaque reduced confusion with the pedestrian crossing signs and the use of the “crosswalk” reduced confusion over the dual meaning of the **School Advance** sign. Additional questions remained, however, so new alternatives were developed for the follow-up survey.

Results for the Phase II Follow-Up Survey

The follow-up survey attempted to determine the value of using the word **SCHOOL** in the legend. Figure III-12 illustrates the alternatives evaluated in the follow-up survey and Table III-19 presents the question, responses, and response rates for each of the alternatives.

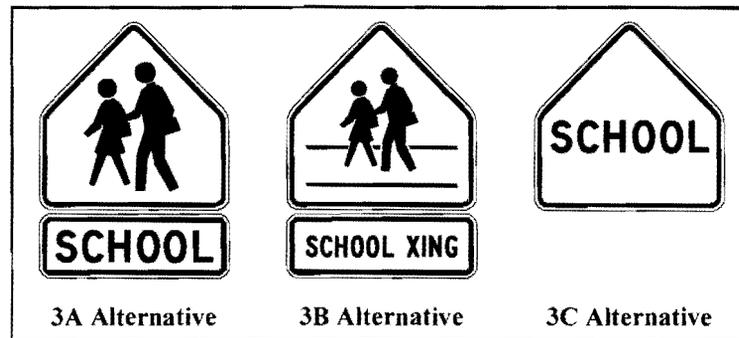


Figure III-12. School Advance Sign Alternatives Evaluated in Phase II Follow-Up Survey

Table III-19. Phase II Follow-Up Survey Results (Percent) for School Advance Alternatives

SIGN ALTERNATIVE			QUESTION AND RESPONSES
3A	3B	3C	
			Please circle ANY of the following responses that apply when you see this sign. You may circle MORE THAN ONE answer.
77.8	4.3	85.5	<i>There is a school area ahead.</i> ¹
30.6	1.4	2.9	Pedestrians may be walking on the shoulder or sidewalk.
23.6	7.1	2.9	There is a pedestrian crosswalk ahead.
81.9	87.1	8.7	<i>There is a school crosswalk ahead.</i> ²
0.0	0.0	0.0	I am not sure what this sign means.
72	70	69	Sample Size
±7.5	±6.6	±7.0	Precision of responses (90 percent confidence interval)

Notes: ¹ Correct response for Alternatives 3A and 3C.

² Correct response for Alternatives 3A and 3B.

Alternative 3A was the same sign evaluated in the initial survey. For this alternative, there was no statistical difference in the response rates between the two survey evaluations (at 90 percent confidence level) for all responses except the “school crosswalk ahead” response. In both surveys, the respondents indicated a strong association with this alternative to a “school area” and to a “school crosswalk,” both of which were correct responses.

The other two alternatives were intended to better distinguish between the dual meanings of the **School Advance** sign, while also reducing confusion with pedestrian crossings. Alternative 3B used a standard **School Crossing** sign with a plaque containing the legend **SCHOOL XING**. The survey results indicated a strong association with a school crossing and little confusion with a school area or pedestrian crossing. Therefore, the sign would not be appropriate to use as a school area sign. Alternative 3C, with the legend **SCHOOL**, was strongly associated with a school area. There was little confusion with a school crossing or pedestrian crossing, which would indicate that this sign would not be appropriate as a school crossing sign.

Recommendations for the School Advance Sign - Based on Current Research

The Phase II surveys focused on the dual meaning of the **School Advance** sign (S1-1). The initial survey results indicated that motorists generally do not recognize both of the meanings. The results also indicated confusion between school and pedestrian crossings. The use of the word **SCHOOL** on a supplemental plaque below the S1-1 sign improved association of the sign with a school and reduced confusion with a pedestrian crossing. A distance plaque (**250 FT**) also proved to be effective for distinguishing an advance school crossing.

In the follow-up survey a pentagon-shaped sign with the legend **SCHOOL** significantly improved understanding of the “school area” message and dramatically reduced any association with pedestrian or crossing issues. The use of the words **SCHOOL XING** on a supplemental plaque was effective in distinguishing the advance school crossing and the school area messages.

Based on the results from both surveys, the following recommendations are made for an advance treatment for a school area and a school crosswalk:

School Area. A pentagon with the word legend **SCHOOL** should be used to indicate a school area. This sign is illustrated in Figure III-13a. This recommendation is based on the responses in the follow-up survey.

Advance School Crossing. The existing **School Advance** sign (S1-1) should be used with a supplemental plaque containing the legend **SCHOOL XING 250 FEET**. This sign is illustrated in Figure III-13b. This recommendation is based on the initial survey results that indicated the **250 FEET** plaque reduced confusion with the school area and follow-up survey results for Alternative 3B that indicated the **SCHOOL XING** plaque reduced confusion with both the school area and pedestrian crossing interpretations. It should be noted, however, that this recommendation uses the existing **School Advance** sign (without the crosswalk). This research did not evaluate the ability of drivers to distinguish between advance crossing and crossing signs. Therefore, there is not sufficient justification to change the application of the two pentagon-shaped signs.

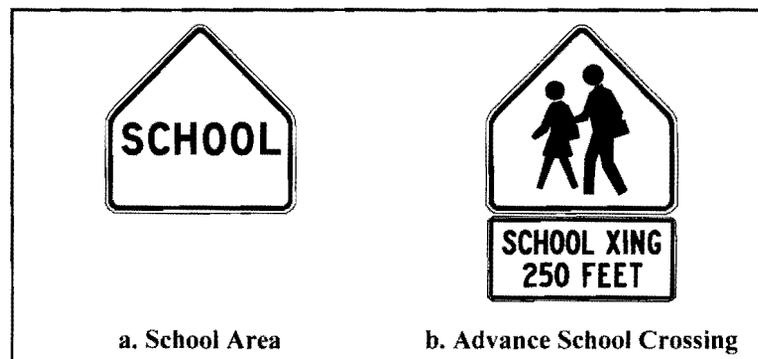


Figure III-13. Recommended Signs for School Advance Signing Applications

Recommendations for the School Advance Sign - Based on Further Evaluation

As mentioned, this research did not address differences between the “advance school crossing” meaning of the S1-1 sign and the “crossing” meaning of the S2-1 sign. The follow-up survey results indicated that the **SCHOOL XING** plaque may reduce confusion with both the school area and pedestrian crossing interpretations, but was not thoroughly evaluated with respect to the interpretation of the **School Crossing** sign (S2-1) alone.

Traffic control for school areas is a complicated subject, as it involves several different devices and is of great concern to parents and school administrators. For it to be effective, the individual devices must function as a system rather than as individual elements. The research described above addressed only two elements of the system — understanding of the school area message and understanding of the advance school crossing message. Before the recommendations are implemented, further evaluations of the complete system should be conducted to determine the most effective manner of controlling traffic in school areas. This evaluation should address the following items:

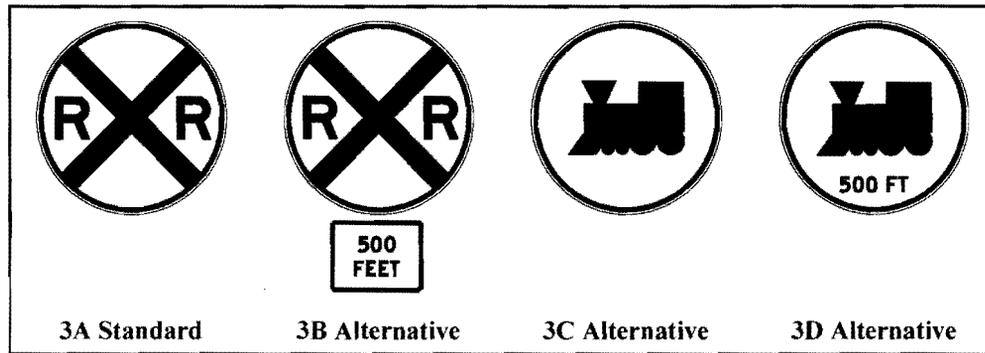
- Distinguishing between school area and advance school crossing messages (confirm the recommendations of this research);
- Distinguishing between school crossing and pedestrian crossing messages (confirm the recommendations of this research);
- Distinguishing between the advance school crossing and school crossing messages;
- Identification of the beginning of school speed limit zones;
- Identification of the ending of school speed limit zones (addressed in the focus groups of this research project);
- Identification of school bus stops;
- The use of flashing lights and **STOP** signs on school buses to control traffic (these devices are not treated as traffic control devices in the MUTCD);
- School crossing protection (crossing guards are not addressed in the MUTCD, even though they essentially function as a flagger); and
- Use of pavement markings to define advance school crossings, school crossings, school speed limit zones, end of school speed limit zones, and school bus stops.

These additional evaluations should address a variety of factors that are beyond the scope of this research project. These factors include the selection, design, application, and operation of these devices. Specific issues that should be investigated include the legibility of any new signs or supplemental plaques, how to coordinate school area traffic control with parent and school organizations, the appropriate number and sequence of school area traffic control, the manner in which various devices for school area traffic control interact, the need for redundant signing (i.e., is a **School Advance** sign needed if a **School Speed Limit** sign is used?), traffic

routing (one-way vs. two-way), parking and waiting, impact of age of students on the need for traffic control, and necessary training for school crossing guards.

Railroad Advance Warning Sign (W10-1)

The **Railroad Advance Warning** sign (W10-1) and three alternatives, presented in Figure III-14, were evaluated in the Phase II initial survey. Survey participants were asked to choose a single, correct answer from seven different response choices. The question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each alternative is presented in Table III-20.



**Figure III-14. Railroad Advance Warning Sign Alternatives
Evaluated in Phase II Initial Survey**

**Table III-20. Phase II Initial Survey Results (Percent)
for Railroad Advance Warning Sign Alternatives**

SIGN ALTERNATIVE				QUESTION AND RESPONSES
3A	3B	3C	3D	
				What is the meaning of this sign? Circle only ONE answer.
0.0	0.5	10.6	3.7	There is a train museum ahead.
1.1	2.6	10.1	3.7	There is a train coming at the crossing ahead.
17.6	5.3	8.0	4.3	There is a railroad crossing next to this sign.
81.3	90.5	51.1	80.8	There is a railroad crossing ahead.
0.0	0.0	0.0	0.0	The Recreational Road ahead is temporarily closed.
0.0	0.5	0.0	0.5	You are about to intersect a Ranch Road.
0.0	0.5	20.2	7.0	I am not sure what this sign means.
176	190	188	187	Sample Size
±6.0	±3.4	±5.4	±5.6	Precision of responses (90 percent confidence interval)

Results of Phase II Initial Survey

The standard sign demonstrated the comprehension difficulties most often associated with this sign. While 81 percent selected the correct response, another 18 percent associated this sign as one “next” to the crossing. The responses for Alternatives 3A and 3B are not statistically different at a 99 percent confidence level except for the response “there is a railroad crossing next to this sign.” Therefore, the addition of the plaque significantly reduces confusion of this sign “next” to the crossing.

The train symbol signs were not understood as well as the standard **Railroad Advance** signs. The train symbol alone exhibited a high percentage of “I am not sure what this sign means” (20 percent). The addition of a distance to the train symbol also improved comprehension of the sign.

Recommendations for Railroad Advance Warning Sign

The survey results indicated that all of the respondents associated the current standard sign with the presence of a train crossing, although there is some confusion over the relation between the position of the sign and the location of the crossing. The addition of a distance plaque reduces this confusion. Based on the survey results, the use of a distance plaque with the standard W10-1 sign should be identified as an option to improve comprehension of the sign’s message.

Parallel Railroad Advance Warning Sign (W10-3)

Four versions of the **Parallel Railroad Advance Warning Sign** were evaluated with a multiple choice question for which there was only one correct answer. Figure III-15 illustrates the signs that were evaluated in the survey. Table III-21 presents the question, the responses, the percentage of total participants choosing each response, the sample size, and the precision for each of the alternatives.

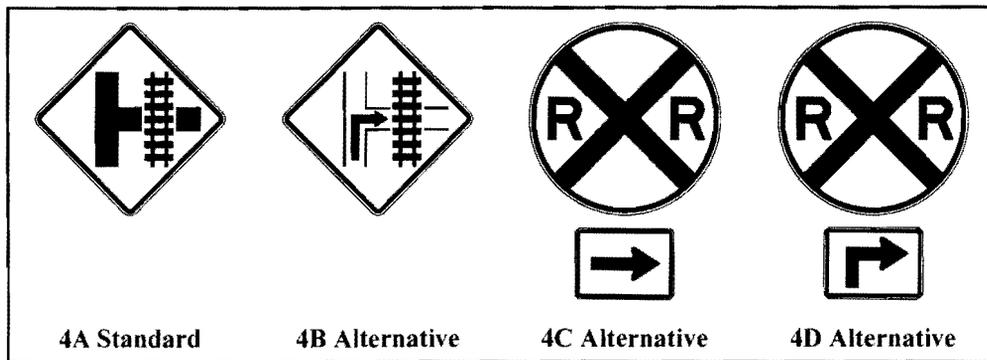


Figure III-15. Parallel Railroad Advance Warning Sign Alternatives Evaluated in Phase II Initial Survey

Table III-21. Phase II Initial Survey Results (Percent) for Parallel Railroad Advance Warning Sign Alternatives

SIGN ALTERNATIVE				QUESTION AND RESPONSES
4A	4B	4C	4D	
				What is the meaning of this sign? Circle only ONE answer.
0.6 84.1	0.5 88.1	1.6 90.5	0.0 87.2	You will go through a tunnel if you turn right. You will cross a railroad track if you turn right at the intersection. You are driving next to an unpaved road. There is a fence along the right side of the road. You will be on a Ranch Road if you turn right at the next intersection. You will be required to turn right at the intersection ahead. I am not sure what this sign means.
176	193	190	187	Sample Size
±4.5	±3.8	±3.5	±4.0	Precision of responses (90 percent confidence interval)

Results of Phase II Initial Survey

An examination of the results shown in Table III-21 indicated that the existing standard sign (W10-3, Alternative 4A) had the lowest correct response rate and the highest “not sure” response rate, although not statistically different than the other three alternatives. The use of the standard circular railroad warning sign (W10-1) with a supplemental right arrow plaque (Alternative 4C) had the highest correct response rate and the second lowest “not sure” rate. Again, however, the results are not statistically significant. For Alternatives 4A, 4B, and 4C, the correct and “not sure” responses accounted for approximately 94 percent of total responses. For

Alternative 4D, 94 percent of the total was accounted for in the correct and “required to turn right” responses.

Recommendations for Parallel Railroad Advance Warning Sign

The results for this question indicated that the standard circular sign (W10-1) with a right arrow plaque (Alternative 4C) had a higher comprehension rate than the standard **Parallel Railroad Advance Warning** sign (W10-3), but, yet, was not statistically different. Consideration should be given to using Alternative 4C as the standard sign for this application because it appears to be a better understood sign. It should be noted, however, that the current standard (W10-3) still exhibited a relatively high comprehension level (84 percent). Therefore, it need not be eliminated from use. If Alternative 4C is not established as the standard or preferred sign, then it should be identified as an optional sign.

CHAPTER IV

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Three different evaluations were conducted during Phase II of this project. The evaluations focused on taking the recommendations from Phase I, which identified traffic control devices for further research, developing alternative sign designs, and evaluating these designs. The three Phase II evaluations included: focus groups to develop alternative designs, an initial driver survey to evaluate comprehension levels of current and alternative designs, and a follow-up survey to further evaluate specific device alternatives or device features (i.e., words or symbols). A total of 978 drivers evaluated ten traffic control devices in these three evaluations. The focus groups are described and the findings are presented in detail in Chapter II of this report, and the two Phase II surveys are described and the results are presented in Chapter III of this report.

This chapter summarizes the Phase II findings and recommendations for the ten devices evaluated. The recommendations are based on an analysis of the Phase II survey results. The recommendations for each device are divided into four primary recommendations, which include:

- Retain the current standard sign design;
- Adopt the standard word message sign as the preferred version over the standard symbol sign;
- Adopt an alternative sign design; and/or
- Conduct additional evaluations.

Under these primary recommendations, secondary recommendations are also proposed for five of the devices. The two secondary recommendations include:

- Use supplemental plaque; and/or
- Increase driver education/training.

RETAIN CURRENT STANDARD

Based on adequate comprehension levels, the following three devices should retain their current standard designs.

End School Zone Sign (S5-2)

In the Phase II focus groups, all of the participants indicated a strong preference for the use of the **END SCHOOL ZONE** (S5-2) sign, either alone or in combination with a **SPEED LIMIT** (R2-1) sign. Furthermore, they were not able to suggest many alternatives to the sign other than a sign with the legend **Resume Speed**. As a result, alternative designs for this sign were not evaluated further, and the standard design, shown in Figure IV-1, is recommended for continued use.

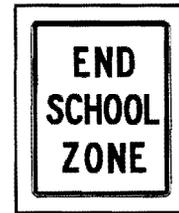


Figure IV-1.
S5-2 Sign

Two-Way Left Turn Only Sign (R3-9b)

The standard sign (R3-9b) was understood by over 80 percent of the survey respondents in the initial survey, and no statistical difference existed between the four alternatives. The results, however, did indicate that approximately 30 percent of the respondents believed that two-way left turn lanes (TWLTLs) can be used for storage purposes when crossing or entering the roadway. Based on these results, the current sign, shown in Figure IV-2, is recommended for continued use as the ground mounted sign for TWLTLs, but the Texas MUTCD and/or the *Texas Driver's Handbook* should make additional efforts to clarify the use of these lanes for storage purposes. If it is not intended for this purpose, then driver education/training curriculums should make additional efforts to inform drivers of appropriate driving practices in these lanes.

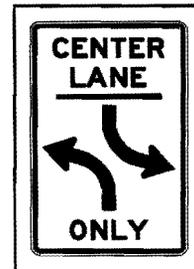
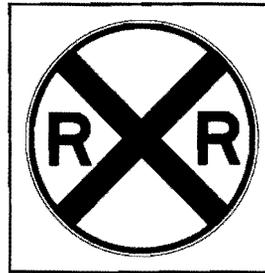


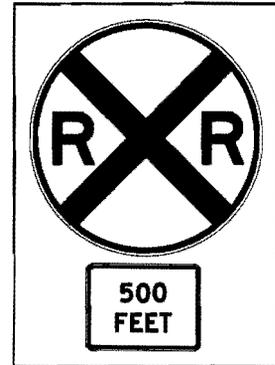
Figure IV-2.
R3-9b Sign

Railroad Advance Warning Sign (W10-1)

The Phase II survey results indicated that all of the respondents associated the current standard sign (W10-1), shown in Figure IV-3, with the presence of a train crossing, although there is some confusion over the relationship between the position of the sign and the location of the crossing. The addition of a supplemental distance plaque reduced this confusion. The use of a distance plaque with the standard W10-1 sign is recommended as the preferred alternative over just the standard sign. This recommended sign is shown in Figure IV-4.



