A STUDY OF FACTORS

INFLUENCING TRAFFIC SPEEDS

by

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SYNOPSIS

This report was developed from a research project conducted by the Texas Transportation Institute in cooperation with the Texas Highway Department. The over-all objectives of the research project were (1) to evaluate the effectiveness of speed limits established by present practices and (2) to develop new or more substantial criteria for the establishment of speed zones. The results of the first phase of the research were reported previously.[1] This report covers the second phase of the research and dealt specifically with an evaluation of factors influencing the drivers' selection of speed.

The first part of this report deals with a study of factors which influence traffic speeds in areas of transition from rural to urban conditions. In these areas the measurable factors can generally be categorized into three basic groups. These groups are:

(1) Roadway geometrics.
(2) Characteristics of development.
(3) Traffic conditions.

Two study techniques were used to measure speeds in transition areas.

(1) Individual Vehicle Speed Study Method - Measurement of the average speed of each vehicle through each of several sectors of the transition zone.

(2) Test Car Method - Continuous measurement of the speed of a test car through the transition zone.

The studies pointed up several roadway and development characteristics which influenced traffic speeds. The most significant were:

(1) Horizontal and vertical curves.
(2) Sight distance.
(3) Changes in roadway cross-section.
(4) Commercial development.
(5) Appearance of residential development.

Several studies involving 12- and 24-hour speed observations were conducted to determine the influence of changing traffic conditions on traffic speeds. These studies showed that speeds were subject to only minor variations during the hours of normal traffic operation.

Other studies were concerned with the influence of radar enforcement operations on traffic speeds. These studies showed that enforcement operations caused appreciable speed reductions, but the influence did not extend beyond four miles on either side of the enforcement unit.

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INTRODUCTION

In 1958 the Texas Transportation Institute initiated a research project aimed at providing data for the development of new or more substantial criteria for the establishment of speed zones. The project, which was sponsored by the Texas Highway Department, was conducted in two phases. The first phase consisted of an evaluation of the effectiveness of speed limits established on the basis of 85-percentile speeds. The results of the first phase have been reported previously.[1]

In the first phase of the research project, comparative "Before" and "After" studies were conducted in 186 spot speed study locations to determine the effect of speed limit signs on traffic speeds. This large number of studies permitted an analysis of data for conditions when the speed limits were changed from 60 down to 30 mph, and from 30 up to 55 mph in increments of 5 miles per hour. The results of this study indicated that speed limit signs actually had very little influence on the drivers' choice of speed. Figure 1 typically illustrates the results of the study. The only notable influence on traffic speeds was a slight decrease in the over-all dispersion of traffic speeds. A summary listing of the results is included in Table A in the Appendix.

These findings should not be construed to mean that speed zoning serves no worthwhile purpose. Speed zoning is necessary to provide the needed flexibility in the general speed laws, so that traffic speeds can legally conform to the desirable operational characteristics of the roadway.

This report covers the second phase of the research which dealt with an evaluation of factors influencing the drivers' selection of speed.

The speed of an individual vehicle is subject to considerable variation throughout a given section of roadway. This is particularly true if the section of roadway is in an area of transition from rural to urban conditions. The factors causing the variation in speed are innumerable. They may be physical or psychological; tangible or intangible. However, it is pre-supposed that variations or changes in the speed of a vehicle are functions of the driver's evaluation of the existing conditions ahead.

Most of the tangible or measurable factors can be categorized into three basic groups. These groups are:

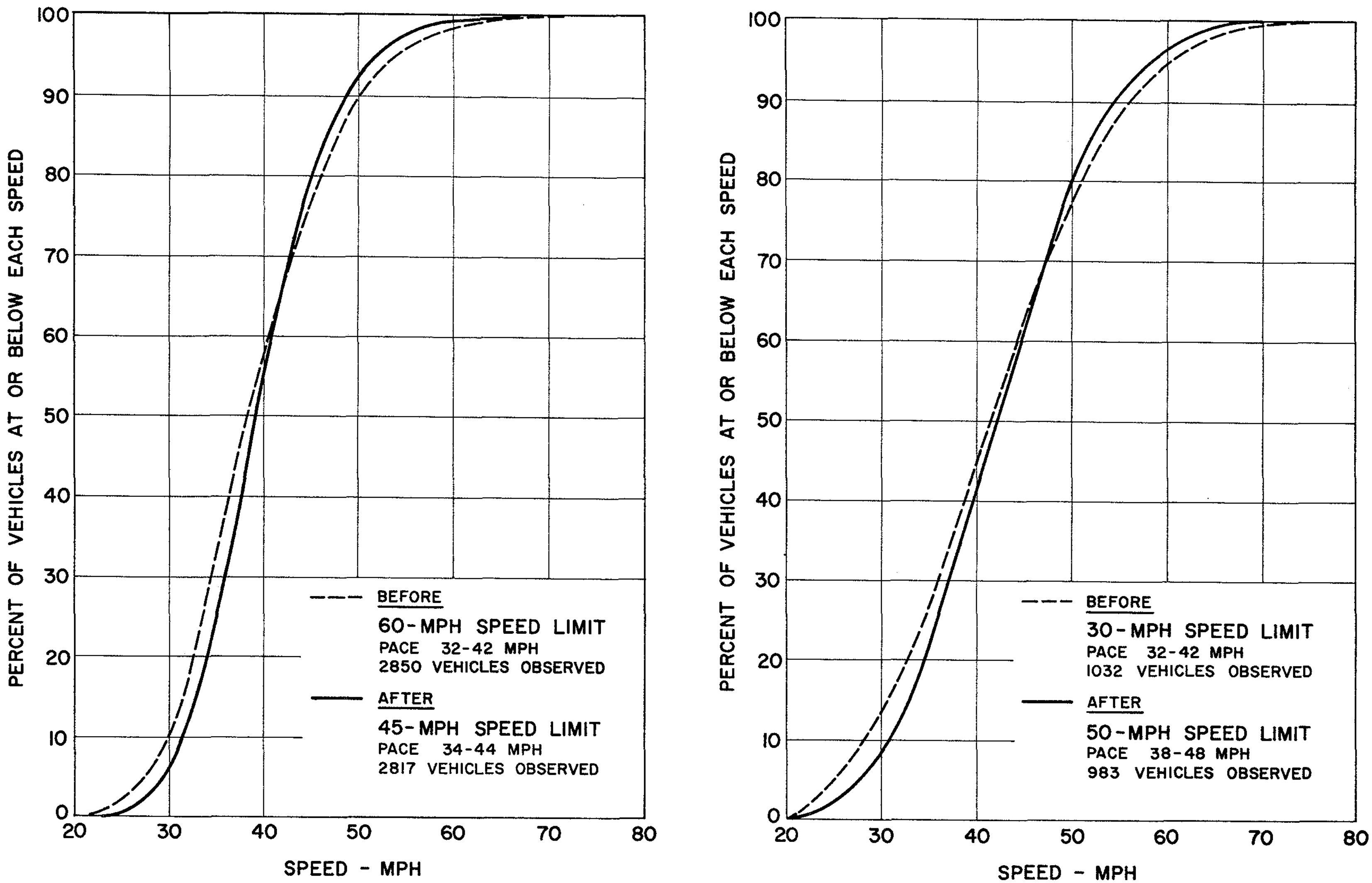
(1) roadway geometrics.
(2) characteristics of development.
(3) traffic conditions.

In transition from rural to urban conditions these factors rarely occur independently, but in complex combinations. Also successive occurrences of the various factors involved cause speed changes to occur almost continuously throughout the transition area.

In the second phase of the research, studies were conducted to evaluate the specific factors influencing individual speeds in transition areas (rural to urban). In the studies, primary consideration was given to geometric and roadside development characteristics. The influence of traffic conditions was reduced as much as possible by selecting free-flow vehicles for the main consideration in the analysis.

The influence of traffic conditions was given greater consideration in additional studies conducted to determine the variations in traffic speeds throughout the day. These studies consisted of evaluation of all speeds during 12- and 24-hour speed observations on three different types of roadways.

Studies were also conducted to evaluate the influence of radar enforcement practices on traffic speeds. These studies were made to determine the effects of enforcement on traffic speed in the immediate vicinity of the radar unit and the distance along the roadway to which the influence extended.



TYPICAL SPEED DISTRIBUTION CURVES FOR "BEFORE" AND "AFTER" CONDITIONS OF SPEED ZONING

FIGURE 1

TABLE 1

GENERAL DESCRIPTION OF STUDY LOCATIONS

Study No.	I	II	III	IV	V
Study Location (Town)	Waller	Madisonville	Cameron	Bremond	Oakwood
Highway Number	US 290	SH 21	US 77	SH 6	US 79
Roadway Classification	Primary; truck route	Secondary	Primary	Primary	Primary
Predominant Type of Development	Commercial	Residential	Mixed	Mixed	Residential & Commercial (segregated)
Length of Study Section, (feet)	4958	6585	5898	5492	5978
Number of Sectors	6	7	5	9	8
ADT, Rural (within 4 Miles of City Limit)	5940	1330	2200	1980	1600
Population (1960 Census)	1000	3000	5052	1141	759

FACTORS INFLUENCING TRAFFIC SPEEDS IN TRANSITION AREAS

STUDY PROCEDURE

As pointed out in the introduction, most of the tangible factors which influence traffic speeds in transition areas can be categorized into the following three groups:

(1) roadway geometrics.
(2) characteristics of development.
(3) traffic conditions.

In an effort to identify various influencing factors and evaluate their effects, studies were conducted in several transition areas where significant speed changes occurred. Two study techniques were used:

(1) Individual Vehicle Speed Study Method: -- Measurement of the average speed of each individual vehicle through each of several control sections or sectors of the transition zone.

(2) Test Car Method: -- Continuous measurement of the speed of selected drivers in a test car for several trips through the transition zone.

Study Locations

The major problems of speed zoning in Texas have been encountered in the transition sections to small towns on two-lane highways. For this reason, five study locations were selected to provide a good representation of the various conditions normally encountered. Table 1 summarizes very briefly the general characteristics of each of the five study locations. The study sections were approximately one mile in length. The ADT values on these roadways ranged from 1330 to 5940 vehicles per day. Development in the study sections ranged from predominantly residential to predominantly commercial. The geographic location of the study sites is shown in Figure 2.

A number of variables were eliminated or controlled through careful selection of study sites. Care was exercised to avoid roadway sections which contained:

(1) traffic signals or control devices other than flashing amber beacons,

(2) horizontal and vertical curves that severely limited traffic speeds,
(3) major intersections presenting complex traffic problems, and
(4) serious pavement surface irregularities.

In general, an attempt was made to select study sections in which the factors affecting vehicle speeds could be categorized into roadway geometrics, development characteristics, and traffic conditions.

Study Methods

Individual Vehicle Speed Study Method -- A very comprehensive type survey was used to collect traffic data in each of the study locations. The survey consisted of four components: (1) measurement of individual vehicle speeds throughout various sectors of the study section, (2) concurrent measurement of individual vehicle speeds in an adjacent rural section, (3) observation of all passing, turning or crossing traffic, and (4) a study of the development and roadway geometrics in the study section.

In order to develop a profile of individual vehicle speeds through the transition zone the section of roadway selected for study was divided into control sections, referred to as sectors. The limits of these sectors were determined by changes in development and by physical changes in the roadway geometry. The average speed of each vehicle was measured through each of the designated sectors.

An event recorder was used in the measurement of individual vehicle speeds in the urban areas. This recorder (a 20-pen ink type recorder) was used with a series of road tubes and air switches to measure the time required for a vehicle to travel the length of each of the sectors. To measure the time increments, the road tubes and air switches were placed at the limits of each of the sectors, as illustrated in Figure 3. By means of field telephone cable each air switch was connected to a pre-selected pen in the 20-pen recorder. As a vehicle passed through the study section, a "blip" was recorded by each corresponding pen as the vehicle crossed each of the road tubes. Since the chart in the recorder moved at a constant predetermined speed, the distance between successive "blips" was proportional to the time required for the vehicle to travel between the road tubes. An example of the chart record is also shown in Figure 3.

In order to identify the direction in which the vehicles were traveling, two different road tube arrangements were used. The arrangement most commonly used resembled the letter "J" as illustrated in Figure 3. To form this arrangement, the road tube was extended from the centerline to one edge of the pavement, then along the pavement edge for approximately fifteen feet (about 1½ times the normal wheelbase of a passenger car), and then across both lanes to the air switch. This arrangement provided two "blips" on the chart for 2-axle vehicles in one direction and four "blips" for 2-axle vehicles traveling in the other direction.

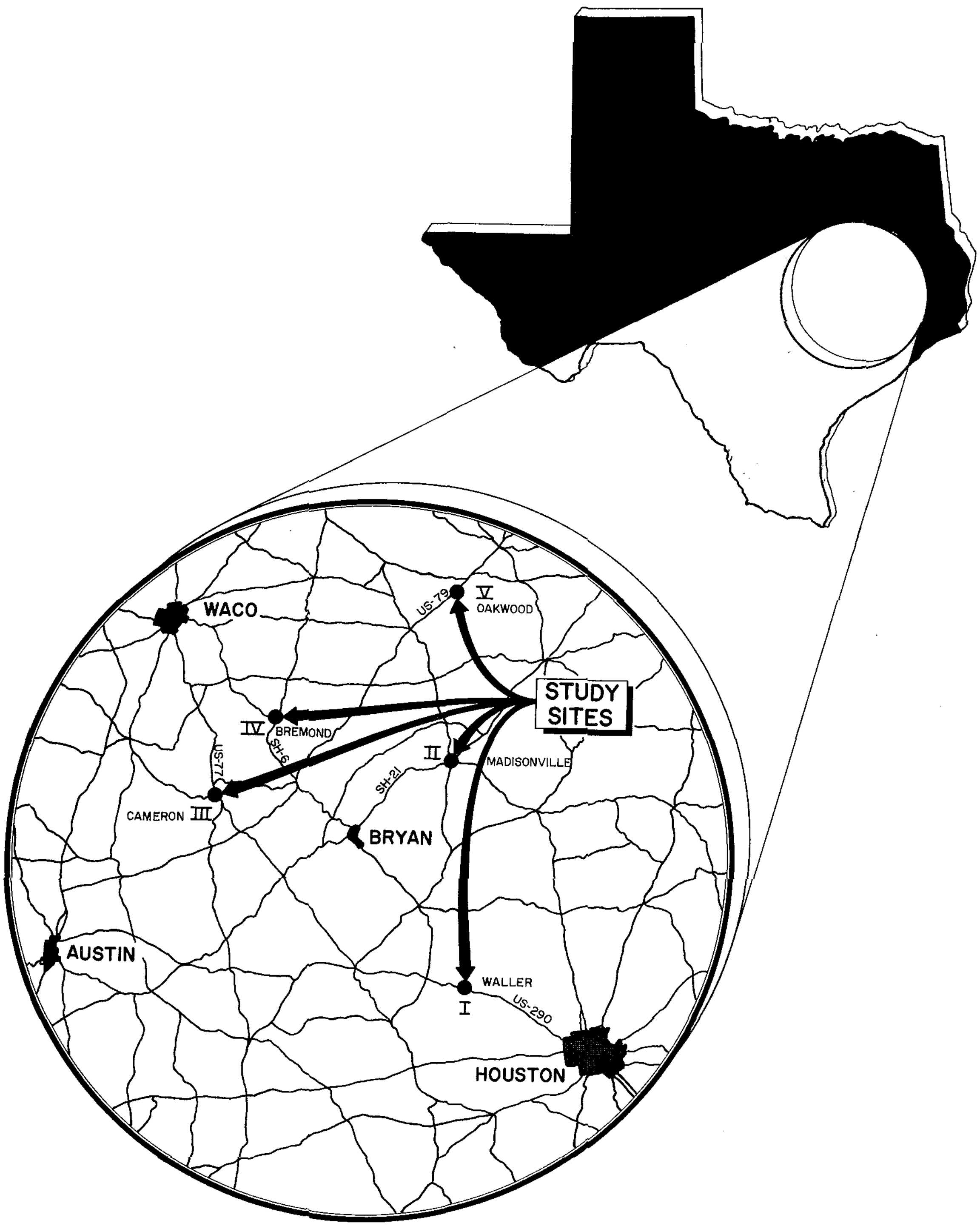
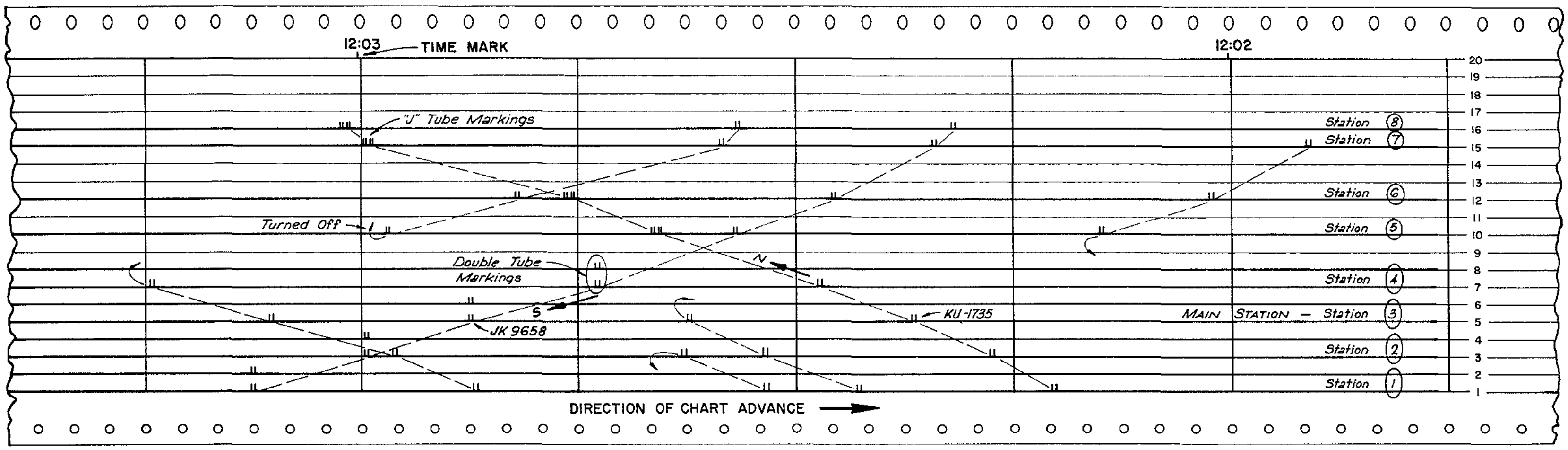
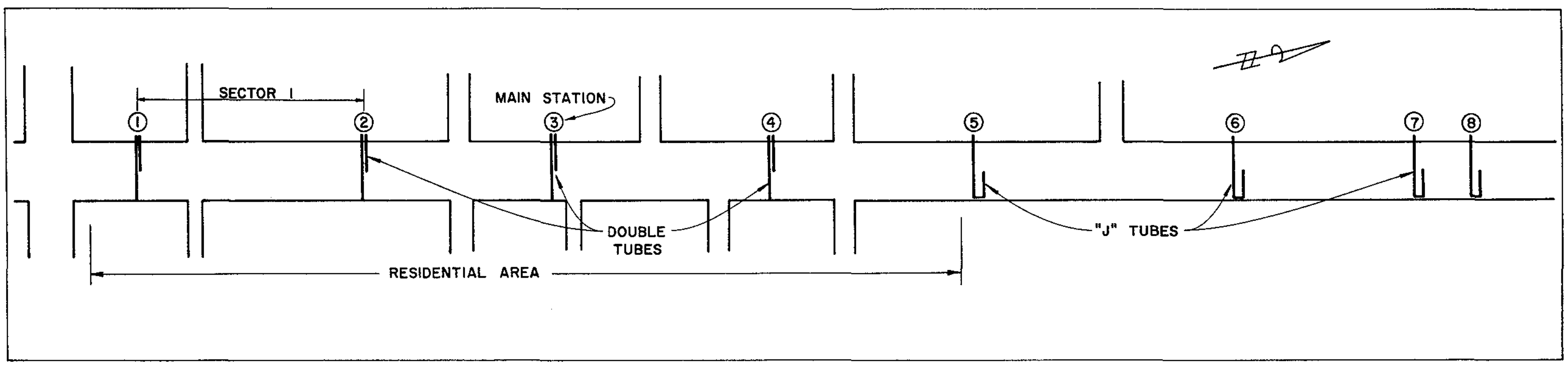

WACO
US-79
V
OAKWOOD
STUDY SITES
IV
BREMOND
SH-6
US-77
II
MADISONVILLE
SH-21
CAMERON
III
BRYAN
AUSTIN
WALLER
I
US-290
HOUSTON

FIGURE 2





EXAMPLE OF 20-PEN RECORDER CHART RESULTING FROM ROAD TUBES LOCATED AS SHOWN AT STUDY SITE

FIGURE 3

A more positive means of simultaneously indicating direction of travel and identifying vehicles with three or more axles was provided by the double road tube arrangement, also illustrated in Figure 3. In this system, two road tubes were placed side by side and connected to two separate air switches. One of the tubes extended only to the centerline of the roadway. Vehicles traveling in one direction crossed the long road tube and actuated one pen in the recorder, while vehicles traveling in the opposite direction crossed both road tubes and simultaneously actuated two pens in the recorder. With this arrangement the number of "blips" in a group on the chart always represented the actual number of axles of the vehicles.

At a station near the center of the study area each vehicle was identified by its license number and the direction of travel as it crossed one of the double road tube arrangements. The information was recorded on a portable voice recorder in chronological order. In addition, frequent time indications were recorded on the voice recorder and the event recorder simultaneously to facilitate later identification of vehicles.

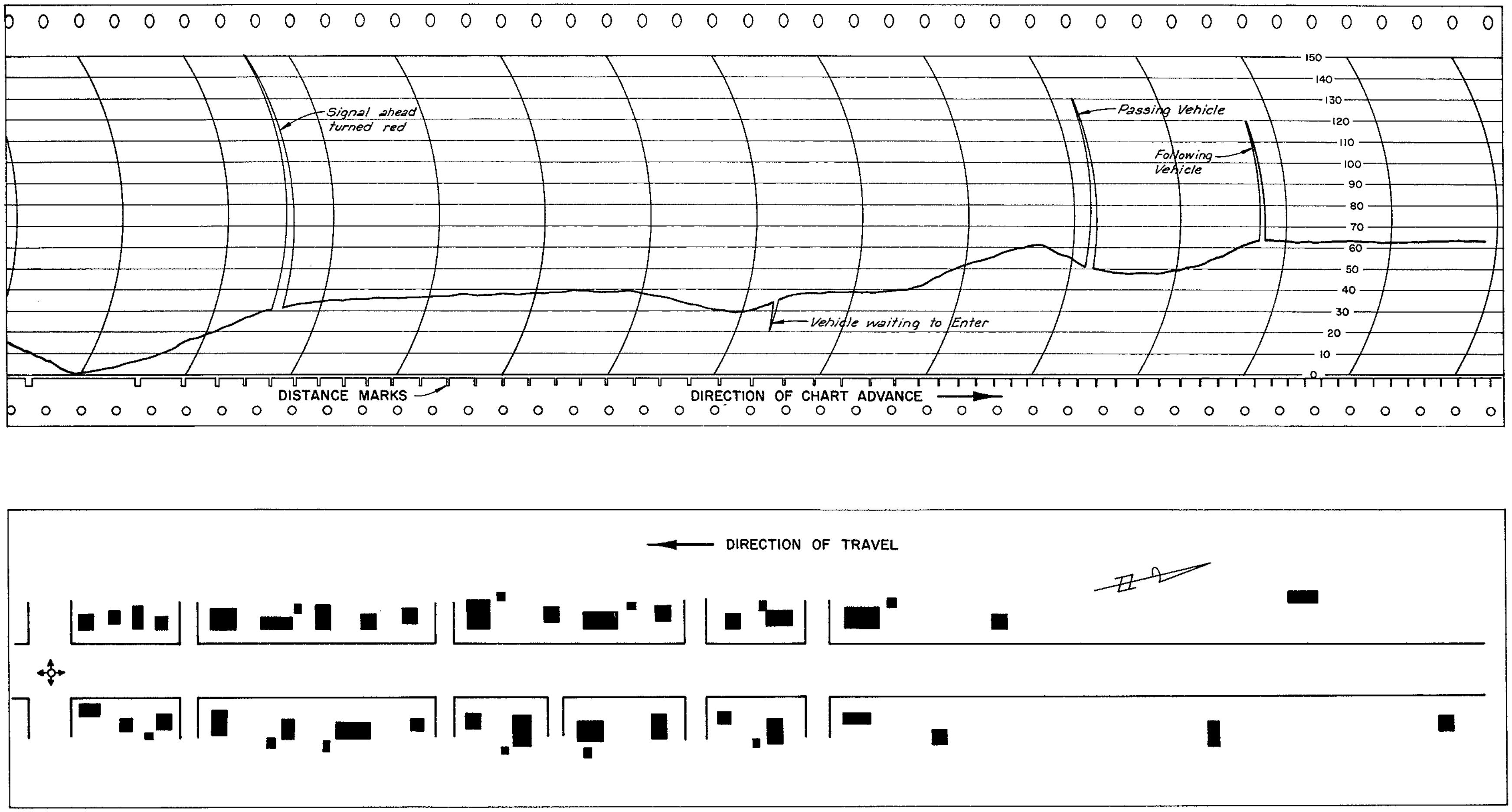
To record turning, crossing, and passing movements in each sector, a sufficient number of observers were stationed at vantage points throughout the study section. All entrance, exit, and passing maneuvers were recorded as to the exact time of occurrence to facilitate later interpretation of the 20-pen recorder charts.

