Effect of Speed Limit Signs on Speed on Suburban Arterial Streets

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Speed control has been identified as one of the most important tools in attempting to counteract excessively fast driving and to reduce accidents. At the same time, speed control also has been recognized as a difficult and controversial issue due to the fact that criteria for establishing speed zones do not have the same degree of acceptability as have other traffic controls; for example, no-passing zones or traffic signals. Numerous speed studies have been conducted throughout the United States; very few, however, deal with speed patterns within the fringe area between the genuine rural and genuine urban area, generally termed the suburban area.

This paper reports the results of a study at five suburban areas of the combined effect of various speed limits and roadside development on driver speed patterns. Three of the locations concerned were two lane U.S. highways traversing suburban development of predominantly residential, commercial, and industrial type, respectively. One location was a four-lane, partially divided highway recently reconstructed from two lanes to four lanes. No speed limits had been posted along this highway after the reconstruction had been completed. Consequently, this highway was an excellent location for studying the effects of various posted speed limits, making possible comparisons between unrestricted and restricted speeds. Only free moving passenger vehicles traveling on dry pavement under optimum day and night visibility conditions were considered. Speed patterns for local and non-local vehicles were analyzed separately; local vehicles being those officially registered in the actual county as verified by the prefix on the license plate. Spot speeds were recorded, using an Electro-matic radar speed meter, at various points at each location, during day and night, before and after speed limit signs had been posted. Altogether, 31,573 vehicles were recorded, of which 20,552 were during the day and 11,021 were during the night.

The study revealed that the drivers paid little, if any, attention to posted speed limits. They seemed to choose a speed which they themselves considered appropriate for prevailing conditions. Non-local vehicles traveled significantly faster than local vehicles in many instances. Noticeable differences between day speeds and night speeds were also recorded at some sites. Variabilities in the speed distribution at a few individual stations for the same sign and road conditions were unexpectedly high, thus somewhat challenging the accuracy of fixed-point speed measurements.

The influence on the speed pattern of various types of roadside development was difficult to distinguish intelligibly, and was evidenced by the revelation of distinct interaction effects between the diverse factors. The limited number of locations, adequate for the roadside development study, also contributed to making difficult an ultimate conclusion.

● FOR YEARS philosophers have argued that speed, per se, is not destructive. The elliptical path traveled by the earth with a speed exceeding 66,000 mph in its annual trip around the sun is actually a highly advanced freeway. There are, however, as yet,

no appreciable conflicts or frictions along this freeway in terms of crossroads or other vehicles.

To a mathematician, physicist, or astronomer, speed may simply mean the ratio of distance to time; to a traffic engineer speed means nothing, but in conjunction with terms such as mean speed, speed percentiles, speed zones, and other measurements it has significant connotations.

Man always has strived and always will strive for attaining faster and faster speeds on the land, on the sea, and in the air. The problem, therefore, is not only to develop vehicles which are able to travel at high speeds, but also to develop additional devices which will assist man to safely and efficiently control and use the speeds attained. McMonagle (1) has stated the same thing this way: "Speed is one of the great essential benefits which make highway transportation indispensable in modern America. It must be provided for and protected."

What speed is safe? Drastically expressed, the only safe speed is 0 mph (2,3), for accidents occur at all speeds. However, higher speeds do increase the chances of exposure to situations and the rapidity at which these develop may reduce the ability of a driver to react properly and may lead to more accidents. It also is generally true that speed is a factor in the severity of an accident (4).

Ever since the early growth in the use of motor vehicles, special attention has been given the problem of safe speed. In 1925 Dickinson and Marvin (5) defined safe speed as "such that a driver will be able to stop his vehicle within the distance ahead that is certain to be free from any obstruction." This is certainly still true today. What is then a good driver? Johnston (6) defines him as "one who starting on a journey regardless of the roadway, weather, vehicle, or traffic arrives at his destination without having any trouble himself or without causing anyone else any trouble." Is this a driver who always drives at a safe speed? A research study in Pennsylvania (7) revealed that the speeds of drivers with accident records were only slightly higher than those for drivers without accident records.

Yet, speed is often advocated as the greatest contributing cause to accidents. Thorough studies, however, have indicated that this may not be entirely true. A study in Minnesota of 40,000 accidents (2) in which data as to vehicle speeds were stated, showed that if every accident in which speed was the only violation could have been prevented the number of accidents would have been reduced less than 10 percent, and if all accidents could have been prevented in which speed was the primary cause of the accident the reduction in number of accidents would not have been much greater. Actually nearly 75 percent of the accidents involved some violation other than a speed violation. In 1955 the Chicago Park District ascribed speed as the principal cause of only nine percent of automobile accidents (8).