**Figure IV-3.
W10-1 Sign**



**Figure IV-4.
W10-1 Sign with
Suppl. Plaque**

USE STANDARD WORD MESSAGE SIGN

Based on the Phase II survey results, a word message sign should be adopted as the preferred sign for the following three devices. The standard symbol sign may continue to be used in certain situations.

Lane Reduction Transition Sign (W4-2)

Based on the Phase II survey results, the word message signs with the legend **RIGHT (LEFT) LANE CLOSED 500 FT (CW20-5)** and **RIGHT LANE ENDS (W9-1)**, shown in Figures IV-5 and IV-6, were the best understood signs, especially when Hispanic or non-English speaking drivers were involved. The Texas



**Figure IV-5.
CW20-5 Sign**



**Figure IV-6.
W9-1 Sign**

MUTCD should allow either of these two word message signs to be used as the primary warning sign for a lane reduction transition instead of the standard symbol sign. When only one sign is installed, the MUTCD should allow one of these word message signs to be used. The MUTCD,

however, should allow the current standard symbol sign (W4-2), shown in Figure IV-7, to be used to supplement either of the word message signs. The preferred sequence should be either of the two word message signs, supplemented by the symbol sign and the **LANE ENDS MERGE LEFT** sign (W9-2). This proposed sequence is depicted in Figure IV-8.

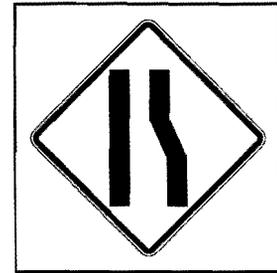


Figure IV-7.
W4-2 Sign

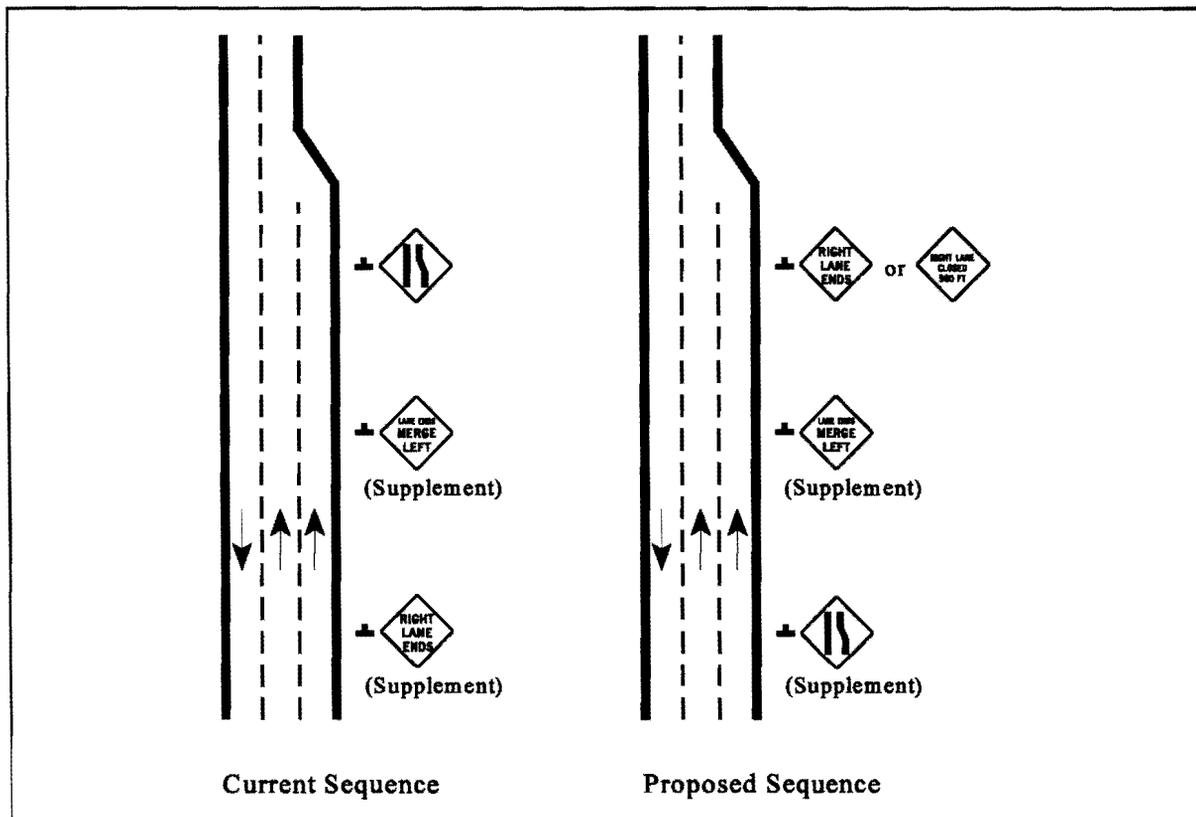
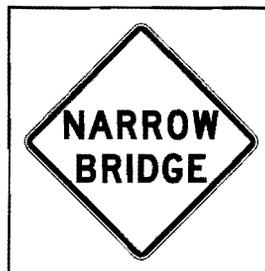


Figure IV-8. Proposed Sequence of Signs for Lane Reduction Transition

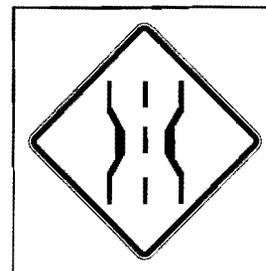
The **RIGHT LANE CLOSED 500 FT** sign, already part of the construction and maintenance operations section of the MUTCD, should be added to Chapter 2C for use as a general warning sign with a yellow background. The MUTCD language for this sign should provide an option that allows the distance to be displayed in a supplemental plaque instead of in the sign legend.

Narrow Bridge Sign (W5-2a)

Based on the Phase II survey results, the current standard **Narrow Bridge** signs (W5-2 and W5-2a), shown in Figures IV-9 and IV-10, should continue to be used. The standard word message sign (W5-2) was better understood among the survey respondents; therefore, it is recommended as the preferred sign. In areas with a significant proportion of non-English speaking drivers, the symbol sign may be used as the preferred sign.



**Figure IV-9.
W5-2 Sign**



**Figure IV-10.
W5-2a Sign**

The survey results also indicated that drivers associated these signs more with a reduction in lane width than a shoulder becoming narrower or ending. This indicates the need to emphasize this message to drivers. Options for increasing driver awareness of this message include:

- Clarifying the description of the **Narrow Bridge** sign in the *Texas Drivers Handbook*;
- Increasing the emphasis on narrow bridge situations in driver education/training curriculums;
- Including this sign in public information campaigns; and/or
- Using other traffic control devices such as pavement markings or supplemental signs to indicate the change in shoulder condition.

Truck Crossing Sign (W11-10)

The Phase II survey results indicated that the word message versions that were evaluated appeared to have slightly higher comprehension levels than the symbol sign alternatives, but the differences were not statistically significant. Furthermore, the use of supplemental plaques on both signs improved the comprehension. Based on these results, it is recommended that the existing standard symbol sign (W11-10) and the word message sign (W8-6) should continue to be used. If the symbol sign is used for a single truck crossing, it should be accompanied by the

TRUCK XING educational plaque, as shown in Figure IV-11a. However, if the word message sign is used for a single crossing, it should be accompanied by a distance plaque, as shown in Figure IV-11b. If the sign is intended for multiple crossings, either sign should be accompanied by a **NEXT 5 MILES** (or appropriate distance) plaque, as shown in Figures IV-11c or IV-11d.

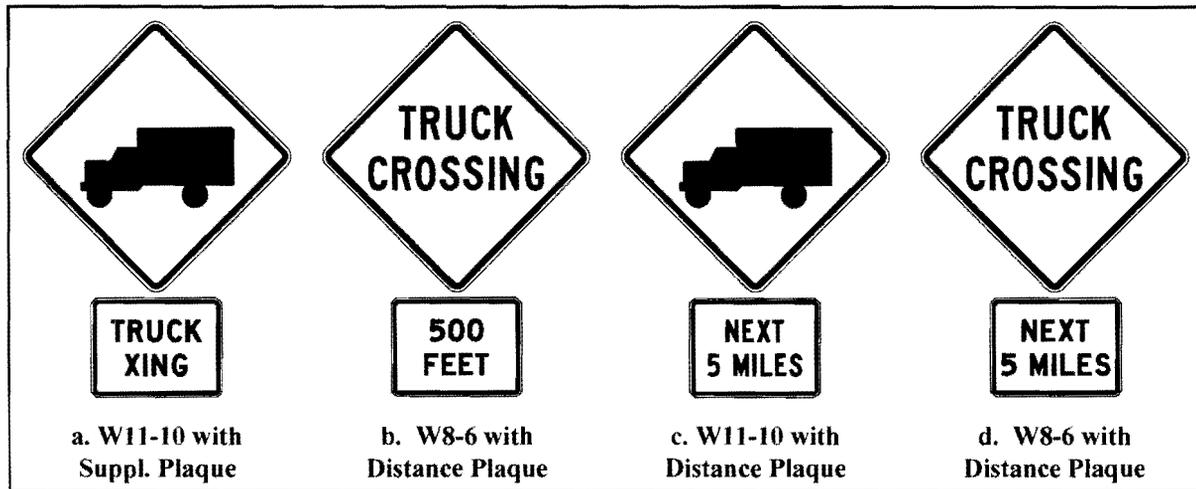


Figure IV-11. Recommended Truck Crossing Treatments

ADOPT ALTERNATIVE DESIGN

Based on the Phase II survey results, alternative sign designs should be adopted for the following three devices in order to improve motorist comprehension.

Slow Down on Wet Road Sign (W8-5)

The results of the two Phase II surveys indicated that understanding of the sign can be improved by adding “raindrops” and changing the design of the “tire marks” in the current sign. The alternative design, shown in Figure IV-12, should replace the current standard sign, based on improved comprehension results. Prior to implementation, however, evaluations should be conducted of the legibility of the “raindrops” in the proposed sign. This is necessary to determine the optimal size of the “raindrops.” Even if the “raindrops”

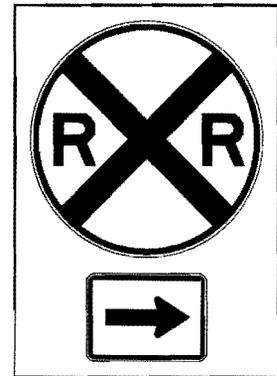


**Figure IV-12.
Alternative Design
for W8-5**

prove to have limited legibility, the comprehension results of using the revised “tire mark” pattern indicated that the “tire marks” in the current standard sign should be changed.

Parallel Railroad Advance Warning Sign (W10-3)

The Phase II survey results indicated that the standard circular sign (W10-1) with a right arrow plaque (Alternative 4C) had a higher comprehension rate than the standard **Parallel Railroad Advance Warning** sign (W10-3), but was not statistically significant. It is recommended, however that this sign, shown in Figure IV-13, be adopted as the standard sign for this application because it appears to be a better understood sign. It should be noted, however, that the current standard (W10-3) still exhibited a relatively high comprehension level. Therefore, it need not be eliminated from use. If the alternative is not adopted as the standard or preferred sign, then it should be identified as an optional sign.



**Figure IV-13.
Alternative Design
for W10-3**

School Advance Sign (S1-1)

The Phase II surveys focused on the dual meaning of the **School Advance** sign (S1-1). The results indicated that this sign is poorly associated with a school area or an advanced school crosswalk, and there is also confusion between school and pedestrian crossings. The use of the word **SCHOOL** on the sign legend or on a supplemental plaque and the use of the words **250 FT** and **SCHOOL XING** on supplemental plaques proved to be effective in distinguishing a school area and an advance school crosswalk, respectively.

Therefore, a pentagon-shaped sign with the legend **SCHOOL** is recommended for use to indicate a school area. This sign is depicted in Figure IV-14. The existing **School Advance** sign (S1-1) is recommended for use with a supplemental plaque containing the legend **SCHOOL XING 250 FEET** to indicate an advance school crossing. This sign is depicted in Figure IV-15.

The research did not attempt to address any differences between the “advance school crossing” meaning of the S1-1 sign with the current **School Crossing** sign (S2-1), the sign that is used at an established crossing. The follow-up survey results indicated that the **SCHOOL XING** plaque may reduce confusion with both the school area and pedestrian crossing interpretations, but the complex interactions between various school signs, such as the **School Advance** sign and the **School Crossing** sign, was beyond the scope of this study.



Figure IV-14.
Alternative Design
for S1-1 :
School Area



Figure IV-15.
Alternative Design
for S1-1 :
Advance Crossing

CONDUCT ADDITIONAL EVALUATIONS

Based on the Phase II survey results, additional evaluations should be conducted for the following traffic control treatments.

Traffic Control Devices for a School Area

Traffic control for school areas is a complicated subject, as it involves several different devices and is of great concern to parents and school administrators. For it to be effective, the individual devices must function as a system rather than as individual elements. The research described in this report addressed only two elements of the system — understanding of the school area message and understanding of the advance school crossing message. Before the recommendations are implemented, further evaluations of the complete system should be conducted to determine the most effective manner of controlling traffic in school areas. Specific issues that should be investigated include:

- the legibility of any new signs or supplemental plaques;
- how to coordinate school area traffic control with parent/ school organizations;
- the appropriate number and sequence of school area traffic control devices;
- the manner in which various devices for a school area interact;
- the need for redundant signing;

- traffic routing, parking and waiting;
- the impact of age of students on the need for traffic control; and/or
- the necessary training for school crossing guards.

Traffic Control Devices for Two-Way and Four-Way Stop Controlled Intersections

It was not clear from the survey results as to what treatment would best distinguish a two-way stop from a four-way stop controlled intersection. Color and wording in the alternative designs did not seem to have an impact on comprehension levels. However, many of the issues related to this application were not evaluated in either of the surveys. Before any recommendations can be made, it is necessary to evaluate factors such as comprehension, target value, and driver behavior with respect to various treatments, including treatments that do not involve a supplemental plaque. At a minimum, field studies of alternative treatments should be conducted before any recommendations are offered. These issues will be evaluated in a separate TxDOT research project (0-1374) being conducted by TTI ([26](#)).

SUMMARY

The primary and secondary recommendations made for each device that may potentially improve motorist comprehension and previously discussed in this chapter are summarized in Table IV-1.

Table IV-1. Summary of Phase II Evaluation Recommendations

Device Name	Sign Label	Number of Alternatives Evaluated		Recommendations					
				Primary Recommendation				Secondary Recommendation	
		Initial Survey	Follow-Up Survey	Retain Current Standard	Word Message Sign Preferred	Adopt Alternative Sign Design	Conduct Additional Evaluations	Use Supplemental Plaque	Increase Education
End School Zone	S5-2	0	0	Yes					
Two-Way Left Turn Only	R3-9b	4	0	Yes					Yes
Railroad Advance Warning	W10-1	4	0	Yes				Yes ¹	
Lane Reduction Transition	W4-2	8	0	Yes ²	Yes	Yes ³		Yes ¹	
Narrow Bridge	W5-2a	5	3	Yes ⁴	Yes				Yes
Truck Crossing	W11-10	6	3	Yes ⁵	Yes ⁵			Yes ⁶	
Slow Down on Wet Road	W8-5	4	3			Yes	Yes ⁷		
Parallel Railroad Advance Warning	W10-3	4	0	Yes		Yes		Yes ⁸	
School Advance	S1-1	4	3			Yes	Yes	Yes	
Two-Way Supplemental Plaque	---	4	3				Yes		

- Note:
- ¹ Supplemental distance plaque.
 - ² Current standard symbol sign to be an alternative to the preferred word message sign.
 - ³ Use the legend in the current CW20-5 construction warning sign.
 - ⁴ Preferred sign in areas with significant proportions of non-English speaking drivers.
 - ⁵ Either the symbol or word message signs are equally acceptable.
 - ⁶ For single crossings, use an educational plaque with the symbol sign or a distance plaque with the word message sign. For multiple crossings, use a distance plaque with either sign.
 - ⁷ Evaluate legibility of the “raindrops” in the sign.
 - ⁸ Supplemental arrow plaque for the alternative design.

CHAPTER V
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APPENDIX A
FOCUS GROUP SUMMARY

This appendix provides an illustrative summary of the alternative sign designs developed by the participants in the four focus group sessions that were conducted (see Figures A-1 through A-9). These alternative designs are depicted as drawn by the participants, and were analyzed by the research team in order to develop alternative traffic control devices to be tested in further evaluations.

Each of the devices evaluated in the Phase II focus groups were also evaluated in previous Phase I research activities. Table A-1 summarizes the ten devices and the Phase I evaluations.

**Table A-1. List of Ten Traffic Control Devices
and Previous Research Evaluations**

Type of Device	Device Name	Sign Label	Phase I Evaluations			
			Statewide Survey	Auto Shows		Focus Groups
				1992	1993	
Regulatory Signs	Two-Way Left Turn Only	R3-9b	✓	✓		
	Two-Way Supplemental Plaque	N/A ¹	✓ ²	✓ ²		✓ ²
Warning Signs	Lane Reduction Transition	W4-2	✓		✓ ³	✓
	Narrow Bridge	W5-2a	✓			
	Slow Down on Wet Road ⁴	W8-5	✓	✓		✓
	Truck Crossing	W11-10	✓			
School Signs	School Advance	S1-1		✓		
	End School Zone	S5-2	✓ ⁵			
Railroad Signs	Railroad Advance Warning	W10-1	✓	✓		✓
	Parallel RR Advance Warning	W10-3	✓			

Notes: ¹ There is no standard sign for indicating this condition.
² Understanding of the difference between two- and four-way stop controlled intersections studied.
³ **Lane Ends Merge Left** sign (W9-2) evaluated.
⁴ This sign is labeled **Slippery When Wet** in the National MUTCD.
⁵ Understanding of the end of a School Speed Limit evaluated.

