APPENDIX 11

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AASHTO Roadside Design Guide

CHAPTER 6: MEDIAN BARRIERS

6.0 OVERVIEW

A median barrier is a longitudinal barrier most commonly used to separate opposing traffic on a divided highway. It is also used along heavily traveled roadways to separate through traffic from local traffic or to separate carpool/vanpool traffic from other highway users. By definition, any longitudinal barrier placed on the left side of a divided roadway may be considered a median barrier, but this chapter will address only those that are designed to redirect vehicles striking either side of the barrier.

This chapter references the performance requirements for median barriers, provides warrants for their use, and contains guidelines for selecting and installing an appropriate barrier system. The structural and safety characteristics of selected median barriers, including end treatments and transition sections, are presented. Finally, selection and placement guidelines are included for new construction and methods are presented for identifying and upgrading existing substandard systems.

6.1 PERFORMANCE REQUIREMENTS

The performance requirements for median barriers are identical to those for roadside barriers as stated in Section 5.1. National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features,* contains detailed information on the required series of standard crash tests needed to evaluate the performance of longitudinal barriers.

6.2 WARRANTS

As with all types of traffic barriers, a median barrier should be installed only if striking the barrier is less severe than the consequences that would result if no barrier existed. Figure 6.1 suggests a warrant for median barriers on high-speed, controlled-access roadways which have relatively flat, traversable medians. These criteria are based on a limited analysis of median crossover accidents[1] and research studies,[2] and are suggested for use in the absence of more current (or site-specific) data. Barriers are typically considered for combinations of average daily traffic (ADT) and median widths that fall within the indicated area. At low ADTs, the frequency of median encroachments is relatively low. Thus, for ADTs less than 20,000 and median widths within the optional areas of Figure 6.1, a barrier is warranted only if there has been a history of cross-median accidents. Likewise, for relatively wide medians the probability of a vehicle crossing the median is also low. Thus, for median widths greater than 10 m and within the optional area of the figure, a barrier may or may not be warranted, again depending on the cross-median accident history. Flat medians that are wider than 15 m do not warrant a barrier unless there is an adverse accident history. It should be noted that after a warranted median barrier is installed, accident severity may decrease, but accident frequency may increase since the space available for return-to-the-road maneuvers is reduced. Further, it should be noted that as a result of metrication the former warrant limit of 9.1 m (30 feet) became 10 m (32.8 feet). Existing medians with a width of 9.1 m or more should also be considered as meeting the suggested warrants.

Median barriers are sometimes used on high-volume, non-access controlled facilities. However, safely terminating such barriers can be difficult and sight distance may be a significant problem at intersections.

Special consideration should be given to barrier needs for medians separating roadways at different elevations. The ability of an errant driver leaving the higher roadway to return to the road or to stop diminishes as the difference in elevation increases. Thus, the potential for cross-over accidents increases. For such sections, the clear zone criterion given in Chapter 3 should be used as a guideline for establishing barrier need. Section 6.6.1.2 addresses the placement of barrier on sloped medians.

6.3 PERFORMANCE LEVEL SELECTION PROCEDURES

As with roadside barriers, most median barriers have been developed, tested, and installed with the intention of containing and redirecting passenger vehicles. Some highway agencies have identified locations, however, where heavy vehicle containment was considered necessary and have designed and installed high performance median barriers having significantly greater capabilities than commonly used designs. Factors most often considered in reaching a decision on such barrier use include:

- high percentage or large average daily number of heavy vehicles
- adverse geometrics (horizontal curvature)
- severe consequences of vehicular (or cargo) penetration into opposing traffic lanes

Section 6.4 includes information on the maximum size of vehicle which has been successfully crash tested for each median barrier system described in that Section.

6.4 STRUCTURAL AND SAFETY CHARACTERISTICS OF MEDIAN BARRIERS

This section identifies selected median barrier systems and summarizes the structural and safety characteristics of each. It is subdivided into standard sections, transitions, and end treatments. Characteristics unique to each system are emphasized.

