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YIELD SIGN STUDY

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YIELD SIGN STUDY

INTRODUCTION

A. Nature of Problem

Yield signs were first installed as a traffic control device in Tulsa, Oklahoma early in 1951. Since then, there has been increased use at many intersections in cities and on highways throughout the country.¹ Since their introduction, the signs have been predominantly yellow background with black lettering. The earlier signs read YIELD RIGHT OF WAY in four lines (Photo 1). Recently, some signs have been modified to read only YIELD in somewhat larger letters, but still on a yellow background with a narrow black border (Photo 2). This is the type of sign that was used in the initial phase of this study. The theory is that a yield sign instead of a stop sign at an intersection will facilitate traffic movement because the driver need not stop at a yield sign in every instance. The driver approaching a yield sign can adjust his speed so as to arrive and proceed through the intersection

¹ "Application of Yield Right-Of-Way Signs" by James H. Kell, Traffic Engineering, Vol. 28, No. 10, July 1958.

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without stopping, allowing a greater traffic flow. This sign also has the advantage over an unmarked intersection in serving as a warning or regulation regarding opposing traffic. The question then arises whether yellow is the best color for this intended purpose. Is the yield sign in actuality a "warning" device for which the color is justly yellow, or is the yield sign a regulatory device for which some other color should be utilized? The special committee on color of the National Joint Committee on Uniform Traffic Control Devices has recommended to the technical committees of the National Joint Committee that the yield sign have red legend on white background with red border.² This indicates that the yield sign may be "regulatory" or "prohibitive" in nature.

B. Objectives of Study

The objective of this study is to evaluate the effect on drivers of two different variations of red yield signs at various types of intersections, in contrast to the yellow yield sign, all other conditions being assumed to remain unchanged.

GENERAL THEORY

A. Warrants for Yield Signs

Yield sign warrants are established in the Manual on Uniform Traffic Control Devices as follows:

²"Color in Traffic Control" by C.C. Robinson, Traffic Engineering, Vol. 37, No. 8, May 1967.

1. On a minor road at the entrance to an intersection where it is necessary to assign right-of-way to the major road, but where a stop is not necessary at all times, and where the safe approach speed on the minor road exceeds 10 mph.

2. On the entrance ramp to an expressway where an acceleration lane is not provided.

3. Within an intersection with a divided highway, where a stop sign is present at the entrance to the first roadway and further control is necessary at the entrance to the second roadway, and where the median width between the two roadways exceeds 30 ft.

4. Where a free right turn is permitted without adequate acceleration.

5. At any intersection where a special problem exists and where an engineering study indicates the problem to be susceptible to correction by use of the yield sign.

B. New Jersey law³ specifies as follows for yield signs:

The design and location of standard YIELD RIGHT OF WAY signs shall be as follows:

(a) Shape - Equilateral triangle with 1 point downward.

(b) Colors - Yellow background with black letters and border, all YIELD RIGHT OF WAY signs shall be illuminated or reflectorized.

³ Motor Vehicle and Traffic Regulations, Title 39 of the Revised Statutes, N.J. Department of Law and Public Safety, Division of Motor Vehicles, 39:4-183.16.

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- (c) Dimensions - All 3 sides shall be a minimum of 30 inches in length.
- (d) Message - YIELD RIGHT OF WAY.
- (e) Location - YIELD RIGHT OF WAY signs shall be located and erected in the same manner as stop signs.

For purposes of this study, special permission was obtained from the New Jersey Attorney General's office for the use of different color and message. Also, the YIELD RIGHT OF WAY message on the signs at the study locations were replaced by the message YIELD to conform with the M.U.T.C.D. for comparison in the "before" portion of the study.

The standardization of the general shape and message on the yield sign is of recent date, and there are still minor variations in use. For the purposes of this study, all signs were triangular, apex at bottom (point downward), with the single word YIELD. Three variations of the yield sign were studied. The study is essentially a "before" and "after" study. The sign used in the "before" portion of the study has a yellow background with black message and black border (Photo 2). The signs at 5 of the 6 locations were 36" x 36" with 6" D series letters and a 1/2" border. At the remaining location, the sign was 42" x 42" with 6" D series letters and a 5/8" border.