A development or land-use survey was conducted at each study location. From the survey, strip maps were prepared showing roadway dimensions, driveway and building locations, the size and use of the buildings, and the type and extent of access to the main roadway.

This method of measuring vehicle speeds was subject to certain limitations. The study method could only be used satisfactorily on two-lane roadways. The increased freedom to maneuver on multi-lane facilities would make it almost impossible to trace a vehicle through the study section, and the greater density which is usually present on this type of facility would further complicate the procedure.

In order that a direct correlation could be made of individual vehicle speeds under rural and urban conditions, rural traffic speeds were observed concurrently with the urban study at a station located two to four miles from the urban study section. A radar speed meter with graphic recorder was used for the rural speed observations. The unit was concealed in a mailbox-type camouflage, and the recorder was removed to an inconspicuous position. The license number, type of vehicle, and the direction of travel for each vehicle were written directly on the speed recorder chart.

Test Car Study Method -- In addition to the studies involving the observation of individual vehicle speed, a "test car" method was devised and utilized in four of the five selected study locations. Selected drivers operating the test car made a series of runs through transition zones. The



EXAMPLE OF RECORDING SPEEDOMETER CHART AND STUDY SITE COMPARISON

FIGURE 4

test car was equipped with a recording speedometer to provide a continuous record of the vehicle speed. An example of the speed chart is shown in Figure 4. To record the traffic conditions confronting the driver, the vehicle was equipped with a sequence camera actuated by the distance marker on the speed recorder.

The test car method of study was developed to provide, under controlled conditions, an evaluation of the relationships between vehicle speeds and the factors influencing speeds. The method provided a continuous speed indication whereas the previously described method was a point-to-point type survey measuring average speeds within sectors. It was anticipated that this study method would indicate points of reaction which may not necessarily be reflected in the individual vehicle speed studies using the average sector speed approach.

The study method was used to conduct limited studies in three of the selected study locations, and a comprehensive study in a fourth location. This study method was not used in the fifth location because the roadway in the test section was reconstructed to a 4-lane facility. In the limited studies at the three locations, two drivers were used to make four test car runs in each direction. The results of these studies were used merely to determine more specifically the true shape of the speed profile through the section.

The comprehensive study, using the test car method, was conducted in one of the selected locations to provide data on specific reation patterns of drivers. In this study ten drivers made four test car runs in each direction. The experimental design and the results of the study are reported in a later section of the report.

ANALYSIS OF DATA - INDIVIDUAL VEHICLE SPEED STUDIES

Because of the large volume of data collected in the Individual Vehicle Speed Studies, electronic data-processing equipment was utilized to a great extent in the analysis. After interpreting the recorder charts, as illustrated in Figure 3, the linear time measurements for each vehicle and other supplemental data were transferred to IBM bunch cards. Then, the various computations involved were made by electronic computer.

The speed parameters used in the evaluations were average speeds, 85-percentile speed, 15-percentile speed, and the speed differential. These parameters were considered as most representative of the speed distributions observed. The pace was also used in the initial stages of the analysis but was later ruled out because of its apparent over-sensitivity. An analysis showed that the pace could fluctuate greatly over the straight portion of the speed distribution curve when the speed differential was large. In other words, the pace was considered reliable only when it closely approximated the speed differential.

The traffic speeds observed in each of the studies were divided into three groups, dependent upon traffic flow conditions; these groups were "all vehicles," "through vehicles," and "free-flow vehicles." In this report, "all vehicles" represents all the vehicles observed in each sector during the study period regardless of trip length or flow conditions; "through vehicles" indicates the vehicles which traveled throughout the entire length of the study section; and "free-flow vehicles" describes only the portion of "through vehicles" which were not influenced by slower-moving vehicles in the traffic stream. The condition of free-flow was ascertained from interpretation of the recorder charts, where queuing and the rate of closure were readily discernible.

The speed parameter values for free-flow vehicles in each of the studies were plotted in relation to roadway geometry, development, and traffic movement, as shown in subsequent figures. By using free-flow vehicle speeds, the influence of traffic conditions was reduced to the psychological effects of anticipated conflicts. The traffic volumes observed during the study are expressed in terms of average hourly volume and maximum hourly volume at each road tube station. Also, the average and maximum hourly turning movements are indicated within the sector in which they occurred. A detailed description of each study location can be found in Tables 2 through 6.

The measurement of individual vehicle speeds through each of the sectors in a study made it possible to examine speed changes in relation to the speed in the previous sector. Figure 6, which typically represents these relationships, shows the percent change in speed between any two sectors for inbound and outbound traffic. These changes in speed can best be illustrated by example. The first graph in the lower half of the figure shows speed changes between Sectors 1 and 2 in the outbound direction. The third bar in this graph shows 26 vehicles (width of bar) were in the 40- to 45-MPH group in Sector 1, and their average speed in that sector was 42.6 MPH. The change in speed of this group between Sector 1 and 2 was 10 percent of their average speed in Sector 1. The other bars in the first graph represent speed changes for the various 5-MPH speed groups. The width of each bar (vertical dimension) represents the number of vehicles in the group, the center of the bar indicates the average speed of the group, and the bar length (horizontal dimension) indicates the percent change in speed between the two sectors for the same manner, the other graphs represent speed changes between the sectors indicated.

In the final analysis there was no distinction made between commercial and passenger vehicles because the number of commercial vehicles in each study was too small to be treated separately with any statistical reliability. The comparison of the average truck speeds with average speeds of the composite free-flow traffic stream is given in Table B of the Appendix.

A complete listing of the results of the studies is included in the Appendix (Tables C through G).

DISCUSSION OF RESULTS - INDIVIDUAL VEHICLE SPEED STUDIES

The results of the individual vehicle speed studies repeatedly pointed up several factors of roadway geometrics and roadside development which directly affected traffic speeds. However, the sequence in which these factors occurred in the test section determined to a great extent their effect on speeds. In other words, the influence of certain factors was dependent upon the conditions that the driver had experienced in previous portions of the test section. Each study will be discussed individually in order that previous influences will be accounted for in the evaluation of specific variables or combinations.

Study I

This study was conducted as a preliminary study primarily to evaluate study techniques and to determine if the data would reflect the extent of influence from the various factors. A site was selected for this preliminary study for which the general speed pattern was known, and which had few variations in conditions through out the section. The traffic volume through this section was higher than desired, but this afforded a better check on the operation of the equipment and the study techniques being tested. This preliminary test was conduted just prior to the reconstruction of the study section to a 4-lane facility. Therefore, additional studies could not be conducted.

As illustrated in Figure 5, the test section was composed almost entirely of commercial development. This development was limited to the north side of the roadway because of the proximity of the railroad tracks on the south side. Ingress and egress to the various businesses was provided by a continuous paved shoulder. The roadway was straight throughout the test section and adjacent areas, and the grades were negligible; therefore, no sight distance problems were encountered. The cross section of the roadway was the same throughout the study area with the exception of the paved shoulder provided next to the development. A detailed description of the study section is given in Table 2.

The speed profiles in Figure 5 show that traffic speeds in the rural areas were essentially the same for both directions of travel. As the vehicles entered the developed area in the eastbound direction, their speeds reduced gradually, reaching a minimum in Sector 4. At this point the speeds began to increase gradually because the drivers could clearly see the end of the developed area. In the westbound direction speeds were reduced gradually as traffic entered the developed area, reaching a minimum in Sectors 4 and 3. Again speeds gradually increased until the vehicles had passed through the developed area in Sector 1. The westbound traffic did not attain rural speeds within the test section.

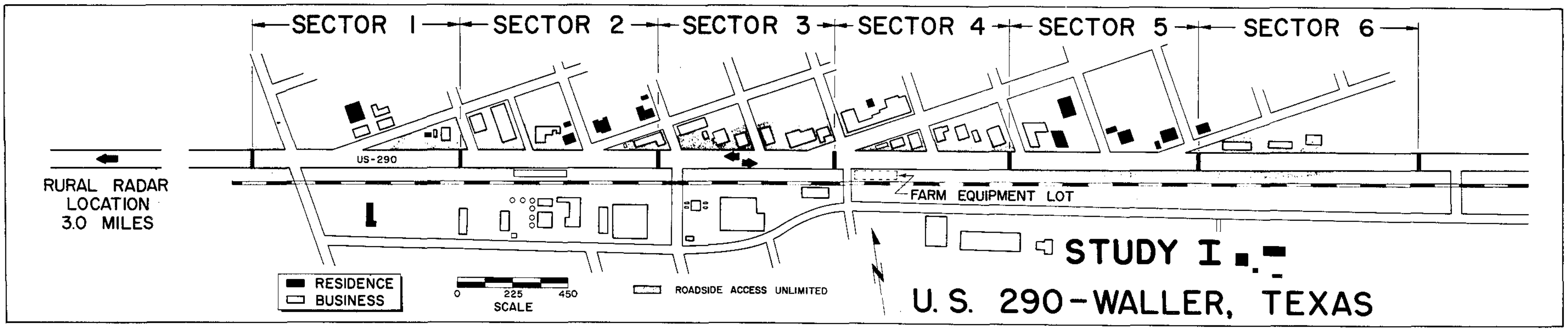
The speeds on the developed side of the roadway were significantly lower than the speeds on the undeveloped side.

TABLE 2

DETAILED DESCRIPTION OF STUDY SECTION

Study I - Waller

Sector No.	1	2	3	4	5	6
Sector Length, feet	886	842	752	749	796	933
Pavement Width, feet	24'	24'	24'	24'	24'	24'
Shoulder Type	Gravel	Gravel	Paved One Side	Paved One Side	Gravel	Gravel
Horizontal Curves	-	-	-	-	-	-
Flashing Amber Signal	-	-	-	*	-	-
Type of Development	Commercial	Commercial	Commercial	Commercial	Commercial	Commercial
No. of Residential Units	1	3	1	0	4	1
No. of Commercial Units	5	4	6	8	1	3
No. of Driveways	0	0	0	0	0	0
Percent of Sector With Unlimited Access	75%	100%	100%	100%	100%	50% Unlimited 50% Rural
Number of Intersecting Streets	2	3	3	3	3	0
Sight Distance Less than 1000' at any point within Sector						
Northbound	No	No	No	No	No	No
Southbound	No	No	No	No	No	No



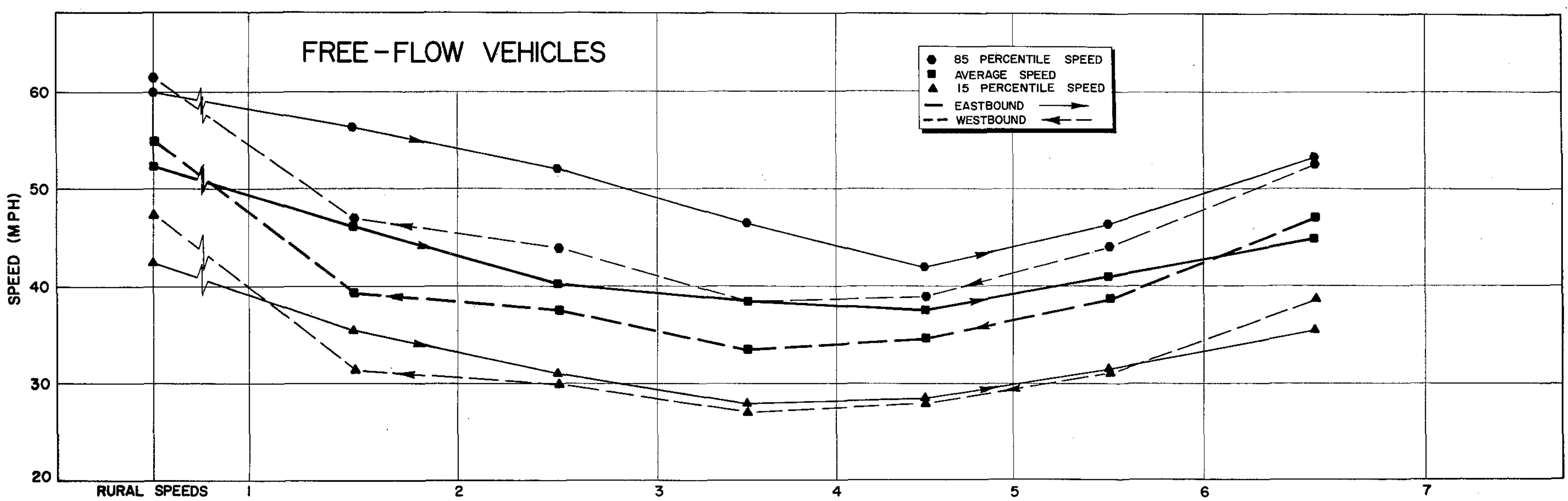


FIGURE 5 INDIVIDUAL VEHICLE SPEED STUDY I

Study II

The location for Study II was selected to afford an analysis of the influence of purely residential development. A strip map of the study section is shown in Figure 7, and a detailed description is given in Table 3. In the first two sectors the roadway was a curbed street with parking permitted on both sides. In Sector 3, the cross section changed to a two-lane rural type highway with grass shoulders. A 4-degree horizontal curve was located in Sector 5, and a second 4-degree curve was located just outside Sector 7. Sight distance was restricted in certain portions of the test section by the horizontal curves and by the slightly rolling profile through the test section.

The speed profiles for inbound traffic indicated a general deceleration pattern throughout the study section. Deviations from a constant deceleration pattern could be directly related to features of the roadway and the appearance of the development. The abrupt reduction in speed in Sector 5 was caused by the sight distance restrictions imposed on the driver by the horizontal curve in that sector. The speed change relationships between Sectors 6 and 5, shown in Figure 6, indicated that these conditions caused a proportionately greater reduction in the higher speed ranges.

A second abrupt reduction in the speed of the inbound traffic was observed as the roadway cross section changed from a rural to a curbed urban section (Sector 3). This reduction was not altogether due to the change in cross section. There was a significant change in the development in the general area of the speed change. The development in the urban section differed from that in the rural section by extensive planting of trees and shrubbery near the curbline. Again the speed change relationships in Figure 6 shows the higher speed ranges to have been most severely affected between Sectors 3 and 2, where the change in development occurred.

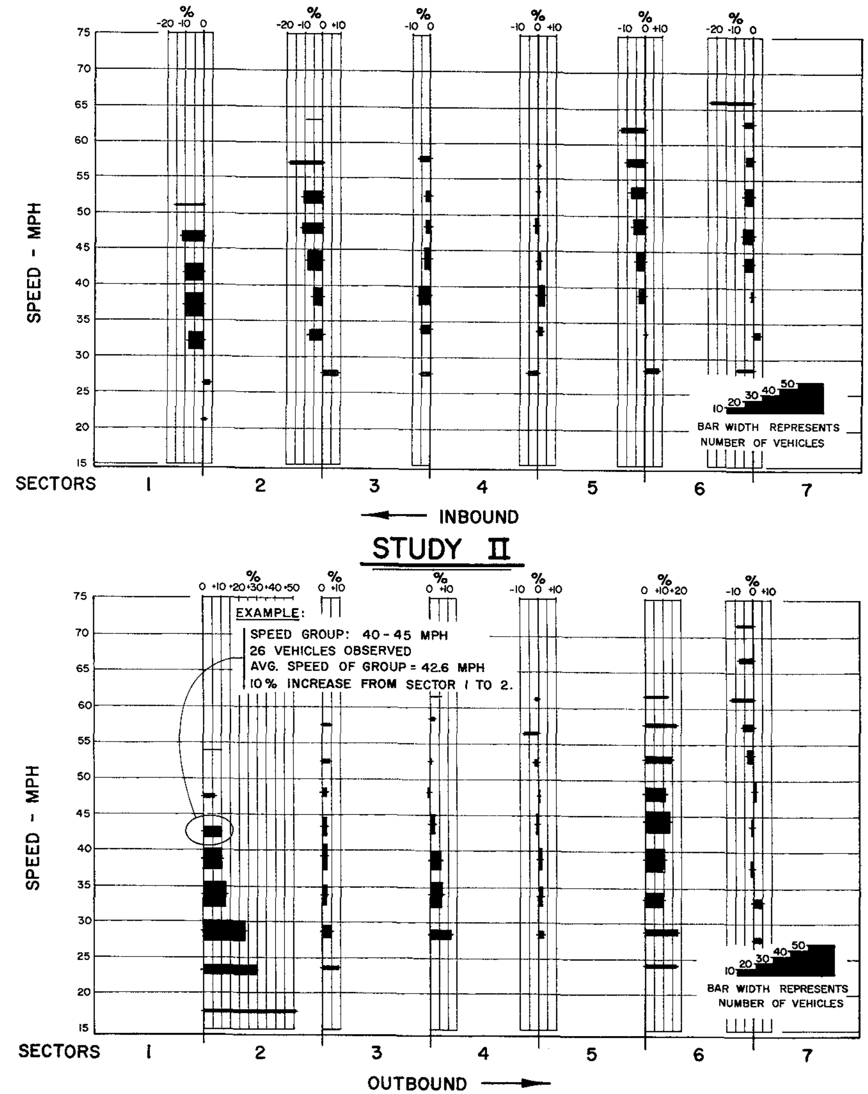
The speeds of the outbound traffic indicated the same general tendency to follow a constant speed change pattern except where deviations were caused by horizontal curves and the sight distance restrictions imposed by the curves. This effect was observed in Sector 5 and again in Sector 7. Figure 6 shows a marked reduction in the higher speed ranges while the lower speeds were affected to a lesser degree.

TABLE 3

DETAILED DESCRIPTION OF STUDY SECTION

Study II - Madisonville

Sector No.	1	2	3	4	5	6	7
Sector Length, feet	1353	1140	211	1187	1365	230	1099
Pavement Width, feet	40	40	Trans-ition	20	20	20	20
Shoulder Type	Curb	Curb	Trans-ition	grass	grass	grass	grass
Horizontal Curves					D=4°		
Type of Development	Resi-dential	Resi-dential	Resi-dential	Resi-dential	Resi-dential	Resi-dential	Resi-dential
No. of Residential Units	19	15	1	11	9	2	7
No. of Driveways	17	17	0	10	6	2	3
Percent of Sector With Unlimited Access	0	0	0	0	0	0	0
Number of Inter-secting Streets	4	2	1	1	1	0	0
Sight Distance Less than 1000' at any point within Sector							
Inbound	Yes	Yes	No	No	Yes	Yes	Yes
Outbound	Yes	Yes	No	Yes	Yes	No	Yes



PERCENT CHANGE IN SPEED OF 5-MPH GROUPS

MADISONVILLE, TEXAS

FIGURE 6

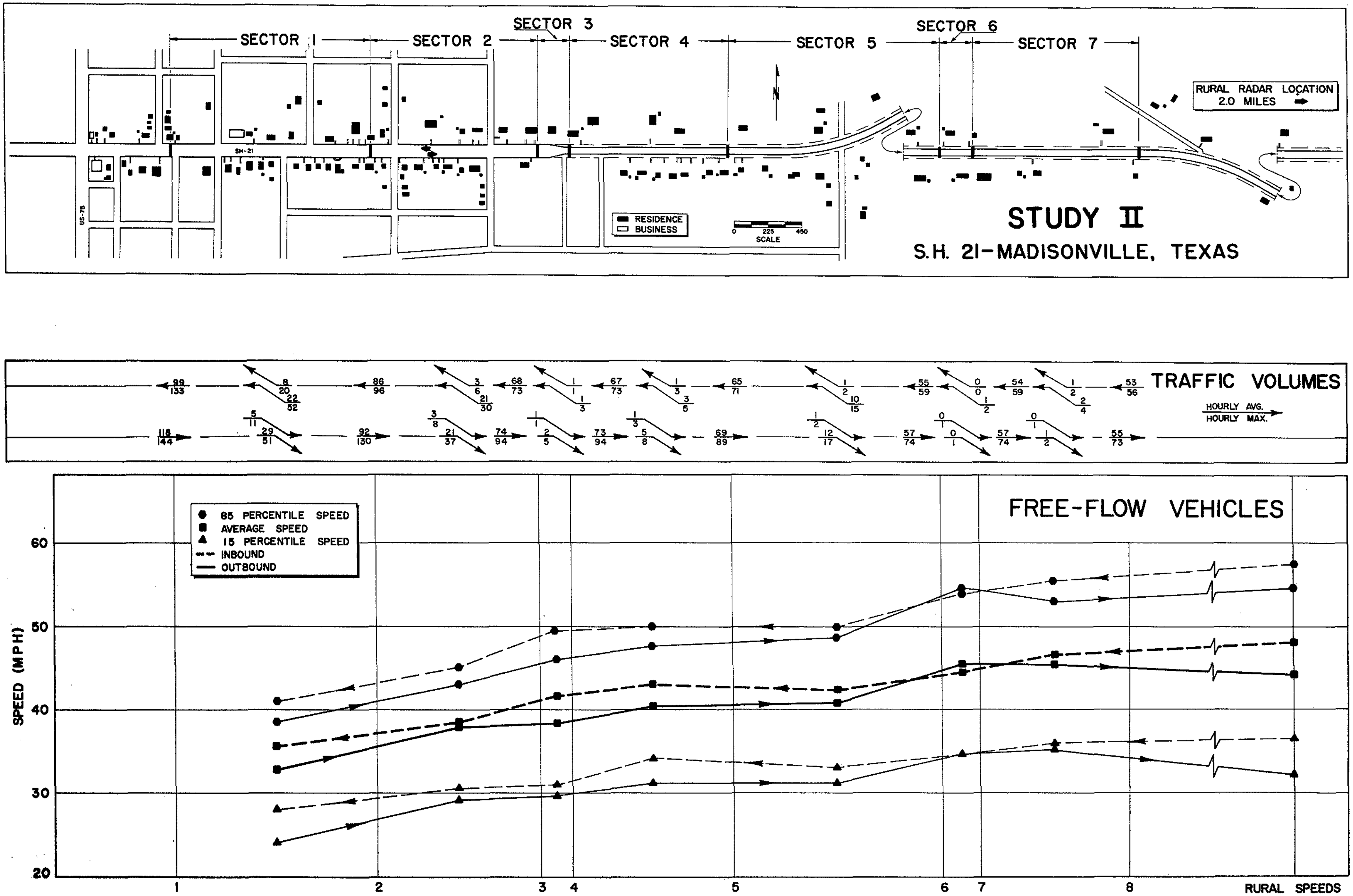


FIGURE 7 INDIVIDUAL VEHICLE SPEED STUDY II

STUDY III

The location for Study III was selected to permit an analysis of traffic speed patterns in relation to mixed development. The study site consisted of a transition section with intermittent commercial and residential development followed by a continuously developed city street of extended length as shown in Figure 9. In Sectors 1, 2, and 3 the roadway was a curbed street with parking permitted on both sides. A flashing amber beacon was located within Sector 2. Between Sectors 3 and 4 the roadway cross-section changed to a two-lane rural highway with grass shoulders.