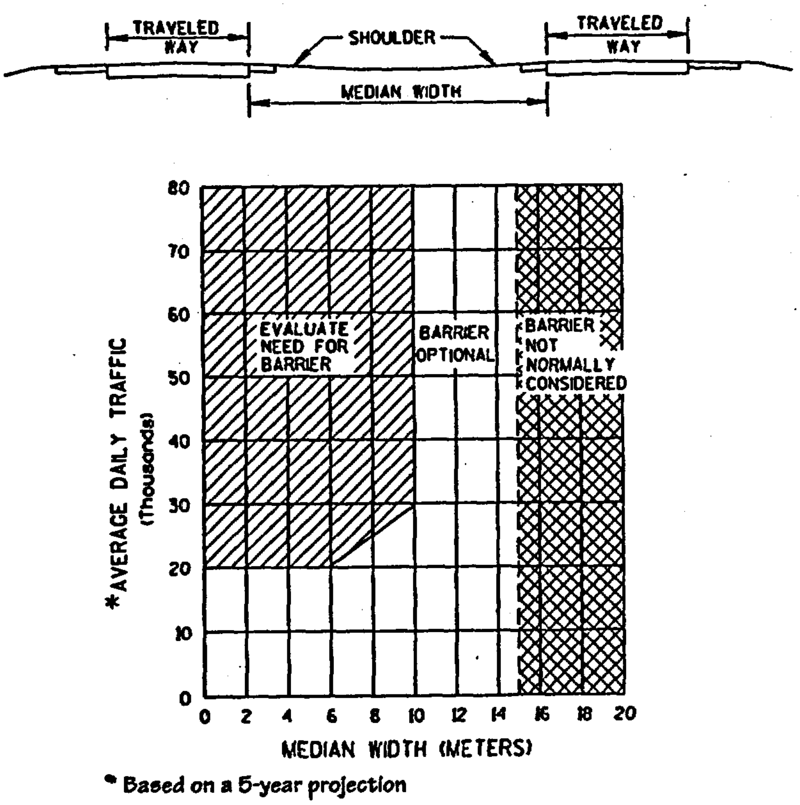

FIGURE 6.1 Median Barrier Warrants for Freeways and Expressways

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6.0 OVERVIEW

A median barrier is a longitudinal barrier most commonly used to separate opposing traffic on a divided highway. It is also used along heavily-travelled roadways to separate through traffic from local traffic or to separate carpool/vanpool traffic from other highway users. By definition, any longitudinal barrier placed on the left side of a divided roadway may be considered a median barrier, but this chapter will address only those that are symmetrical, i.e. designed to redirect vehicles striking either side of the barrier.

This chapter references the performance requirements for median barriers, provides warrants for their use, and contains guidelines for selecting and installing an appropriate barrier system. The structural and safety characteristics of selected median barriers, including end treatments and transition sections, are presented. Finally, selection and placement guidelines are included for new construction and methods are presented for identifying and upgrading existing substandard systems.

6.1 PERFORMANCE REQUIREMENTS

The performance requirements for median barriers are identical to those for roadside barriers as discussed in Section 5.1. National Cooperative Highway Research Program (NCHRP) Report No 230, "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances" contains detailed information on the required series of full-scale crash tests needed to evaluate the performance of longitudinal barriers.

6.2 WARRANTS

As with all types of traffic barriers, a median barrier should be installed only if striking the barrier is less severe than the consequences that would result if no barrier existed. Figure 6.1 suggests warrants for median barriers on high speed, controlled access roadways which have relatively flat, traversable medians. These criteria are based on a limited analysis of median crossover accidents[1] and research studies[2], and are suggested for use in the absence of more current (or site-specific) data. Barriers are typically considered for combinations of average daily traffic (ADT) and median widths that fall within the dotted area. At low ADT's, the frequency of median encroachments is relatively low. Thus, for ADT's less than 20,000 and median widths within the optional areas of Figure 6.1, a barrier is warranted only if there has been a history of cross-median accidents. Likewise, for relatively wide medians, the probability of a vehicle crossing the median is also low. Thus, for median widths greater than 30 feet and within the optional area of the figure, a barrier may or may not be warranted, again depending on the cross-median accident history. Flat medians that are wider than 50 feet do not warrant a barrier unless there is an adverse accident history. It should be noted that after a warranted median barrier is installed, accident severity may decrease, but accident frequency may increase since the space available for return-to-the-road maneuvers is lessened.