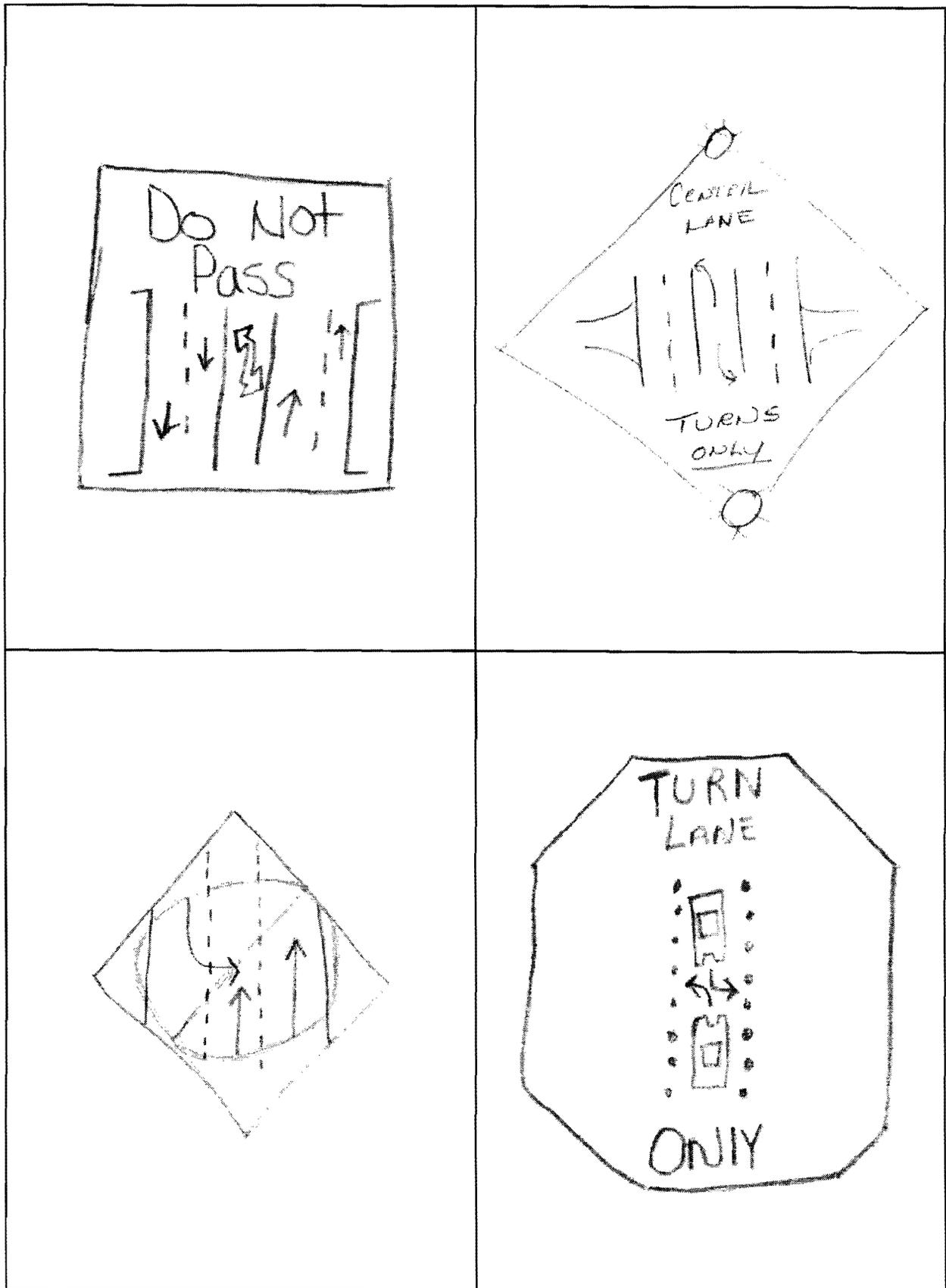


Figure A-1. Alternative Sign Designs: Two-Way Left Turn Only Sign (R3-9b)

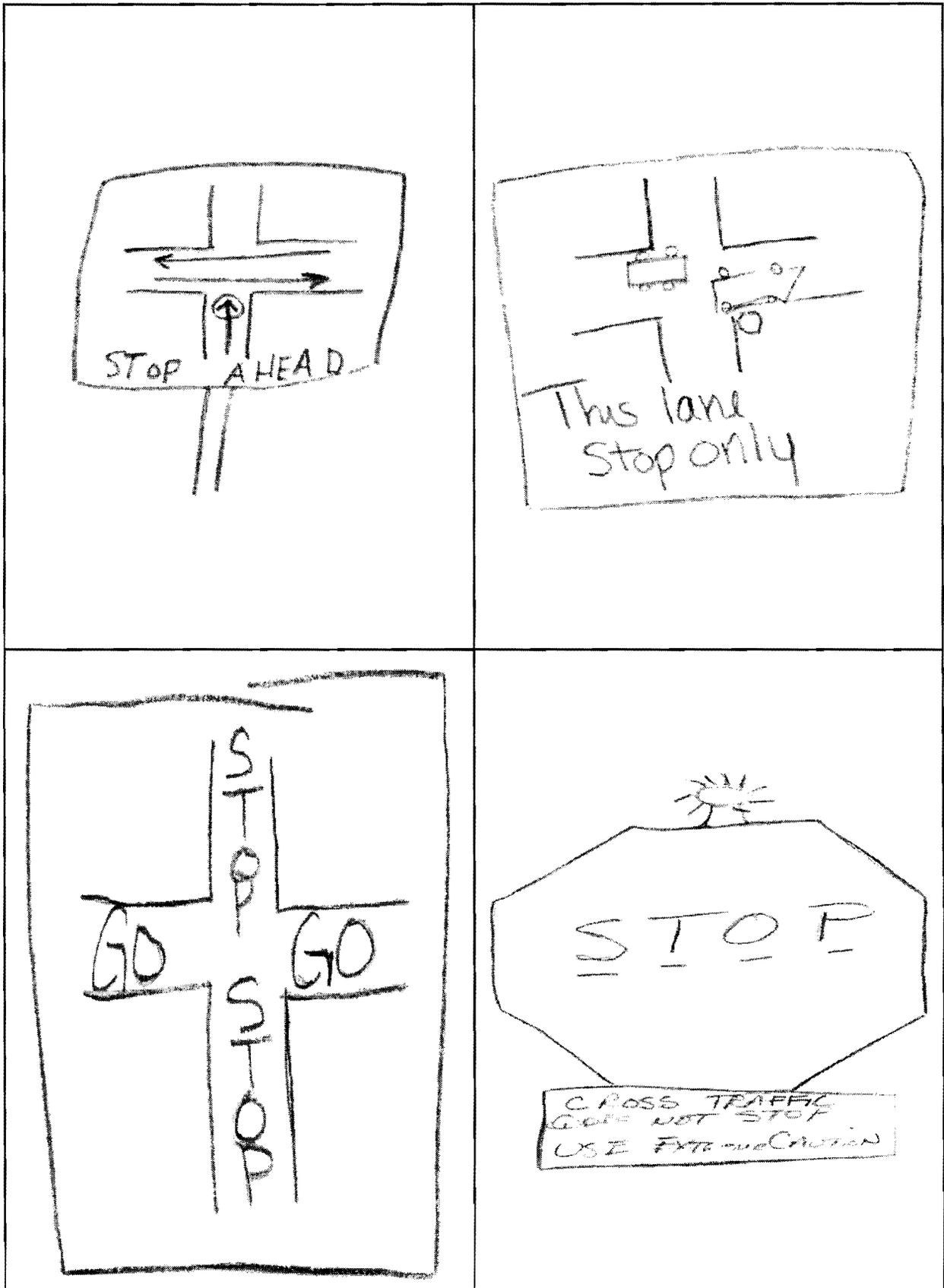


Figure A-2. Alternative Sign Designs: Two-Way Stop Controlled Intersection

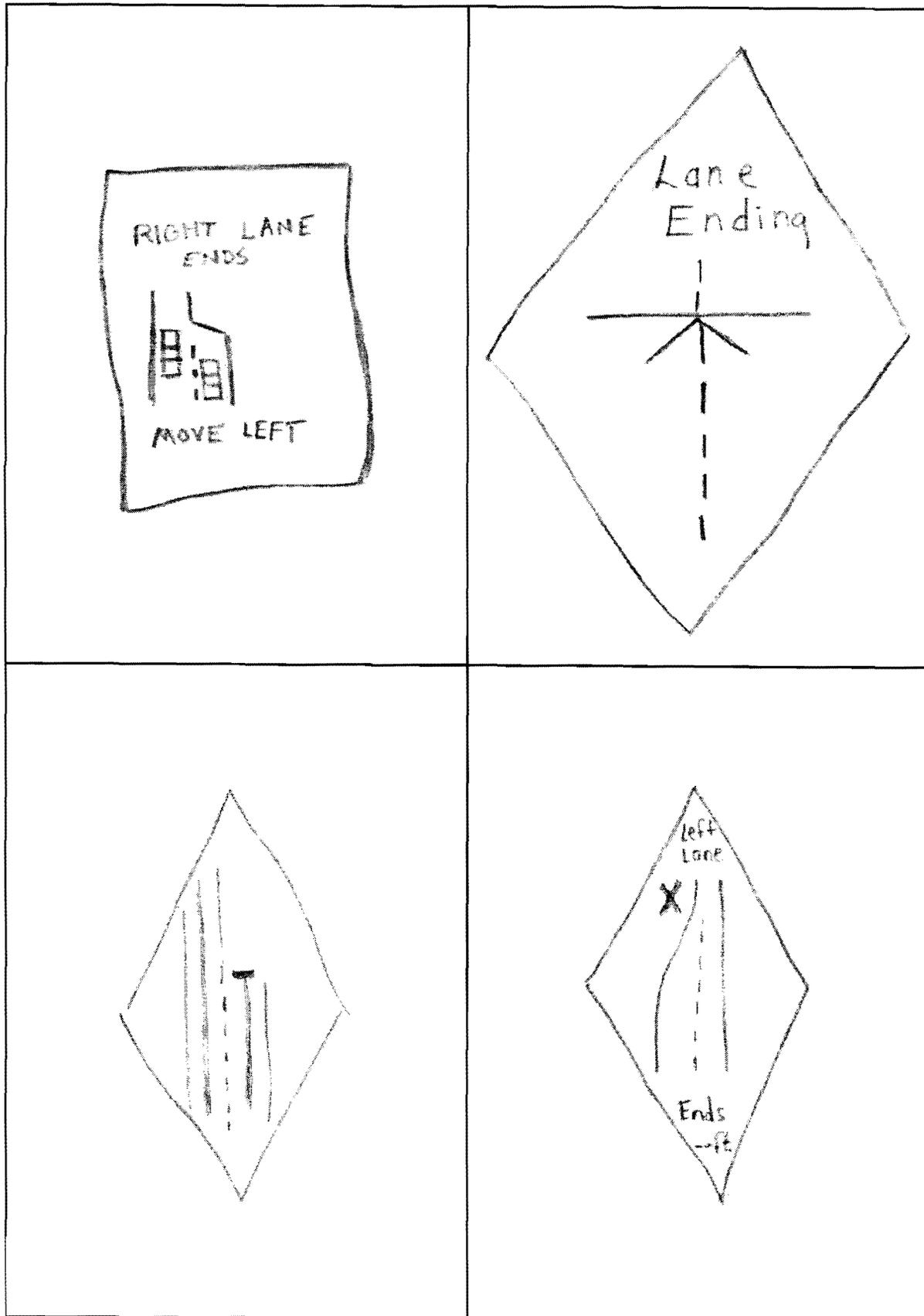


Figure A-3. Alternative Sign Designs: Lane Reduction Transition Sign (W4-2)

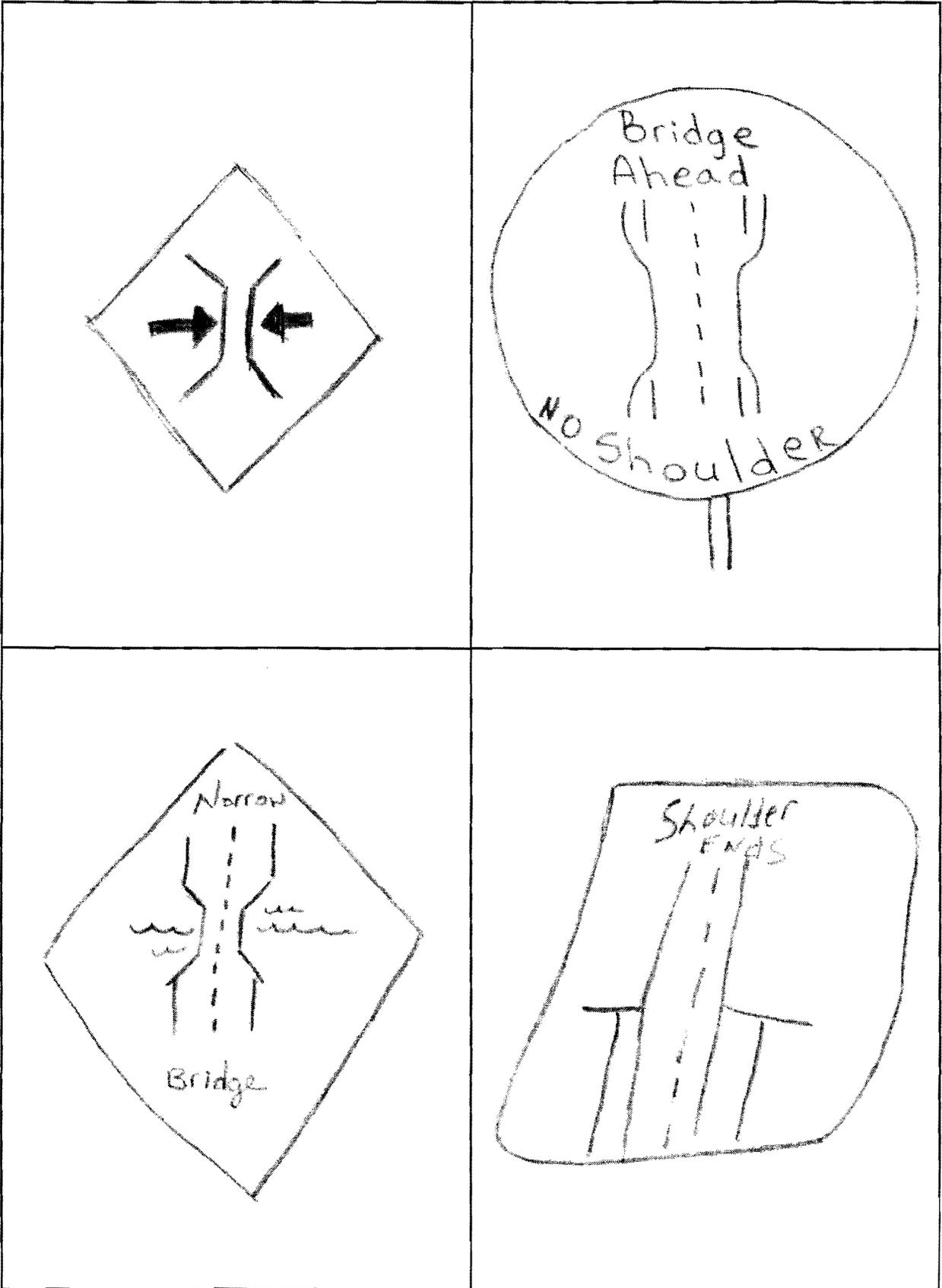


Figure A-4. Alternative Sign Designs: Narrow Bridge Sign (W5-2a)

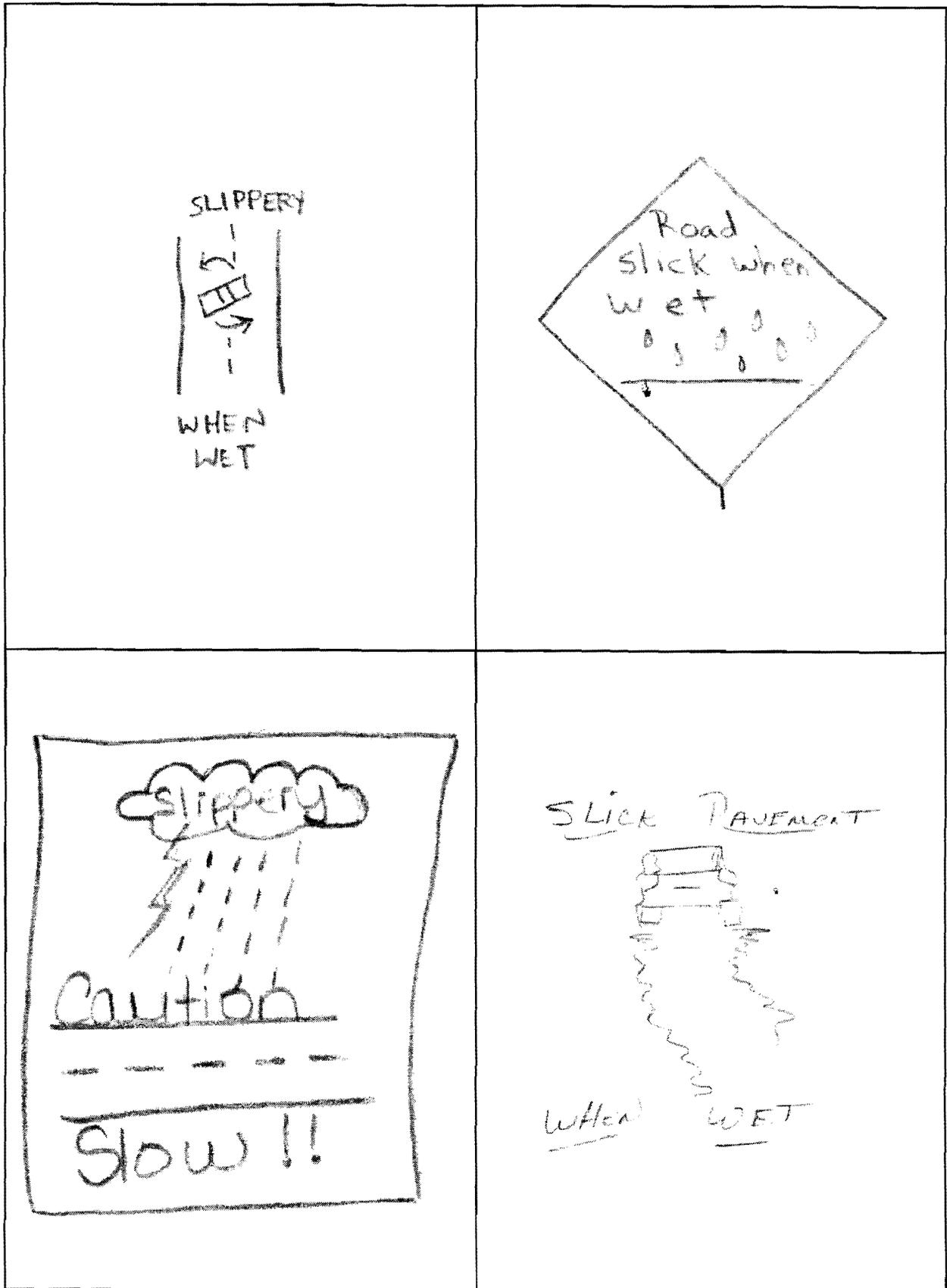


Figure A-5. Alternative Sign Designs: Slow Down on Wet Road Sign (W8-5)