It is not surprising, therefore, that speed control is one of the most difficult and controversial problems of traffic operations. Criteria for establishing speed zones do not have the degree of acceptability as have such other traffic controls as no-passing zones or traffic signals. Speed control is difficult because variations in driving behavior between individuals complicate the establishment of adequate, reasonable, and uniform warrants based on objective speed surveys. Speed control is controversial because of the divergence of opinion among engineers, enforcement officers, the motorists, and the people living along the highway as to the proper speed and the appropriate methods for controlling speeds.

Speed control, however, is important because properly done it may facilitate movement at uniform speed and thereby contribute to improved capacity and safety. It may also assist the motorist in selecting speeds that are safe and that permit him to obtain the maximum utility, economy, and convenience from his vehicle and the road. Speed zoning has therefore developed and is defined as the establishment of reasonable speed limits, based on engineering study, for sections of street or highway where any general statewide legislative speed limits do not fit the road and traffic conditions (9). Speed limits for such speed zones are established for favorable weather and traffic conditions with further reduction due to inclement conditions regarded as the responsibility of the driver.

Approaching an urban area, speed zones generally begin in the fringe areas — usually

termed the suburban — in which roadside development of all kinds such as residences, filling stations, drive-in-theaters, cafes, and trailer courts may occur. This transition zone between rural and urban development is also often the transition zone for speed limits. Should there be a series of speed limit signs, gradually limiting the speed from the statewide limit in the rural area to the limit used in the urban area? What warrants should be used and where should signs be placed? Is the type of roadside development in the area a factor to be considered in signing the area? The answers to these questions were the purposes of a research project which the authors conducted and are the subject of this paper.

TABLE 1

SPEED STUDY LOCATIONS

Location	Urban Area	Highway	Direction from Which Vehicles Approach the Urban Area	Direction of Study	ADT
A	West Lafayette	US 52	North	Southbound & northbound	4,600-5,500
B	West Lafayette	Ind. 43	North	Southbound	2,800-4,300
C	Logansport	US 35	South	Northbound	3,500-4,100
D	Peru	US 31	North	Southbound	4,100-4,300
E	Wabash	US 24	East	Westbound	4,300-4,500

STUDY LOCATIONS

Five locations, given in Table 1 and shown in Figure 1, were selected as study sites. These locations generally met the following pre-set requirements:

1. The highway was straight and level so that the motorist could easily perceive the change from rural to suburban to urban area.
2. Posted speed limits if any, were not overly restrictive, and the limits were placed in reasonable decreasing order when approaching from the rural area.
3. No signals, stop signs or warning signs which might have an adverse effect on the speed pattern were present.
4. The roadside development was predominately of one type — residential, commercial, or industrial — on each section.

One of the five locations, referred to as Location A, was chosen for a comprehensive speed limit signing study due to the fact that the highway had been recently reconstructed from a two-lane to a four-lane facility and no speed limits had as yet been posted.

This highway in the rural area is a four-lane divided facility with a 30-ft wide grass median which narrows to a 5-ft concrete median as it enters the city limits (Fig. 2). The lane width is 12 ft. On one side of the highway are golf courses, on the other, some development which is not closely situated to the highway. The effect of this development on speed was subsequently found to be negligible. The highway inside the city has four undivided lanes, each 12 ft wide, and it runs through a developed residential area (Fig. 3). The test section of this highway was approximately 9,000 ft long with 3,800 ft of this distance primarily undeveloped or lightly developed and 5,200 ft highly developed as an urban residential area. The reconstruction of this highway was completed in the fall of 1958. From that date until June 1959 no speed zoning was in effect. Speed surveys were extensively performed during this period of time, especially in the inbound direction. At seven sites a radar speed meter was concealed and used to measure the speed of free-moving passenger vehicles. Vehicles were also classified into local and non-local vehicles with a local vehicle being one registered in the county