The centerline profile through the study section was slightly rolling with crest vertical curves located in Sectors 2, 3 and 4. Also a sag type vertical curve was located within the horizontal curve in Sector 4. A detailed description of the study section is given in Table 4.

The speed profile in Figure 9 shows that the major speed changes of inbound traffic occurred between Sectors 3 and 5. It was noted that intermittent development outside the study section had caused a slight reduction in the speed of inbound traffic before it entered the study section. However, limited test car studies indicated that part of this reduction was due to sight distance restrictions imposed on the inbound traffic by a crest vertical curve located in the vicinity of Station 5.

The speed reduction observed between Sectors 5 and 4 was due to the re-introduction of development and critical sight distance restrictions imposed on the driver by the combination of horizontal and vertical curvature, which occurred in Sector 4. Figure 8 shows the greatest reduction to have occurred in the higher speed ranges.

The greatest reduction in speeds of the inboud traffic was observed between Sectors 4 and 3. This reduction was the result of a combination of factors including the change in cross section, an increase in the proportion of commercial development, and restrictive sight distance due to a crest vertical curve in Sector 3. The commercial development in the area generated frequent traffic conflicts.

Speeds were essentially constant through Sectors 1 and 2 where the drivers were confronted with a continuously developed city street section. However, the limited test car studies indicated an internal reaction in Sector 2 where there was an important intersection controlled by a flashing amber beacon. Also, sight distance was restricted by a crest vertical curve near the intersection. The reaction was a slight depression in the test car speed profile immediately preceding and within the intersection area. The reduction was only slightly reflected in the average sector speeds.

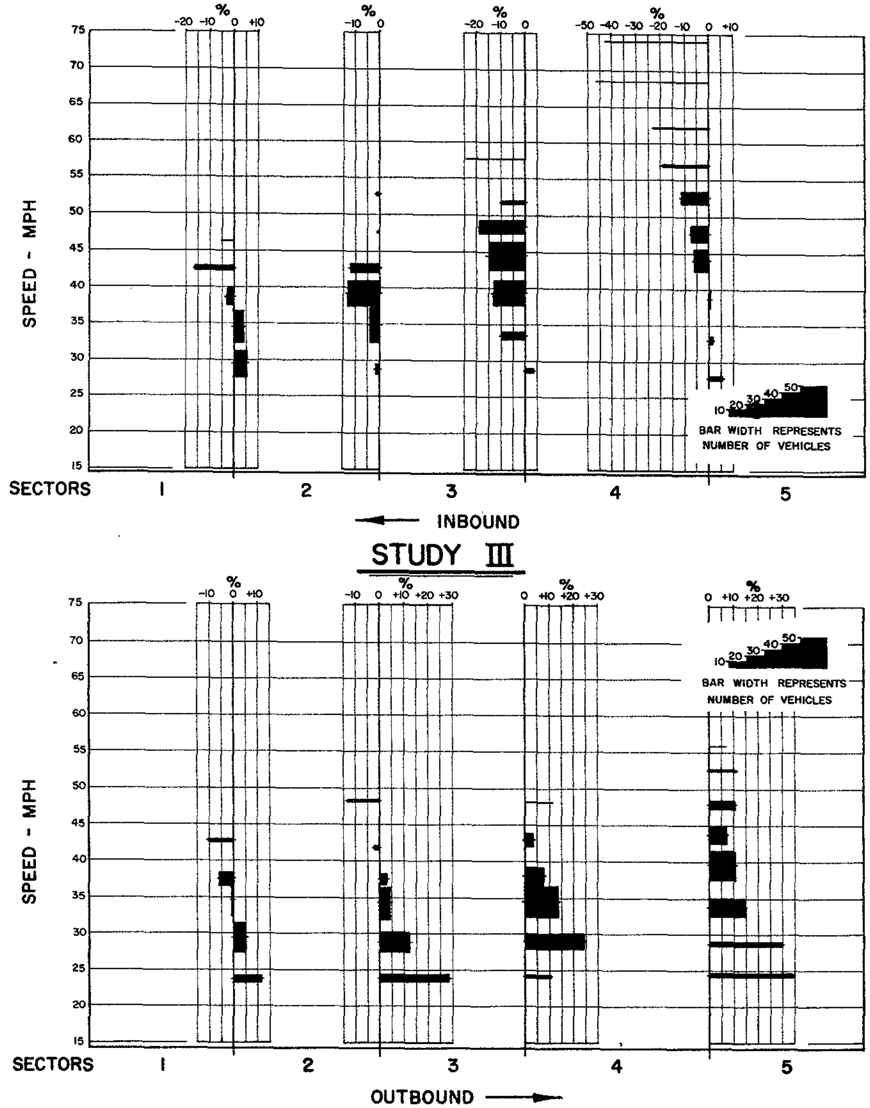
In the outbound direction, traffic speeds exhibited many of the same characteristics as previously pointed out for the inbound traffic. Speeds were fairly constant through Sectors 1 and 2, where the roadway did not portray the characteristics of a transition area. As in the inbound direction, the major transitional speed change occurred between Sectors 3 and 5.

TABLE 4

DETAILED DESCRIPTION OF STUDY SECTION

Study III - Cameron

Sector No.	1	2	3	4	5
Sector Length, feet	1167	1207	1230	1012	1282
Pavement Width, feet	40	40	40	40	40
Shoulder Type	curb	curb	curb	gravel	gravel
Horizontal Curves				D=2° (approx.)	
Flashing Amber Signal	-	*	-	-	-
Type of Development Predominant	Residential	Mixed	Mixed	Mixed	Rural
No. of Residential Units	13	20	15	5	1
No. of Commercial Units	1	5	6	1	0
No. Driveways	4	12	13	7	0
Percent of Sector with uncontrolled access	0	5	10	5	0
Number of Intersecting Streets	4	3	5	0	1
Sight Distance Less than 1000' At Any Point Within Sector					
Inbound	No	Yes	Yes	Yes	Yes
Outbound	No	Yes	Yes	Yes	Yes



PERCENT CHANGE IN SPEED OF 5-MPH GROUPS

CAMERON, TEXAS

FIGURE 8

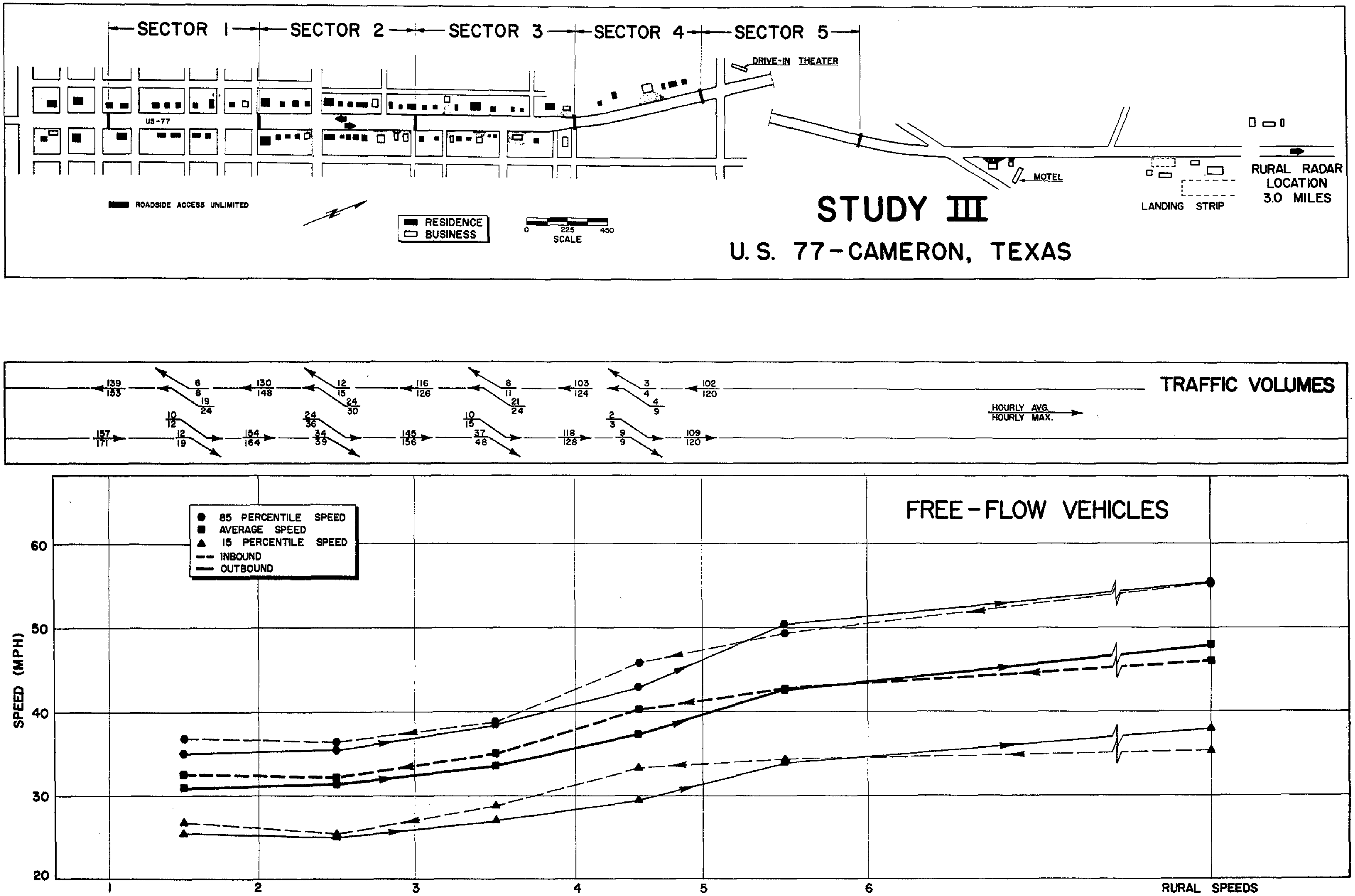


FIGURE 9 INDIVIDUAL VEHICLE SPEED STUDY III

Study IV

The location for Study IV was selected to provide data for an analysis of the influence of mixed development on traffic speed patterns in a relatively short transition area. A detailed description of the study section is given in Table 5. A rural type two-lane highway cross section with grass or gravel shoulders was continuous throughout the study section. Traffic volumes were low, and there were few intersecting streets of any significance.

The transition section was preceded by two 2-degree horizontal curves as shown in Figure 11. With regard to horizontal alignment, this location was similar to Study II, where the transition section involved two 4-degree curves. However, no direct comparison could be made since the curves in Study IV did not impose the same sight distance restrictions and there was no associated development.

In evaluating the results of this study, the first reduction in speed of the inbound traffic was noted in Sector 6 (see Figure 11) and the deceleration was continued into Sector 5. This substantial reduction was due to a combination of circumstances which confronted the driver. The extent of the concentrated commercial development in Sector 5 (see strip map, Figure 11) became apparent to the driver as he entered Sector 6, and his sight distance was restricted by a vertical curve in the approximate vicinity of Station 5. The speed-change relationships in Figure 10 show that the greatest speed reductions between Sectors 6 and 5 occurred in the higher ranges.

As the inbound traffic left the area of concentrated commercial development, there was a tendency toward a slight increase in speed. In the area where the increase occurred, there was also an increase in the sight distance afforded the driver, and the development had assumed a residential appearance. The sudden change in conditions acted as a vacuum and encouraged higher speeds. However, the re-occurrence of commercial development again caused a reduction in speed in Sector 3. The development causing the reduction was actually located in Sector 2, but it came into prominent view just before the vehicles entered Sector 3.

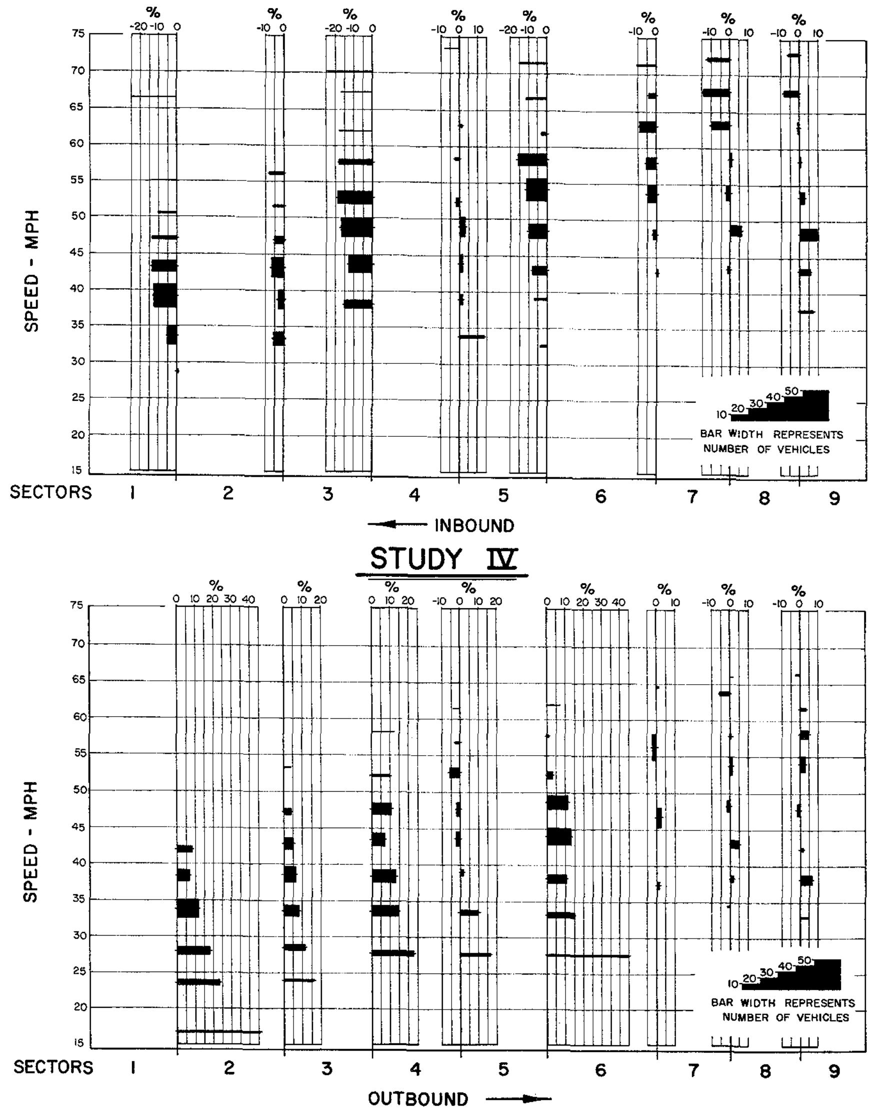
Traffic speeds in the outbound direction exhibited essentially the same characteristics as the inbound speeds. A general acceleration pattern was followed by the traffic throughout the study section except for deviations occurring in Sectors 4 and 5. A significant increase in speed occurred in Sector 4 as the traffic passed from a commercial area into an area which was predominantly residential. In Sector 5, a reduction in speed was due to the concentrated commercial development in that sector. Also, there was a slight reduction in speed noted in Sector 7. Figure 10 shows this reduction to have occurred only in the higher ranges of speeds. At this point the drivers were confronted by a horizontal curve superimposed upon a sag vertical curve, a condition which presented a deceptive appearance.

TABLE 5

DETAILED DESCRIPTION OF STUDY SECTION

Study IV - Bremond

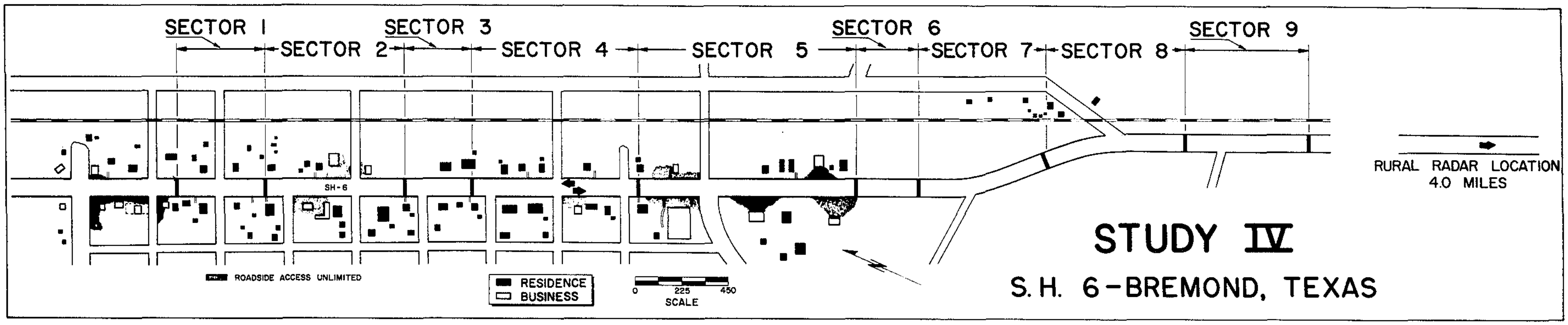
Sector No.	1	2	3	4	5	6	7	8	9
Sector Length, feet	432	687	333	916	1080	304	678	820	718
Pavement Width, feet	20	20	20	20	20	20	20	20	20
Shoulder Type	grass and/or gravel								
Horizontal Curves							D=2°	D=2°	
Flashing Amber Signal									
Type of Development	Residential	Mixed	Residential	Residential	Commercial	Rural	Rural	Rural	Rural
No. of Residential Units	7	8	5	10	7	0	0	3	0
No. of Commercial Units	0	3	0	1	5	0	0	0	0
No. Driveways	2	2	1	4	4	0	0	0	0
Percent of Sector with uncontrolled access	0	30	0	5	50	0	0	0	0
Number of Intersecting Streets	1	2	1	3	1	0	1	1	1
Sight Distance Less than 1000' at any point within sector									
Inbound	No	No	No	No	Yes	Yes	No	Yes	Yes
Outbound	No	No	Yes	Yes	No	No	Yes	No	No



PERCENT CHANGE IN SPEED OF 5-MPH GROUPS

BREMOND, TEXAS

FIGURE 10



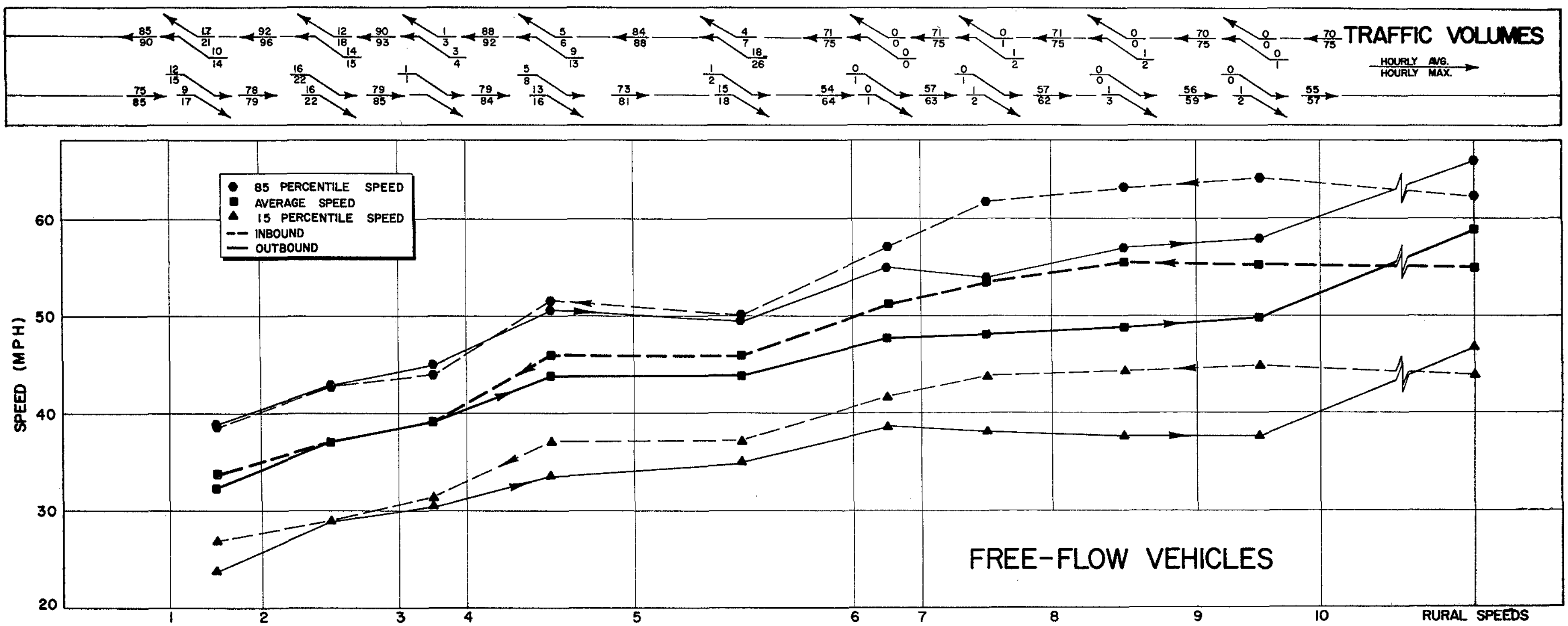


FIGURE 11 INDIVIDUAL VEHICLE SPEED STUDY IV

Study V

The location for Study V was selected to afford an analysis of traffic speed patterns in relation to segregated but adjacent areas of commercial and residential development. The developed area was composed of a concentrated business area surrounded by a tightly grouped zone of residential development, all of which was centered on a single main highway (see Figure 13). The roadway through the test section was a two-lane rural type highway with grass or gravel shoulders. The gravel shoulders provided continuous access throughout the business area. A detailed description of the study section is given in Table 6.

In view of the general conditions outlined above, it was possible to include all of the developed area in the study section and thus obtain speed data on vehicles passing through the entire town. This condition is illustrated in Figure 13.

Two studies were conducted in this location because volumes were low during the periods of observation. The studies were first analyzed independently. Since the results of the two studies were very similar, they were combined in order to provide a more reliable sample.

In this study, the effects of horizontal and vertical alignment were very limited. There was a slight vertical curve which crested at Station 4 and hid the business district from traffic approaching in the northbound direction. There was a 4-degree horizontal curve contained in Sector 6 which restricted the approaching southbound driver's view of the business district until he reached the approximate center of the curve. Although the immediate effect of these elements was not readily discernible in average sector speeds, the limited test car study indicated very definite driver reactions. At these points the drivers assumed a more rapid deceleration rate which continued into the business area.

The speed profiles in Figure 13 show that the traffic entering and leaving the developed area followed a linear speed-change pattern. This pattern occurred in short, compact transition sections which were virtually free from isolated influences of commercial development and critical geometric elements. However, it was noted that southbound traffic speeds did not completely conform to this general pattern in Sector 1. Furthermore, there was no obvious explanation for the deviation. It occurred on the fringe of development and there were no sight restrictions, although there was a one-degree curve ahead. While this deviation did not occur in the limited test car studies, it is worthy of note that it was evident in both of the individual vehicle speed studies.