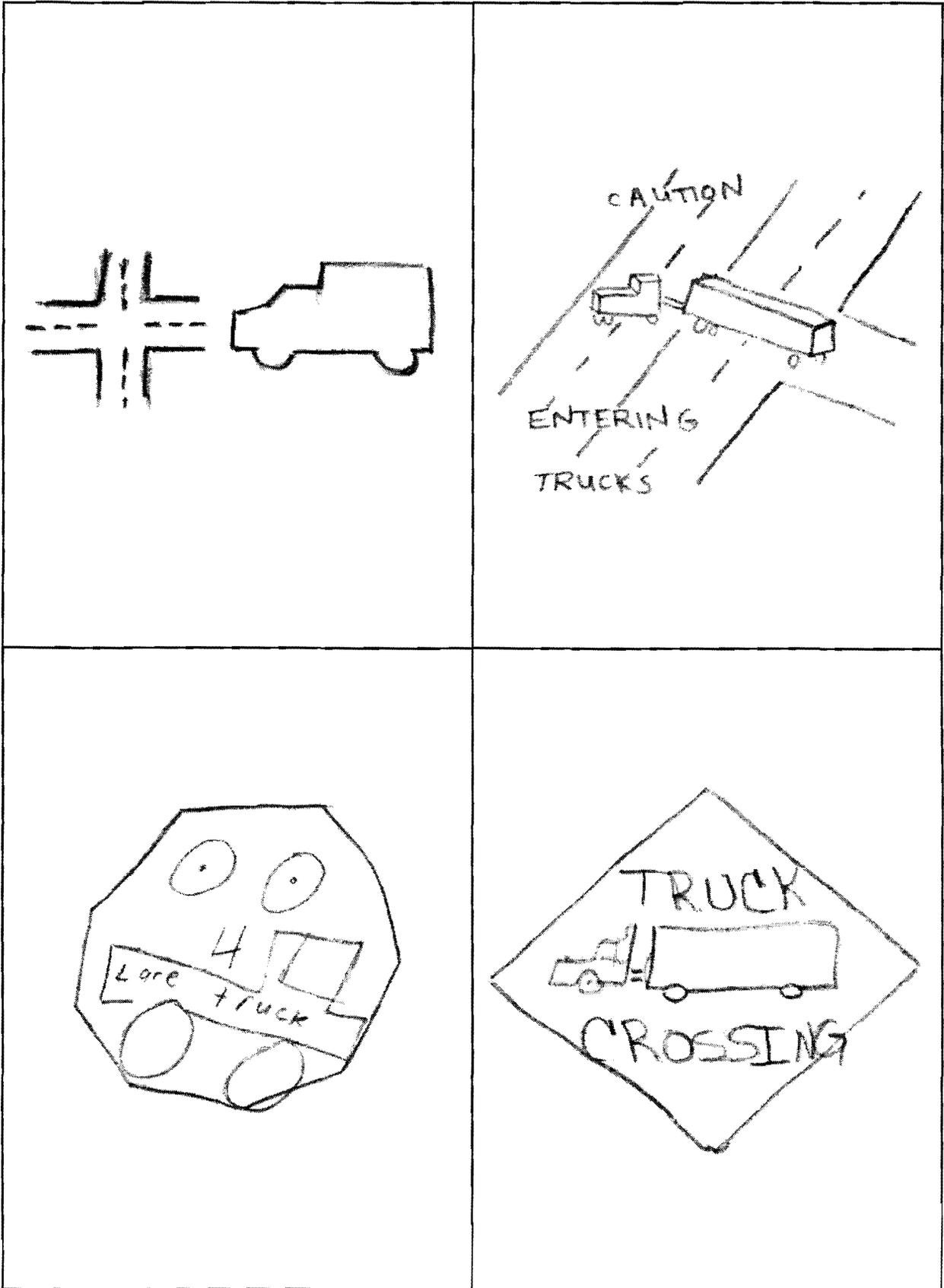


Figure A-6. Alternative Sign Designs: Truck Crossing Sign (W11-10)

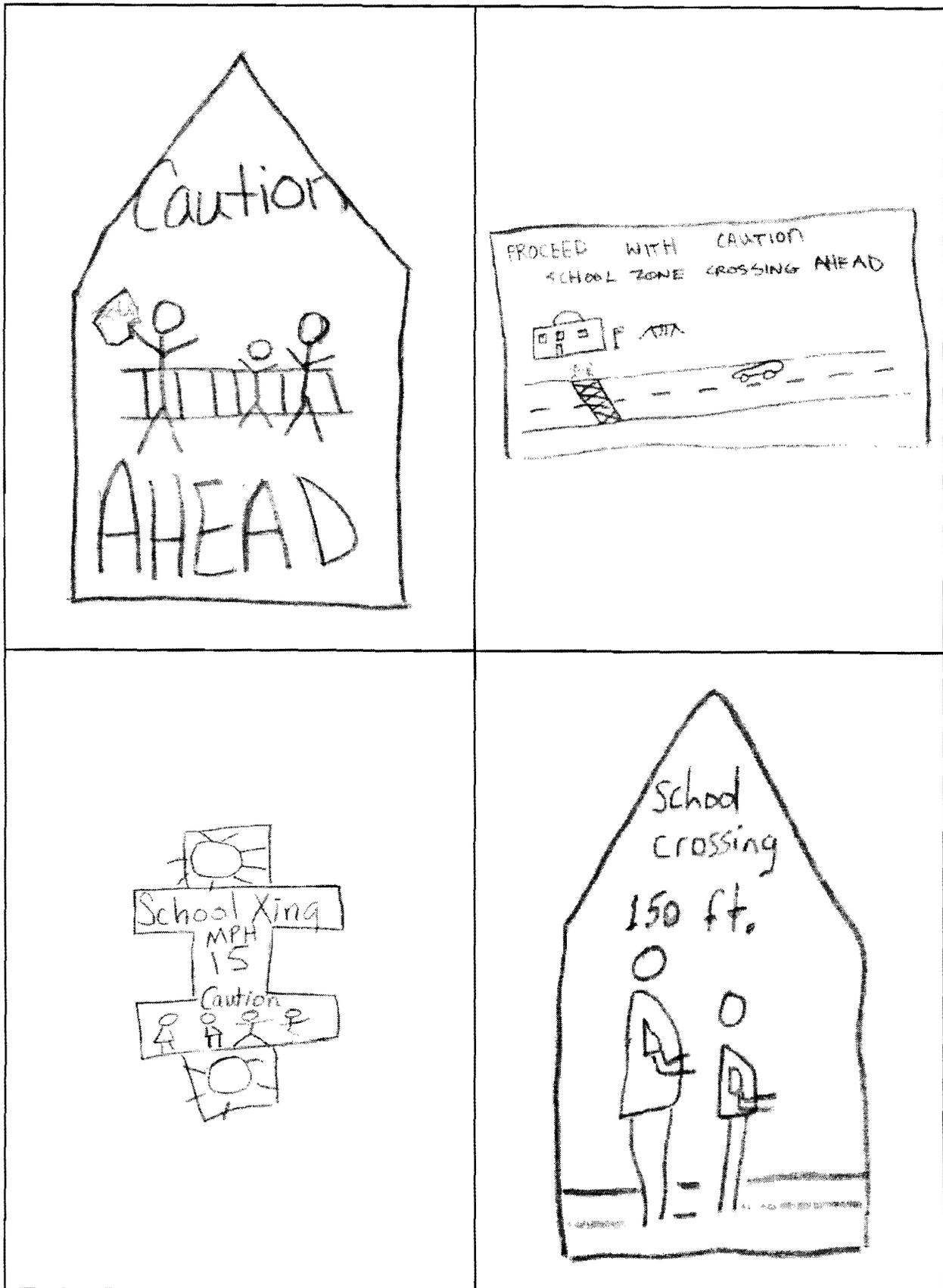


Figure A-7. Alternative Sign Designs: School Advance Sign (S1-1)

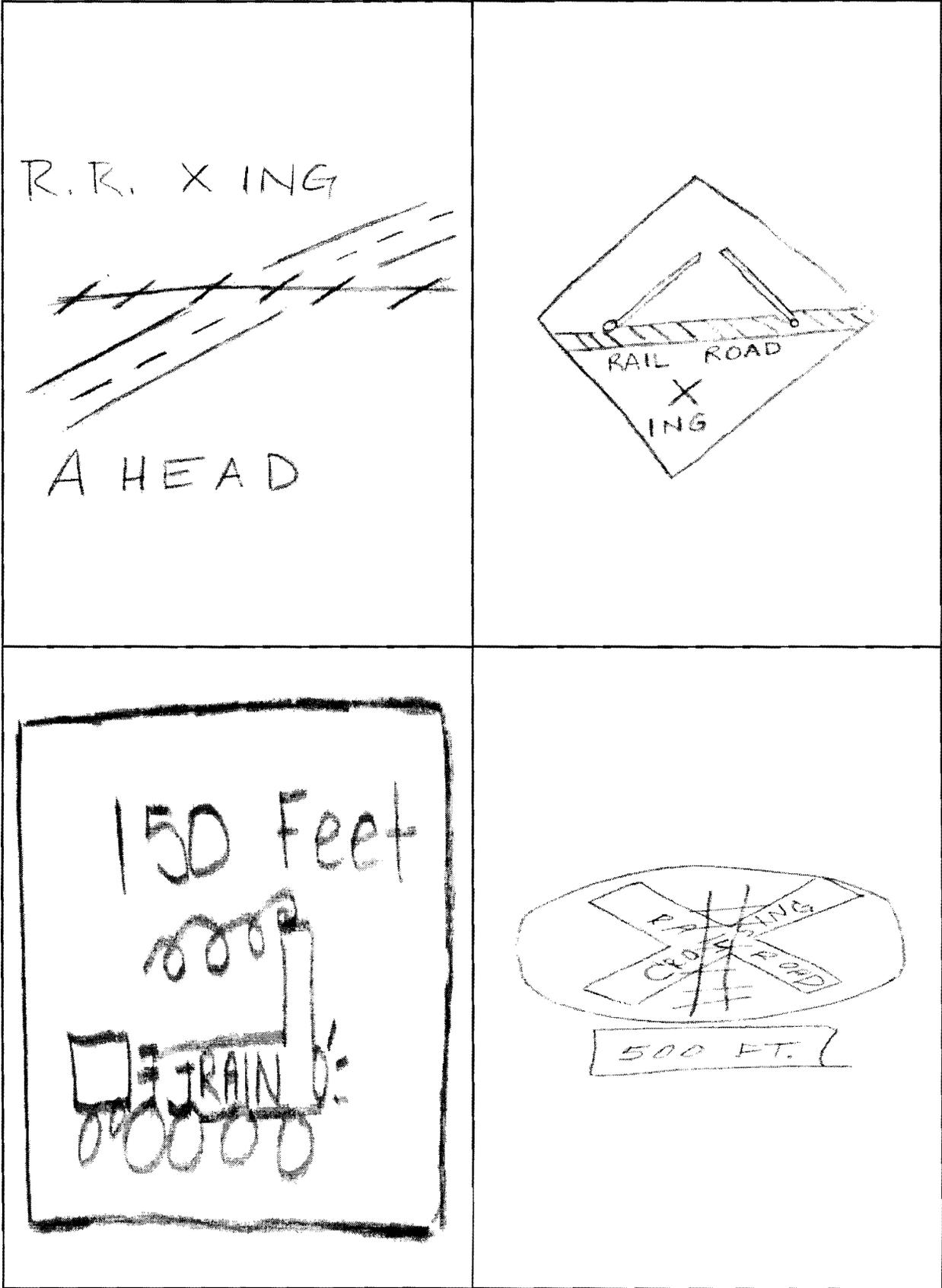


Figure A-8. Alternative Sign Designs: Railroad Advance Warning Sign (W10-1)

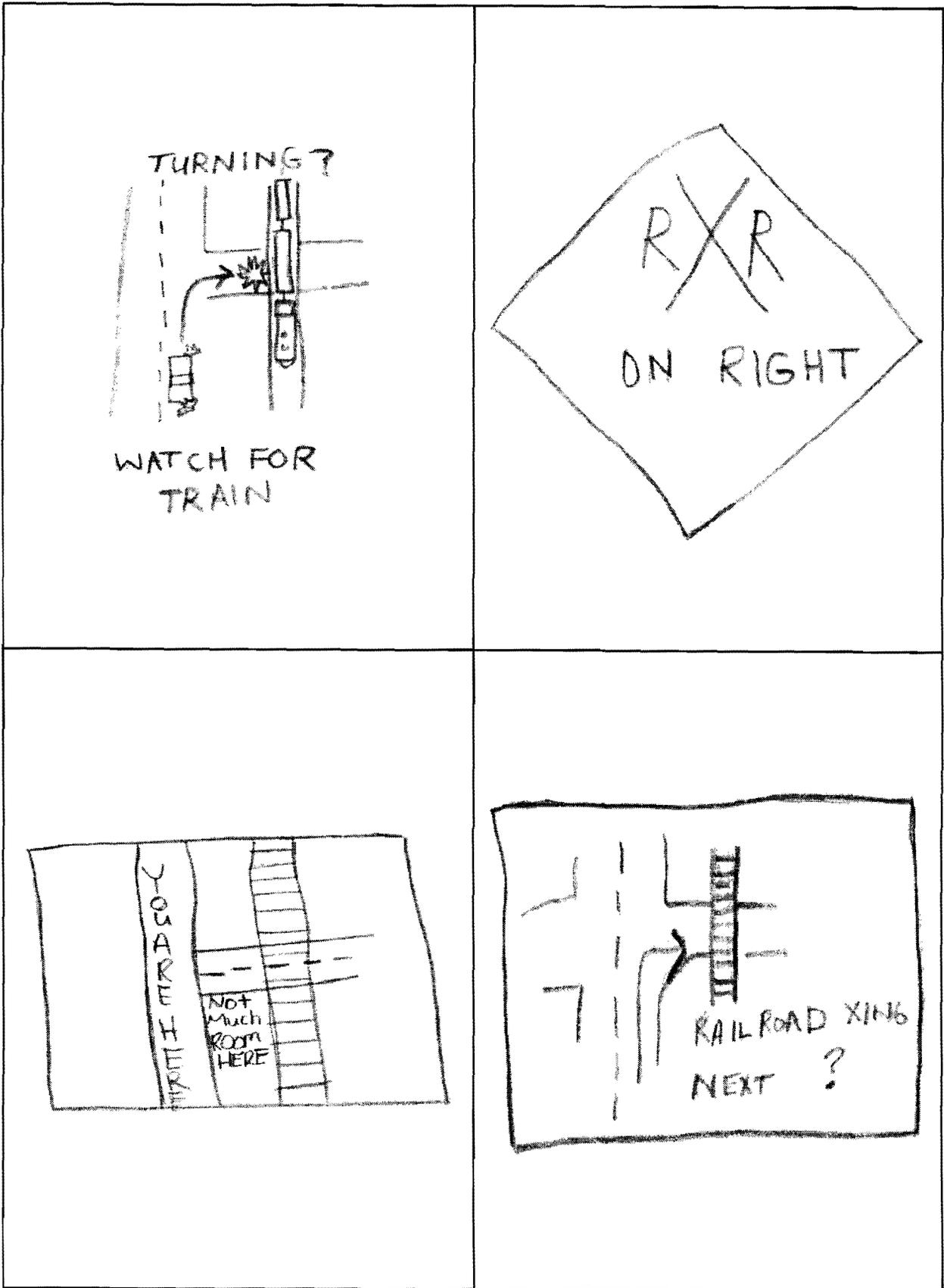


Figure A-9. Alternative Sign Designs: Parallel RR Advance Warning Sign (W10-3)

APPENDIX B

PHASE II INITIAL SURVEY SUMMARY

This appendix presents a close representation of the Phase II initial survey that was administered in seven Texas cities. The survey instrument was presented in a three-ring binder and consisted of several multiple-choice questions for the respondents to answer. As the respondents held the binder open, an in-context picture of a traffic control device was depicted on the top of the left page. This image was an actual photograph depicting a roadway condition, but modified by a computer graphics software program to display the device being tested. Below this image on the same page was a close-up view of the same device, created by the same software program. On the top of the facing page, a multiple-choice question was presented for the respondents to answer. The participants recorded their responses on a separate answer sheet.

The survey instrument consisted of four different versions. The first version, Set A, was designated with a color-code of red and consisted of only standard traffic control devices, the same ones selected for further evaluation in previous research on this project. The color-code was signified by the color of the three-ring binder as well as the answer sheet that accompanied the survey. The second, third, and fourth versions of the survey (Sets B, C, and D) were designated with blue, gray, and green color designations, respectively, and consisted of alternative sign designs that were developed by the research team as a direct result of the 1995 Focus Group evaluations. A Spanish language survey was also developed for each of the four survey sets and administered to non-English speaking participants with the aid of a translator. A summary of the survey instrument is presented in Table B-1.

Table B-1. Summary of Phase II Initial Survey Instrument

Survey Set	Color Designation	No. of Devices Evaluated	Type of Device Evaluated
A	Red	11	Standard MUTCD
B	Blue	11	Alternative Designs
C	Gray	11	Alternative Designs
D	Green	10	Alternative Designs

The only differences between the images presented in this appendix and the ones viewed by the participants are that the images in the actual survey were in color and at a higher graphics resolution than the ones presented here. Also, the response percentages were not part of the actual survey instrument. The questions in this appendix are grouped according to similar traffic control devices, and not in the order that they were presented in the actual survey.