Median barriers are sometimes used on high-volume, non-access controlled facilities. However, safely terminating such barriers can be difficult and sight distance may be a significant problem at intersections.

Special consideration should be given to barrier needs for medians separating roadways at different elevations. The ability of an errant driver leaving the higher roadway to return to the road or to stop diminishes as the difference in elevation increases. Thus, the potential for cross-over accidents increases. For such sections, the clear zone criterion given in Chapter 3 should be used as a guideline for establishing barrier need. Section 6.6.1.2 address the placement of barrier on sloped medians.

The warranting criteria included in Figure 6.1 is

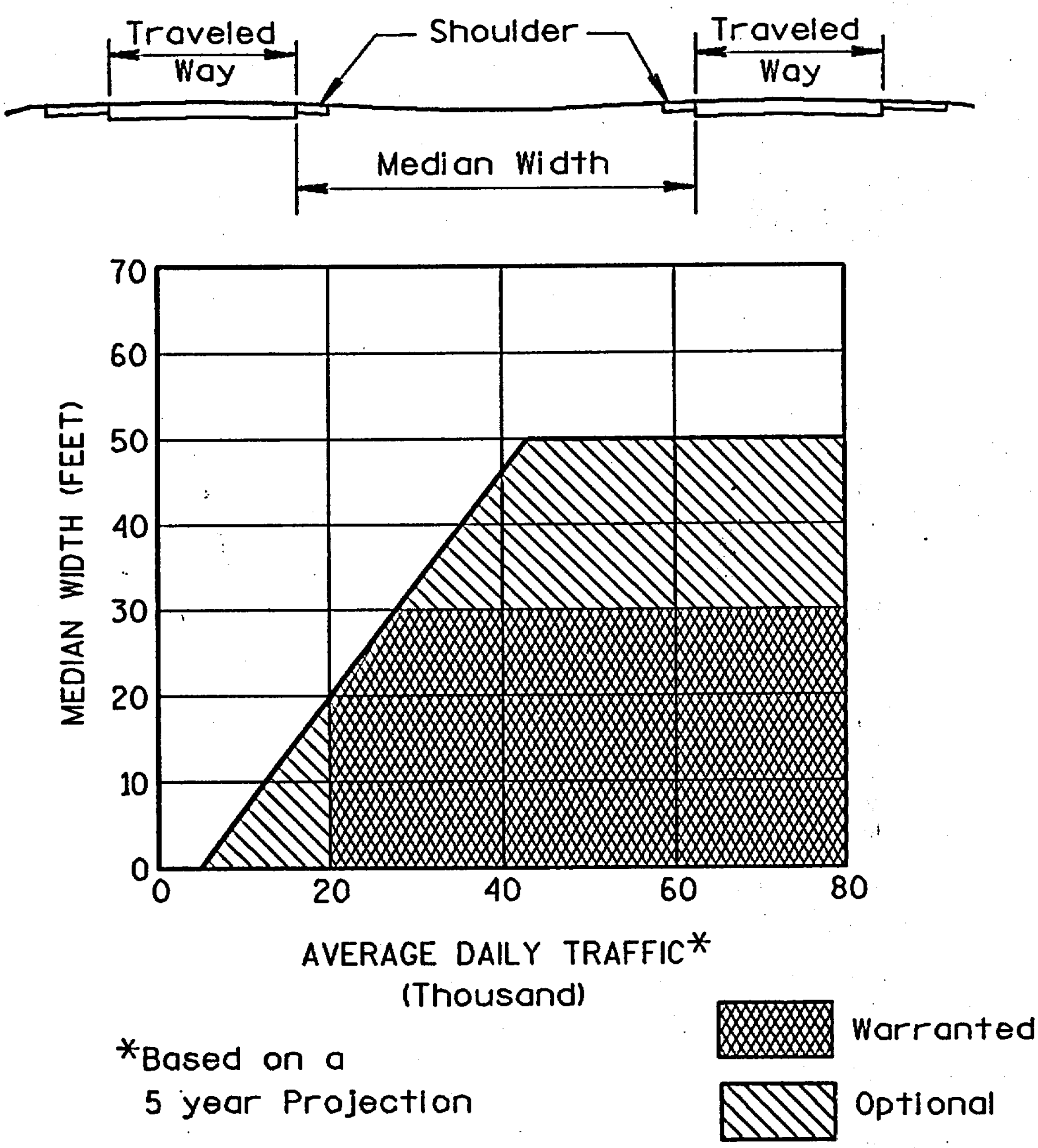

FIGURE 6.1 Median Barrier Warrants for Freeways and Expressways

relatively subjective and does not specifically address the cost-effectiveness issue. Efforts are currently underway to develop more sophisticated criteria using a benefit to cost model that will address vehicle speed and traffic mix as well as ADT and median slope and width. The designer should keep informed of progress in this area.

6.3 PERFORMANCE LEVEL SELECTION PROCEDURES

As with roadside barriers, most median barriers have been developed, tested and installed with the intention of containing and redirecting passenger vehicles.

Summary Report

HSIS

HIGHWAY SAFETY INFORMATION SYSTEM

The Highway Safety Information Systems (HSIS) is a multi-State safety data base that contains accident, roadway inventory, and traffic volume data for a select group of States. The participating States, Illinois, Maine, Michigan, Minnesota, and Utah, were selected based on the quality of their data, the range of data available, and their ability to merge data from the various files. The HSIS is used by FHWA staff, contractors, university researchers, and others to study current highway safety issues, direct research efforts, and evaluate the effectiveness of accident countermeasures.

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THE ASSOCIATION OF MEDIAN WIDTH AND HIGHWAY ACCIDENT RATE

Medians on divided highways may be used as recovery areas by out-of-control vehicles. In some regions, the median widths of new highways are being minimized to control the amount of right-of-way required, and in others, existing highway medians are being reduced so that additional travel lanes can be built to improve capacity. Such actions tradeoff safety to reduce costs or increase efficiency (as measured by capacity). Correcting a deficiency after a road has been built is more expensive than building without the deficiency. The design of new highways must balance safety, cost, environment, and efficiency considerations. This study examined the effect of median width on the frequency and severity of accidents on homogeneous highway sections with a traversable (nonbarrier) median.