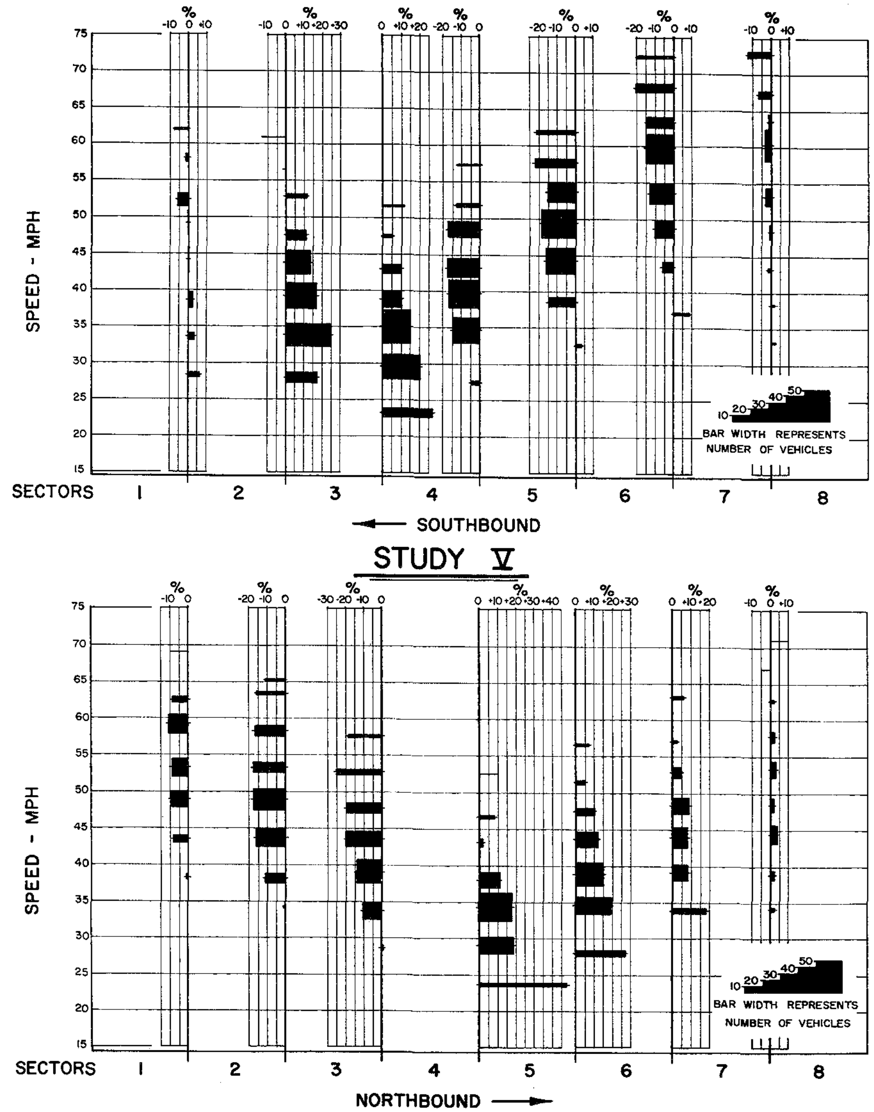
As in other studies, a general divergence was noted between inbound and outbound speeds. However, the magnitude of divergence in this study was greater than that observed in the other studies and was attributed primarily to the short, compact characteristics of the transition sections.

TABLE 6

DETAILED DESCRIPTION OF STUDY SECTION

Study V - Oakwood

Sector No.	1	2	3	4	5	6	7	8
Sector Length, feet	300	1000	754	716	756	1366	300	300
Pavement Width, feet	20	20	20	20	20	20	20	20
Shoulder Type	grass and/or gravel							
Horizontal Curves						D=4°		
Flashing Amber Signal				*				
Type of Development	Residential	Residential	Residential	Commercial	Commercial	Residential	Rural	Rural
No. of Residential Units	3	8	6	5	4	7	0	0
No. of Commercial Units	0	0	3	4	3	0	0	0
No. Driveways	4	9	2	0	2	1	0	0
Percent of Sector with uncontrolled access	0	0	5	100	35	5	0	0
Number of Intersecting Streets	1	1	2	2	1	1	0	0
Sight Distance Less than 1000' at any point within sector								
Northbound	No	No	Yes	Yes	Yes	No	No	No
Southbound	No	No	No	Yes	Yes	Yes	No	No



PERCENT CHANGE IN SPEED OF 5-MPH GROUPS

OAKWOOD, TEXAS

FIGURE 12

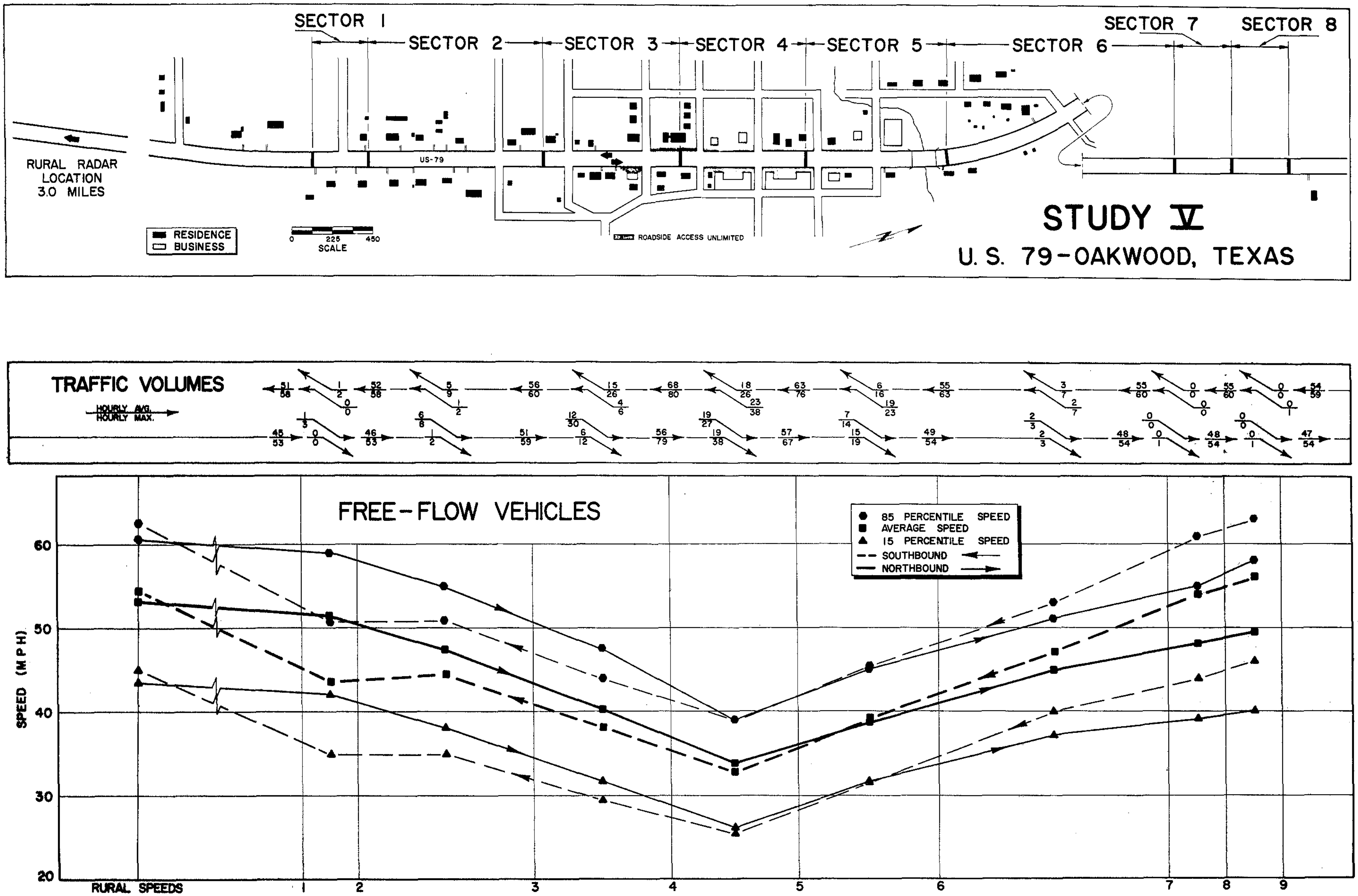


FIGURE 13 INDIVIDUAL VEHICLE SPEED STUDY V

Summary of Findings - Individual Vehicle Speed Studies

The results of each of the individual vehicle speed studies repeatedly pointed up several factors of roadway and development characteristics which influenced traffic speeds. The most significant were as follows:

1. Roadway Geometry and Sight Distance -- The two most common elements of roadway geometry which were found to influence speeds were horizontal and vertical curves. These elements not only imposed physical limitations on vehicle operation, but they generally imposed limitations on sight distance, or the distance ahead at which the roadway and related development were visible. The visibility relationship appeared to be of most significance when traffic speeds were below the design speed of the geometric elements. However, restricted sight distance did not materially influence speeds unless associated with development. Apparently its effect on speed was the result of the driver's anticipation of traffic conflicts beyond the limits of his vision.

2. Cross-Section -- In the two studies where there were changes in cross-section, there were corresponding changes in speed. Although these factors could not be isolated for evaluation because of other factors, it was apparent that they contributed to an urbanized appearance.

3. Commercial Development -- In several of the studies, concentrated commercial development appeared to have a substantial influence on speed. Its full impact was demonstrated in Study IV by the increase in speeds observed as the traffic passed from the commercial area into a predominantly residential area of equal or greater density. However, it is recognized that restricted sight distance in the commercial area was also a contributing factor. The second occurrence of concentrated commercial development in the study also caused a marked reduction in speeds. In this case there were no additional factors involved.

4. Residential Development -- Residential development did not indicate the same level of importance as did commercial development. This may be due to its lower traffic generation characteristics. The appearance of residential development determined to a great extent its level of influence on traffic speeds. Residential areas having good lateral clearances had far less influence on speeds than those where shrubbery and trees were planted near the curbline.

5. Density of Development -- The density of residential development expressed as a percent of occupancy did not appear to correlate with speeds, except in its extreme ranges. It was noted that areas of residential development having the same density had entirely different appearances to the driver; and as pointed out previously, the appearance of development seemed to have a great influence on the driver's selection of speed.

6. Deceleration Pattern -- In some of the individual vehicle speed studies, traffic speeds followed a generally constant deceleration pattern

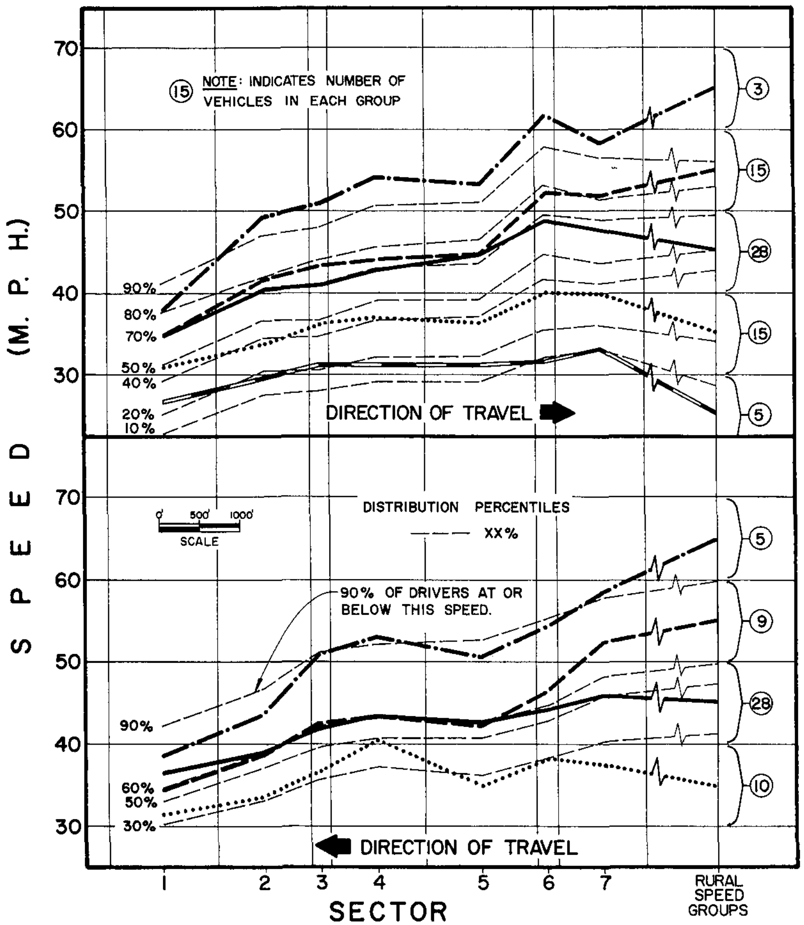
in transition from rural to urban conditions. In other studies, deviations from a constant deceleration line were directly related to certain characteristics of the roadway and development.

7. Divergence of Speeds -- In the studies involving short transition sections (Studies I and IV) the inbound and outbound speed patterns were significantly different. There was noted a general divergence between the speed profiles of the two directions. This characteristic was observed in the other studies where transition sections were longer, but the divergence was much smaller.

RURAL VS. URBAN SPEED RELATIONSHIPS

The individual vehicle speed data were analyzed to evaluate the consistency of drivers to travel at approximately the same percentile speed throughout the rural and urban areas. The free-flow vehicles which traveled throughout the urban and rural test section were selected for this analysis. Their speeds at the rural observation stations were grouped in ten-mile-per-hour increments, and the average speed of each of these groups was computed for each of the sectors in the urban sections. These values were plotted for comparison as shown in Figure 14 to 17. Also, percentile bands were plotted to show the relationship of these speed groups to the distribution of free-flow vehicles traveling throughout the urban section. However, it should be pointed out that the percentile bands plotted at the rural stations represent the entire traffic stream since free-flow vehicles were not separated at that point.

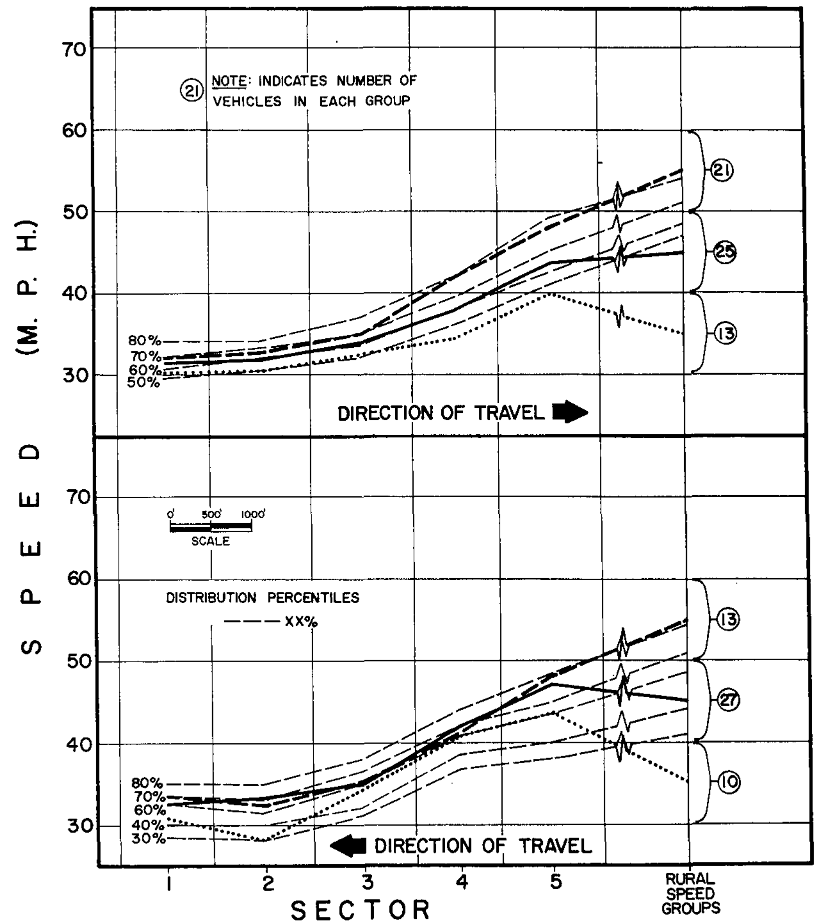
As shown in Figure 14 to 17, there was a general tendency for the speed groups to maintain their same relative position in the over-all distribution throughout the rural and urban areas. In other words, the faster drivers in rural areas were generally the faster drivers throughout the transition areas. However, the speed groups merged under city street traffic conditions as indicated in Sectors 1, 2, and 3 of Study III. Also, there was more consistency in the distribution of the speed groups in the outbound direction than in the inbound direction.



AVERAGE SPEEDS THROUGH URBAN SECTORS COMPARED TO RURAL SPEEDS

STUDY II

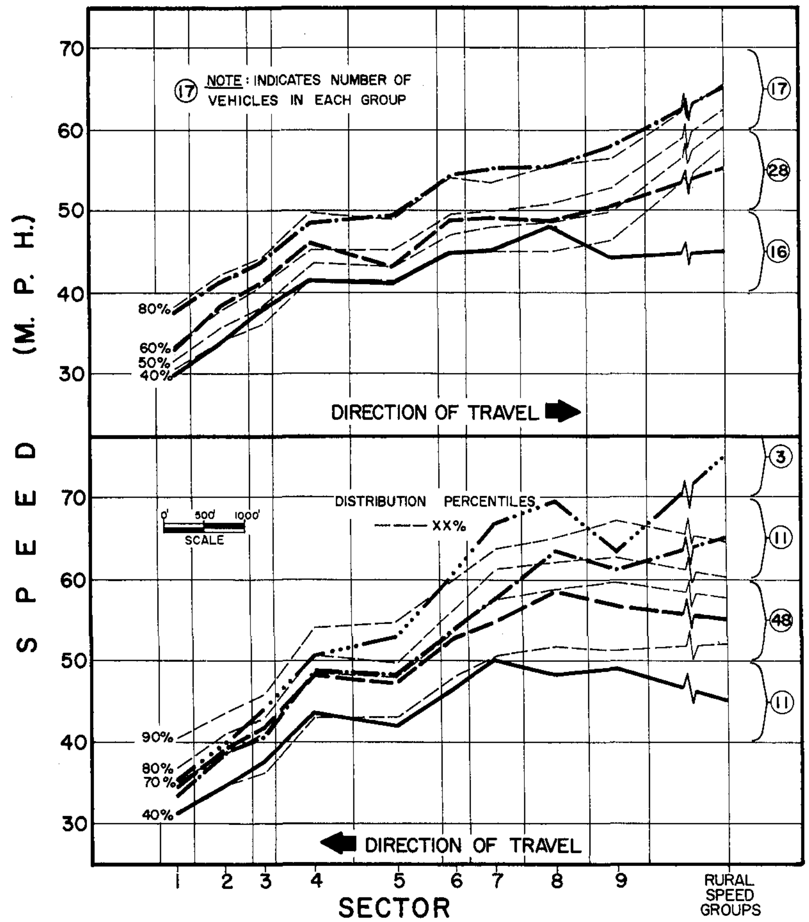
FIGURE 14



AVERAGE SPEEDS THROUGH URBAN SECTORS COMPARED TO RURAL SPEEDS

STUDY III

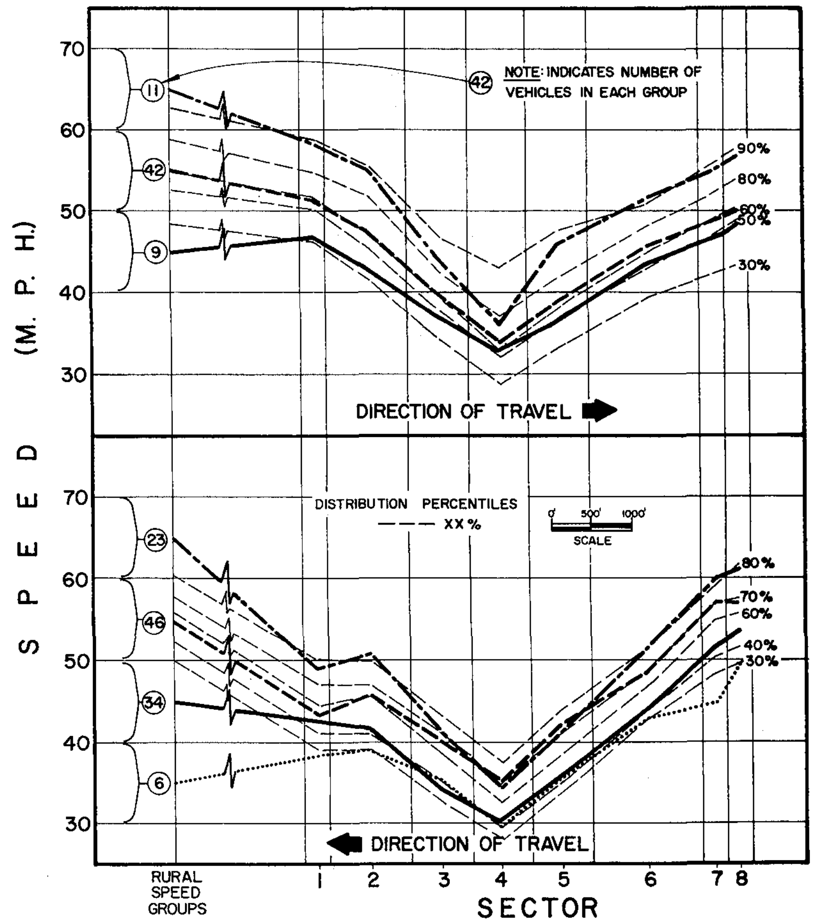
FIGURE 15



AVERAGE SPEEDS THROUGH URBAN SECTORS COMPARED TO RURAL SPEEDS

STUDY IV

FIGURE 16



AVERAGE SPEEDS THROUGH URBAN SECTORS COMPARED TO RURAL SPEEDS

STUDY V

FIGURE 17

LOCAL VS. NONLOCAL SPEED CHARACTERISTICS

The Individual Vehicle Speed Study data were used to evaluate the differences in speeds of local and nonlocal vehicle trips. The speeds of the vehicles which traveled the entire length of the urban study section were separated from the total sample and designated as nonlocal vehicle speeds. The remaining portion of the sample, those that traveled through only part of the study section, were designated as local trips. The average speeds of each of these two groups of vehicles were computed for each of the sectors in the study sections. The results are listed comparatively in Table 7.

A comparison of the two groups shows that the average speeds of nonlocal vehicles were higher than those of local vehicles, almost without exception.