The correct response is indicated with an asterisk (*) in the close-up image. Table B-2 provides a cross-reference which can be used to identify the question and page number for a particular device. Table B-3 presents a summary of the demographic characteristics of the Phase II initial survey sample from all seven cities.

Table B-2. Cross-Reference for Traffic Control Device Questions

Type of Device	Device Name	Sign Label	No. of Devices Evaluated	Appendix Page Number
Regulatory Signs	Two-Way Left Turn Only	R3-9b	4	B-4 to B-7
	Two-Way Supplemental Plaque	N/A ¹	4	B-8 to B-11
Warning Signs	Lane Reduction Transition	W4-2	8	B-12 to B-19
	Narrow Bridge	W5-2a	5	B-20 to B-24
	Slow Down on Wet Road ²	W8-5	4	B-25 to B-28
	Truck Crossing	W11-10	6	B-29 to B-34
School Sign	School Advance Sign	S1-1	4	B-35 to B-38
Railroad Signs	Railroad Advance Warning	W10-1	4	B-39 to B-42
	Parallel Railroad Advance Warning	W10-3	4	B-43 to B-46
TOTAL			43	

Notes: ¹ There is no standard sign indicating this condition.

² This sign is labeled **Slippery When Wet** in the National MUTCD.

Table B-3. Demographic Characteristics of Phase II Initial Survey Sample

Characteristics		Number	Percent	Texas Population	
				General	Driving
Gender	Male	380	51.3	49.3	51.5
	Female	360	48.7	50.7	48.5
Age	16 to 24	214	28.9	18.9	15.2
	25 to 54	442	59.7	57.4	62.4
	55 to 64	54	7.3	10.2	10.4
	65+	31	4.2	13.6	12.0
Ethnicity	African American (Black)	79	10.7	11.6	—
	Anglos (White)	449	60.6	60.6	—
	Hispanic	178	24.0	25.6	—
	Other	35	4.7	2.2	—
Education Level	Less Than High School	82	11.3	28.1	—
	High School (or Equivalent)	231	31.7	25.9	—
	Some College	240	32.9	27.8	—
	College Graduate	175	24.0	18.1	—
Total¹		747	100.0	100.0	—

Note: ¹ Individual totals may not reflect the overall total. A few participants chose not to answer some or all of the demographic questions.

DEVICE NAME: Two-Way Left Turn Only Sign
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R3-9b
SURVEY SET: A
QUESTION NUMBER: 9
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-1a. In-Context Picture:
 Two-Way Left Turn Only Sign Standard**



- 2.8% A. The center lane can be used for passing and overtaking other vehicles.
- *17.6% B. Drivers in the center lane should be aware of head-on traffic.
- 2.3% C. You cannot drive in this area for any reason.
- *81.8% D. The center lane can be used for making left turns in either direction.
- 30.7% E. The center lane can be used as a waiting area when turning onto or crossing the road.
- 0.6% F. The center lane can be used as a parking area for businesses along the road.
- 2.8% G. I am not sure what this sign means.

**Figure B-1b. Close-up with Responses:
 Two-Way Left Turn Only Sign Standard**

DEVICE NAME: Two-Way-Left Turn Only Sign
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R3-9b (Alternative)
SURVEY SET: B
QUESTION NUMBER: 9
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-2a. In-Context Picture:
 Two-Way Left Turn Only Sign Alternative 1**



- | | |
|--------|--|
| 1.0% | A. The center lane can be used for passing and overtaking other vehicles. |
| *22.3% | B. Drivers in the center lane should be aware of head-on traffic. |
| 3.1% | C. You cannot drive in this area for any reason. |
| *86.5% | D. The center lane can be used for making left turns in either direction. |
| 31.1% | E. The center lane can be used as a waiting area when turning onto or crossing the road. |
| 1.0% | F. The center lane can be used as a parking area for businesses along the road. |
| 2.6% | G. I am not sure what this sign means. |

**Figure B-2b. Close-up with Responses:
 Two-Way Left Turn Only Sign Alternative 1**

DEVICE NAME: Two-Way Left Turn Only Sign

TYPE OF DEVICE: Regulatory Sign

SIGN LABEL: R3-9b (Alternative)

SURVEY SET: C

QUESTION NUMBER: 9

QUESTION: Which of the following responses apply when you see this sign?
You may circle **MORE THAN ONE** answer.



**Figure B-3a. In-Context Picture:
Two-Way Left Turn Only Sign Alternative 2**



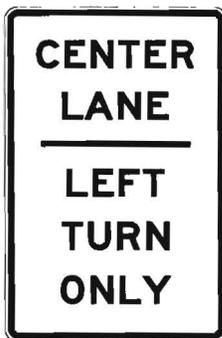
- | | |
|--------|--|
| 4.2% | A. The center lane can be used for passing and overtaking other vehicles. |
| *22.1% | B. Drivers in the center lane should be aware of head-on traffic. |
| 6.3% | C. You cannot drive in this area for any reason. |
| *84.2% | D. The center lane can be used for making left turns in either direction. |
| 34.7% | E. The center lane can be used as a waiting area when turning onto or crossing the road. |
| 2.1% | F. The center lane can be used as a parking area for businesses along the road. |
| 2.1% | G. I am not sure what this sign means. |

**Figure B-3b. Close-up with Responses:
Two-Way Left Turn Only Sign Alternative 2**

DEVICE NAME: Two-Way Left Turn Only Sign
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R3-9b (Alternative)
SURVEY SET: D
QUESTION NUMBER: 8
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-4a. In-Context Picture:
 Two-Way Left Turn Only Sign Alternative 3**



- | | |
|--------|--|
| 3.2% | A. The center lane can be used for passing and overtaking other vehicles. |
| *18.6% | B. Drivers in the center lane should be aware of head-on traffic. |
| 3.7% | C. You cannot drive in this area for any reason. |
| *78.2% | D. The center lane can be used for making left turns in either direction. |
| 32.4% | E. The center lane can be used as a waiting area when turning onto or crossing the road. |
| 1.6% | F. The center lane can be used as a parking area for businesses along the road. |
| 3.7% | G. I am not sure what this sign means. |

**Figure B-4b. Close-up with Responses:
 Two-Way Left Turn Only Sign Alternative 3**

DEVICE NAME: Stop Sign
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1
SURVEY SET: A
QUESTION NUMBER: 5
QUESTION: *What is this sign telling you?
 Circle only ONE answer.*



**Figure B-5a. In-Context Picture:
 Stop Sign Standard**



- 3.3% A. You do not have to stop because you are crossing the intersection.
- 37.0% B. Traffic from all directions must stop at the intersection.
- *56.5% C. Traffic from the right or left may not slow down or stop at the intersection.
- 3.3% D. I am not sure what this sign means.

**Figure B-5b. Close-up with Responses:
 Stop Sign Standard**

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 5
QUESTION: *What is this sign telling you?
 Circle only ONE answer.*



**Figure B-6a. In-Context Picture:
 Stop Sign Supplemental Plaque Alternative 1**



- | | |
|--------|--|
| 3.3% | A. You do not have to stop because you are crossing the intersection. |
| 12.5% | B. Traffic from all directions must stop at the intersection. |
| *83.3% | C. Traffic from the right or left may not slow down or stop at the intersection. |
| 0.8% | D. I am not sure what this sign means. |

**Figure B-6b. Close-up with Responses:
 Stop Sign Supplemental Plaque Alternative 1**

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 5
QUESTION: *What is this sign telling you?*
*Circle only **ONE** answer.*



Figure B-7a. In-Context Picture:
Stop Sign Supplemental Plaque Alternative 2



- 4.2% A. You do not have to stop because you are crossing the intersection.
- 7.1% B. Traffic from all directions must stop at the intersection.
- *87.5% C. Traffic from the right or left may not slow down or stop at the intersection.
- 1.2% D. I am not sure what this sign means.

Figure B-7b. Close-up with Responses:
Stop Sign Supplemental Plaque Alternative 2

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 5
QUESTION: *What is this sign telling you?*
*Circle only **ONE** answer.*



Figure B-8a. In-Context Picture:
Stop Sign Supplemental Plaque Alternative 3



- | | |
|--------|--|
| 1.2% | A. You do not have to stop because you are crossing the intersection. |
| 25.2% | B. Traffic from all directions must stop at the intersection. |
| *68.3% | C. Traffic from the right or left may not slow down or stop at the intersection. |
| 5.4% | D. I am not sure what this sign means. |

Figure B-8b. Close-up with Responses:
Stop Sign Supplemental Plaque Alternative 3

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W4-2
SURVEY SET: A
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?*
*Circle only **ONE** answer.*



**Figure B-9a. In-Context Picture:
Lane Reduction Transition Sign Standard**



- | | |
|---|--|
| <p>*71.6%</p> <p>7.4%</p> <p>5.7%</p> <p>4.6%</p> <p>9.7%</p> <p>1.1%</p> | <p>A. The lane ends and traffic in the right lane should move into the left lane.</p> <p>B. The lane ends and traffic in the left lane should move into the right lane.</p> <p>C. The median between opposing traffic will end.</p> <p>D. There is a single lane ahead for both directions of traffic.</p> <p>E. The lane you are in will become narrower.</p> <p>F. I am not sure what this sign means.</p> |
|---|--|

**Figure B-9b. Close-up with Responses:
Lane Reduction Transition Sign Standard**

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W4-2 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-10a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 1**



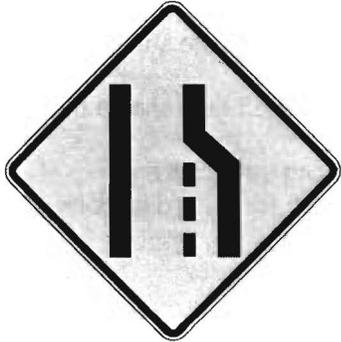
- | | |
|--------|--|
| *78.2% | A. The lane ends and traffic in the right lane should move into the left lane. |
| 6.2% | B. The lane ends and traffic in the left lane should move into the right lane. |
| 2.6% | C. The median between opposing traffic will end. |
| 3.1% | D. There is a single lane ahead for both directions of traffic. |
| 8.3% | E. The lane you are in will become narrower. |
| 1.6% | F. I am not sure what this sign means. |

**Figure B-10b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 1**

DEVICE NAME: Lane Reduction Transition sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W4-2 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-11a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 2**



- *70.9% A. The lane ends and traffic in the right lane should move into the left lane.
- 5.8% B. The lane ends and traffic in the left lane should move into the right lane.
- 8.5% C. The median between opposing traffic will end.
- 4.8% D. There is a single lane ahead for both directions of traffic.
- 4.8% E. The lane you are in will become narrower.
- 5.3% F. I am not sure what this sign means.

**Figure B-11b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 2**

DEVICE NAME: Lane Reduction Transition sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W4-2 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-12a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 3**



- *71.3% A. The lane ends and traffic in the right lane should move into the left lane.
- 6.4% B. The lane ends and traffic in the left lane should move into the right lane.
- 2.1% C. The median between opposing traffic will end.
- 11.2% D. There is a single lane ahead for both directions of traffic.
- 4.3% E. The lane you are in will become narrower.
- 4.8% F. I am not sure what this sign means.

**Figure B-12b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 3**

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W9-1 (Alternative to W4-2)
SURVEY SET: A
QUESTION NUMBER: 6
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-13a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 4**



- | | |
|--------|--|
| 8.6% | A. The median between opposing traffic will end. |
| 2.3% | B. The lane you are in will become narrower. |
| 3.5% | C. The lane ends and traffic in the left lane should move into the right lane. |
| 4.6% | D. There is a single lane ahead for both directions of traffic. |
| *81.0% | E. The lane ends and traffic in the right lane should move into the left lane. |
| 0.0% | F. I am not sure what this sign means. |

**Figure B-13b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 4**

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W9-2 (Alternative to W4-2)
SURVEY SET: B
QUESTION NUMBER: 6
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-14a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 5**



- 14.6% A. The median between opposing traffic will end.
- 2.6% B. The lane you are in will become narrower.
- 10.4% C. The lane ends and traffic in the left lane should move into the right lane.
- 4.7% D. There is a single lane ahead for both directions of traffic.
- *66.7% E. The lane ends and traffic in the right lane should move into the left lane.
- 1.0% F. I am not sure what this sign means.

**Figure B-14b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 5**

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: CW20-5 (Alternative to W4-2)
SURVEY SET: C
QUESTION NUMBER: 7
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-15a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 6**



- 1.1% A. The median between opposing traffic will end.
- 2.1% B. The lane you are in will become narrower.
- 4.8% C. The lane ends and traffic in the left lane should move into the right lane.
- 5.8% D. There is a single lane ahead for both directions of traffic.
- *84.1% E. The lane ends and traffic in the right lane should move into the left lane.
- 2.1% F. I am not sure what this sign means.

**Figure B-15b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 6**

DEVICE NAME: Lane Reduction Transition Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W4-2 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 7
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-16a. In-Context Picture:
 Lane Reduction Transition Sign Alternative 7**



- | | |
|--------|--|
| 4.8% | A. The median between opposing traffic will end. |
| 8.1% | B. The lane you are in will become narrower. |
| 2.7% | C. The lane ends and traffic in the left lane should move into the right lane. |
| 7.5% | D. There is a single lane ahead for both directions of traffic. |
| *76.3% | E. The lane ends and traffic in the right lane should move into the left lane. |
| 0.5% | F. I am not sure what this sign means. |

**Figure B-16b. Close-up with Responses:
 Lane Reduction Transition Sign Alternative 7**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a
SURVEY SET: A
QUESTION NUMBER: 10
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-17a. In-Context Picture:
 Narrow Bridge Sign Standard**



- | | |
|--------|--|
| 2.8% | A. You will go under an overpass ahead. |
| *34.1% | B. The shoulder may get narrower or end. |
| 6.8% | C. You will have to share your lane with traffic from the other direction. |
| 6.8% | D. You are about to enter a tunnel. |
| *52.8% | E. The lane you are in may get narrower. |
| 34.1% | F. There is a bridge ahead. |
| 6.8% | G. I am not sure what this sign means. |

**Figure B-17b. Close-up with Responses:
 Narrow Bridge Sign Standard**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a (Alternative)
SURVEY SET: B
QUESTION NUMBER: 7

QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-18a. In-Context Picture:
 Narrow Bridge Sign Alternative 1**



- | | |
|---|--|
| <p> 2.1%
 *29.5%
 13.5%

 1.0%
 *59.1%
 70.5%
 1.6% </p> | <p> A. You will go under an overpass ahead.
 B. The shoulder may get narrower or end.
 C. You will have to share your lane with traffic from the other direction.

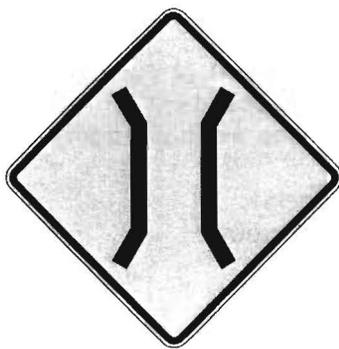
 D. You are about to enter a tunnel.
 E. The lane you are in may get narrower.
 F. There is a bridge ahead.
 G. I am not sure what this sign means. </p> |
|---|--|

**Figure B-18b. Close-up with Responses:
 Narrow Bridge Sign Alternative 1**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a (Alternative)
SURVEY SET: B
QUESTION NUMBER: 11
QUESTION: Which of the following responses apply when you see this sign?
 You may circle ***MORE THAN ONE*** answer.



**Figure B-19a. In-Context Picture:
 Narrow Bridge Sign Alternative 2**



- | | |
|--------|--|
| 5.2% | A. You are about to enter a tunnel. |
| 24.9% | B. There is a bridge ahead. |
| 11.9% | C. You will have to share your lane with traffic from the other direction. |
| *54.4% | D. The lane you are in may get narrower. |
| *31.1% | E. The shoulder may get narrower or end. |
| 1.0% | F. You will go under an overpass ahead. |
| 16.1% | G. I am not sure what this sign means. |

**Figure B-19b. Close-up with Responses:
 Narrow Bridge Sign Alternative 2**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a (Alternative)
SURVEY SET: C
QUESTION NUMBER: 10
QUESTION:

*Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.*



**Figure B-20a. In-Context Picture:
 Narrow Bridge Sign Alternative 3**



- | | |
|--------|--|
| 3.7% | A. You will go under an overpass ahead. |
| 4.7% | B. You will have to share your lane with traffic from the other direction. |
| 1.6% | C. You are about to enter a tunnel. |
| *23.7% | D. The shoulder may get narrower or end. |
| *39.5% | E. The lane you are in may get narrower. |
| 63.7% | F. There is a bridge ahead. |
| 12.6% | G. I am not sure what this sign means. |

**Figure B-20b. Close-up with Responses:
 Narrow Bridge Sign Alternative 3**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a (Alternative)
SURVEY SET: D
QUESTION NUMBER: 9

QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-21a. In-Context Picture:
 Narrow Bridge Sign Alternative 4**



- | | |
|--------|--|
| 1.6% | A. You will go under an overpass ahead. |
| 12.8% | B. You will have to share your lane with traffic from the other direction. |
| 0.5% | C. You are about to enter a tunnel. |
| *30.3% | D. The shoulder may get narrower or end. |
| *67.0% | E. The lane you are in may get narrower. |
| 74.5% | F. There is a bridge ahead. |
| 2.1% | G. I am not sure what this sign means. |

**Figure B-21b. Close-up with Responses:
 Narrow Bridge Sign Alternative 4**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5
SURVEY SET: A
QUESTION NUMBER: 11
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.