Two variations of the red yield sign were used in the "after" portion of the study. At three locations, a yield sign with white message and red background and white border was used. The signs were

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36" x 36" with 6" D series letters and a 5/8" border (Photo 3). At three other locations, a yield sign with white background and red message and red border was used. The signs were 36" x 36" with 4" D series letters and a 3" red border (Photo 4). The size of the border reduced the letter size. This sign was used at two locations. The same color sign was used at the third location, but the size was 42" x 42" with 6" D series letters and a 3" red border. This was done so as to keep the same size signs for both portions of the study. For the sake of brevity, the yellow background sign with black message and black border will be referred to as the yellow yield sign; the red background sign with white letters and white border will be referred to as the red yield sign; and the sign with white background, red message and red border will be referred to as the white yield sign.

SCOPE AND METHOD OF STUDY

This project was limited to studying the effect of the different color and pattern signs on YIELD control at six different intersections. The purpose is to evaluate the effectiveness of the red or white yield signs in relation to the yellow yield sign.

A typical "before" and "after" method of study was utilized, the yellow yield sign was used in the "before" portion at each of the locations; the red yield sign was used in the "after" portion at three locations, and the white yield sign was used at three locations.

A. Type Intersections

Three basic types of intersections utilizing YIELD control were studied.

Type 1 - T or + intersection with a channelized right turn; yield control for channelized right turn only.

Type 2 - Y intersection with the approach to the stem being controlled by yield sign.

Type 3 - A ramp merge intersection with ramp being controlled by a yield sign.

B. Descriptions of Study Sites

Site 1 - Type 1 (Figure 1) Arctic Parkway into Spruce Street, Ewing Township, Mercer County, New Jersey. These are both city (township) streets serving local traffic. Arctic Parkway is one block long (1800 ft.) between North Olden Avenue and Spruce Street, and the land use is basically commercial in nature (see Figure 1 for physical description of site). The original yellow yield sign at this location was replaced by a red yield sign.

Site 2 - Type 1 (Figure 2) Old Trenton Road (County Route 535) into Hightstown-Princeton Road (County Route 571) Locust Corner, East Windsor Township, Mercer County, New Jersey. Route 535 and Route 571 are County roads. Route 571 is the main artery between the Boroughs of Hightstown and Princeton (see Figure 2 for physical description of site). The

original yellow yield sign at this location was replaced by a white yield sign.

Site 3 - Type 3 (Figure 3) Route 18 (from New Brunswick) into Route 1 (south), New Brunswick, Middlesex County, New Jersey. This ramp entrance is one of several on this interchange, on one of the busiest highways in the State (see Figure 3 for physical description of site). The yellow yield sign was replaced by a red yield sign.

Site 4 - Type 3 (Figure 4) Route 68 (from Fort Dix) into Route 206 (to Trenton), Mansfield Square, Burlington County, New Jersey. This intersection serves to merge traffic from one of the busiest military installations in the country (Fort Dix - McGuire Air Force Base) with one of the busiest highway links from South Jersey (Atlantic City to Trenton). (See Figure 4 for physical description of site.) Two original yellow signs, one on each side of Route 68 point of merge, were replaced by white yield signs.

Site 5 - Type 2 (Figure 5) Calhoun Street into Princeton Avenue, City of Trenton, Mercer County, New Jersey. Both of these are busy, heavily travelled city streets, in a densely populated area. This street is a direct alternate connection to Pennsylvania via the Calhoun Street Bridge. Princeton Avenue is a direct connection between downtown Trenton and Route I and is designated Route IA (see Figure 5 for physical description of site). The original yellow yield sign was replaced by a red yield sign.

Site 6 - Type 2 (Figure 6) Arena Drive into South Olden Avenue, Hamilton Township, Mercer County, New Jersey. These two streets are moderately travelled local service streets through a typically mixed commercial-residential suburban area (see Figure 6 for physical description of site). The original yellow yield sign at this location was replaced by a white yield sign. This location utilized the 42" x 42" yield signs in both the "before" and "after" portion of the study.

C. Study Procedure

Since theoretically a yield sign is intended to cause a vehicle to stop or yield the right-of-way only when there is a vehicle on the roadway to be entered, it was decided to study, on a "before" and "after" basis, the following choices and reactions that a driver has when approaching a yield sign.