Analysis Methods

Median width was defined as the width of the portion of divided highway separating the traveled ways for traffic in opposite directions (including the inside shoulder). In addition to median width, several roadway characteristics affect the frequency, severity, and type of accidents. To isolate the effect of median width, these other variables must be controlled either by restricting the road sections to having particular characteristics or by making statistical adjustments. Both methods were used in this study.

The analyses were restricted to two-way, four-lane, rural and urban Interstate, freeway, and major highway road sections in Utah and Illinois of a length exceeding 0.11 km (0.07 mi), with a posted speed limit of at least 56.3 km/h (35 mi/h), and with no median or an unprotected median no wider than 33.5 m (110 ft). In addition, the Utah analysis was restricted to road sections with 3.66-m (12-ft) lane widths. No such restriction was placed on the Illinois analysis as there was no explicit lane width variable in that data base.

The Utah analysis was based on 982 highway sections with an average length of 1.59 km (0.99 mi). A total of 37,544 reported accidents occurred on those sections from 1987 through 1990. The Illinois analysis involved 2,481 highway sections with an average length of 1.35 km (0.84 mi). A total of 55,706 accidents on those sections was reported over the period from 1987 through 1989.

A log-linear regression model assuming a negative-binomial variance function was used to assess the effects of median width and several other roadway variables on the accident rate. This model assumes that the effect of variables on the accident rate is multiplicative rather than additive as in a linear model. The log-linear model may be represented algebraically as:

$$\log(\lambda) = a + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k$$

where λ is a function of the accident rate, log denotes natural logarithm, and the X_i are dummy variables for categorical roadway characteristics or actual values for quantitative roadway characteristics. The beta coefficients were estimated by the method of quasi-likelihood.

Results

The total accident rate appears to decline steadily with increasing median width from 0 to 33.5 m (0 to 110 ft). For Utah it declines by a factor of six, and for Illinois, it declines by a factor of 13. Over this range of median width, the rates of serious injury, all injury, and property-damage-only accidents also decline by up to a factor of 15. The rate of multivehicle accidents declines steadily with increasing median width. The rate of single-vehicle accidents in Utah shows little relationship to median width, however.