TABLE 7

COMPARISON OF THE AVERAGE SPEEDS OF LOCAL AND NONLOCAL VEHICLE TRIPS

Sector No.	Average Speed of Vehicles		Speed Diff.	Average Speed of Vehicles		Speed Diff.
	Through	Local		Through	Local	
			STUDY I			
1	40.1	38.8	-1.3	45.0	40.6	-4.4
2	37.4	33.3	-4.1	37.9	36.0	-1.9
3	33.0	29.6	-3.4	35.1	31.2	-3.9
4	32.7	30.5	-2.2	35.9	30.6	-5.3
5	37.9	35.2	-2.7	39.9	34.9	-5.0
6	47.2	43.8	-3.4	43.9	40.8	-3.1
			STUDY II			
1	32.6	33.7	+1.1	35.0	34.5	-0.5
2	37.4	36.9	-0.5	38.8	36.7	-2.1
3	38.0	37.3	-0.7	41.4	39.0	-2.4
4	39.8	39.1	-0.7	43.0	38.6	-4.4
5	40.2	38.7	-1.5	42.1	37.5	-4.6
6	45.1	37.9	-7.2	44.7	37.4	-7.3
7	44.5	40.2	-4.3	46.8	41.9	-4.9
			STUDY III			
1	30.9	29.4	-1.5	32.2	29.8	-2.4
2	31.1	31.1	0	31.6	30.6	-1.0
3	32.7	33.0	+0.3	35.0	32.2	-2.8
4	36.5	36.0	-0.5	40.1	36.5	-3.6
5	41.2	40.8	-0.4	43.3	43.5	+0.2
			STUDY IV			
1	32.1	29.0	-3.1	33.2	29.9	-3.3
2	36.9	31.5	-5.4	36.7	31.4	-5.3
3	38.9	32.4	-6.5	38.8	32.1	-6.7
4	43.5	39.5	-4.0	44.3	37.6	-6.7
5	43.2	40.1	-3.1	44.2	41.6	-2.6
6	47.4	42.5	-4.9	50.3	43.8	-6.5
7	48.3	43.7	-4.6	53.0	47.6	-5.4
8	47.6	42.0	-5.6	54.2	47.9	-6.3
9	49.8	45.9	-3.9	54.3	49.2	-5.1
			STUDY V			
1	51.4	44.1	-7.3	43.5	38.5	-5.0
2	47.3	42.3	-5.0	44.4	38.7	-5.7
3	39.9	32.4	-7.5	38.2	30.7	-7.5
4	33.7	29.8	-3.9	32.8	25.7	-7.1
5	38.7	33.3	-5.4	39.1	35.4	-3.7
6	45.0	40.1	-5.9	47.3	44.1	-3.2
7	48.1	42.3	-5.8	53.9	48.6	-5.3
8	49.7	43.8	-5.9	55.6	50.5	-5.1

TABLE 8

COMPARISON OF TEST CAR SPEEDS WITH NORMAL TRAFFIC SPEEDS

INBOUND DIRECTION

Sector	1	2	3	4	5	6	7
Average Speed of Test Car in Sector, MPH (Average for 10 drivers)	50.0	55.9	60.3	61.3	61.1	63.6	65.5
85-Percentile Speed of Normal Traffic, MPH (Results of Individual Vehicle Speed Study II)	41.0	45.0	49.5	50.0	50.0	54.0	55.5
Difference, MPH	9.0	10.9	10.8	11.3	11.1	9.6	10.0

OUTBOUND DIRECTION

Sector	1	2	3	4	5	6	7
Average Speed of Test Car in Sector, MPH (Average for 10 drivers)	46.2	52.4	54.9	57.3	57.7	61.4	64.0
85-Percentile Speed of Normal Traffic, MPH (Results of Individual Vehicle Speed Study II)	38.5	43.0	46.0	47.5	48.5	54.5	53.0
Difference, MPH	7.7	9.4	8.9	9.8	9.2	6.9	11.0

TEST CAR STUDY

The test car study method was used to conduct a comprehensive study at one of the previously selected study locations. This location, which was the same as for Study II of the Individual Speed Studies, was selected because of the several geometric influences it presented, and because of the singularity in the type of development (purely residential) in the area. In general, the study site provided a number of influential factors which could be separated for intensive study.

In planning the study, ten drivers were selected to operate the test car on a prescribed route which included the test section selected. The total length of the route was approximately five miles, including about three miles of rural highway outside the study section. Each of the ten drivers was required to drive the prescribed route in an alternating inbound-outbound pattern until he had completed four acceptable runs in each direction.

The ten drivers selected were students at Texas A. & M. College. They were between the ages of 21 and 28. Although they were part-time employees of the Texas Transportation Institute on other projects, they were not familiar with the objectives or survey techniques of this study. Before beginning the test runs, each driver was instructed to drive the prescribed route repetitively. Each driver continued to drive the route until the observer had determined that he had made four runs in each direction without interference from other vehicles.

During the study, the existing speed limit signs were completely covered with paper to eliminate any possible influence on the driver. Also all test equipment except the sequence camera was placed in the rear of the station wagon to simulate as nearly as possible normal driving conditions.

It is probable that the test driver was more alert and more attentive to his driving than a normal driver. The fact that he was employed for the specific purpose of driving the test car is fairly substantial justification for this assumption. However, if most reactions to factors influencing speeds are of a subconscious nature, the test driver should react in much the same manner as the normal driver. This was fairly well substantiated by a comparison of the test car speeds with 85-percentile speeds from the individual vehicle speed study (Table 8). The test car speeds were 9 to 11 MPH higher except in Sectors 1 and 6. These differences may have resulted from vehicle performance characteristics. The two sectors in which they occurred were acceleration areas; and the test vehicle, a 1961 six-cylinder station wagon with automatic transmission, had less-than-average acceleration characteristics.

Test car runs were plotted so that the individual runs of each driver could be compared. Since this comparison showed that each driver's runs were very similar in reaction pattern, an average run was plotted for each driver. The average runs for all of the drivers are shown comparatively in subsequent figures.

The comparison of individual test car runs for each of the drivers indicated a slight increase in speeds in the order in which the runs were made. This trend probably resulted from increased familiarity with the roadway.

To facilitate a comparison of the test car speeds with roadway and development conditions, a strip map of the study section and a plot of sight distance are provided in proper proportion with the speed plots (Figures 19 and 20.) A detailed description of the study section was given in Table 3.

In Figure 18, a series of photographs taken from the test car shows the general characteristics of the roadway as viewed by the driver. These photographs were selected from a more complete series of snapshots taken during one of the travel runs. They provide an acceptable representation of the conditions confronting the drivers during the test runs.

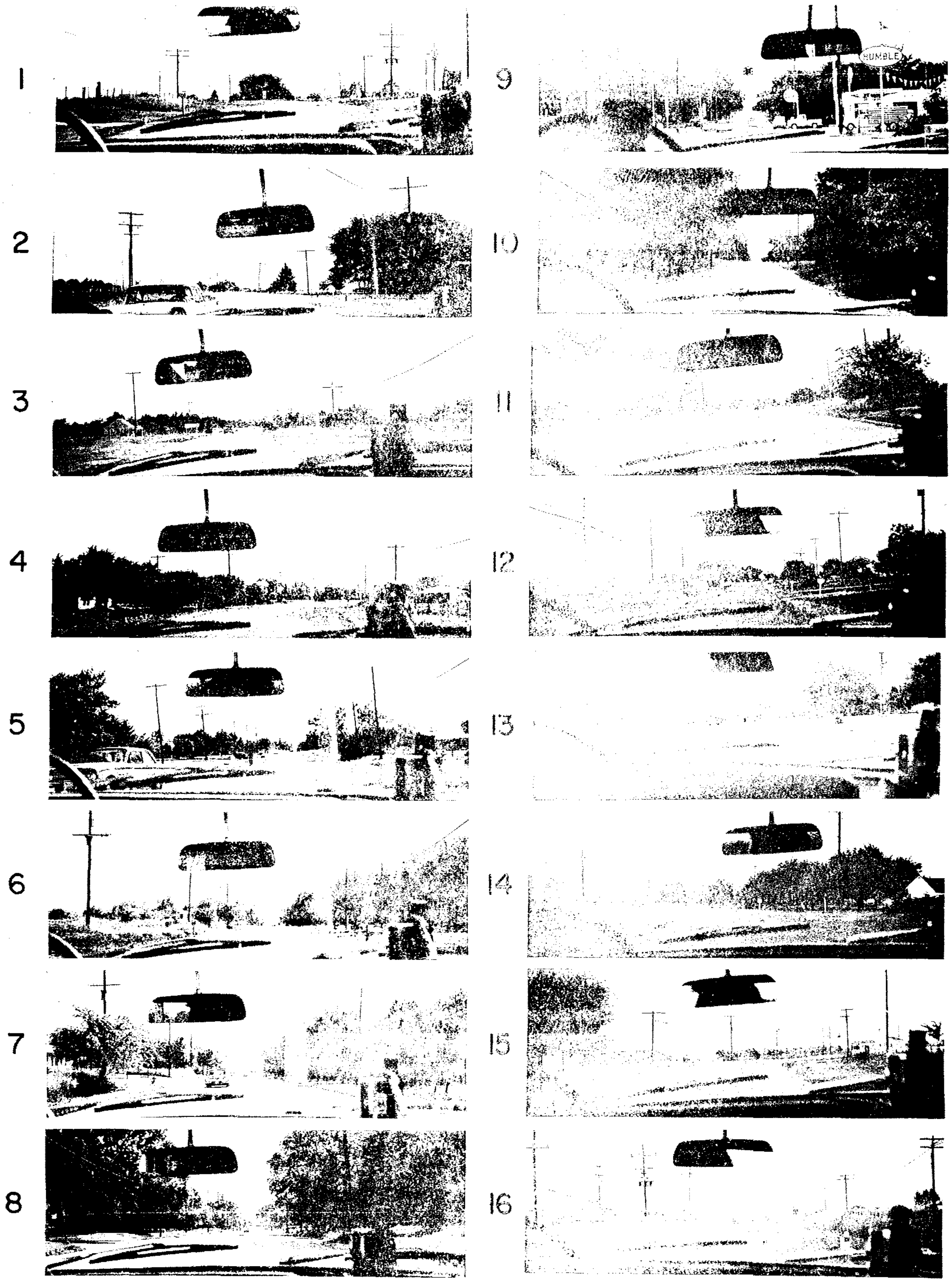
In the evaluation of the results, primary consideration was given to a visual comparison of the speed profile with the existent conditions of roadway geometrics and development characteristics. This comparison pointed up several influencing factors and indicated the point and extent of reaction to these factors.

Discussion of Results

Evaluating the test runs in the inbound direction, it was noted that the drivers were decelerating when they entered the test section (Figure 19). This deceleration continued until a point was reached within the first 4-degree curve. Since these speeds were in excess of the design value of the curve, the majority of the reduction in speed was attributed to the drivers' evaluation of the physical limitations of the curve. However, due consideration should be given to the fact that sight distance was rapidly decreasing in the presence of limited development as the drivers were nearing the curve, and increased suddenly to more than 2000 feet at the point where speeds began to increase. (The term "sight distance" describes the distance ahead in which the driver could see the roadway and related development.)

Upon leaving the first curve, the drivers continued to accelerate until reaching a point where sight distance was reduced to approximately 1100 feet. From this point they followed a constant deceleration pattern into the second 4-degree curve. The general appearance of the area in which the deceleration occurred is shown in photo no. 3 in Figure 18.

Test car speeds were more or less constant in the second curve, but increased slightly upon leaving it, even though the density of development was greater than that preceding the curve. However, the sight distance had



INBOUND OUTBOUND

TEST CAR STUDY SITE

FIGURE 18

increased, and as shown in sequence photo no. 5, the development in the area confronting the driver did not impose any undue lateral sight restrictions. Also, access to the individual residential units was provided by culverts, and very little shrubbery was planted near the roadway.

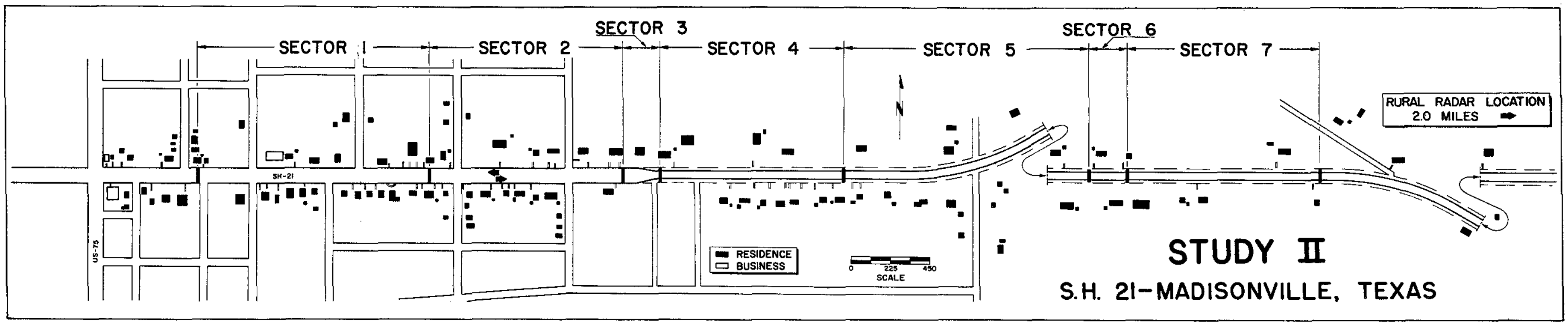
The next significant change in test car speed was observed when the transition from rural to urban cross-section came into view. At this point, the drivers entered a distinct deceleration pattern which continued to a point approximately 400 feet beyond the transition section. The rapid change in speed was attributed to the change in cross-section accompanied by a significant change in development characteristics. Although the density of the residential units was essentially the same as the drivers had previously experienced in the test section, the appearance was completely different, as shown in sequence photo no. 7. The change in appearance was caused by extensive planting of trees and shrubbery up to the property line, giving the driver a feeling of lateral restriction. The change in appearance of the development and the change in cross-section combined to give the drivers a feeling of urban conditions, and resulted in a significant speed change.

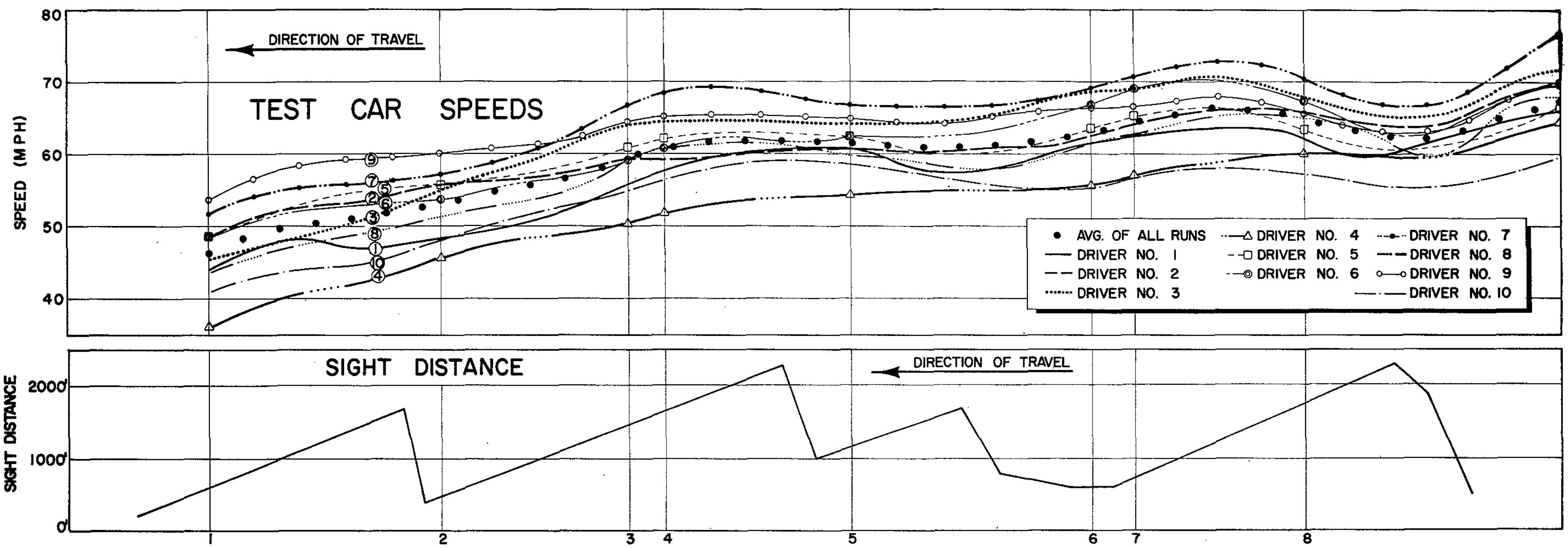
A less pronounced rate of deceleration was observed following the influence of the transition to urban conditions. The rate of deceleration was comparable to that observed in the approach to the second curve. It was noted that sight distance conditions in the two sections were also comparable. In both cases, the drivers were subjected to sight distances less than 1000 to 1100 feet.

As the drivers continued in the inbound direction, their speeds became constant when sight distance was again restored. However, they assumed another similar deceleration pattern at approximately 1000 feet from the intersection of U.S. 75. This intersection was 600 feet outside the test section. The deceleration patterns outside the test section were highly variable depending upon the signal at the major highway intersection.

The test car runs in the outbound direction were very similar in many respects to the inbound runs. However, several differences were considered worthy of discussion. Figure 20 shows that the drivers were still accelerating quite rapidly as they entered the test section, 600 feet beyond the signalized intersection. The rate of acceleration decreased slowly as the drivers slowly approached a speed commensurate with the existing conditions. As indicated by the sight distance plot, the drivers were confronted with a crest vertical curve just inside the test section. However, the restricted sight distance imposed by the vertical curve did not appear to influence the speeds because the drivers were still in the process of accelerating to what they considered a normal speed for the existing conditions.

Once the drivers had negotiated the first vertical curve, they were immediately confronted by a second vertical curve completely within the urban section. When sight distance was reduced to approximately 1200 feet, some of the drivers altered their rate of acceleration. Once sight distance





TEST CAR STUDY

FIGURE 19

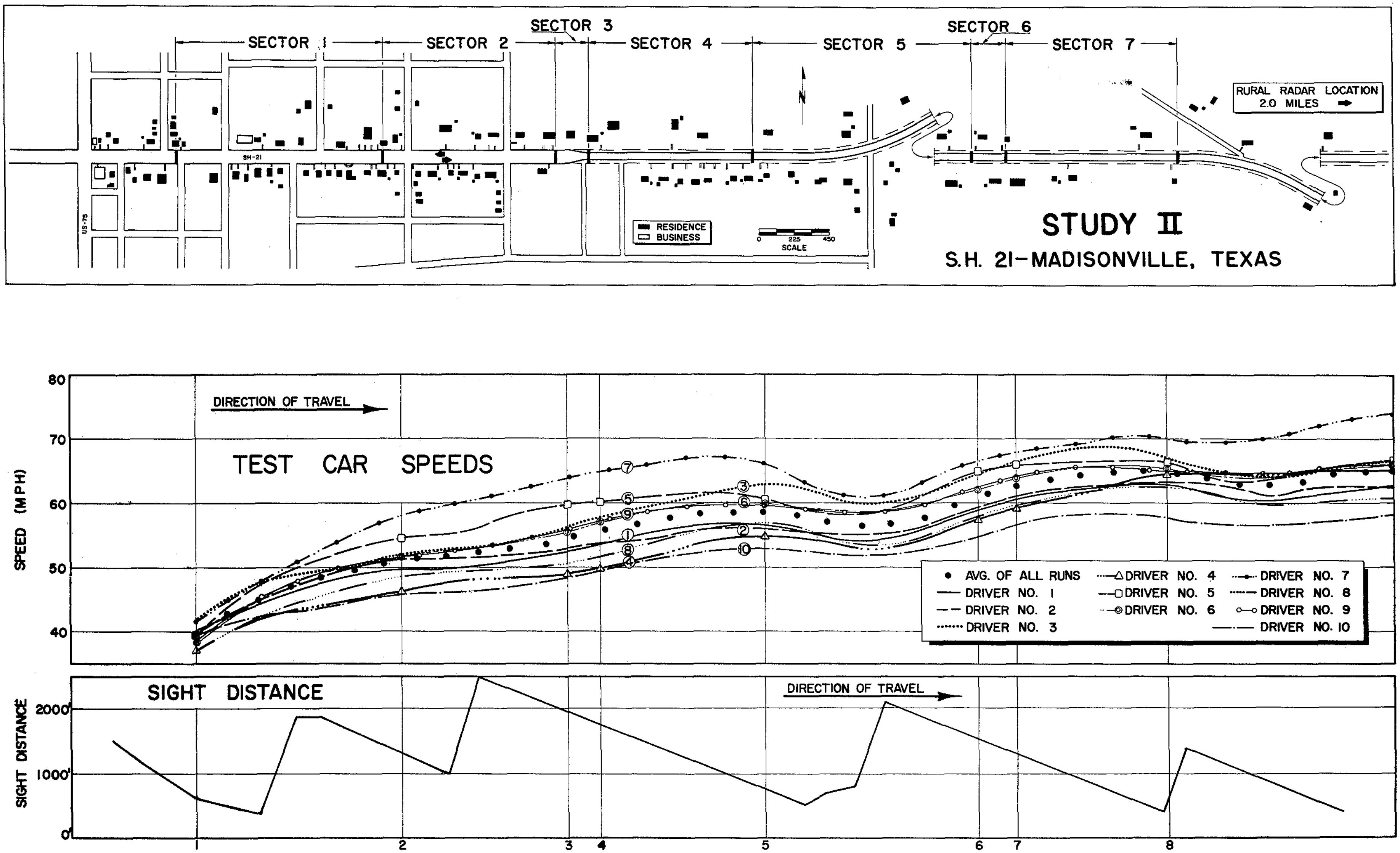
INBOUND DIRECTION OF TRAVEL

was restored, their speeds increased uniformly. Actually the major change in the speed profile occurred approximately 200 feet from the transition to urban cross-section. Sequence photo no. 11 shows the roadway ahead of the driver at the point of change.

The next major change in speed occurred in the approach to the first horizontal curve in the outbound direction. The drivers assumed a deceleration pattern when sight distance was reduced to 1000 feet, and continued to decelerate into the curve until adequate sight distance was restored.

When sight distance was restored, the roadway and surrounding area had assumed an appearance of rural conditions. As a result, the drivers accelerated rapidly, approaching their normal rural speeds. As the drivers approached the second curve in the outbound direction, their sight distance was once more reduced below 1000 feet, and a slight reduction in speed was observed. This reduction was considered primarily a reaction to the curve, since speeds returned to normal as the drivers passed from the curve into a completely rural section, as shown in sequence photo no. 16.

Although the sight distance was less than 1000 feet at the end of the curve, the speed profile indicated a slight increase in speeds. Apparently the drivers did not consider sight distance as important outside the developed areas.



TEST CAR STUDY

FIGURE 20

OUTBOUND DIRECTION OF TRAVEL

Summary of Findings   Test Car Study

The average test car speeds in each of the sectors were consistently 9 to 11 MPH higher than corresponding 85-percentile speeds of the normal drivers. This over-all difference was attributed to the characteristics of the age group of the test car drivers, 21 to 28 years, and their knowledge of being tested.

Through the use of the test car technique it was possible to isolate certain variables for specific evaluation. Because of the continuous speed record, the point of reaction related to a certain variable could often be detected.

The test car study served to substantiate further many of the findings of the individual vehicle speed studies. Of most significance was the influence of sight distance on speeds. In practically every situation where horizontal or vertical curves limited sight distances to less than 1000 to 1200 feet, there was a distinct reduction in speeds. The drivers began to decelerate or to decelerate more rapidly each time sight distance became restrictive.

Although the influence of restrictive sight distance was demonstrated in the developed areas, it was apparently of little or no significance in the rural or undeveloped areas.

The influence of the appearance of development and roadway cross-section was also demonstrated in the test car study. The drivers decelerated rapidly over a section extending 400 feet on each side of the transition from rural to urban cross-section. In this same area there was also a significant change in the appearance of the development, caused by extensive shrubbery and trees near the roadway. This combination of factors caused a sudden change from rural to urban appearance.

HOURLY VARIATIONS IN TRAFFIC SPEEDS

Previous research has established that variations in traffic speeds generally exist over a 24-hour period.[2] For this reason, it was felt that studies should be conducted to establish a possible relationship between traffic speeds and variations in traffic conditions.

The studies were conducted at four sites to provide data on the variations of speeds throughout the day. Speeds were observed for all vehicles during a 24-hour period at three locations and for a 12-hour period at the fourth location. Concealed radar units equipped with graphic recorders were used to measure speeds.

Study Locations

These studies were conducted at four locations on three different types of roadways.

Location 1 - A mid-block location on a 4-lane undivided major street which also served as a primary highway route.

Location 2 - An intersection location in a shopping center area on a 4-lane, channelized major street (same facility as Location 1). (See Figure 21.)