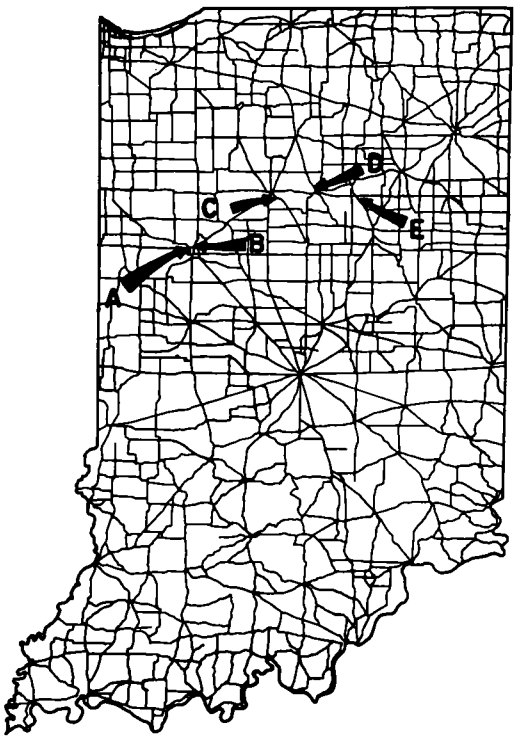

Figure 1. Study locations.

where the road was located. This was done because it was felt that local vehicles being familiar with the environment might be less sensitive to changes in posted speed limits than non-local vehicles. The effect of speed limits during day and night hours was also separately analyzed.

For more than one-half year this highway operated without posted speed limits and it was under these conditions that speed distributions for weekday operation were first obtained at the seven sites. It was from these comprehensive data that speed limits along the highway were determined and put into effect. The numerical values for the speed limits and their locations along the highway coincided as practically as possible with the 85th percentile speed found under no-sign conditions. Signs placed on the section included speed zone ahead and 50-, 40-, 35- and 30-mph speed limits. Only one sign at a time was posted starting with the higher speed limit, and the effect on the entire section was studied for several weeks before a new sign was added. This procedure continued until the complete signing plan (Table 2) had been completed.

Locations B, C, D, and E, the other four locations of this study, are similar in that they are the transition sections from rural to urban of major highways. Each of these locations was speed zoned prior to the study by the state highway department with the intent of reducing vehicle speeds from the 65-mph rural limit to a 30-mph urban limit. Location B was characterized by little development along it with none on one side of the highways due to a paralleling and nearby river. The development along Location C was almost entirely residential, that along Location D was primarily commercial and that along Location E primarily industrial.

Speed at Locations B, C, D, and E were taken at preselected sites throughout the suburban area in sufficient quantity to present a clear picture of the speed pattern for inbound vehicles in each zone. Speeds were taken in such a manner that the motorists were not aware that they were being checked. This was accomplished by concealing all personnel and the radar meter from the motorists view.

All speeds were taken at all locations under non-peak volume conditions and for each site this was when volume was less than the capacity of the road section. Speeds were taken of passenger cars only. Enforcement during the period of the study was not increased or decreased. Local authorities were requested to provide normal enforcement at the study locations.

TABLE 2

SPEED SIGNING PLAN AT LOCATION A

Area	Speed Sign Installed
Rural	65 mph, state limit
Approach to urban	Speed zone ahead
Residential development	Begin 50
Increasing in intensity	Begin 40
↓	40
	40
	Begin 35
	Begin 30

ANALYSIS OF SPEED PARAMETERS

The field data were analyzed to yield values of speed parameters for each station at each site by speed limit in effect at that station, residence of vehicle (local or non-local) and time of study (day or night). The parameters calculated were a measure of two characteristics of the speed distribution: the magnitude and the dispersion. The parameters of magnitude obtained were the mean speed, the median (or 50th percentile) speed, and the 15th and 85th percentile speed; those of dispersion were the variance (or square of the standard deviation), the speed differential, and the pace.