Due to confounding by other variables, the observed reductions in the accident rate cannot all be attributed to the effect of increasing median width. After adjusting for these other variables, the decline in the total accident rate persists, though to a lesser degree (figure 1). This figure depicts the relative effect of median width on total accident rates in Utah and Illinois when median width is represented both as a categorical and as a continuous variable relative to the rate for medians of zero width. The upper and lower values are the boundaries of the 95-percent confidence interval for median width as a categorical variable. Over the range of median widths, Utah accident rates drop about one-half and Illinois rates drop about one-third.

The interpretation of these relative effects is that when all the other variables are the same and the only difference is the median width, the relative effect describes the proportional reduction in the total accident rate. For example, using the Illinois model shown in figure 1, the total accident rate for an average median width of 12.2 m (40 ft) is about 76 percent of the rate for median width zero (no median), and for an average median width of 19.5 m (64 ft), it is 62 percent of the zero width rate. If, in designing a new highway, the engineer wants to consider the safety benefits of increasing the median width from 12.2 to 19.5 m (40 to 64 ft), this is obtained as (0.62-0.76)/0.76 = -0.18. Therefore, you would expect an

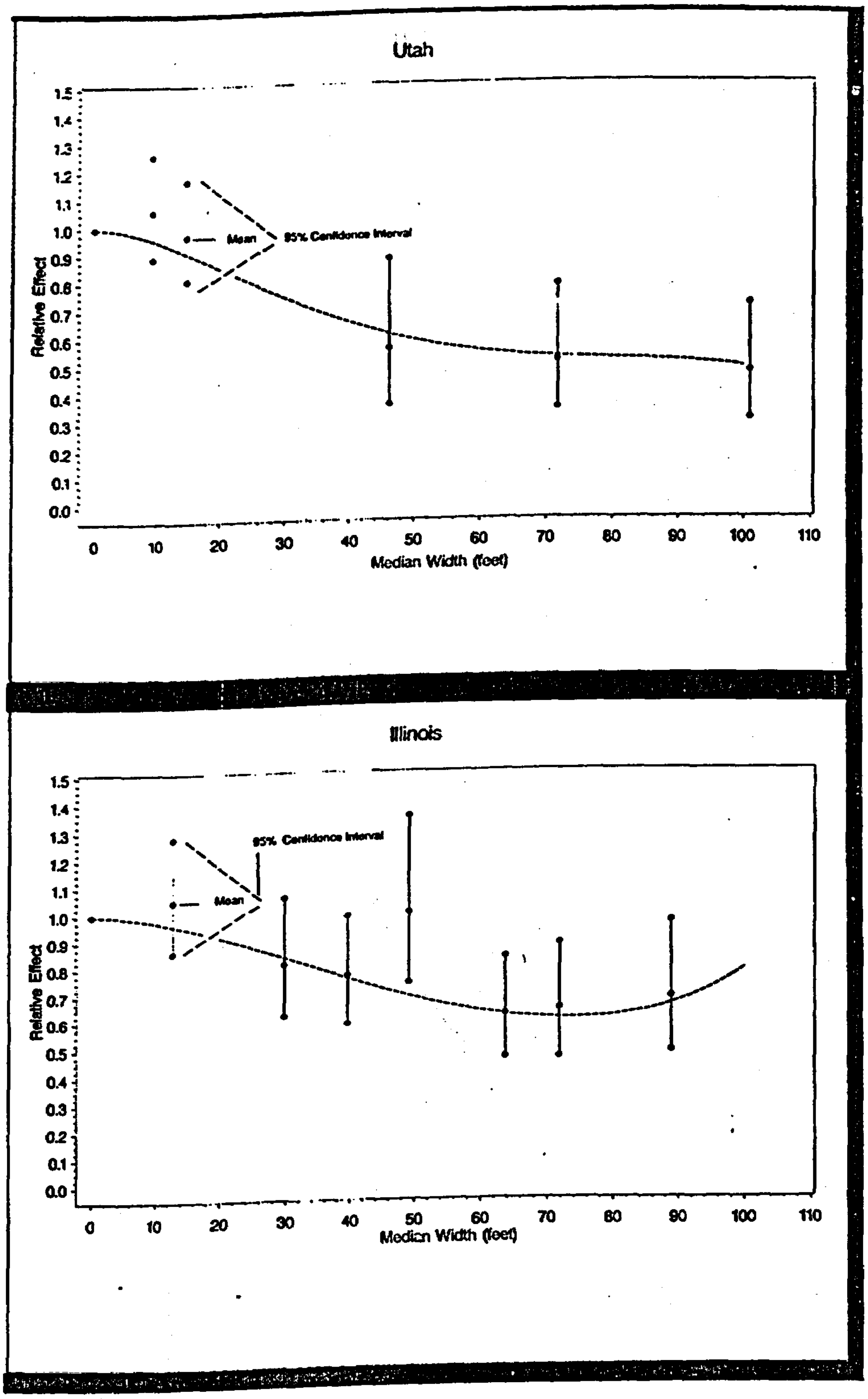

Figure 1. Relative effect of median width on total accident rate (median width represented as both a categorical variable and as a continuous variable).