1. First, a vehicle approaching a yield sign can be the first vehicle in line at the sign; in other words, there is no vehicle in front of him to hinder his movement into the mainstream. If he is the first vehicle he has two major choices.

(a) He can stop when:

- 1) there is a vehicle approaching on the mainstream within the "zone of influence."
- 2) there is no vehicle approaching on the mainstream within the "zone of influence."

(b) He can pass through without stopping when:

- 1) there is a vehicle in the "zone of influence."
- 2) there is no vehicle in the "zone of influence."

2. Second, the vehicle approaching the yield sign may not be the first vehicle in line, i.e., there is a vehicle in front of him that causes him to wait. Since the vehicle in line was caused to stop by a vehicle in front of him, he had no choice of stopping or passing--he was forced to stop. These vehicles were not analyzed.

The "zone of influence" previously mentioned is a specific distance measured along the highway to be entered by the vehicle on the yield approach. Figure 1 shows a typical "zone of influence." The determination of this "zone" or "measured distance" was determined for each individual intersection. Table 1 shows the length of the "zones of influence" for each study site. The "zone" was defined by determining the time lag or gap in the mainstream traffic that was accepted by 50% of the vehicles entering the stream. (A sample size of 50 vehicles was used.) This time is in seconds and by multiplying this time by the average speed of vehicles in feet/sec. in the mainstream, the "zone of influence" can be set. An example would be as follows: The median lag or gap acceptance was found to be 3.0 seconds. In other words, 50% of the vehicles entering the mainstream accepted a lag or gap of three seconds or less. The mean speed on the mainstream was 45.9 ft./sec. (31.3 mph).

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The "zone of influence" would then be $45.9 \text{ ft./sec.} \times 3.0 \text{ sec.} = 138 \text{ ft.}$ This distance is measured from the point of entry of the side street vehicle to the outer limits of the distance determined above. Figures 1 through 6 show the "zones of influence" for each intersection. The 50% acceptance figure was selected arbitrarily, as any other percent would have probably sufficed since it was to be used for comparison of "before" and "after" data.

After the "zone of influence" had been marked on the pavement for each opposing leg, for each intersection, observations were made by an observer with a field sheet with the column headings as follows:

Column 1 - vehicle number

Column 2 - vehicle stopped

Column 3 - vehicle stopped in line

Column 4 - vehicle passed

Column 5 - entered with vehicle in left "zone of influence"

Column 6 - entered with vehicle in right "zone of influence"

Referring to Figure 7 the following example is given:

Vehicle 1 stopped for yield sign (column 2) and entered when no vehicle was in the "zone of influence." (No mark in columns 5 or 6.) Vehicle 2 arrived at the intersection and did not stop (column 4) and entered the mainstream when there was a vehicle in the left "zone of influence" (mark in column 5).

The only case where a mark would appear in both columns 5 and 6 would be when a vehicle had to cross opposing traffic in one zone to merge with the traffic in the second zone. An example would be when a vehicle stopped or passed in front of vehicles opposing from the left to merge with vehicles opposing from the right. Observers were stationed near the point of merge where they could observe fully each "zone of influence," as well as the vehicles on the yield approach.

The number of vehicles observed was 400 in both the "before" and "after" conditions at sites 1, 2, 3 and 4 and 800 observations at sites 5 and 6. The difference in sample size was due to the fact that vehicles at the first four sites were merging with the mainstream to the right only, while at sites 5 and 6, they could either merge to the right or cross the mainstream and merge to the left.

ANALYSIS

The data was collected on weekdays during off-peak hours. "Before" and "after" data was collected on the same day of the week and during the same hours of the day so as to attempt to have the same conditions for the "before" and "after" study. The red signs were not evaluated until they had been in service for at least a one-month period so as not to be affected by the "novelty" of the sign.

The data collected was analyzed statistically by utilizing the test for statistical differences in proportions. This is a standard

statistical test and utilizes the following formula:

$$t = \frac{P_1 - P_2}{\sqrt{\frac{P_1 (1-P_1)}{N_1} + \frac{P_2 (1-P_2)}{N_2}}}$$

Where:

P_1 and P_2 are the two sample proportions

N_1 and N_2 are the sample sizes

P_1 and P_2 are the proportions in the two populations (estimated by P_1 and P_2).