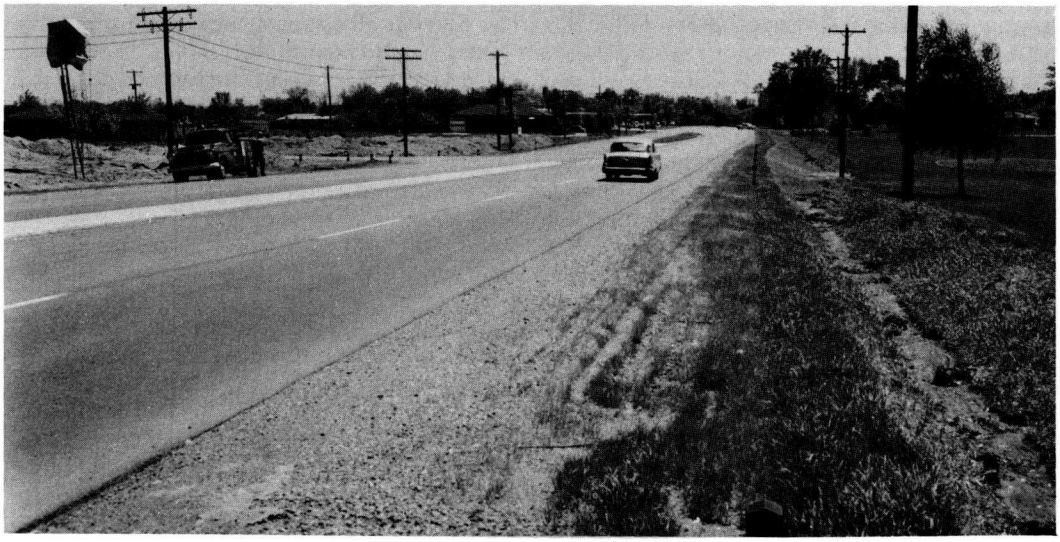

Figure 2. The sparse land development in the 50-mph zone of Location A is clearly evident.

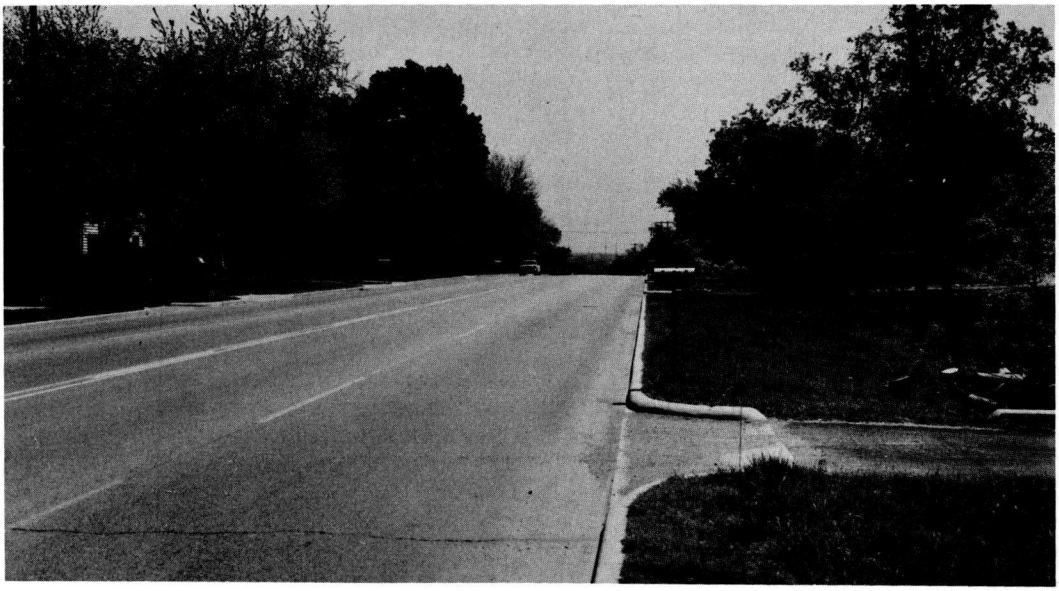

Figure 3. The almost complete residential development in the 40-mph zone of Location A is indicated by the residential drives, mailboxes, and residences.

These parameters were then analyzed by statistical methods to determine if differences in parameter values were significant for the different conditions and the source of such variation.

Location A

The effect of speed limit signs on speed in a suburban area as found in the comprehensive study at Location A is typically illustrated by the effect on the 85th percentile speed in Figures 4 to 7. These figures are for local vehicles, non-local vehicles, day, and night conditions, respectively, and for the after condition the data shown were obtained with the full speed limit signing plan (Table 2) in place.

The 85th percentile speeds of local vehicles were slightly higher after posting speed limit signs than they were before (Fig. 4). The increase is slight, however, and may be because of the removal of the uncertainity from some local motorists as to whether a lower speed limit, which had existed on the road before its reconstruction, still was in effect even though no signs were present. On the other hand, non-local drivers appeared to change their speeds very little after the posting of the limits (Fig. 5). Although there were some slight mathematical differences between the before-and-after 85th percentile speeds in the respective cases shown, there were no statistically significant differences at a five percent significance level.