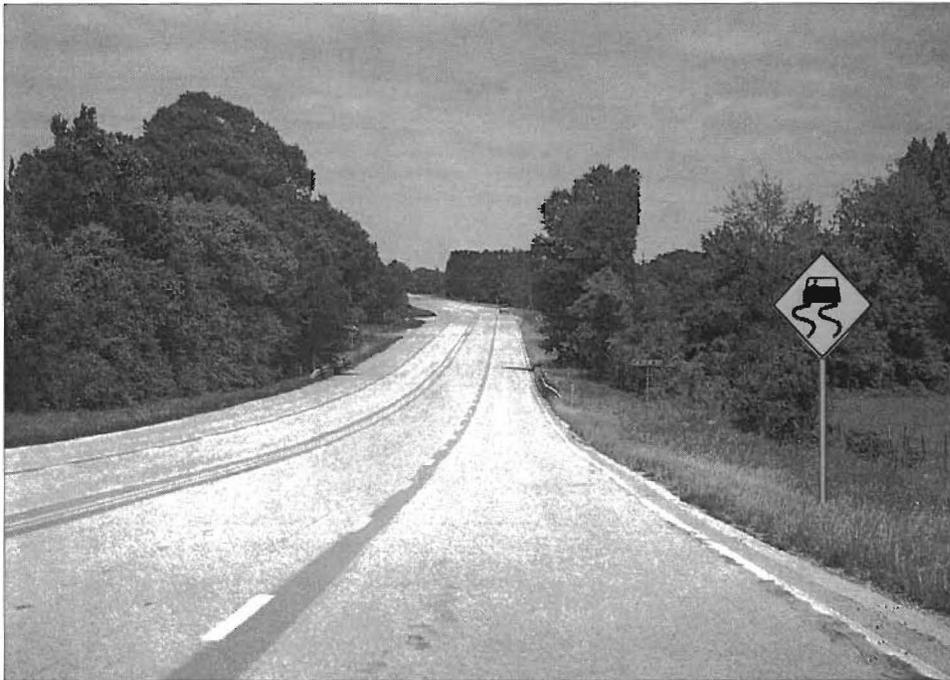


Figure B-22a. In-Context Picture:
Slow Down on Wet Road Sign Standard



- | | |
|--------|---|
| 37.5% | A. Be prepared for several curves in the road ahead. |
| 7.4% | B. Watch out for cars that are out-of-control. |
| 35.8% | C. Slow down to keep from losing control. |
| 4.0% | D. Be prepared for potholes in the road that might cause you to lose control. |
| *62.5% | E. Slow down when the road is wet to keep from losing control. |
| 5.7% | F. Watch out for large puddles of water on the road when it is raining. |
| 2.3% | G. I am not sure what this sign means. |

Figure B-22b. Close-up with Responses:
Slow Down on Wet Road Sign Standard

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 10
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-23a. In-Context Picture:
 Slow Down on Wet Road Sign Alternative 1**



- | | |
|--------|---|
| 16.1% | A. Be prepared for several curves in the road ahead. |
| 5.2% | B. Watch out for cars that are out-of-control. |
| 26.4% | C. Slow down to keep from losing control. |
| 2.6% | D. Be prepared for potholes in the road that might cause you to lose control. |
| *90.7% | E. Slow down when the road is wet to keep from losing control. |
| 17.6% | F. Watch out for large puddles of water on the road when it is raining. |
| 0.5% | G. I am not sure what this sign means. |

**Figure B-23b. Close-up with Responses:
 Slow Down on Wet Road Sign Alternative 1**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 11
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure B-24a. In-Context Picture:
 Slow Down on Wet Road Sign Alternative 2**



- 18.4% A. Be prepared for several curves in the road ahead.
- 8.4% B. Watch out for cars that are out-of-control.
- 34.2% C. Slow down to keep from losing control.
- 2.1% D. Be prepared for potholes in the road that might cause you to lose control.
- *72.1% E. Slow down when the road is wet to keep from losing control.
- 15.3% F. Watch out for large puddles of water on the road when it is raining.
- 5.3% G. I am not sure what this sign means.

**Figure B-24b. Close-up with Responses:
 Slow Down on Wet Road Sign Alternative 2**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 10
QUESTION: Which of the following responses apply when you see this sign?
 You may circle ***MORE THAN ONE*** answer.

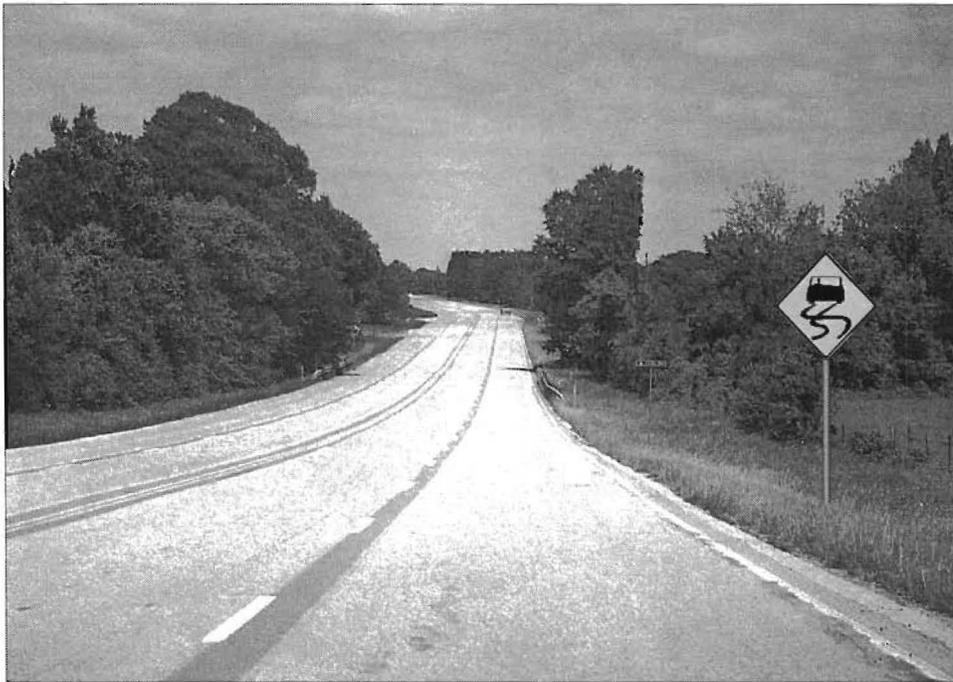


Figure B-25a. In-Context Picture:
Slow Down on Wet Road Sign Alternative 3



- 19.7% A. Be prepared for several curves in the road ahead.
- 9.6% B. Watch out for cars that are out-of-control.
- *49.5% C. Slow down to keep from losing control.
- 3.7% D. Be prepared for potholes in the road that might cause you to lose control.
- *67.6% E. Slow down when the road is wet to keep from losing control.
- *9.6% F. Watch out for large puddles of water on the road when it is raining.
- 4.3% G. I am not sure what this sign means.

Figure B-25b. Close-up with Responses:
Slow Down on Wet Road Sign Alternative 3

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10
SURVEY SET: A
QUESTION NUMBER: 2
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-26a. In-Context Picture:
 Truck Crossing Sign Standard**



- 26.7% A. This is a warning that this roadway is heavily used by trucks.
- *33.0% B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 11.9% C. Be prepared for slow moving trucks using the roadway.
- 21.0% D. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 1.7% E. No cars are allowed on this section of the road, only large trucks.
- 5.7% F. I am not sure what this sign means.

**Figure B-26b. Close-up with Responses:
 Truck Crossing Sign Standard**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: A
QUESTION NUMBER: 7
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-27a. In-Context Picture:
 Truck Crossing Sign Alternative 1**



- 49.7% A. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 4.0% B. Be prepared for slow moving trucks using the roadway.
- 6.9% C. This is a warning that this roadway is heavily used by trucks.
- 4.0% D. No cars are allowed on this section of the road, only heavy trucks.
- *33.7% E. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 1.7% F. I am not sure what this sign means.

**Figure B-27b. Close-up with Responses:
 Truck Crossing Sign Alternative 1**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 2
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-28a. In-Context Picture:
 Truck Crossing Sign Alternative 2**



- 6.8% A. This is a warning that this roadway is heavily used by trucks.
- *29.8% B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 9.4% C. Be prepared for slow moving trucks using the roadway.
- *48.2% D. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 0.5% E. No cars are allowed on this section of the road, only large trucks.
- 5.2% F. I am not sure what this sign means.

**Figure B-28b. Close-up with Responses:
 Truck Crossing Sign Alternative 2**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 2
QUESTION: *What is the most correct meaning of this sign?*
*Circle only **ONE** answer.*



**Figure B-29a. In-Context Picture:
Truck Crossing Sign Alternative 3**



- 16.9% A. This is a warning that this roadway is heavily used by trucks.
- *54.5% B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 16.9% C. Be prepared for slow moving trucks using the roadway.
- 9.5% D. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 0.0% E. No cars are allowed on this section of the road, only large trucks.
- 2.1% F. I am not sure what this sign means.

**Figure B-29b. Close-up with Responses:
Truck Crossing Sign Alternative 3**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 8
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-30a. In-Context Picture:
 Truck Crossing Sign Alternative 4**



- 28.4% A. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 3.2% B. Be prepared for slow moving trucks using the roadway.
- 6.8% C. This is a warning that this roadway is heavily used by trucks.
- 3.7% D. No cars are allowed on this section of the road, only heavy trucks.
- *30.0% E. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 27.9% F. I am not sure what this sign means.

**Figure B-30b. Close-up with Responses:
 Truck Crossing Sign Alternative 4**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 2
QUESTION: *What is the most correct meaning of this sign?*
*Circle only **ONE** answer.*



**Figure B-31a. In-Context Picture:
Truck Crossing Sign Alternative 5**



- | | |
|--------|---|
| 10.1% | A. This is a warning that this roadway is heavily used by trucks. |
| *41.5% | B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway. |
| 7.5% | C. Be prepared for slow moving trucks using the roadway. |
| 38.8% | D. Trucks may be entering or crossing the road at a single location a short distance ahead. |
| 0.0% | E. No cars are allowed on this section of the road, only large trucks. |
| 2.1% | F. I am not sure what this sign means. |

**Figure B-31b. Close-up with Responses:
Truck Crossing Sign Alternative 5**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1
SURVEY SET: A
QUESTION NUMBER: 8
QUESTION: Please circle ANY of the following responses that apply when you see this sign?
 You may circle MORE THAN ONE answer.



**Figure B-32a. In-Context Picture:
School Advance Sign Standard**



- | | |
|--------|--|
| *32.4% | A. There is a school area ahead. |
| 36.9% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 49.4% | C. There is a pedestrian crossing ahead. |
| *45.5% | D. There is a school crosswalk ahead. |
| 0.6% | E. I am not sure what this sign means. |

**Figure B-32b. Close-up with Responses:
School Advance Sign Standard**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 8
QUESTION: Please circle ANY of the following responses that apply when you see this sign?
 You may circle MORE THAN ONE answer.



**Figure B-33a. In-Context Picture:
School Advance Sign Alternative 1**



- | | |
|--------|--|
| *67.9% | A. There is a school area ahead. |
| 26.9% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 21.8% | C. There is a pedestrian crossing ahead. |
| *68.4% | D. There is a school crosswalk ahead. |
| 0.0% | E. I am not sure what this sign means. |

**Figure B-33b. Close-up with Responses:
School Advance Sign Alternative 1**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 6
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



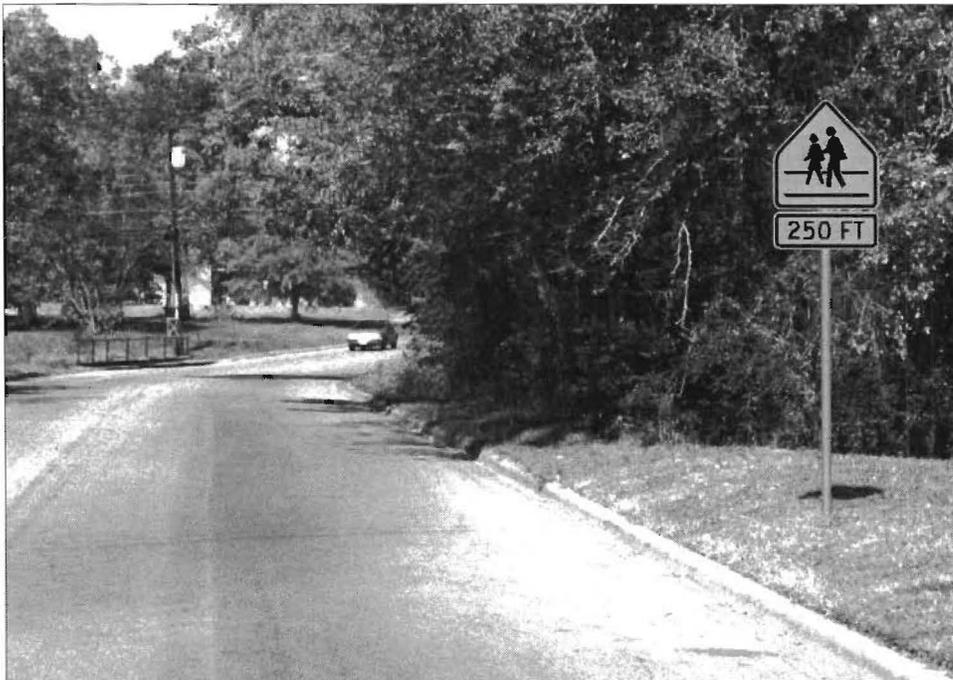
**Figure B-34a. In-Context Picture:
 School Advance Sign Alternative 2**



- | | |
|--------|--|
| 9.4% | A. There is a school area ahead. |
| 10.6% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 45.0% | C. There is a pedestrian crossing ahead. |
| *34.4% | D. There is a school crosswalk ahead. |
| 0.6% | E. I am not sure what this sign means. |

**Figure B-34b. Close-up with Responses:
 School Advance Sign Alternative 2**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 6
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure B-35a. In-Context Picture:
 School Advance Sign Alternative 3**



- | | |
|--------|--|
| 6.0% | A. There is a school area ahead. |
| 8.1% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 52.4% | C. There is a pedestrian crossing ahead. |
| *33.0% | D. There is a school crosswalk ahead. |
| 0.5% | E. I am not sure what this sign means. |

**Figure B-35b. Close-up with Responses:
 School Advance Sign Alternative 3**

DEVICE NAME: Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-1
SURVEY SET: A
QUESTION NUMBER: 3
QUESTION: *What is meaning of this sign?*
Circle only ONE answer.

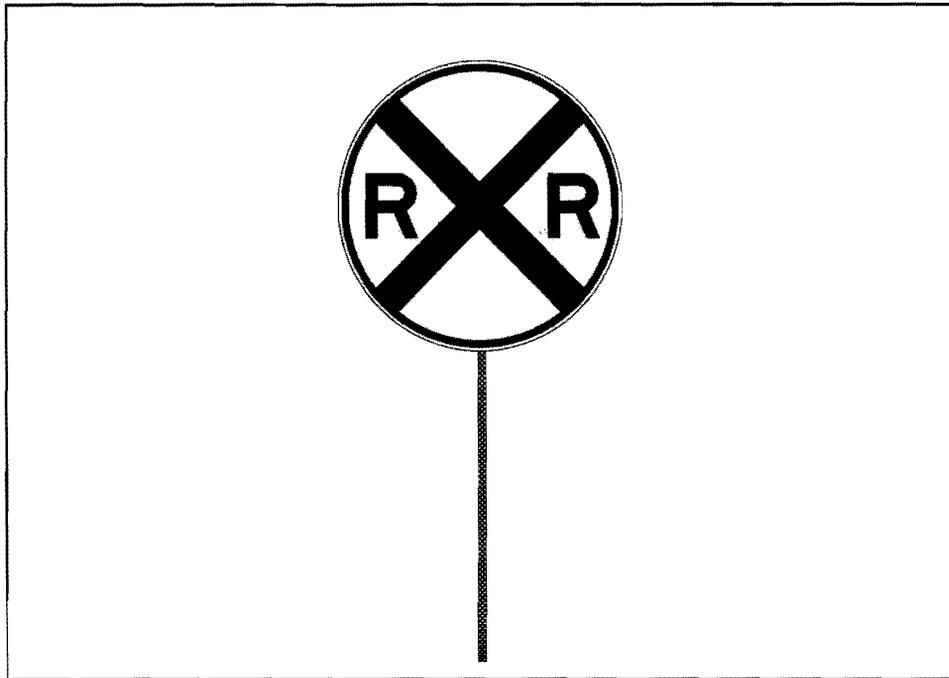
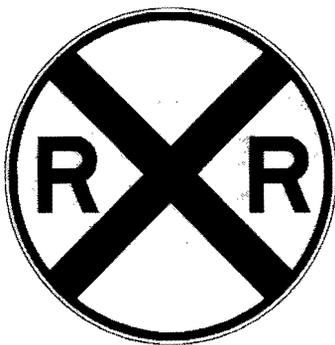


Figure B-36a. In-Context Picture:
Railroad Advance Warning Sign Standard



- | | |
|--------|---|
| 0.0% | A. There is a train museum ahead. |
| 1.1% | B. There is a train coming at the crossing ahead. |
| 17.6% | C. There is a railroad crossing next to this sign. |
| *81.3% | D. There is a railroad crossing ahead. |
| 0.0% | E. The Recreational Road ahead is temporarily closed. |
| 0.0% | F. You are about to intersect a Ranch Road. |
| 0.0% | G. I am not sure what this sign means. |

Figure B-36b. Close-up with Responses:
Railroad Advance Warning Sign Standard

DEVICE NAME: Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-1 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 3
QUESTION: *What is meaning of this sign?*
Circle only ONE answer.