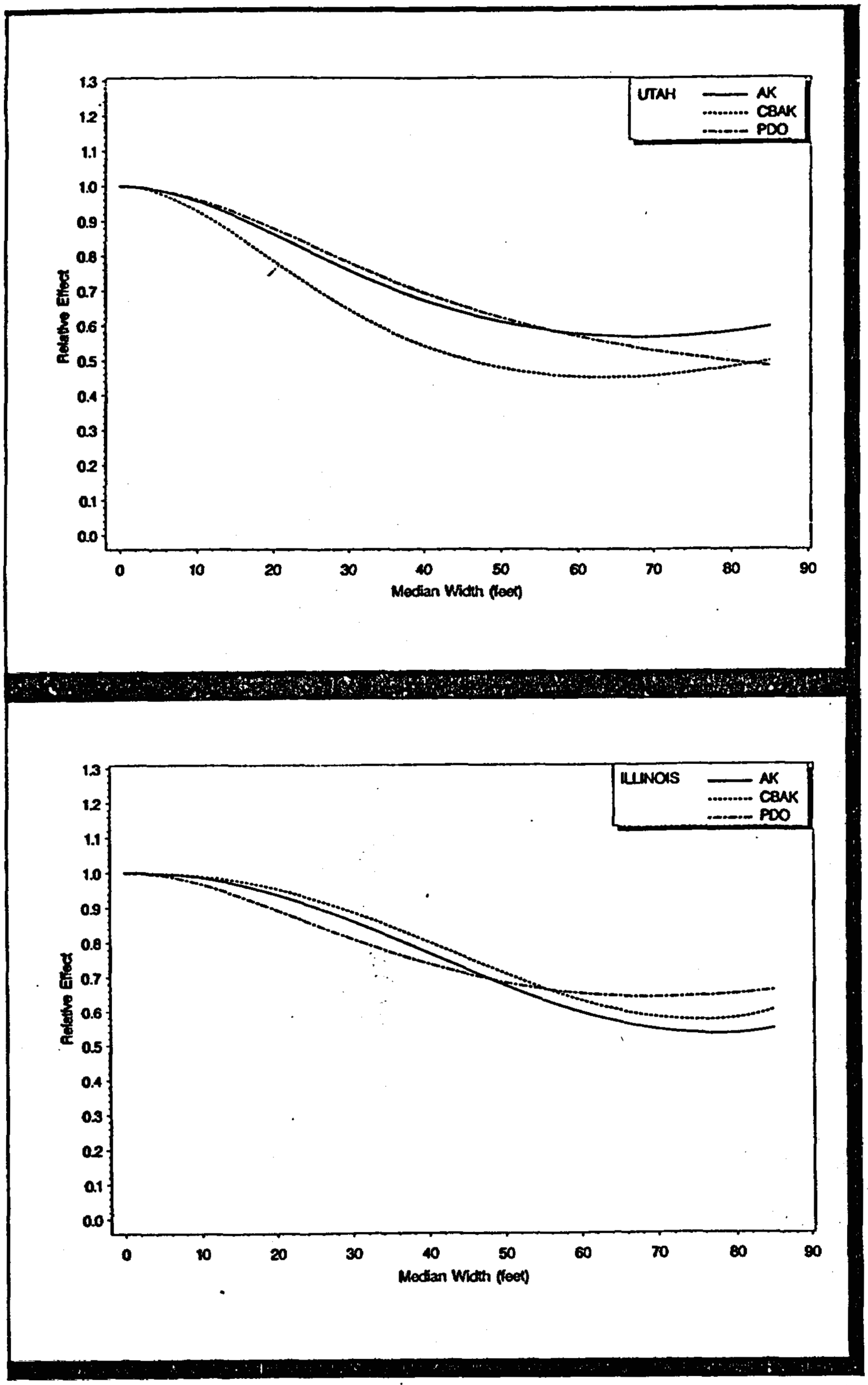

Figure 2. Relative effects of median width by accident severity (AK= severe, CBAK = all injury, PDO = property damage only).

18-percent reduction in the accident rate. Similarly, if you reduce an existing 19.5-m (64-ft) median to a 12.2-m (40-ft) one, you would expect a 23-percent increase in the total accident rate [(0.76-0.62)/0.62 = 0.23].

Relative accident rates for more specific accident severities or types {such as serious accident or head-on/sideswipe opposite direction (HO)} generally declined with increasing median width (figures 2 and 3). Figure 2 shows that in Utah, for instance, relative accident rates for both serious (AK) and injury accidents (CBAK) declined steadily as median width increased from 0 to 12.2 m (0 to 40 ft). These rates remained stable for median widths exceeding 12.2 m (40 ft). The relative accident rate for property-damage-only accidents (PDO) fell steadily as median width increased from 0 to 24.4 m (0 to 80 ft). In Illinois, the AK and CBAK relative accident rates fell until median width had increased to 21.3 m (70 ft). Although the data indicate a slight increase beyond 21.3 m (70 ft), it is believed this is an artifact of the small sample sizes available at this median width. The relative accident rates would be expected to remain constant beyond 21.3 m (70 ft).

According to figure 3 (on page 4), relative accident rates for rollover accidents (Roll) in Utah fell to a minimum when median width had increased to 21.3 m (70 ft). The relative rates for multivehicle accidents (MVeh), single-vehicle accidents (SVeh), and head-on/sideswipe opposite direction accidents generally declined with increasing median width. For Illinois, the relative rate for head-on/sideswipe accidents dropped sharply, then stabilized around 0.12 at a median