Analysis of other parameters — average speed, 15th and 50th percentile speed, and the 10 mph pace — also revealed that in general they were not affected by the placing of speed limit signs.

Two well-known speed characteristics were also noted in this study. Speeds were, at most locations, significantly lower at night than during the day, but only by a small amount. Local vehicles were found to travel significantly slower than non-local vehicles but again by only a small amount and only at some stations.

At one site additional signing was studied. Data were obtained there for four conditions of posted speed limit, no posted limit, 40 mph, 35 mph, and 30 mph. The effect on the various parameters is given in Table 3.

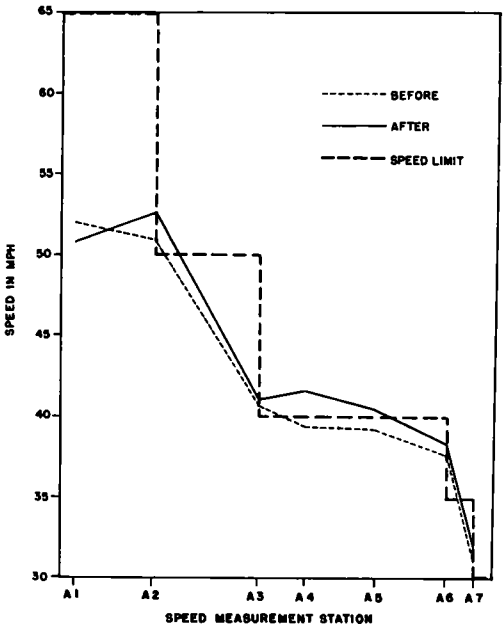

Figure 4. 85th percentile speed before and after posting of speed limits (local vehicles).

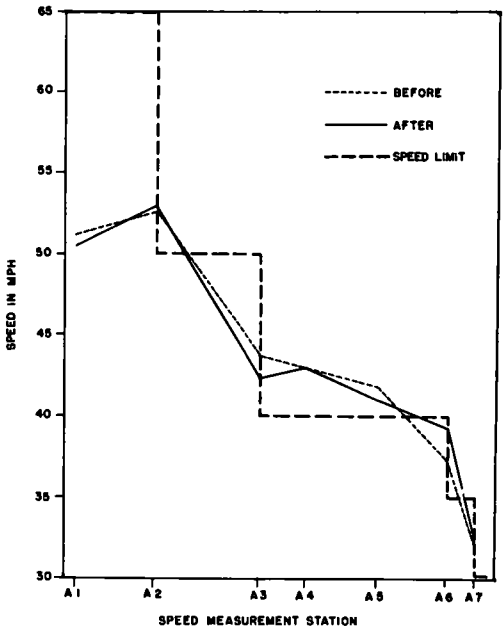

Figure 5. 85th percentile speed before and after posting of speed limits (non-local vehicles).

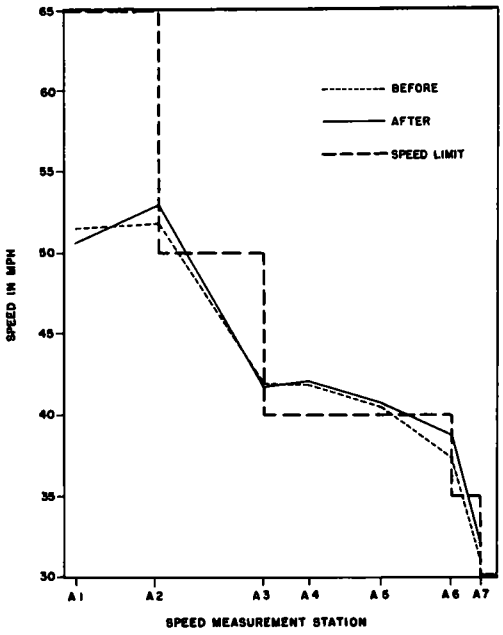

Figure 6. 85th percentile speed before and after posting of speed limits (day condition).