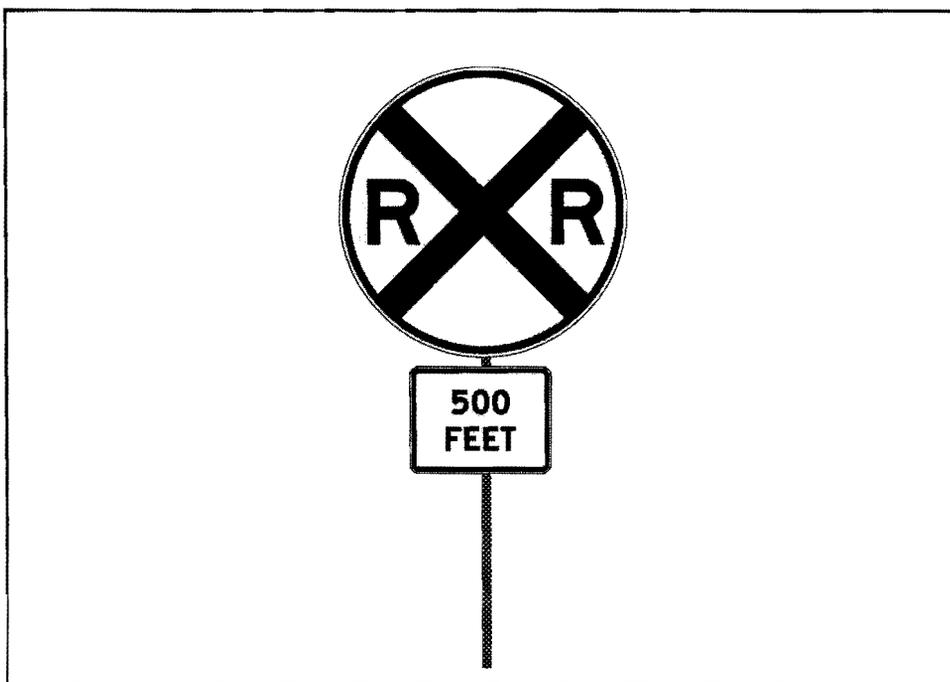


Figure B-37a. In-Context Picture:
Railroad Advance Warning Sign Alternative 1



- | | |
|--------|---|
| 0.5% | A. There is a train museum ahead. |
| 2.6% | B. There is a train coming at the crossing ahead. |
| 5.3% | C. There is a railroad crossing next to this sign. |
| *90.5% | D. There is a railroad crossing ahead. |
| 0.0% | E. The Recreational Road ahead is temporarily closed. |
| 0.5% | F. You are about to intersect a Ranch Road. |
| 0.5% | G. I am not sure what this sign means. |

Figure B-37b. Close-up with Responses:
Railroad Advance Warning Sign Alternative 1

DEVICE NAME: Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-1 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 3
QUESTION: *What is meaning of this sign?*
Circle only ONE answer.

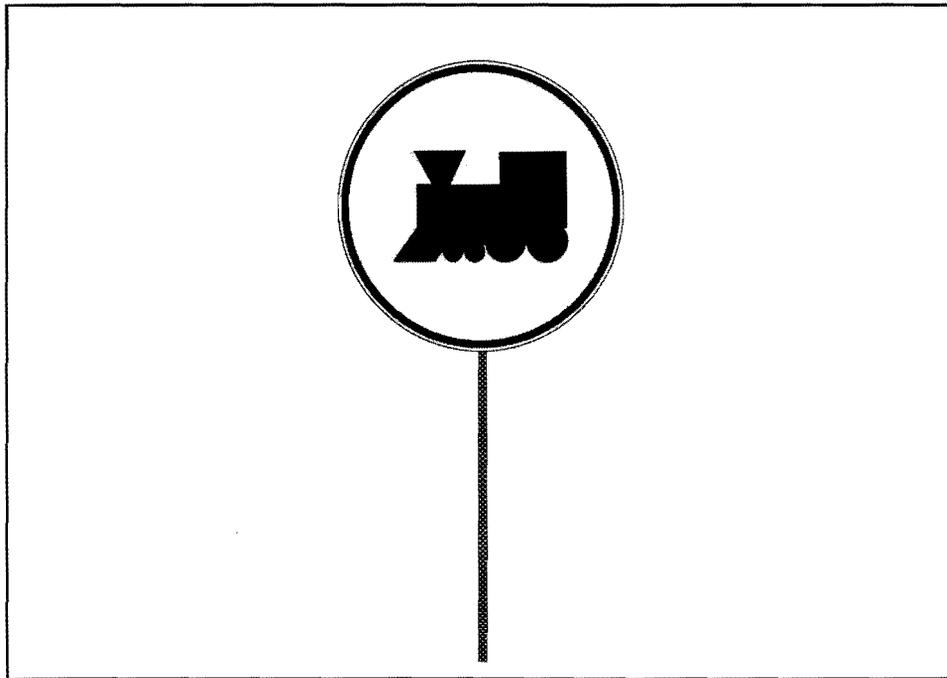
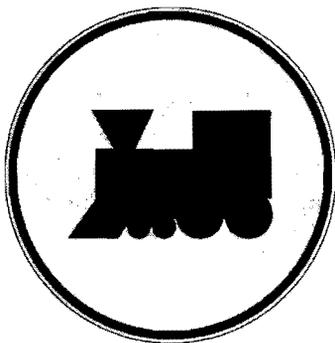


Figure B-38a. In-Context Picture:
Railroad Advance Warning Sign Alternative 2



- | | |
|--------|---|
| 10.6% | A. There is a train museum ahead. |
| 10.1% | B. There is a train coming at the crossing ahead. |
| 8.0% | C. There is a railroad crossing next to this sign. |
| *51.1% | D. There is a railroad crossing ahead. |
| 0.0% | E. The Recreational Road ahead is temporarily closed. |
| 0.0% | F. You are about to intersect a Ranch Road. |
| 20.2% | G. I am not sure what this sign means. |

Figure B-38b. Close-up with Responses:
Railroad Advance Warning Sign Alternative 2

DEVICE NAME: Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-1 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 3
QUESTION: *What is meaning of this sign?*
*Circle only **ONE** answer.*

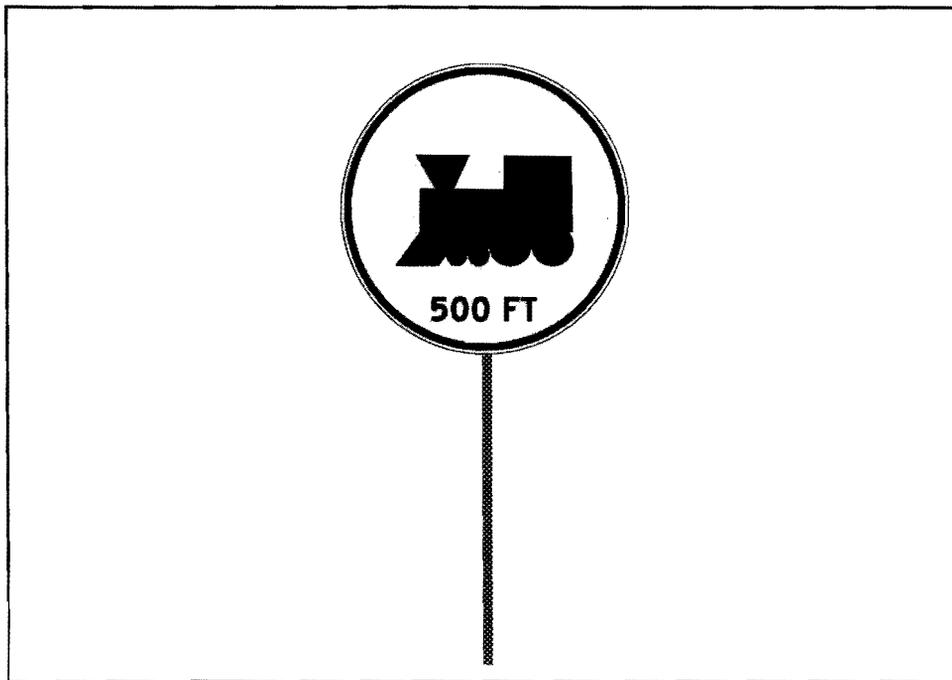
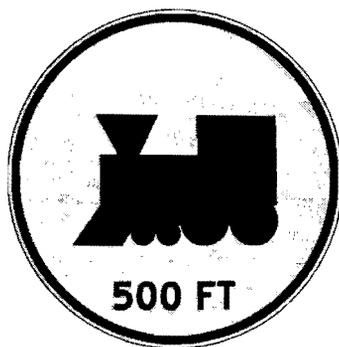


Figure B-39a. In-Context Picture:
Railroad Advance Warning Sign Alternative 3



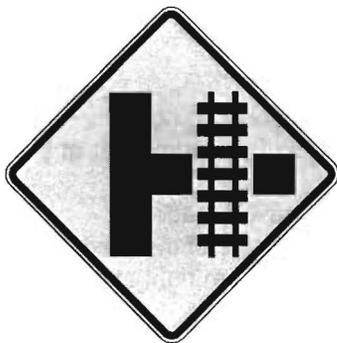
- | | |
|--------|---|
| 3.7% | A. There is a train museum ahead. |
| 3.7% | B. There is a train coming at the crossing ahead. |
| 4.3% | C. There is a railroad crossing next to this sign. |
| *80.8% | D. There is a railroad crossing ahead. |
| 0.0% | E. The Recreational Road ahead is temporarily closed. |
| 0.5% | F. You are about to intersect a Ranch Road. |
| 7.0% | G. I am not sure what this sign means. |

Figure B-39b. Close-up with Responses:
Railroad Advance Warning Sign Alternative 3

DEVICE NAME: Parallel Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-3
SURVEY SET: A
QUESTION NUMBER: 4
QUESTION: *What is meaning of this sign?
 Circle only ONE answer.*



**Figure B-40a. In-Context Picture:
 Parallel RR Advance Warning Sign Standard**



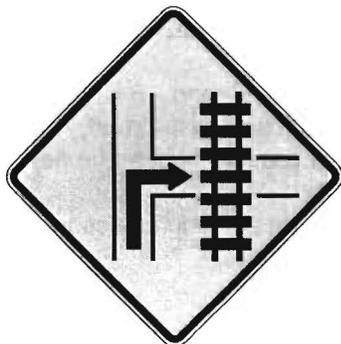
- | | |
|--------|--|
| 0.6% | A. You will go through a tunnel if you turn right. |
| *84.1% | B. You will cross a railroad track if you turn right at the intersection. |
| 2.3% | C. You are driving next to an unpaved road. |
| 1.1% | D. There is a fence along the right side of the road. |
| 1.1% | E. You will be on a ranch road if you turn right at the next intersection. |
| 0.6% | F. You will be required to turn right at the intersection. |
| 10.2% | G. I am not sure what this sign means. |

**Figure B-40b. Close-up with Responses:
 Parallel RR Advance Warning Sign Standard**

DEVICE NAME: Parallel Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-3 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 4
QUESTION: *What is meaning of this sign?*
Circle only ONE answer.



Figure B-41a. In-Context Picture:
Parallel RR Advance Warning Sign Alternative 1



- | | |
|---|--|
| <p>0.5%</p> <p>*88.1%</p> <p>1.0%</p> <p>1.0%</p> <p>0.5%</p> <p>2.6%</p> <p>6.2%</p> | <p>A. You will go through a tunnel if you turn right.</p> <p>B. You will cross a railroad track if you turn right at the intersection.</p> <p>C. You are driving next to an unpaved road.</p> <p>D. There is a fence along the right side of the road.</p> <p>E. You will be on a ranch road if you turn right at the next intersection.</p> <p>F. You will be required to turn right at the intersection.</p> <p>G. I am not sure what this sign means.</p> |
|---|--|

Figure B-41b. Close-up with Responses:
Parallel RR Advance Warning Sign Alternative 1

DEVICE NAME: Parallel Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-3 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 4
QUESTION: *What is meaning of this sign?*
Circle only ONE answer.



Figure B-42a. In-Context Picture:
Parallel RR Advance Warning Sign Alternative 2



- | | |
|--------|--|
| 1.6% | A. You will go through a tunnel if you turn right. |
| *90.5% | B. You will cross a railroad track if you turn right at the intersection. |
| 0.0% | C. You are driving next to an unpaved road. |
| 0.0% | D. There is a fence along the right side of the road. |
| 1.6% | E. You will be on a ranch road if you turn right at the next intersection. |
| 3.2% | F. You will be required to turn right at the intersection. |
| 3.2% | G. I am not sure what this sign means. |

Figure B-42b. Close-up with Responses:
Parallel RR Advance Warning Sign Alternative 2

DEVICE NAME: Parallel Railroad Advance Warning Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W10-3 (Alternative)
SURVEY SET: D
QUESTION NUMBER: 4
QUESTION: *What is meaning of this sign?*
*Circle only **ONE** answer.*



Figure B-43a. In-Context Picture:
Parallel RR Advance Warning Sign Alternative 3



- | | |
|--------|--|
| 0.0% | A. You will go through a tunnel if you turn right. |
| *87.2% | B. You will cross a railroad track if you turn right at the intersection. |
| 0.5% | C. You are driving next to an unpaved road. |
| 1.6% | D. There is a fence along the right side of the road. |
| 2.1% | E. You will be on a ranch road if you turn right at the next intersection. |
| 7.0% | F. You will be required to turn right at the intersection. |
| 1.6% | G. I am not sure what this sign means. |

Figure B-43b. Close-up with Responses:
Parallel RR Advance Warning Sign Alternative 3

APPENDIX C

PHASE II FOLLOW-UP SURVEY SUMMARY

This appendix presents a representation of the Phase II follow-up survey that was administered in two Texas cities. The survey instrument had a similar format and layout to that of the Phase II initial survey instrument in that it was presented in a three-ring binder and contained in-context pictures of traffic control devices, a close-up view of the same device below the picture, and a multiple-choice comprehension question for the participant to answer.

The survey instrument used for the follow-up evaluation consisted of three color-coded survey versions each with five questions. Unlike the initial survey in which one of the survey sets contained all standard sign designs, two of the follow-up survey sets contained a combination of both standard sign designs and alternative sign designs, and one contained only alternative designs. Many of the alternative designs for the follow-up evaluation were slightly modified, either by a change in sign legend, an addition of a supplemental plaque, and/or a modification of specific sign elements. A Spanish language version of this survey was not developed for this evaluation. A summary of the three survey sets used for this follow-up evaluation is presented in Table C-1.

Table C-1. Summary of Phase II Follow-Up Survey Instrument

Survey Set	Color Designation	No. of Devices Evaluated	Type of Device Evaluated
A	Red	5	Standard/Alternative Designs
B	Blue	5	Standard/Alternative Designs
C	Green	5	Alternative Designs

The only differences between the images presented in this appendix and the ones viewed by the participants are that the images in the actual survey were in color and at a higher graphics resolution than the ones presented here. Also, the response percentages were not part of the actual survey instrument. The questions in this appendix are grouped according to similar traffic control devices, and not in the order that they were presented in the actual survey.

The correct response is indicated with an asterisk (*) in the close-up image. Table C-2 provides a cross-reference which can be used to identify the question and page number for a particular device. Table C-3 presents a summary of the demographic characteristics of the Phase II follow-up survey from the two cities in which the survey was administered.

Table C-2. Cross-Reference for Traffic Control Device Questions

Type of Device	Device Name	Sign Label	No. of Devices Evaluated	Appendix Page Number
Regulatory Sign	Stop Sign Supplemental Plaque	N/A ¹	3	C-3 to C-5
Warning Signs	Narrow Bridge	W5-2a	3	C-6 to C-8
	Slow Down on Wet Road	W8-5 ²	3	C-9 to C-11
	Truck Crossing	W11-10	3	C-12 to C-14
School Sign	School Advance Sign	S1-1	3	C-15 to C-17
TOTAL			15	

Notes: ¹ There is no standard sign indicating this condition.

² This sign is labeled **Slippery When Wet** in the National MUTCD.

Table C-3. Demographic Characteristics of Phase II Follow-Up Survey Sample

Characteristics		Number	Percent	Texas Population	
				General	Driving
Gender	Male	110	51.9	49.3	51.5
	Female	102	48.1	50.7	48.5
Age	16 to 24	79	37.3	18.9	15.2
	25 to 54	110	51.9	57.4	62.4
	55 to 64	12	5.7	10.2	10.4
	65+	11	5.2	13.6	12.0
Ethnicity	African American	13	6.1	11.6	—
	Anglo	173	81.6	60.6	—
	Hispanic	18	8.5	25.6	—
	Other	8	3.8	2.2	—
Education Level	Less Than High School	34	16.1	28.1	—
	High School (or Equivalent)	76	36.0	25.9	—
	Some College	63	29.9	27.8	—
	College Graduate	38	18.0	18.1	—
Total¹		212	100.0	100.0	—

Note: ¹ Individual totals may not reflect the overall total. A few participants chose not to answer demographic questions.

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: A
QUESTION NUMBER: 2
QUESTION: *What is this sign telling you?
 Circle only ONE answer.*



**Figure C-1a. In-Context Picture:
 Stop Sign Supplemental Plaque Alternative 1**



- | | |
|--------|--|
| 0.0% | A. You do not have to stop because you are crossing the intersection. |
| 9.9% | B. Traffic from all directions must stop at the intersection. |
| *84.5% | C. Traffic from the right or left may not slow down or stop at the intersection. |
| 5.6% | D. I am not sure what this sign means. |

**Figure C-1b. Close-up with Responses:
 Stop Sign Supplemental Plaque Alternative 1**

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 2
QUESTION: *What is this sign telling you?*
*Circle only **ONE** answer.*



Figure C-2a. In-Context Picture:
Stop Sign Supplemental Plaque Alternative 2



- | | |
|--------|--|
| 7.1% | A. You do not have to stop because you are crossing the intersection. |
| 10.0% | B. Traffic from all directions must stop at the intersection. |
| *81.4% | C. Traffic from the right or left may not slow down or stop at the intersection. |
| 1.4% | D. I am not sure what this sign means. |

Figure C-2b. Close-up with Responses:
Stop Sign Supplemental Plaque Alternative 2

DEVICE NAME: Stop Sign Supplemental Plaque
TYPE OF DEVICE: Regulatory Sign
SIGN LABEL: R1-1 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 2
QUESTION: *What is this sign telling you?*
Circle only ONE answer.



Figure C-3a. In-Context Picture:
Stop Sign Supplemental Plaque Alternative 3



- 2.9% A. You do not have to stop because you are crossing the intersection.
- 2.9% B. Traffic from all directions must stop at the intersection.
- *91.4% C. Traffic from the right or left may not slow down or stop at the intersection.
- 2.9% D. I am not sure what this sign means.

Figure C-3b. Close-up with Responses:
Stop Sign Supplemental Plaque Alternative 3

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2
SURVEY SET: A
QUESTION NUMBER: 4
QUESTION: Which of the following responses apply when you see this sign?
 You may circle ***MORE THAN ONE*** answer.