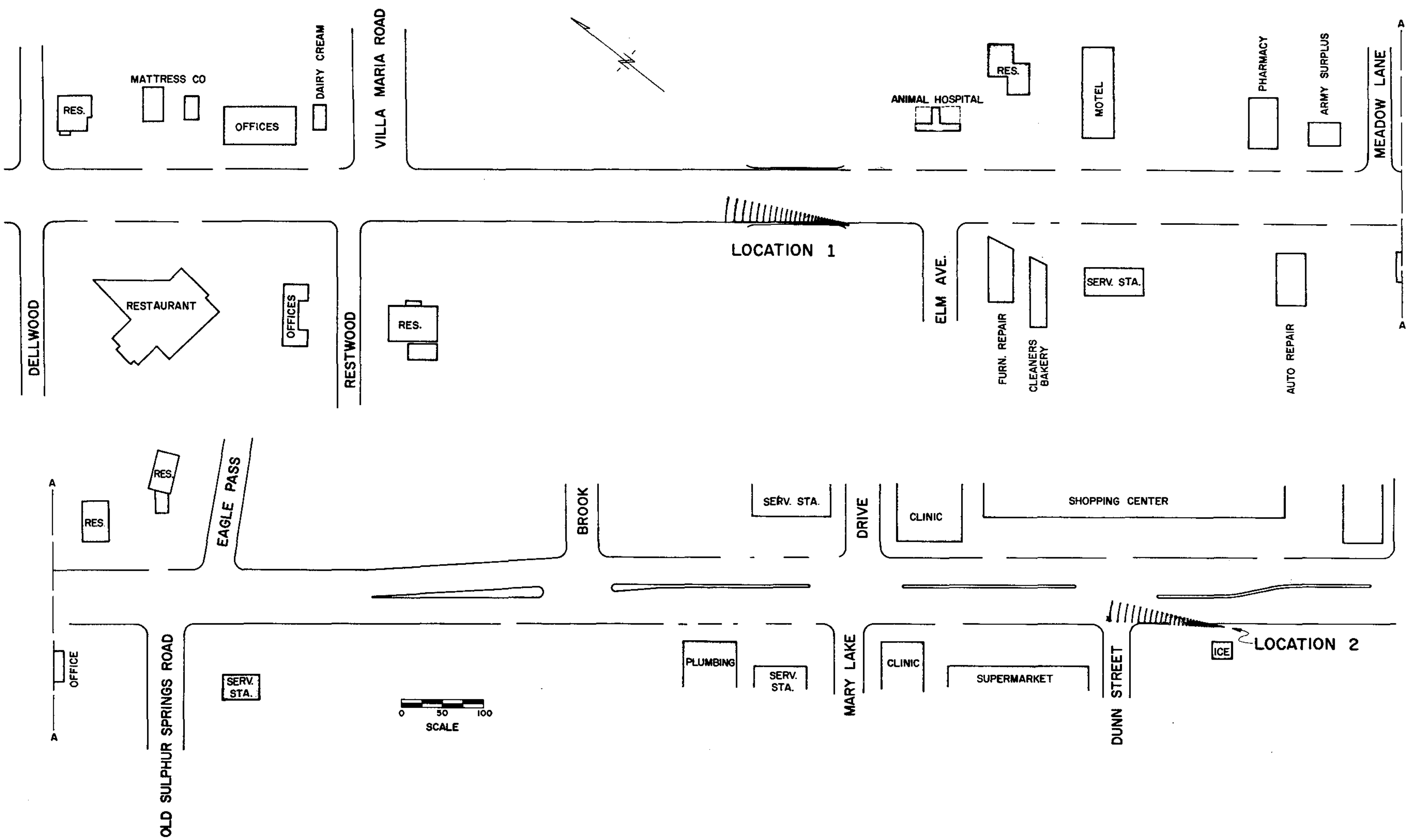
Location 3 - A rural section of a 4-lane divided State Highway serving an industrial area.

Location 4 - A 2-lane secondary highway carrying a rather high volume of traffic for this type of roadway.

It will be noted that Location 1 was a mid-block section virtually free from turning movements, while Location 2 was at an intersection in a shopping center complex. The studies at these locations were conducted concurrently to provide a comparative evaluation of the effects of turning movements on traffic speeds. At Location 2, observers recorded all turning movements in the intersection area and counted the number of through vehicles in the southbound direction during the business hours. Because of the excessive width of the street and high traffic volumes, speeds were observed in the southbound direction only.

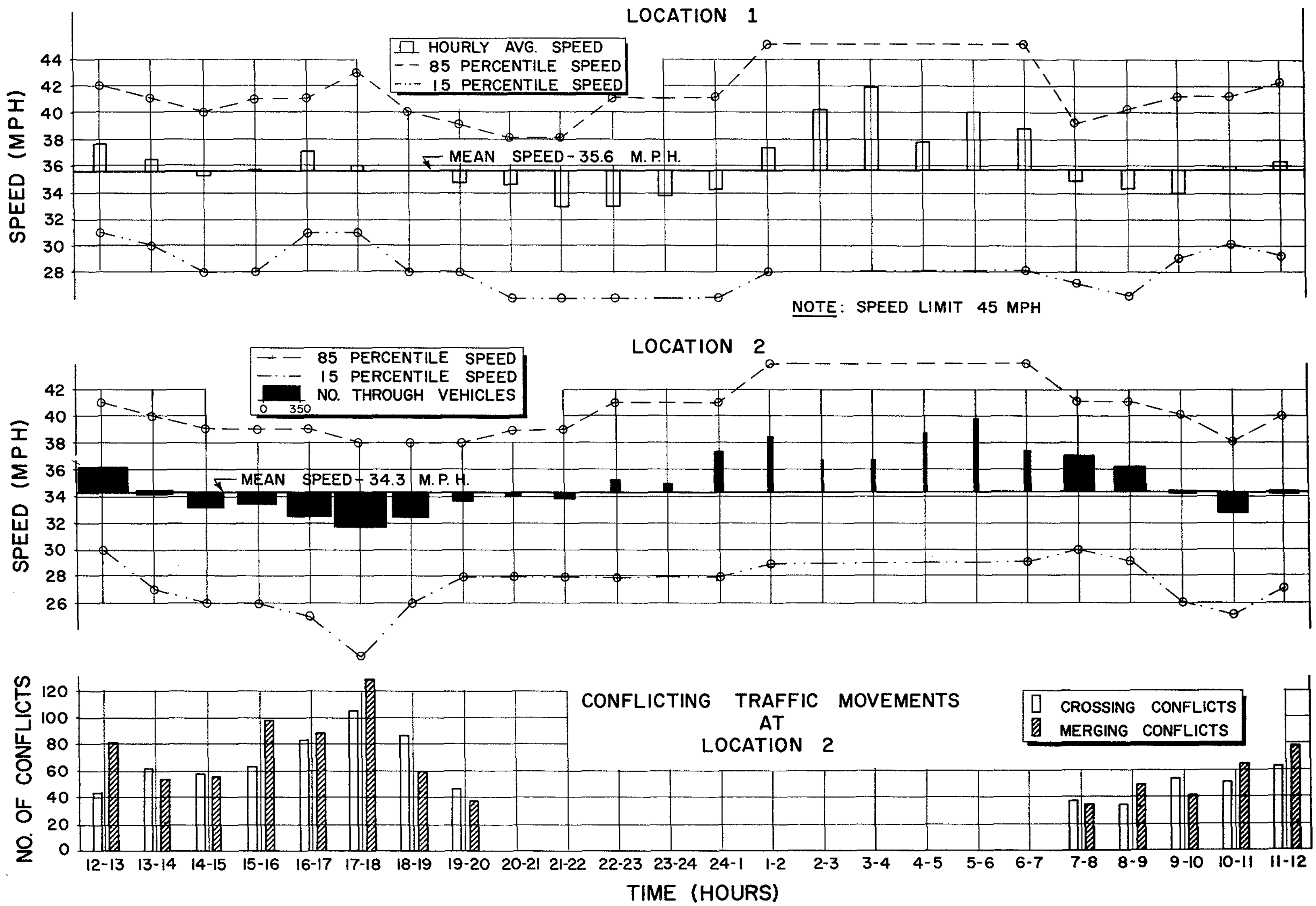
At Location 3, speeds were observed in only one direction of travel, because the facility was a 4-lane divided highway.

At Location 4, the study was conducted over a 12-hour period during the daylight hours. Speeds were observed in both directions of travel, and because a graphic recorder was used unattended, the speeds could not be separated according to direction.



24-HOUR SPEED STUDY LOCATIONS

FIGURE 21



HOURLY VARIATIONS IN TRAFFIC SPEEDS

FIGURE 22

Analysis of Data

In each of the studies, the hourly average speed was compared to the mean speed for the entire study, as shown in Figures 22 and 23. The 85- and 15-percentile speeds for those hours having sufficient volume were plotted as an envelope about the mean speed. In the night and early morning hours when volumes were low, hourly speed observations were combined to yield statistically reliable percentile values for the group. This will be noted as a horizontal line joining two far-removed data points.

It will be noted on the chart in Figure 22 that the number of "through" vehicles for each hour is indicated by the width of the bar. These values, as well as the conflicting movements shown in the lower chart, were determined by manual counting. Because the volumes at Location 1 and 2 were essentially the same, no attempt was made to obtain an actual count at Location 1.

The volumes indicated on the charts for Locations 3 and 4 were determined through interpretation of the speed recorder charts and are therefore subject to a small amount of error due to the normal difficulties involved in measuring speeds of two lanes of traffic simultaneously.

Discussion of Results

The studies at Locations 1 and 2 provided data for the evaluation of variations in speeds on a typical major street where moderately high volumes and heavy traffic conflicts are experienced. Under these conditions, the maximum deviation from the mean of any hourly average speed was approximately 3 miles per hour, as shown in Figure 22. Larger deviations were noted only in the early morning hours when traffic conflicts were essentially nonexistent. Except for the early morning hours, the 85-percentile speeds varied over a 5-MPH range at Location 1 and a 3-MPH range at Location 2.

With the exception of the early morning hours, the maximum deviations in average speed occurred during the peak hours. These deviations were not always below the mean as might be expected. At Location 2, the average speeds during the morning and noon peaks ranged from 2 to 3 miles per hour above the mean, even in the presence of moderate conflicts at the intersection. These higher speeds can be explained by considering that the majority of the drivers were under the compulsion of a tight schedule. The concept of the influence of compulsion on the part of the driver is further substantiated by noting the low average speeds at both locations during the off-peak hours (10-11 and 14-15 hours). At these times the traffic stream was composed largely of shoppers and others who were not influenced by rigid schedules.

The effect of large numbers of conflicts can be realized through a comparison of average speeds at Locations 1 and 2 during the afternoon peaks

(17-18 hours). The average speed at Location 1 was slightly above the mean while the average speed at Location 2, where the large number of conflicts occurred, was approximately 2.5 MPH below the mean (Figure 22).

There was an apparent difference in the average speeds at Locations 1 and 2 during the morning peaks. This difference was the result of a large number of vehicles entering Texas Avenue from Villa Maria Road (see Figure 21) during this period and had not yet attained normal operating speeds before entering the range of the radar unit at Location 1. Similar differences were observed during the late evening hours (21 to 01). These differences were caused by traffic entering Texas Avenue from a drive-in theater on Villa Maria Road and from a restaurant and drive-in cafe in the general area (see Figure 21). Again, this traffic had not yet attained full operating speeds before entering the range of the radar unit.

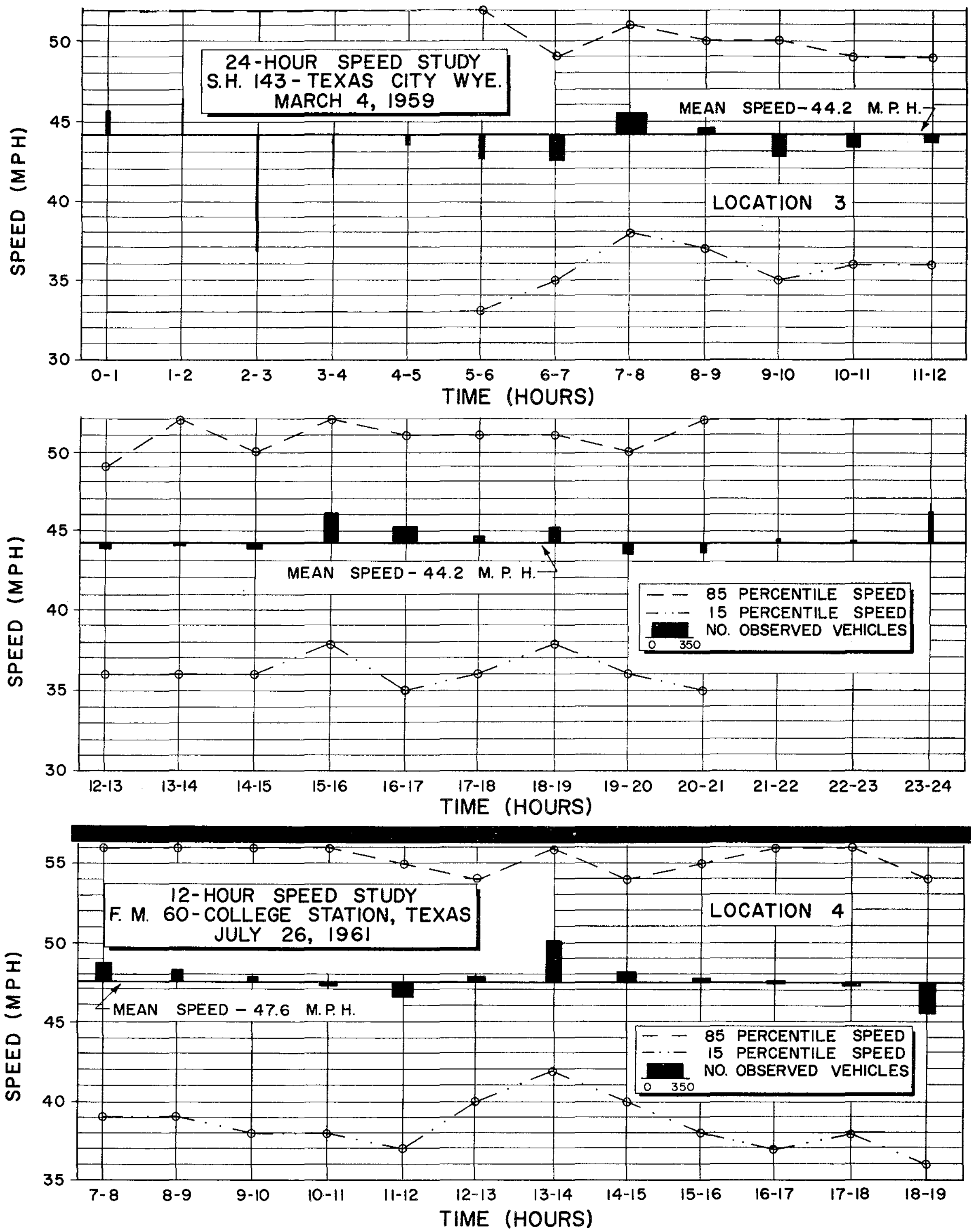
The study at Location 3 provided data for the evaluation of the variations in speeds on a high-type facility which primarily served industrial commuter traffic. This service was provided under comparatively low volume conditions and essentially no traffic conflicts.

The peak periods observed in the study reflected the shift changes at refineries and chemical plants in the general area. These shift changes normally occurred in two cycles: 7:00 a.m. - 3:00 p.m. - 11:00 p.m.; and 8:00 a.m. - 4:00 p.m. - Midnight. The study shows (Figure 23) that average speeds observed during the shift changes were generally above the mean of the entire study. This further substantiates the previous ideas regarding the relationship between speeds and the pressure of a rigid schedule.

The study at Location 4 was conducted to provide data on variations in speeds on a 2-lane secondary type roadway. In addition to serving the rural area, it also provided access to a small commercial airport and to limited facilities for some agricultural research and extension services.

The speeds were observed at a point approximately one-half mile outside the College Station City Limit. Although the area was primarily rural, there were widely scattered residences in the general area.

In evaluating the results of the study, it was noted that the maximum deviation in hourly average speeds was approximately 3 miles per hour (see Figure 23). However, deviations were less than one mile per hour during 8 of the 12 hours of observation. The greatest variation in the 85-percentile speeds was 2 miles per hour.



HOURLY VARIATIONS IN TRAFFIC SPEEDS

FIGURE 23

Summary of Findings

In each of the four studies, hourly average speeds did not differ greatly throughout the daylight and evening hours. Even smaller variations were noted in the 85-percentile speeds during these periods.

The higher traffic speeds were observed during (1) extremely low volume conditions in the late evening and early morning hours, and (2) rush hour periods when the driver was operating on a tight schedule. A large number of traffic conflicts resulted in a reduction in traffic speeds.

The result of these studies indicates that traffic speeds varied little throughout daylight hours. The 85-percentile, mean, and 15-percentile speeds during any hour were representative of the speeds during the remainder of the daylight hours. During the peak "rush" hours, increased intersection conflicts caused a reduction in speeds in the vicinity of the intersection. At none of the sites studied was the volume sufficiently close to the capacity of the roadway to cause a significant reduction in speed from the volume of traffic alone.

These studies indicated that for a spot speed study to be representative of a certain section of roadway, the selection of the specific site for the study is an important consideration.

THE EFFECT OF RADAR ENFORCEMENT ON TRAFFIC SPEEDS

The first phase of this project showed that without rigid enforcement drivers generally disregard speed limit signs and select driving speeds according to their judgment of prevailing roadway and traffic conditions. However, little is known of the driver's reaction to efforts aimed at the enforcement of speed limits. From observation it is evident that the presence of enforcement officials and equipment will reduce traffic speeds, but the extent of the effect in the enforced area and in adjacent sections is not fully known.

A study was undertaken in cooperation with the local Highway Patrol unit of the Texas Department of Public Safety to determine the effects of routine radar enforcement practices on traffic speeds. The study was designed to indicate changes in speed characteristics in the immediate area of the radar unit and to determine the distance from the radar unit that speeds were affected.

Enforcement Procedure

In routine enforcement operations, the patrol unit used a radar speed meter mounted on a tripod at the shoulder of the roadway. There was no attempt to conceal the unit; however, during the hours of darkness, the radar unit was not readily discernible by the driver until he had entered its range of operation.

During the operation, a patrolman observed speeds from an official vehicle parked 150 to 200 feet beyond the radar unit. He identified speeding vehicles and relayed the information to awaiting patrolmen at the pick-up station normally one-fourth to one-half mile beyond the radar unit. Whenever possible, the pick-up station was located within the view of the patrolman observing speeds in order that violators could be more positively identified and apprehended. This method of operation limited the apprehension of violators to only one direction of traffic, commonly referred to as the enforced direction.

Study Procedure

Studies to evaluate the effects of enforcement were conducted in two phases. The first phase consisted of studies conducted at isolated locations to (1) record traffic speeds in each direction of travel at the enforcement radar unit during enforcement operations and (2) observe traffic speeds with a concealed radar unit at the same locations without the presence of enforcement officials. In the second phase, studies were conducted to determine how far the effect of enforcement extended along the roadway on each side of the enforcement unit. To accomplish this aim, concealed radar units were used to observe traffic speeds during enforcement operations in an "Area" which extended four miles on either side of the enforcement unit.

Study Locations

The locations selected for all studies were in general conformance with the convenience and best interests of the enforcement officials. They were normally situated in sections of roadway where speeds were not governed by geometrics. The locations for speed studies in the first phase, the point survey, were as follows:

Location 1 - S.H. 6 - one mile south of College Station.
Location 2 - S.H. 6 - five miles north of Navasota.
Location 3 - S.H. 6 - one mile north of Bryan.
Location 4 - S.H. 21 - Navasota River Bridge.

In the second phase which consisted of the "Area" enforcement studies, an exact number of study locations could not be pre-determined. With the two radar units available for research purposes, it was necessary to conduct studies on four different occasions in order to obtain sufficient data for the analysis. These four studies were not conducted at the same location because it was thought that repeat drivers would have begun to anticipate radar operations. The locations at which the area studies were conducted are as follows:

<u>Area One</u> - S.H. 6 - South of College Station. Research radar units located 4 miles in advance and 1.25 miles beyond enforcement unit.
<u>Area Two</u> - S.H. 6 - South of College Station. Research radar units located 2 miles in advance and 3 miles beyond enforcement unit.
<u>Area Three</u>- S.H. 36 - North of Caldwell. Research radar units located 1 mile in advance and 2 miles beyond enforcement unit.
<u>Area Four</u> - S.H. 6 - South of College Station. Research radar units located 2 miles and 4 miles beyond enforcement unit.

Analysis of Data

The analysis of data from the enforcement studies was aimed at evaluating by comparison any differences in traffic speeds or their distribution resulting from radar enforcement operations. To facilitate this comparison, the speed characteristics listed in Tables 9 to 11 were calculated, and the speed distribution curves were plotted.

In the analysis, the speeds of trucks and buses were separated from passenger car speeds and are given special consideration.

Discussion of Results

Phase I - Studies With and Without Enforcement -- In evaluating the results of studies conducted at the four locations with and without enforcement activity, it was noted that enforcement caused a reduction of traffic speeds in the direction opposite to the enforced direction (see Figure 24). This reduction was attributable to enforcement activity because there was no significant difference in speeds by direction of travel when observed under conditions of no enforcement. The difference observed under enforced conditions was largely attributable to the presence of the pick-up unit, which the drivers in the opposing direction had observed shortly before arriving at the radar unit.

Comparing the average speeds listed in Table 9, it will be noted that the magnitude of the speed differences resulting from enforcement ranged from 5.0 to 6.6 miles per hour. Comparison of other speed characteristics indicates similar differences.

Although the four-hour periods of speed observation at each study location provided good sampling of passenger cars, no one study provided a reliable sample of truck speeds. For this reason, truck speeds of all studies conducted with the enforcement unit were combined with respect to their direction of travel. In the studies with no enforcement, truck speeds for all locations were combined to form one large sample. This was considered permissible because an analysis showed no appreciable difference in speeds by direction of travel in the studies with no enforcement.