width of approximately 12.2 m (40 ft). For multivehicle accidents, the relative rates generally fell, though not as rapidly. Relative rates for single-vehicle accidents dropped slightly with increasing median width, while for rollover accidents the relative rates remained between 0.65 and 0.90 for median widths of 12.2 m (40 ft) or wider.

State Data Bases Used

Illinois and Utah were the only HSIS States with accident and roadway data sufficiently complete and reliable to permit an analysis of the effect of median width on accident rates for those medians without barriers.

Study Implications

The general findings indicate that accident rates do decrease with increasing median width for unprotected medians. On the other hand, there was very little decrease for the first 9.1 m (30 ft) of median width suggesting that when constructing new highways, medians need to be at least 9.1 m (30 ft) wide to have a positive safety effect. The data also indicates that the safety benefits of medians increase until widths of 18. 3 to 24.4 m (60 to 80 ft) are reached. While it is difficult to determine the exact accident width where the safety effect is lost, the data suggest that decreasing existing medians to less than 6.1 to 9.1 m (20 to 30 ft) wide to enhance capacity may decrease the level of safety on the roadway.

Unfortunately, the HSIS data set could not be used to determine the median width at which a positive barrier should be used. At the current time, the HSIS States contain only a limited number of miles of roadway with barrier, and the variation in median width on these roadways is insufficient for a statistically valid study. Three to four additional States will be added to the HSIS by the end of 1994. It is anticipated that this will provide a sufficient sample size to conduct this type of analysis.