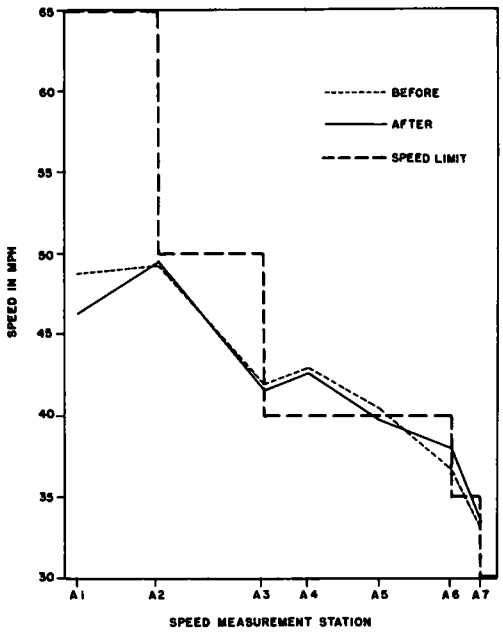

Figure 7. 85th percentile speed before and after posting of speed limits (night condition).

Although the results at this one site cannot be classed as conclusive, the results indicate the small changes which one might expect in speed parameters by speed zoning.

The 85th percentile speed, for example, was found to be virtually the same for the posted 40-, 35-, and 30-mph limits; in other words, the numerical value on the speed limit sign did not have any effect on this parameter at this site. The lower speed limit sign did give a larger percentage in the pace but the pace occurred at a higher range. The possibility of efficient enforcement was also noted. It must be characterized as impossible to apprehend more than one-third of the drivers because of speeding 5 mph over the speed limit (the situation with 30-mph sign); in fact, reputable enforcement officials have stated that apprehension of more than one percent of the drivers would be difficult. This was the approximate percentage in violation more than 5 mph at the posted 40-mph limit at this site.

Locations B, C, D, and E

The results found at the four other locations were similar. Location B, which had little development along it, was found to have a decreasing 85th percentile speed as one approached closer and closer to the urban area, but this speed was found to have little relation to the posted limit at any specific location. This was true because the signs had not been placed as the result of a speed zone study.

Speeds at sites on Locations C, D and E, each one displaying a predominant type of development, were statistically tested against each other to determine whether or not there was any significant differences in speed pattern by type of development. The results revealed significant differences in speed between comparable locations (except for type of development) including significant interactions. The results indicated that type of development may significantly affect actual speeds but the factors which could have affected the speed were so many that it was not possible to come to definite conclusions regarding this effect or to place any quantitative values on it. It was again found, however, that non-local vehicles at all locations traveled noticeably faster than local vehicles. It was also found that night driving speeds generally were significantly

TABLE 3

SPEED PARAMETERS FOR PASSENGER CARS AT ONE SITE WITH DIFFERENT POSTED SPEED LIMITS

Speed Parameter	Speed Limit Posted			
	None	40 mph	35 mph	30 mph
Mean speed (mph)	31.99	33.48	33.91	34.31
85th percentile speed (mph)	37.38	38.44	38.42	38.49
Speed differential (mph)	9.77	9.83	9.09	8.47
10-mph pace	26-35	28-37	28-37	30-39
Percent in pace	73.0	72.8	74.6	78.9
Standard deviation (mph)	4.65	4.83	4.70	4.26
Percent of vehicles exceeding the speed limit by 5 mph or more	0	1.6	10.1	37.8

lower than day speeds at the 5 percent level but by different amounts and the differences were not always significant. Little relationship between the posted speed limit and the 85th percentile speed at that point was noted at any of the locations.

CONCLUSIONS

This study revealed that drivers, in general, do not drive according to posted speed limit signs. Under normal enforcement conditions most of them select a speed which they consider proper, reasonable, and safe for conditions prevalent, regardless of regulations. Moreover, it was shown that when speed limits are determined from the 85th percentile speed, traveled speeds are not materially affected. The fear that the establishment of a speed limit which appears relatively high to some will create a new speed pattern with faster speeds appears to have no foundation.

The status of speed limit signs in this area of Indiana appears to be that most drivers will obey a posted speed limit if, and only if, the sign is properly posted and the numerical limit is that which they would travel without signs. Such signing, however, does permit realistic enforcement of speed limits, and the use of speed limits as an enforcement tool appears to be, in the absence of having an effect on speed, a primary use of speed zoning, at least until better respect for speed limit signs has again been established with the motorists.

The study of the effect of roadside development on speed did not produce conclusive results, but the many significant differences noted in the speeds indicated a strong possibility that there is a significant effect on speed by type of development.

It was also clearly evident that the relationship between speed and roadside development is extremely complex. More detailed studies of this effect would be extremely valuable.

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