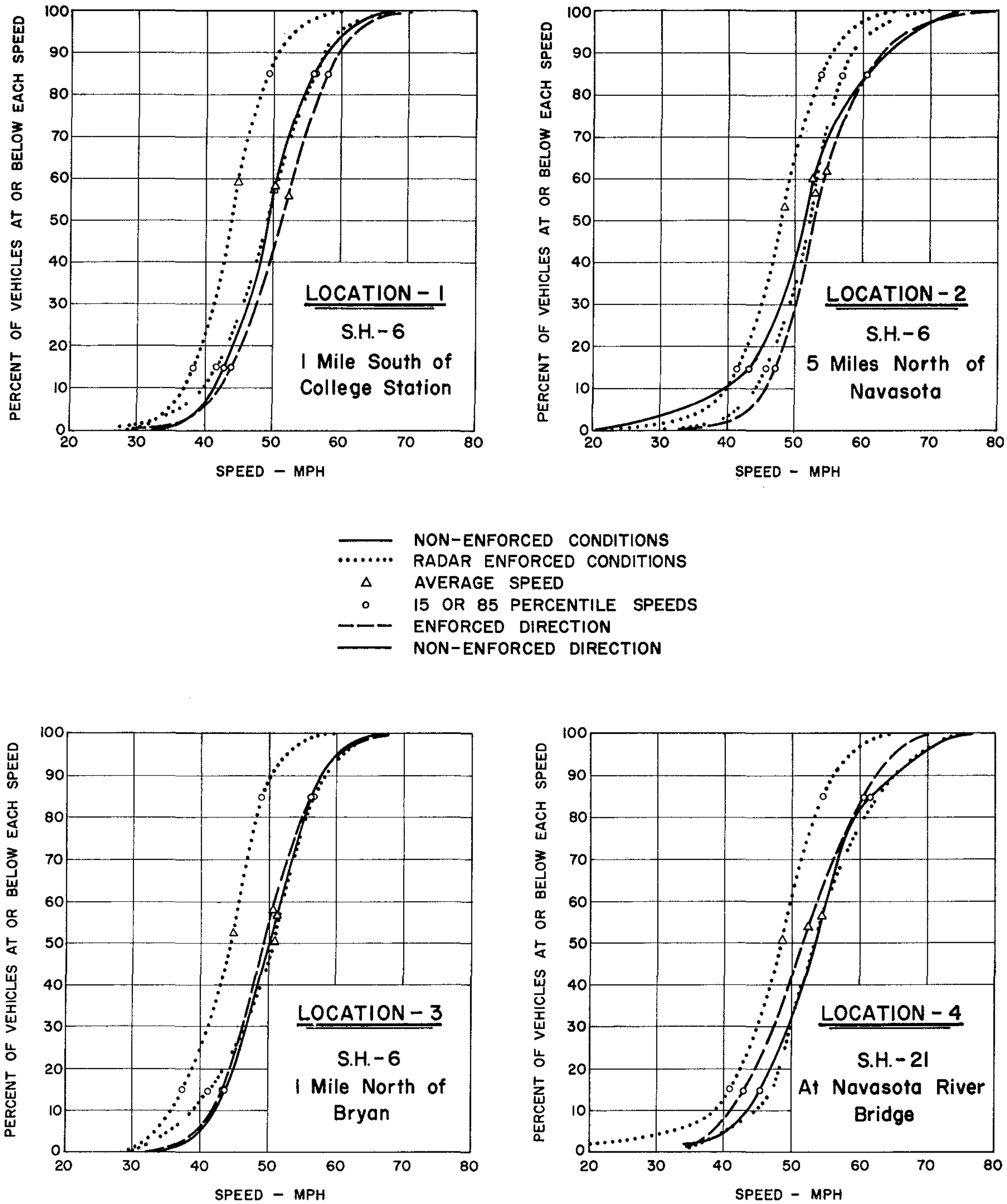
For further comparison, truck speeds from spot speed studies made during daylight hours in the four locations listed in Table 10 were combined to form a sample. These studies were conducted on weekday afternoons using the concealed research radar unit.

As shown in Table 10, the various combinations of data made it possible to compare truck speeds under four different conditions:

(1) Normal operation during daylight hours,
(2) Normal operation during night hours,
(3) During enforcement at night in the enforced direction, and
(4) During enforcement at night in the opposing direction.

The results indicated that truck speeds were essentially the same for day and night conditions in the absence of enforcement operations. Although the speed limit for trucks was 45 MPH, the average speeds under each of the two conditions were 49.4 and 49.9 MPH, respectively. It is notable that approximately three-fourths of the trucks were exceeding the speed limit.

The comparison of truck speeds at night under conditions of enforcement and no enforcement shows a decrease in the average speed from 49.9 to 46.7 MPH in the enforced direction. This decrease was probably the



DISTRIBUTION OF TRAFFIC SPEEDS OPERATING UNDER NON-ENFORCED CONDITIONS VERSUS ROUTINE RADAR ENFORCEMENT

FIGURE 24

TABLE 9

Comparison of Traffic Speeds for Conditions of Radar Enforcement and No Enforcement

Radar Enforcement

Direction of Travel	Enforced Direction				Opposing Direction			
Study Location	1	2	3	4	1	2	3	4
Number of Vehicles Observed	239	446	176	195	262	228	202	76
Average Speed, MPH	50.3	52.8	50.7	55.3	45.3	48.5	45.0	48.7
85-Percentile Speed, MPH	56.5	57.6	57.0	62.0	49.6	54.3	49.7	54.5
15-Percentile Speed, MPH	41.6	45.7	42.2	47.2	38.4	41.3	37.3	41.3
Speed Differential, MPH	14.9	11.9	14.8	14.8	11.2	13.0	12.4	13.2
Percent Exceeding Speed Limit (55 MPH)	24.7	35.7	29.5	49.7	4.6	15.8	2.4	17.1
Standard Deviation, S	6.95	6.26	7.40	7.54	5.55	6.69	5.67	8.03

No Enforcement

Direction of Travel	Enforced Direction				Opposing Direction			
Study Location	1	2	3	4	1	2	3	4
Number of Vehicles Observed	471	272	404	67	402	128	259	133
Average Speed, MPH	52.2	54.6	51.0	52.2	50.3	52.3	51.2	54.7
85-Percentile Speed, MPH	58.1	60.2	56.9	60.0	56.0	60.9	56.7	61.5
15-Percentile Speed, MPH	44.3	47.4	43.3	42.4	42.7	43.3	43.3	45.7
Speed Differential, MPH	13.8	12.8	13.6	17.6	13.3	17.6	13.4	15.8
Percent Exceeding Speed Limit (55 MPH)	35.0	44.5	27.0	43.3	21.6	35.2	29.7	46.6
Standard Deviation, S	6.80	7.11	6.36	8.68	6.48	9.65	6.30	8.24

TABLE 10

Comparison of Truck Speeds
For Daytime, Nighttime and
Radar Enforcement Conditions

(1) Daytime - Observations by concealed research unit
4 locations: Waller, U.S. 290 West
Oakwood, U.S. 79 West
Madisonville, S.H. 21 East
Madisonville, S.H. 21 East

(2) Nighttime - Observations by concealed research unit
4 locations: Navasota S.H. 6 North
College Station, S.H. 6 South
Bryan, S.H. 6 North
Bryan, S.H. 21 East

(3) Nighttime - Enforcement operations
6 locations: Navasota, S.H. 6 North
Navasota, S.H. 6 North
College Station, S.H. 6 South
Bryan, S.H. 6 North
Bryan, S.H. 21 East
Calvert, S.H. 6 North

Conditions	Daytime Normal Operation	Nighttime Normal Operation	Nighttime Radar Enforcement	
Direction of Travel	Combined	Combined	Enforced Direction	Opposing Direction
Total Vehicles Observed	191	146	155	126
Average Speed, MPH	49.4	49.9	46.7	42.9
85-Percentile Speed, MPH	57	54	52	47
15-Percentile Speed, MPH	42	44	40	36
Speed Differential, MPH	15	10	12	11
Percent Exceeding Speed Limit (45 MPH)	73.4	82.2	55.5	28.6
Percent Exceeding 55 MPH	22.5	15.8	9.0	4.0
Standard Deviation, S	7.47	5.82	6.21	5.92

result of "passing the word" among the truck drivers, a practice which seemed to be much more prevalent with truck drivers than with passenger car drivers.

The most significant reduction in truck speeds was observed in the opposing direction of travel, where the vehicles passed the pick-up unit before arriving at the enforcement radar unit.

Phase II - Area Studies -- The results of the "Area" enforcement studies indicate that the influence of enforcement operations loses significance within approximately four miles on either side of the enforcement unit. However, these studies do not show and were not intended to show the far-reaching effects of the over-all enforcement program. To provide this evaluation it would be necessary to study the speed characteristics of a roadway before the initiation of an enforcement program in comparison with the speed characteristics of the roadway after the enforcement program was established.

The extent to which enforcement affects speeds in areas adjacent to the enforcement unit can be ascertained through a careful study of the speed characteristics of the "Area" studies listed in Table H of the Appendix. To permit an easier evaluation of the results of the studies, the average speeds and percent of vehicles exceeding the speed limit have been extracted and are shown in Table 11. This summary of the results shows that speeds in both directions were essentially the same and were apparently unaffected by enforcement at a point four miles in front of the enforcement unit. However, in this same study a significant reduction in the average speed of traffic in the enforced direction had occurred when the traffic arrived at the enforcement unit. A further reduction was observed at a point 1.25 miles beyond the unit. Very substantial reductions were observed in the percent of vehicles exceeding the speed limit.

In the Area Two study, traffic speeds in the enforced direction at a point two miles in front of the enforcement unit apparently were not yet affected by the enforcement activity. When the traffic arrived at the enforcement unit, the average speed and the percent of traffic exceeding the speed limit had decreased. Further reductions were observed three miles beyond the unit.

In the Area Three study, the radar unit placed one mile in front of the enforcement unit was located on an up-grade to the traffic in the enforced direction. Although the grade was not recognized as a speed deterrent at the time of the study, the results showed that speeds at this point were lower than at the enforcement unit. Also, low volume conditions on the roadway reduced the effect of "passing the word" by drivers that had observed the enforcement activity.

A comparison of the speeds in the enforced direction at the enforcement unit and at a point two miles beyond, showed a substantial reduction in average speed and the percent of traffic exceeding the speed limit.

In the fourth study (Area Four) the research units were located two and four miles beyond the enforcement unit. This study indicated only a slight reduction in average speeds between the enforcement unit and a point two miles beyond. However, the traffic exceeding the speed limit had decreased significantly.

At a point four miles beyond the enforcement unit, traffic speeds had not completely returned to normal when compared with speeds in the opposing direction. However, the differences in speed at that point were minor.

A general comparison of speeds within the area of enforcement operations has shown that traffic in the enforced direction began to reduce speed at some point within two miles in front of the enforcement unit. This reduction was apparent at the enforcement unit, but possessed greater significance at points one to three miles beyond the unit. The traffic speeds had, for all practical purposes, returned to normal at a distance of four miles beyond the enforcement unit.

A similar comparison of speeds in the opposing or nonenforced direction showed that traffic had begun to reduce speed at a distance of two miles from the enforcement unit. Again this influence was attributed to "passing the word." From the point at two miles, speeds in the nonenforced direction continued to decrease, reaching a minimum at the enforcement unit. The significant reduction in speed at the enforcement unit was the result of drivers' having just passed the pick-up unit. From observation, it appeared that drivers inherently reacted to the presence of a patrol officer regardless of the speed at which they were traveling.

Traffic speeds in the opposing direction did not completely return to normal immediately after passing the enforcement unit. The influence was still evident two miles from the enforcement unit but had dissipated at four miles.

In comparing speeds by the direction of travel at the enforcement unit, the studies in Area One, Two, and Three show differences in average speed of 5.0 to 6.8 MPH, while Area Four shows a difference of only 2.4 MPH. In the latter study, the pick-up unit was located approximately one-half mile from the enforcement unit as compared with approximately one-fourth mile in the other three studies. This comparison suggests that the pick-up unit was the primary cause of the speed reductions.

Figure 25 indicates the general influence of radar enforcement on traffic speeds. The speed profiles show the minimum speed to be in the vicinity of the pick-up unit. Although speeds were not measured at the pick-up unit for practical reasons, field observation showed that the maximum speed reduction occurred in that general area.

TABLE 11

COMPARISON OF AVERAGE SPEEDS AND PERCENTAGES OF TRAFFIC EXCEEDING SPEED LIMIT

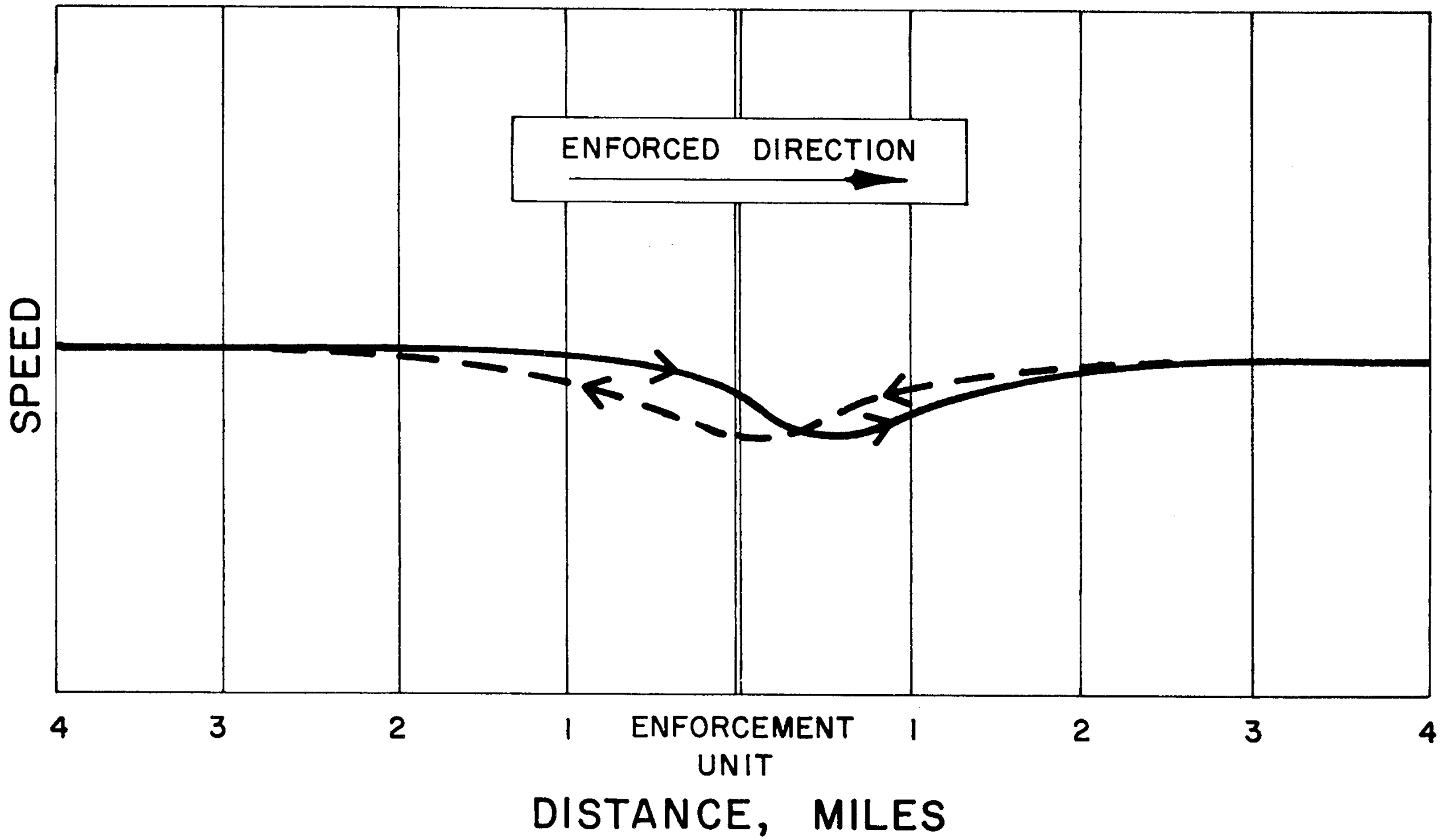
Direction of Travel →
Enforced Direction

Study		4 miles	3 miles	2 miles	1 mile	Enforcement Unit	1.25 miles	2 miles	3 miles	4 miles
Area One	Average Speed, MPH	54.1				51.6	49.8			
	Percent Exceeding Speed Limit	40*				30	12			
Area Two	Average Speed, MPH			54.3		52.9			50.3	
	Percent Exceeding Speed Limit			43		32			19	
Area Three	Average Speed, MPH				** 51.8	53.4		50.0		
	Percent Exceeding Speed Limit				26	34		15		
Area Four	Average Speed, MPH					50.8		50.2		52.1
	Percent Exceeding Speed Limit					25		14		31

* Speed Limit - 55 MPH
** Slight Effect of Grade

← Direction of Travel
Non-Enforced Direction

Study		4 miles	3 miles	2 miles	1 mile	Enforcement Unit	1.25 miles	2 miles	3 miles	4 miles
Area One	Average Speed, MPH	53.8				46.6	49.7			
	Percent Exceeding Speed Limit	40				6	18			
Area Two	Average Speed, MPH			51.6		47.8				
	Percent Exceeding Speed Limit			22		7				
Area Three	Average Speed, MPH				51.6	44.6		52.0		
	Percent Exceeding Speed Limit				26	2		32		
Area Four	Average Speed, MPH					48.4		51.7		53.3
	Percent Exceeding Speed Limit					10		21		38



SPEED PROFILES IN AREA OF ENFORCEMENT

FIGURE 25

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions have been drawn from the results of this research:

1. Substantial speed reductions occurred when sight distance was below 1000 to 1200 feet. This sight distance, defined as the distance ahead in which the driver could see the roadway and related development, appeared to alter the driver's choice of speed only in developed areas where there were potential traffic conflicts.

2. The introduction of a curbed urban street cross-section had an effect on the speed pattern.

3. Continuous residential development caused a reduction in traffic speeds. The extent of this reduction was more dependent upon the lateral restrictions it imposed than on the relative density of development. Extensive planting of trees and shrubbery near the roadway contributed greatly to this result.

4. Concentrated commercial development in transition areas caused substantial reductions in traffic speeds.

5. The faster drivers in the rural areas were generally the faster drivers throughout the transition areas. Generally, the speed groups remained in the same relative position in the over-all distribution throughout the rural and urban areas,

6. The speeds of vehicles making trips entirely within the developed area were consistently slower than vehicles traveling through the the developed area.

7. The test car technique is a reliable means of predicting normal driver reactions to factors influencing traffic speeds.

8. In the 24-hour speed studies, there were no substantial differences in hourly average speeds within the hours of normal traffic operation. Even smaller variations were observed in the 85-percentile speeds.

9. Traffic speeds were reduced in the immediate vicinity of radar enforcement activity. The localized influence of enforcement had essentially dissipated at four miles on either side of the radar unit.

Recommendations

The results of this research have shown that traffic responds to changing conditions on the roadway and surrounding area in a manner which is definitely in the interests of safety. Therefore, it is logical that speed limits be established using as a basis the characteristics of traffic speeds observed on the roadway. Any method or procedure of speed zoning which truly represents the speed characteristics of the traffic is acceptable.

It is reasonable that the speed characteristic chosen as a basis for speed zoning be representative of the majority of the traffic on the roadway. This majority is best defined by a speed value on a cumulative speed distribution curve above which the higher speed values are associated with rapidly decreasing percentages of vehicles, i.e., the breakpoint of the curve. Numerous observations have shown that this breakpoint is closely approximated by the 85-percentile speed.

It is recognized that traffic volumes on many secondary roadways are often too low to provide adequate samples of spot speed data within a reasonable length of time. Under such conditions it appears reasonable that methods of predicting traffic speed characteristics based on prevailing conditions would be much more economical and equally or more reliable than the small speed samples obtainable. However, based on this research, numerical values cannot be assigned to factors influencing speeds because each of the factors most frequently occurs in combination with other factors. These factors are believed to impose variable influences, dependent upon the specific combination, and upon their sequence of occurrence within the developed area.

It is possible that a straight line relationship could be used to predict with reasonable accuracy speed characteristics in short, compact transition sections in small towns. However, fixing the end points of the line would depend upon good engineering judgment. Generally, the rural speed limit could be used at the beginning of concentrated development. The urban end could be fixed by a reliable spot speed study at the inbound end of the transition section.

In longer transition sections where the straight line relationship does not necessarily apply, the test car method could be used in conjunction with a very limited number of reliable spot speed studies to predict the traffic speed characteristics continuously throughout the transition area.

This research has shown that traffic operation on a facility is directly related to its geometric design and the character of development along the roadway. Therefore, if proper consideration is given to the influence of geometric elements and future development, it is possible to predict the level of service afforded throughout the design life of the facility.

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A P P E N D I X

TABLE A

RESULTS OF BEFORE AND AFTER STUDIES TO DETERMINE
THE EFFECT OF POSTED SPEED LIMITS ON TRAFFIC SPEEDS

District 12 (Houston)

Original Speed Limit - 60 M. P. H.

Speed Limit Before	Speed Limit After	Number of Vehicles	85-Percentile Speed (MPH)	15-Percentile Speed (MPH)	Speed Differential (MPH)	Average Speed (MPH)	Pace (MPH)	Standard Deviation (MPH)
60		1518	59.4	42.0	17.4	51.68	48-58	8.61
	60	1564	58.7	41.7	17.0	51.33	48-58	8.62
60		2783	55.5	37.5	18.0	47.33	40-50	8.77
	55	3099	55.0	38.3	16.7	47.62	42-52	8.06
60		2930	53.7	35.5	18.2	45.64	38-48	8.80
	50	2976	52.0	35.1	16.9	44.54	38-48	7.92
60		2850	47.3	31.2	16.1	40.27	32-42	8.00
	45	2817	46.4	32.6	13.8	40.59	34-44	6.93
60		524	41.5	28.3	13.2	35.74	28-38	6.21
	40	481	39.9	28.5	11.4	35.41	30-40	5.56
60		1807	40.2	25.6	14.6	33.70	26-36	7.30
	35	2052	38.9	24.3	14.6	32.77	26-36	7.27
60		531	31.2	21.3	9.9	27.53	22-32	4.98
	30	571	33.2	23.3	9.9	29.23	22-32	4.83

District 1 (Paris)

Original Speed Limit - 60 M. P. H.

Speed Limit Before	Speed Limit After	Number of Vehicles	85-Percentile Speed (MPH)	15-Percentile Speed (MPH)	Speed Differential (MPH)	Average Speed (MPH)	Pace (MPH)	Standard Deviation (MPH)
60		5452	57.0	33.8	23.2	46.22	40-50	10.90
	60	4902	56.6	35.0	21.6	46.85	40-50	10.09
60		407	55.2	35.1	20.1	45.55	38-48	9.09
	55	614	51.2	33.5	17.7	43.86	40-50	8.62
60		2611	51.5	29.3	22.2	41.74	32-42	10.45
	50	2010	50.9	30.7	20.2	42.06	38-48	10.09
60		954	47.6	23.4	24.2	36.72	24-34	11.41
	45	658	43.9	26.3	17.6	36.07	28-38	8.21
60		431	40.4	22.8	17.6	33.17	28-38	8.57
	40	338	38.6	24.7	13.9	32.98	28-38	6.64

District 1 (Paris)

Original Speed Limit - 30 M. P. H.