**Figure C-4a. In-Context Picture:
Narrow Bridge Sign Alternative 1**



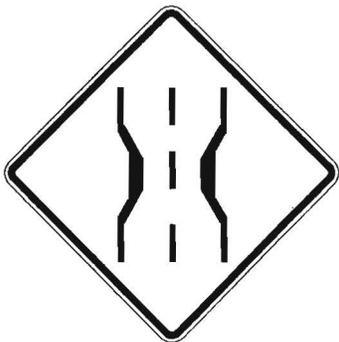
- | | |
|--------|--|
| 6.9% | A. You will go under an overpass ahead. |
| *55.6% | B. The shoulder may get narrower or end. |
| 18.1% | C. You will have to share your lane with traffic from the other direction. |
| 0.0% | D. You are about to enter a tunnel. |
| *83.3% | E. The lane you are in may get narrower. |
| 0.0% | F. I am not sure what this sign means. |

**Figure C-4b. Close-up with Responses:
Narrow Bridge Sign Alternative 1**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a
SURVEY SET: B
QUESTION NUMBER: 4
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure C-5a. In-Context Picture:
 Narrow Bridge Sign Alternative 2**



- | | |
|--------|--|
| 5.7% | A. You will go under an overpass ahead. |
| *48.6% | B. The shoulder may get narrower or end. |
| 7.1% | C. You will have to share your lane with traffic from the other direction. |
| 2.9% | D. You are about to enter a tunnel. |
| *85.7% | E. The lane you are in may get narrower. |
| 1.4% | F. I am not sure what this sign means. |

**Figure C-5b. Close-up with Responses:
 Narrow Bridge Sign Alternative 2**

DEVICE NAME: Narrow Bridge Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W5-2a (Alternative)
SURVEY SET: C
QUESTION NUMBER: 4

QUESTION: Which of the following responses apply when you see this sign?
 You may circle ***MORE THAN ONE*** answer.



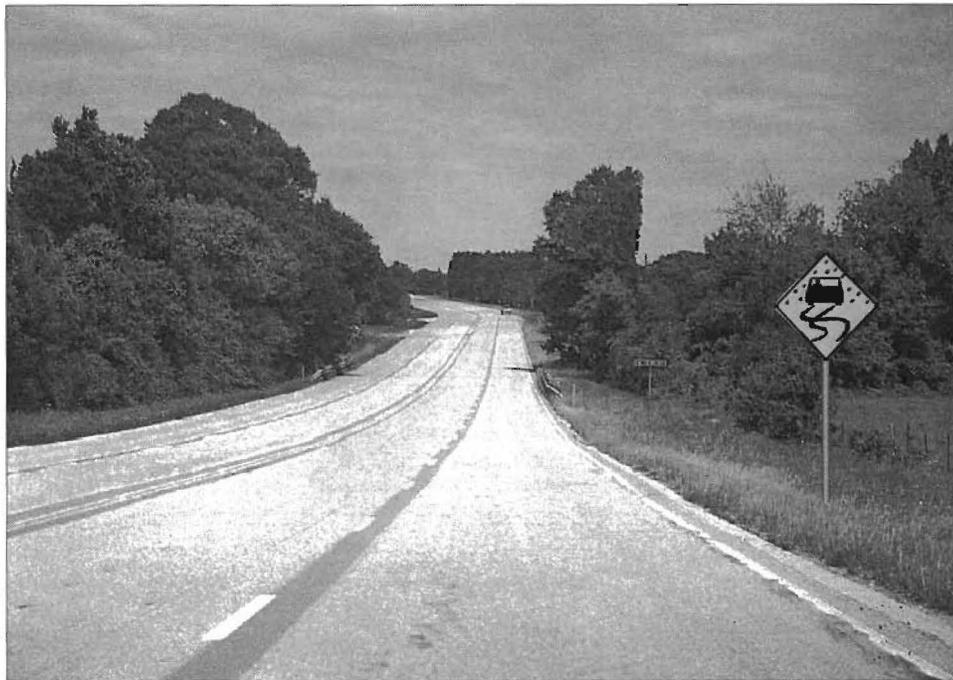
**Figure C-6a. In-Context Picture:
 Narrow Bridge Sign Alternative 3**



- | | |
|--------|--|
| 2.9% | A. You will go under an overpass ahead. |
| *54.3% | B. The shoulder may get narrower or end. |
| 15.7% | C. You will have to share your lane with traffic from the other direction. |
| 1.4% | D. You are about to enter a tunnel. |
| *88.6% | E. The lane you are in may get narrower. |
| 4.3% | F. I am not sure what this sign means. |

**Figure C-6b. Close-up with Responses:
 Narrow Bridge Sign Alternative 3**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: A
QUESTION NUMBER: 5
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



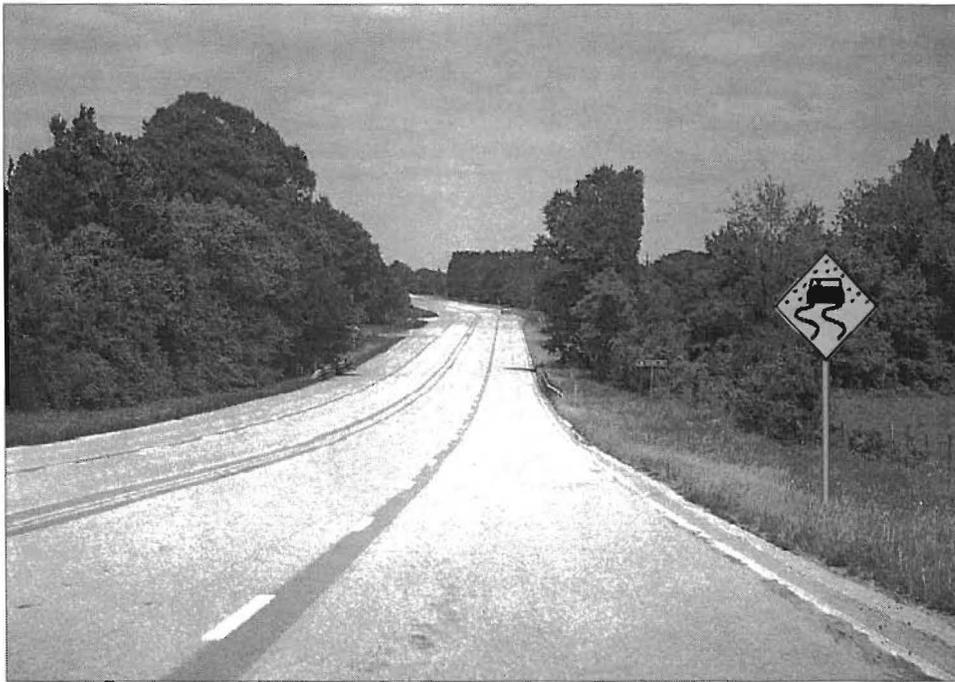
**Figure C-7a. In-Context Picture:
Slow Down on Wet Road Sign Alternative 1**



- | | |
|--------|---|
| 8.3% | A. Be prepared for several curves in the road ahead. |
| 5.6% | B. Watch out for cars that are out-of-control. |
| 31.9% | C. Slow down to keep from losing control. |
| 4.2% | D. Be prepared for potholes in the road that might cause you to lose control. |
| *91.7% | E. Slow down when the road is wet to keep from losing control. |
| 23.6% | F. Watch out for large puddles of water on the road when it is raining. |
| 0.0% | G. I am not sure what this sign means. |

**Figure C-7b. Close-up with Responses:
Slow Down on Wet Road Sign Alternative 1**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 5
QUESTION: Which of the following responses apply when you see this sign?
 You may circle **MORE THAN ONE** answer.



**Figure C-8a. In-Context Picture:
 Slow Down on Wet Road Sign Alternative 2**



- | | |
|--------|---|
| 11.4% | A. Be prepared for several curves in the road ahead. |
| 7.1% | B. Watch out for cars that are out-of-control. |
| 21.4% | C. Slow down to keep from losing control. |
| 0.0% | D. Be prepared for potholes in the road that might cause you to lose control. |
| *95.7% | E. Slow down when the road is wet to keep from losing control. |
| 17.1% | F. Watch out for large puddles of water on the road when it is raining. |
| 0.0% | G. I am not sure what this sign means. |

**Figure C-8b. Close-up with Responses:
 Slow Down on Wet Road Sign Alternative 2**

DEVICE NAME: Slow Down on Wet Road Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W8-5 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 5
QUESTION: Which of the following responses apply when you see this sign?
 You may circle ***MORE THAN ONE*** answer.



Figure C-9a. In-Context Picture:
Slow Down on Wet Road Sign Alternative 3



- | | |
|--------|---|
| 14.3% | A. Be prepared for several curves in the road ahead. |
| 11.4% | B. Watch out for cars that are out-of-control. |
| *27.1% | C. Slow down to keep from losing control. |
| 1.4% | D. Be prepared for potholes in the road that might cause you to lose control. |
| *91.4% | E. Slow down when the road is wet to keep from losing control. |
| 14.3% | F. Watch out for large puddles of water on the road when it is raining. |
| 0.0% | G. I am not sure what this sign means. |

Figure C-9b. Close-up with Responses:
Slow Down on Wet Road Sign Alternative 3

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: A
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure C-10a. In-Context Picture:
 Truck Crossing Sign Alternative 1**



- 9.7% A. This is a warning that this roadway is heavily used by trucks.
- *23.6% B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 4.2% C. Be prepared for slow moving trucks using the roadway.
- 61.1% D. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 0.0% E. No cars are allowed on this section of the road, only large trucks.
- 1.4% F. I am not sure what this sign means.

**Figure C-10b. Close-up with Responses:
 Truck Crossing Sign Alternative 1**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



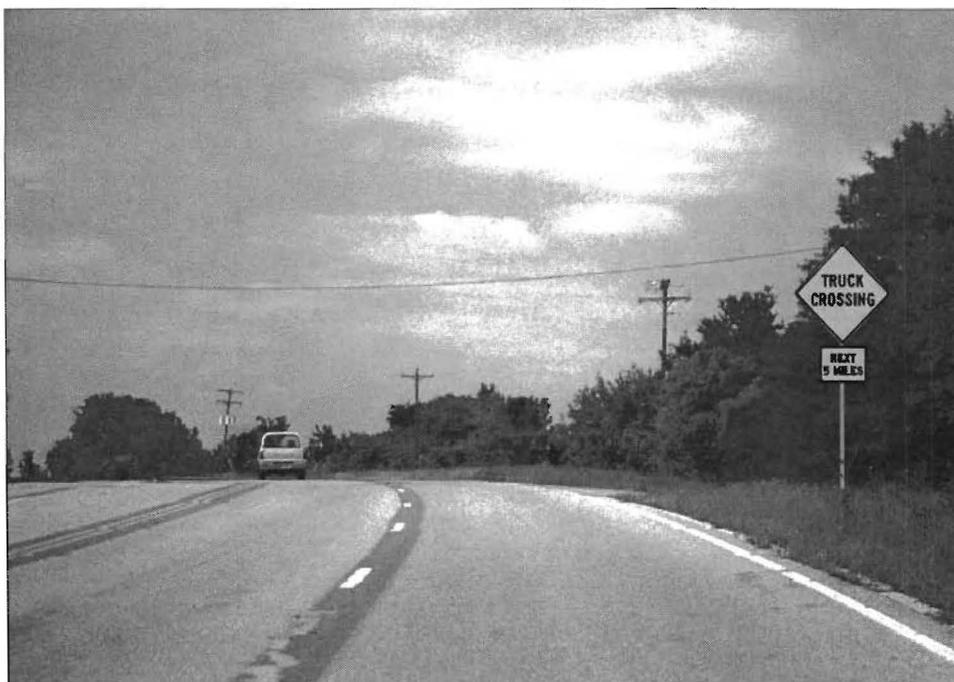
**Figure C-11a. In-Context Picture:
 Truck Crossing Sign Alternative 2**



- 0.0% A. This is a warning that this roadway is heavily used by trucks.
- *30.0% B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway.
- 7.1% C. Be prepared for slow moving trucks using the roadway.
- *62.9% D. Trucks may be entering or crossing the road at a single location a short distance ahead.
- 0.0% E. No cars are allowed on this section of the road, only large trucks.
- 0.0% F. I am not sure what this sign means.

**Figure C-11b. Close-up with Responses:
 Truck Crossing Sign Alternative 2**

DEVICE NAME: Truck Crossing Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: W11-10 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 1
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure C-12a. In-Context Picture:
 Truck Crossing Sign Alternative 3**



- | | |
|--------|---|
| 2.9% | A. This is a warning that this roadway is heavily used by trucks. |
| *68.6% | B. Trucks may be entering or crossing the road at one or several locations on the following section of roadway. |
| 1.4% | C. Be prepared for slow moving trucks using the roadway. |
| 25.7% | D. Trucks may be entering or crossing the road at a single location a short distance ahead. |
| 0.0% | E. No cars are allowed on this section of the road, only large trucks. |
| 1.4% | F. I am not sure what this sign means. |

**Figure C-12b. Close-up with Responses:
 Truck Crossing Sign Alternative 3**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: A
QUESTION NUMBER: 3
QUESTION: Please circle ANY of the following responses that apply when you see this sign?
 You may circle MORE THAN ONE answer.



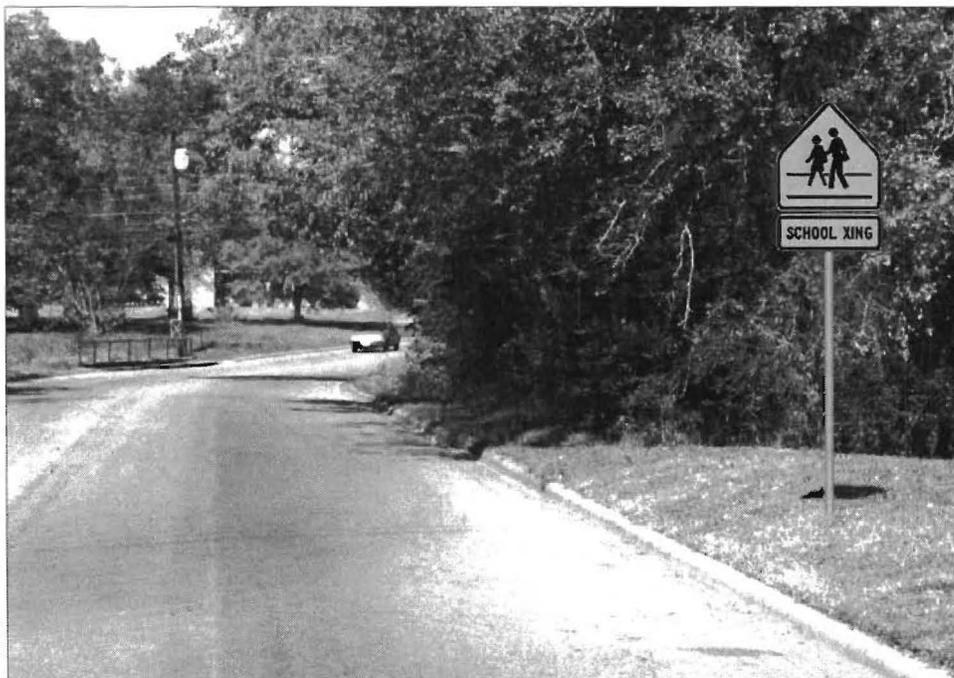
**Figure C-13a. In-Context Picture:
 School Advance Sign Alternative 1**



- | | |
|--------|--|
| *77.8% | A. There is a school area ahead. |
| 30.6% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 23.6% | C. There is a pedestrian crosswalk ahead. |
| *81.9% | D. There is a school crosswalk ahead. |
| 0.0% | E. I am not sure what this sign means. |

**Figure C-13b. Close-up with Responses:
 School Advance Sign Alternative 1**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: B
QUESTION NUMBER: 3
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



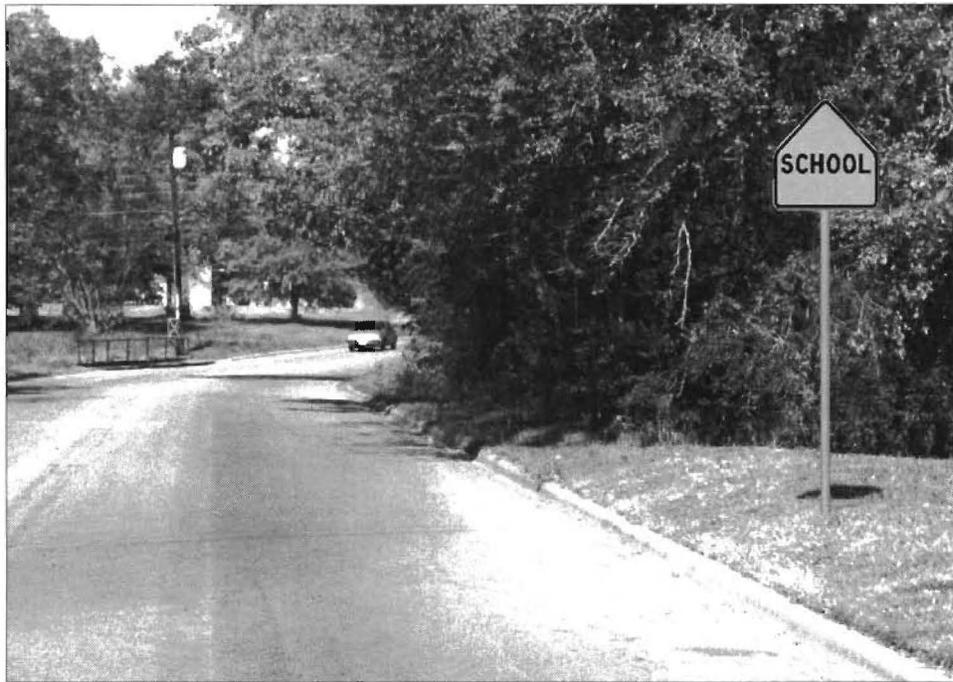
**Figure C-14a. In-Context Picture:
 School Advance Sign Alternative 2**



- | | |
|--------|--|
| 4.3% | A. There is a school area ahead. |
| 1.4% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 7.1% | C. There is a pedestrian crosswalk ahead. |
| *87.1% | D. There is a school crosswalk ahead. |
| 0.0% | E. I am not sure what this sign means. |

**Figure C-14b. Close-up with Responses:
 School Advance Sign Alternative 2**

DEVICE NAME: School Advance Sign
TYPE OF DEVICE: Warning Sign
SIGN LABEL: S1-1 (Alternative)
SURVEY SET: C
QUESTION NUMBER: 3
QUESTION: *What is the most correct meaning of this sign?
 Circle only ONE answer.*



**Figure C-15a. In-Context Picture:
 School Advance Sign Alternative 3**



- | | |
|--------|--|
| *85.5% | A. There is a school area ahead. |
| 2.9% | B. Pedestrians may be walking on the shoulder or sidewalk. |
| 2.9% | C. There is a pedestrian crosswalk ahead. |
| 8.7% | D. There is a school crosswalk ahead. |
| 0.0% | E. I am not sure what this sign means. |

**Figure C-15b. Close-up with Responses:
 School Advance Sign Alternative 3**