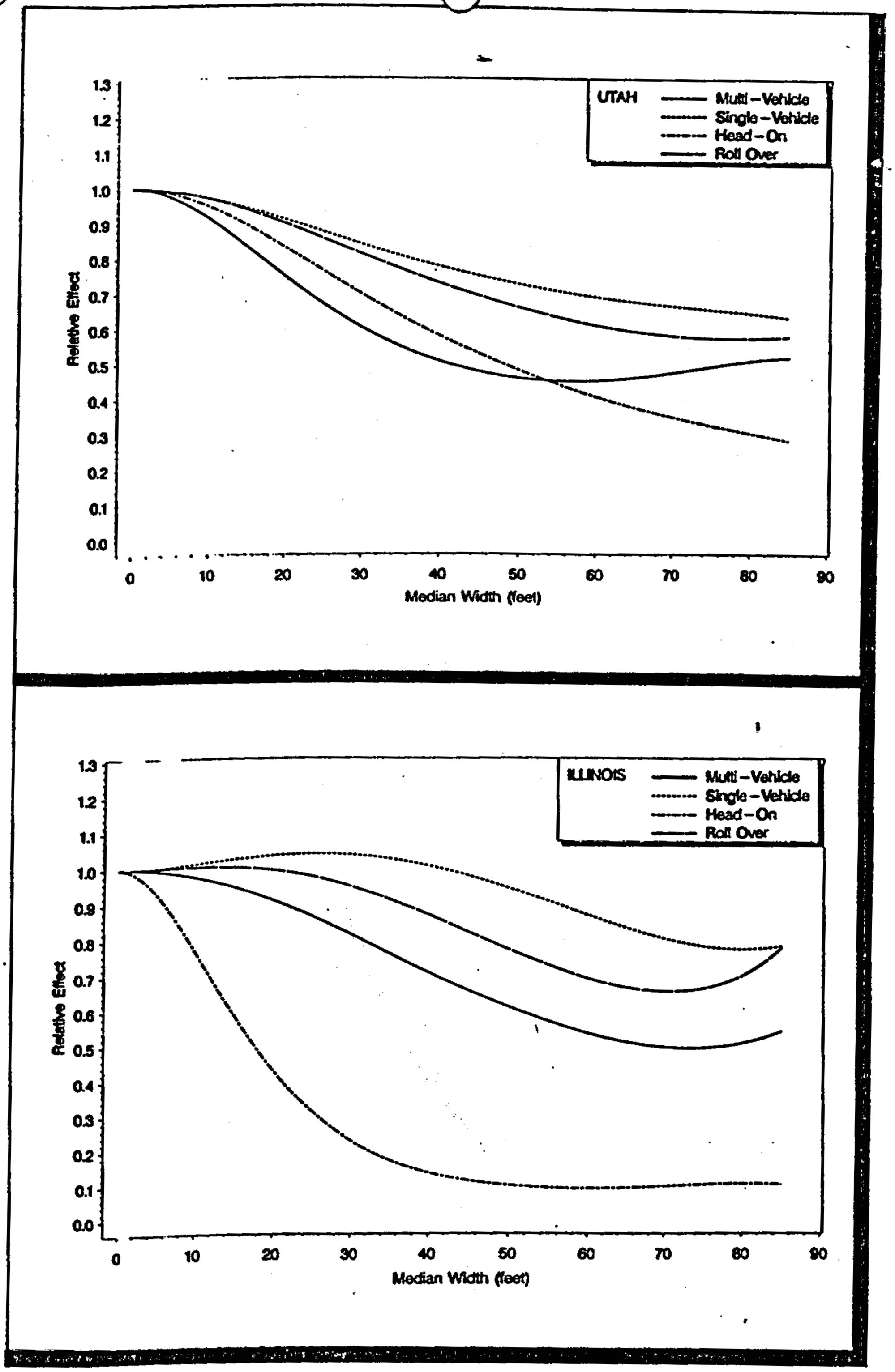

Figure 3. Relative effects of median width by accident type.

For More Information

This research was conducted by Matthew W. Knuiman, a visiting researcher from Australia, and Forrest M. Council and Donald W. Reinfurt of the University of North Carolina Highway Safety Research Center. The final report will be published by the Transportation Research Board as part of an upcoming *Transportation Research Record*. For more information, contact Jeffrey F. Paniati, HSIS Program Manager, HSR-30, (703) 285-2568.