Speed Limit Before	Speed Limit After	Number of Vehicles	85-Percentile Speed (MPH)	15-Percentile Speed (MPH)	Speed Differential (MPH)	Average Speed (MPH)	Pace (MPH)	Standard Deviation (MPH)
30		4584	53.2	30.7	22.5	26.83	38-48	7.10
	55	3596	50.5	33.5	17.0	27.99	38-48	6.96
30		1103	52.6	30.4	22.2	30.18	32-42	7.19
	50	832	51.3	32.5	18.8	31.41	38-48	7.51
30		4742	45.4	28.1	17.3	33.68	30-40	7.97
	45	4156	45.2	28.8	16.4	34.61	32-42	8.12
30		2678	40.3	24.4	15.9	37.50	28-38	8.25
	40	2165	42.0	25.2	16.8	37.89	28-38	7.91
30		1032	36.8	21.4	15.4	42.64	24-34	10.61
	35	983	38.4	23.0	15.4	42.97	24-34	9.06
30		322	33.5	18.3	15.2	43-33	20-30	10.77
	30	400	34.1	19.5	14.6	43.22	22-32	7.96

TABLE B

COMPARISON OF COMMERCIAL WITH ALL FREE-FLOW-VEHICLE SPEEDS

	NORTHBOUND-OUTBOUND				SOUTHBOUND-INBOUND			
	Commercial		Free-Flow		Commercial		Free-Flow	
Sector	No. Veh.	Avg. Speed	No. Veh.	Avg. Speed	No. Veh.	Avg. Speed	No. Veh.	Avg. Speed
STUDY I								
1	15	47.0	51	39.4	6	42.3	27	46.2
2	15	39.5	51	37.6	6	37.3	27	40.2
3	15	35.7	51	33.4	6	33.2	27	38.4
4	15	34.3	51	34.6	6	32.7	27	37.6
5	15	37.8	51	38.7	6	34.9	27	41.0
6	15	38.6	51	47.0	6	38.4	27	44.9
STUDY II								
1	19	27.0	159	32.6	12	34.5	143	35.6
2	19	33.1	159	37.7	12	38.3	143	38.5
3	19	33.5	159	38.2	12	39.6	143	41.5
4	19	34.3	159	40.2	12	41.0	143	43.0
5	19	36.4	159	40.6	12	40.6	143	42.6
6	19	39.6	159	45.5	12	42.3	143	44.4
7	19	38.9	159	45.1	12	45.8	143	46.5
STUDY III								
1	8	28.9	140	30.9	12	30.6	140	32.6
2	8	29.3	140	31.4	12	30.4	140	32.2
3	8	31.5	140	33.5	12	35.7	140	35.1
4	8	33.4	140	37.3	12	39.7	140	40.4
5	8	36.7	140	42.6	12	40.8	140	42.9
STUDY IV								
1	14	25.3	100	32.7	24	30.9	112	33.8
2	14	31.7	100	37.1	24	35.7	112	37.2
3	14	35.0	100	39.2	24	39.0	112	39.2
4	14	38.9	100	43.9	24	46.1	112	45.8
5	14	39.4	100	43.9	24	44.4	112	45.7
6	14	44.6	100	47.6	24	49.8	112	51.0
7	14	44.0	100	48.0	24	50.0	112	53.5
8	14	43.3	100	48.8	24	53.5	112	55.4
9	14	43.2	100	49.9	24	51.6	112	55.1
STUDY V								
1	17	45.7	127	51.5	19	37.2	171	43.6
2	17	42.6	127	47.4	19	38.5	171	44.5
3	17	37.2	127	40.1	19	35.2	171	38.2
4	17	33.0	127	33.8	19	32.0	171	32.8
5	17	36.5	127	38.7	19	36.8	171	39.2
6	17	39.4	127	44.8	19	43.0	171	47.1
7	17	41.6	127	48.1	19	45.7	171	54.0
8	17	42.4	127	49.5	19	47.5	171	56.1

TABLE C

SPEED CHARACTERISTICS FOR EACH SECTOR IN STUDY SECTION

STUDY I

	Northbound			Southbound		
	All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
	Sector 1			Sector 1		
No. Veh.	205	129	51	111	81	27
Avg. Speed	39.9	40.1	39.4	43.8	45.0	46.2
85%	47.5	48.0	47.0	48.5	52.5	56.5
15%	31.0	32.5	31.5	34.5	36.0	35.5
Speed Diff.	16.5	15.5	15.5	14.0	16.5	21.0
Pace	33-43	33-43	33-43	39-49	39-49	35-45
Std. Dev.	8.86	8.07	8.30	7.15	7.56	8.98
	Sector 2			Sector 2		
No. Veh.	236	129	51	129	81	27
Avg. Speed	35.6	37.4	37.6	38.5	37.9	40.2
85%	41.0	42.0	44.0	43.5	44.5	52.0
15%	28.0	31.0	30.0	31.0	29.0	31.0
Speed Diff.	13.0	11.0	14.0	12.5	15.5	21.0
Pace	29-39	33-43	33-43	31-41	33-43	31-41
Std. Dev.	6.45	5.90	6.69	7.14	7.82	8.75
	Sector 3			Sector 3		
No. Veh.	220	129	51	116	81	27
Avg. Speed	31.6	33.0	33.4	34.4	35.1	38.4
85%	36.0	37.0	38.5	39.5	40.0	46.5
15%	25.0	27.0	27.0	26.5	28.5	28.0
Speed Diff.	11.0	10.0	11.5	13.0	11.5	18.0
Pace	27-37	27-37	27-37	29-39	29-39	29-39
Std. Dev.	6.14	5.91	6.30	7.01	7.97	11.11
	Sector 4			Sector 4		
No. Veh.	210	129	51	120	81	27
Avg. Speed	32.3	32.7	34.6	33.3	35.9	37.6
85%	37.5	37.5	39.0	38.0	40.5	42.0
15%	25.5	26.0	28.0	27.0	28.0	28.5
Speed Diff.	12.0	11.5	11.0	11.0	12.5	13.5
Pace	25-35	27-37	31-41	27-37	31-41	31-41
Std. Dev.	6.40	6.10	6.59	6.60	6.49	7.78
	Sector 5			Sector 5		
No. Veh.	225	129	51	120	81	27
Avg. Speed	36.8	37.9	38.7	36.9	39.9	41.0
85%	42.0	43.5	44.0	42.5	43.5	46.5
15%	29.0	29.5	31.0	29.0	32.5	31.5
Speed Diff.	13.0	14.0	13.0	13.5	11.0	15.0
Pace	31-41	35-45	35-45	33-43	33-43	35-45
Std. Dev.	7.06	6.76	6.66	7.42	7.04	9.06

Table C Cont.

	Sector 6			Sector 6		
No. Veh	230	129	51	137	81	27
Avg. Speed	45.9	47.2	47.0	43.3	43.9	44.9
85%	51.5	52.0	52.5	50.0	49.5	53.5
15%	38.0	39.0	38.5	34.5	35.6	35.6
Speed Diff.	13.5	13.0	14.0	15.5	13.9	17.9
Pace	41-51	41-51	41-51	37-47	39-49	39-49
Std. Dev.	7.04	6.74	6.80	7.69	7.06	8.77

TABLE D

SPEED CHARACTERISTICS FOR EACH SECTOR
IN STUDY SECTION

STUDY II

	Outbound			Inbound		
	All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
	Sector 1			Sector 1		
No. Veh.	422	237	159	374	219	143
Avg. Speed	33.0	32.6	32.6	34.8	35.0	35.6
85%	39.0	39.0	38.5	40.0	40.0	41.0
15%	24.5	24.0	24.0	27.0	27.5	28.0
Speed Diff.	14.5	15.0	14.5	13.0	12.5	13.0
Pace	27-37	27-37	27-37	31-41	29-39	29-39
Std. Dev.	7.62	7.41	7.25	7.40	7.61	7.75
	Sector 2			Sector 2		
No. Veh.	347	237	159	323	219	143
Avg. Speed	37.0	37.4	37.7	38.0	38.8	38.5
85%	44.5	45.0	43.0	44.0	44.0	45.0
15%	28.0	28.0	29.0	30.0	31.0	30.5
Speed Diff.	16.5	17.0	14.0	14.0	13.0	14.5
Pace	31-41	31-41	31-41	31-41	33-43	33-43
Std. Dev.	8.22	8.11	7.62	7.47	6.67	6.77
	Sector 3			Sector 3		
No. Veh.	355	237	159	315	219	143
Avg. Speed	38.1	38.0	38.2	40.0	41.4	41.5
85%	47.0	47.0	46.0	47.5	49.0	49.5
15%	27.5	28.5	29.5	30.0	31.5	31.0
Speed Diff.	19.5	18.5	16.5	17.5	17.5	18.5
Pace	31-41	33-43	31-41	35-45	35-45	35-45
Std. Dev.	9.32	9.22	8.30	8.91	8.30	8.54
	Sector 4			Sector 4		
No. Veh.	377	237	159	303	219	143
Avg. Speed	39.5	39.8	40.2	41.8	43.0	43.0
85%	47.5	48.0	47.5	49.0	50.0	50.0
15%	30.0	30.0	31.0	32.5	34.5	34.0
Speed Diff.	17.5	18.0	16.5	16.5	15.5	16.0
Pace	33-43	35-45	35-45	37-47	37-47	37-47
Std. Dev.	8.96	9.12	8.58	8.41	7.75	7.60
	Sector 5			Sector 5		
No. Veh.	274	237	159	262	219	143
Avg. Speed	39.8	40.2	40.6	41.3	42.1	42.6
85%	47.5	48.0	48.5	49.0	49.5	50.0
15%	30.0	30.5	31.0	31.5	32.0	33.0
Speed Diff.	17.5	17.5	17.5	17.5	17.5	17.0
Pace	35-45	35-45	35-45	35-45	35-45	35-45
Std. Dev.	9.26	8.81	8.85	8.98	8.32	8.15

Table D Cont.

	Sector 6			Sector 6		
No. Veh.	280	237	159	261	219	143
Avg. Speed	43.8	45.1	45.5	43.5	44.7	44.4
85%	53.5	54.0	54.5	53.5	53.5	54.0
15%	32.0	34.0	34.5	32.5	34.0	34.5
Speed Diff.	21.5	20.0	20.0	21.0	19.5	19.5
Pace	39-49	39-49	41-51	41-51	41-51	37-47
Std. Dev.	10-83	10.52	10.64	10.26	9.37	9.10
	Sector 7			Sector 7		
No. Veh.	271	237	159	248	219	143
Avg. Speed	43.8	44.5	45.1	46.0	46.8	46.5
85%	52.0	52.5	53.0	54.5	55.0	55.5
15%	33.0	34.0	35.0	35.5	36.5	36.0
Speed Diff.	19.0	18.5	18.0	19.0	18.5	19.5
Pace	41-51	41-51	41-51	43-53	43-53	43-53
Std. Dev.	9.79	9.78	9.25	9.72	9.30	9.76

TABLE E

SPEED CHARACTERISTICS FOR EACH SECTOR IN STUDY SECTION

STUDY III

	Outbound			Inbound		
	All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
	Sector 1			Sector 1		
No. Veh.	469	208	140	344	200	140
Avg. Speed	30.4	30.9	30.9	31.2	32.2	32.6
85%	35.5	35.0	35.0	35.5	36.0	37.0
15%	24.5	25.0	25.5	25.5	26.5	27.0
Speed Diff.	11.0	10.0	9.5	10.0	9.5	10.0
Pace	25-35	27-37	27-37	25-35	25-35	27-37
Std. Dev.	5.57	5.72	5.03	5.34	5.14	5.11
	Sector 2			Sector 2		
No. Veh.	422	208	140	321	200	140
Avg. Speed	31.2	31.1	31.4	31.2	31.6	32.2
85%	35.5	35.0	35.5	35.0	36.0	36.5
15%	24.0	24.5	25.0	25.0	25.0	25.5
Speed Diff.	11.5	10.5	10.5	10.0	11.0	11.0
Pace	25-35	29-39	27-37	25-35	25-35	25-35
Std. Dev.	6.41	5.96	5.97	5.65	5.92	5.41
	Sector 3			Sector 3		
No. Veh.	350	208	140	269	200	140
Avg. Speed	32.8	32.7	33.5	34.3	35.0	35.1
85%	37.5	37.5	38.5	39.5	39.5	39.0
15%	26.5	26.5	27.0	27.5	28.0	29.0
Speed Diff.	11.0	11.0	11.5	12.0	11.5	10.0
Pace	27-37	27-37	27-37	29-39	29-39	29-39
Std. Dev.	7.02	6.35	5.39	7.04	6.06	5.79
	Sector 4			Sector 4		
No. Veh.	360	208	140	281	200	140
Avg. Speed	36.3	36.5	37.3	39.3	40.1	40.4
85%	42.0	42.0	43.0	46.5	46.0	46.0
15%	29.0	28.5	29.5	30.5	33.0	33.5
Speed Diff.	13.0	13.5	13.5	16.0	13.0	12.5
Pace	29-39	33-43	33-43	35-45	35-45	35-45
Std. Dev.	6.66	6.86	7.00	7.61	6.81	6.48
	Sector 5			Sector 5		
No. Veh.	268	208	140	250	200	140
Avg. Speed	41.0	41.2	42.6	44.0	43.3	42.9
85%	49.0	49.0	50.5	51.0	49.5	49.5
15%	33.0	33.0	34.0	34.5	35.0	34.5
Speed Diff.	16.0	16.0	16.5	16.5	14.5	15.0
Pace	33-43	33-43	37-47	39-49	39-49	37-47
Std. Dev.	7.92	8.22	7.93	9.10	7.57	7.59

TABLE F

SPEED CHARACTERISTICS FOR EACH SECTOR
IN STUDY SECTION

STUDY IV

	Outbound			Inbound		
	All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
	Sector 1			Sector 1		
No. Veh.	204	128	100	237	161	112
Avg. Speed	30.6	32.1	32.7	32.2	33.2	33.8
85%	37.5	38.5	39.0	36.5	38.0	38.5
15%	22.0	23.5	24.0	25.5	26.5	27.0
Speed Diff.	15.5	15.0	15.0	11.0	11.5	11.5
Pace	25-35	27-37	31-41	27-37	27-37	27-37
Std. Dev.	7.61	7.10	7.16	6.84	6.07	5.74
	Sector 2			Sector 2		
No. Veh.	237	128	100	246	161	112
Avg. Speed	34.6	36.9	37.1	35.0	36.7	37.2
85%	41.5	43.0	43.0	40.5	42.0	42.5
15%	26.0	29.0	29.0	27.5	29.0	29.5
Speed Diff.	15.5	14.0	14.0	13.0	13.0	13.0
Pace	29-39	31-41	31-41	29-39	29-39	33.43
Std. Dev.	7.86	8.01	7.92	6.80	6.43	6.36
	Sector 3			Sector 3		
No. Veh.	246	128	100	273	161	112
Avg. Speed	35.4	38.9	39.2	36.0	38.8	39.2
85%	43.0	44.5	45.0	42.5	44.0	44.0
15%	26.5	30.5	30.5	28.5	31.0	31.5
Speed Diff.	16.5	14.0	14.5	14.0	13.0	12.5
Pace	29-39	37-47	37-47	29-39	33-43	33-43
Std. Dev.	8.02	7.01	6.95	7.14	6.33	6.34
	Sector 4			Sector 4		
No. Veh.	208	128	100	243	161	112
Avg. Speed	41.6	43.5	43.9	42.1	44.3	45.8
85%	49.0	50.5	50.5	50.0	50.5	51.5
15%	31.5	33.5	33.5	32.5	35.5	37.0
Speed Diff.	17.5	17.0	17.0	17.5	15.0	14.5
Pace	37-47	39-49	37-47	37-47	39-49	43-53
Std. Dev.	8.56	8.12	8.29	8.61	7.94	7.53
	Sector 5			Sector 5		
No. Veh.	174	128	100	209	161	122
Avg. Speed	42.3	43.2	43.9	43.5	44.2	45.7
85%	49.0	49.0	49.5	49.5	49.0	50.0
15%	34.5	34.5	35.0	35.5	36.0	37.0
Speed Diff.	14.5	14.5	14.5	14.0	13.0	13.0
Pace	39-49	41-51	41-51	41-51	41-51	41-51
Std. Dev.	7.66	7.55	7.71	8.90	8.61	7.78

Table F Cont.

	Sector 6				Sector 6	
No. Veh.	179	128	100	225	161	112
Avg. Speed	48.0	47.4	47.6	48.5	50.3	51.0
85%	54.5	54.5	55.0	55.5	57.0	57.5
15%	36.0	38.5	38.5	39.5	41.0	41.5
Speed Diff.	18.5	16.0	16.5	16.0	16.0	16.0
Pace	43-53	43-53	43-53	41-51	45-55	45-55
Std. Dev.	8.99	8.20	8.57	8.35	7.77	8.09
	Sector 7				Sector 7	
No. Veh.	177	128	100	215	161	112
Avg. Speed	46.9	48.3	48.0	51.3	53.0	53.5
85%	55.5	55.0	54.0	60.0	61.0	61.5
15%	37.0	38.5	38.0	42.0	44.0	43.5
Speed Diff.	18.5	16.5	16.0	18.0	17.0	18.0
Pace	45-55	45-55	45-55	45-55	45-55	47-57
Std. Dev.	9.34	8.53	8.34	8.29	8.19	8.84
	Sector 8				Sector 8	
No. Veh.	176	128	100	215	161	112
Avg. Speed	48.1	47.6	48.8	52.8	54.2	55.4
85%	56.5	55.5	57.0	61.0	62.5	63.0
15%	37.0	36.5	37.5	43.5	44.0	44.0
Speed Diff.	19.5	19.0	19.5	17.5	18.5	19.0
Pace	45-55	43-53	45-55	47-57	47-57	49-59
Std. Dev.	9.70	9.58	9.28	8.61	8.44	9.06
	Sector 9				Sector 9	
No. Veh.	172	128	100	214	161	112
Avg. Speed	49.3	49.8	49.9	53.2	54.3	55.1
85%	58.0	58.0	58.0	62.0	64.0	64.0
15%	38.0	37.5	37.5	43.5	44.5	44.5
Speed Diff.	20.0	20.5	20.5	18.5	19.5	19.5
Pace	47-57	47-57	49-59	45-55	45-55	49-59
Std. Dev.	10.02	9.84	9.90	8.61	9.00	9.65

TABLE G

SPEED CHARACTERISTICS FOR EACH SECTOR
IN STUDY SECTION

STUDY V

	Northbound			Southbound		
	All Veh.	Through Vehicles	Free-Flow Vehicles	All Veh.	Through Vehicles	Free-Flow Vehicles
	Sector 1			Sector 1		
No. Veh.	266	172	127	318	212	171
Avg. Speed	48.3	51.4	51.5	41.8	43.5	43.6
85%	57.0	58.5	59.0	50.0	51.0	51.0
15%	36.0	43.0	42.0	31.0	35.0	35.0
Speed Diff.	21.0	15.5	17.0	19.0	16.0	16.0
Pace	47-57	47-57	49-59	37-47	41-51	41-51
Std. Dev.	10.15	8.53	8.32	9.08	8.13	8.20
	Sector 2			Sector 2		
No. Veh.	286	172	127	318	212	171
Avg. Speed	45.1	47.3	47.4	42.5	44.4	44.5
85%	53.5	55.0	55.0	50.5	50.0	51.0
15%	35.0	38.5	38.0	31.5	35.0	35.0
Speed Diff.	18.5	16.5	17.0	19.0	15.0	16.0
Pace	39-49	41-51	41-51	39-49	41-51	41-51
Std. Dev.	9.22	7.85	7.57	9.14	7.97	8.03
	Sector 3			Sector 3		
No. Veh.	270	172	127	325	212	171
Avg. Speed	36.8	39.9	40.1	35.1	38.2	38.2
85%	53.5	55.0	55.0	50.5	50.5	51.0
15%	35.0	38.5	38.0	31.5	35.0	35.0
Speed Diff.	16.5	15.5	16.0	17.0	15.0	14.5
Pace	31-41	31-41	33-43	27-37	31-41	31-41
Std. Dev.	8.59	7.59	7.31	8.35	7.34	7.44
	Sector 4			Sector 4		
No. Veh.	217	172	127	278	212	171
Avg. Speed	33.5	33.7	33.8	31.7	32.8	32.8
85%	39.5	39.5	39.0	39.0	38.5	39.0
15%	25.0	26.5	26.0	23.0	25.0	25.0
Speed Diff.	14.5	13.0	13.0	16.0	13.5	14.0
Pace	27-37	27-37	29-39	25-35	25-35	25-35
Std. Dev.	9.40	6.76	6.30	8.08	6.72	6.61
	Sector 5			Sector 5		
No. Veh.	257	172	127	306	212	171
Avg. Speed	37.5	38.7	38.7	38.0	39.1	39.2
85%	45.0	44.5	45.0	45.5	45.5	45.5
15%	29.5	31.0	31.5	29.5	31.5	31.5
Speed Diff.	15.5	13.5	13.5	16.0	14.0	14.0
Pace	31-41	31-41	31-41	31-41	31-41	31-41
Std. Dev.	8.04	7.05	7.09	7.73	7.03	7.14

Table G. Cont.

		Sector 6			Sector 6	
No. Veh.	279	172	127	323	212	171
Avg. Speed	42.4	45.0	44.8	46.0	47.3	47.1
85%	49.0	51.0	51.0	52.5	53.0	53.0
15%	33.5	36.5	37.0	37.5	39.5	40.0
Speed Diff.	15.5	14.5	14.0	15.0	13.5	13.0
Pace	37-47	37-47	39-49	41-51	41-51	41-51
Std. Dev.	8.16	7.70	7.36	7.06	6.28	6.30
		Sector 7			Sector 7	
No. Veh.	286	172	127	332	212	171
Avg. Speed	45.9	48.1	48.1	52.3	53.9	54.0
85%	53.5	55.0	55.0	60.5	61.0	61.0
15%	36.0	38.5	39.0	42.5	45.0	44.0
Speed Diff.	17.5	16.5	16.0	18.0	16.0	17.0
Pace	41-51	41-51	41-51	45-55	49-59	49-59
Std. Dev.	8.54	8.02	7.96	9.28	7.73	7.79
		Sector 8			Sector 8	
No. Veh.	287	172	127	330	212	171
Avg. Speed	47.3	49.7	49.5	53.7	55.6	56.1
85%	55.5	57.5	58.0	62.0	63.5	63.0
15%	37.0	39.0	40.0	44.0	47.0	46.0
Speed Diff.	18.5	18.5	18.0	18.0	16.5	17.0
Pace	41-51	41-51	43-53	49-59	49-59	49-59
Std. Dev.	8.90	8.67	8.70	8.97	8.30	8.21

TABLE H

SUMMARY OF RESULTS

AREA ENFORCEMENT STUDY

AREA ONE

State Highway 6 - 4 Miles South of College Station

	Location A Research Unit		Enforcement Unit Enforced Direction		Location D Research Unit	
E - Enforced Direction	4 Miles			1.25 Miles		
O - Opposing Direction	E	O	E	O	E	O
Total No. of Vehicles	303	186	283	158	308	160
Average Speed, MPH	54.1	53.8	51.6	46.6	49.8	49.7
85-Percentile Speed, MPH	59	60	57	51	54	56
15-Percentile Speed, MPH	48	46	44	39	44	42
Speed Differential, MPH	11	14	13	12	10	14
Percent Exceeding 55 MPH	39.6	40.0	30.0	6.3	12.3	18.1
Percent Exceeding 60 MPH	13.5	14.5	7.8	1.8	2.0	3.5
Standard Deviation, S	6.75	7.15	6.90	6.32	4.83	6.89

AREA TWO

State Highway 6 - 11 Miles South of College Station

	Location B Research Unit		Enforcement Unit Enforcement Direction		Location G Research Unit	
E - Enforced Direction	2 Miles			3 Miles		
O - Opposing Direction	E	O	E	O	E	O
Total No. of Vehicles	204	191	207	164	220	
Average Speed, MPH	54.3	51.6	52.9	47.8	50.3	
85-Percentile Speed, MPH	60	56	58	52	55	
15-Percentile Speed, MPH	48	45	46	41	45	
Speed Differential, MPH	12	11	12	11	10	
Percent Exceeding 55 MPH	43.1	22.5	31.9	6.7	18.6	
Percent Exceeding 60 MPH	14.2	4.7	8.7	1.8	0.9	
Standard Deviation, S	6.07	6.23	6.20	5.41	5.50	

AREA THREE

State Highway 36 - 7 Miles North of Caldwell

	Location C Research Unit		Enforcement Unit Enforced Direction		Location E Research Unit	
E - Enforced Direction	1 mile			2 miles		
O - Opposing Direction	E	O	E	O	E	O
Total No. of Vehicles	179	89	160	79	182	84
Average Speed, MPH	51.8	51.6	53.4	44.6	50.0	52.0
85-Percentile Speed, MPH	58	56	61	48	54	59
15-Percentile Speed, MPH	45	45	45	39	43	43
Speed Differential, MPH	13	11	16	9	11	16
Percent Exceeding 55 MPH	26.3	25.9	34.3	2.5	15.4	32.2
Percent Exceeding 60 MPH	7.8	3.4	16.8	1.3	0	9.5
Standard Deviation, S	6.50	5.84	7.46	5.41	4.88	7.39

AREA FOUR

State Highway 6 - 9 Miles South of College Station

	Enforcement Unit Enforced Direction		Location F Research Unit		Location H Research Unit	
E - Enforced Direction		2 miles			4 miles	
O - Opposing Direction	E	O	E	O	E	O
Total No. of Vehicles	215	117	263	158	280	169
Average Speed, MPH	50.8	48.4	50.2	51.7	52.1	53.3
85-Percentile Speed, MPH	57	53	54	56	57	59
15-Percentile Speed, MPH	44	41	44	45	45	46
Speed Differential, MPH	13	12	10	11	12	13
Percent Exceeding 55 MPH	25.1	10.3	13.7	20.9	31.4	37.9
Percent Exceeding 60 MPH	5.6	0.9	1.2	7.0	5.0	13.0
Standard Deviation, S	6.70	5.64	5.00	5.82	6.15	7.38