The level of significance used in the test was the 90% level of significance. If the t value obtained in the test is greater than the t value for the 90% level (1.65) of significance, then there is assumed to be significant difference in the results at this level of significance.

The parameters tested in this study "before" and "after" the change in signs were:

1. Total vehicles stopped.
2. Vehicles stopped and proceeded with vehicle in "zone of influence."
3. Vehicles stopped and proceeded with no vehicle in "zone of influence."
4. Total vehicles passed.
5. Vehicles passed with vehicle in "zone of influence."
6. Vehicles passed with no vehicle in "zone of influence."

In testing for total vehicles stopped and total vehicles passed "before" and "after," the results of one are dependent on the results of the other since the total sample of the two is the sum of the two parts. Therefore, if one is significantly different, the other also is; or if one is not significantly different, the other will not be. For instance, if the "after" portion of vehicles stopped is significantly different from the "before" proportion of vehicles stopped, then the "after" proportion of vehicles passed is significantly different from the "before" proportion of vehicles passed. If one was significantly higher, then the other would be significantly less. The same thing holds true for the vehicles entering with a vehicle in the zone and no vehicle in the zone under the stopped and passed categories for the same reasons.

RESULTS

Table 2 shows the results of the statistical test at the six locations. The intersections cannot be compared individually with each other because the characteristics of each intersection are different from all other intersections. The comparisons will be on the "before" and "after" basis. The results of the red signs will be compared with the results of the yellow signs, the white signs with the results of the yellow signs.

1. Total Stopped or Passed - Red Sign

At sites 1, 3, and 5, where the red signs were in place, the total proportion stopped in the "after" portion was significantly

different from the total stopped in the "before" portion. At all three locations, a significantly greater proportion stopped "after." Conversely, the proportion that passed without stopping also was significantly different, and it was significantly less "after" than "before." This appears at this point to indicate that the red sign had a more restrictive effect than the yellow sign.

2. Stopped Vehicles with or without Vehicle in "Zone of Influence" -
Red Sign

At sites 1 and 5 there was a significant difference between the vehicles that stopped and then entered the mainstream with a vehicle in the "zone of influence." Significantly less stopped vehicles entered the mainstream "after" when there was a vehicle in the zone. Also conversely, significantly more stopped vehicles entered the mainstream "after" when there was no vehicle in the zone. This also appears to indicate the sign had a more restrictive effect on the motorist, perhaps causing him to be more cautious before entering the mainstream. At site 3, there was no significant difference in the "before" and "after" results.

3. Passed Vehicles with or without Vehicle in "Zone of Influence" -
Red Sign

At sites 1, 3 and 5 there was a significant difference in the proportion of vehicles that passed with a vehicle in the "zone of

influence." At all three sites, the proportion that passed with a vehicle in the zone was significantly less in the "after" case. Again conversely, significantly more vehicles passed when no vehicle was in the "zone of influence." Here also, it appears that the vehicles that passed were perhaps more cautious in that they were passing in a lesser proportion "after" when there was a vehicle in the "zone of influence."

4. Total Stopped or Passed - White Sign

At site 2 there was no significant difference in the total that stopped or passed between the "before" and "after" period. At site 4 a significantly greater proportion stopped "after" than "before" and a significantly lesser proportion passed "after" than "before." At site 6 the reverse was true--a significantly lesser proportion stopped "after" than "before," while a significantly greater proportion passed "after" than "before." It does not appear at this point that the white sign is any more restrictive than the yellow sign.

5. Stopped Vehicles with or without Vehicle in "Zone of Influence" - White Sign

At sites 2 and 4 there was no significant difference between the "before" and "after" results. At site 6 there was a significantly greater proportion of "after" vehicles that stopped and

then entered the mainstream when there was a vehicle in the "zone of influence" while there was a significantly less proportion that entered when there was no vehicle in the "zone of influence." It appears again that the white sign is no more restrictive than the yellow sign, and at one site appears less restrictive since a greater proportion passed when a vehicle was in the zone.

6. Passed Vehicles with or without Vehicle in "Zone of Influence" - White Sign

At sites 2 and 6 there was no significant difference between the "before" and "after" results. At site 4 a significantly greater proportion of those that passed without stopping entered the mainstream when there was a vehicle in the "zone of influence" and conversely, a lesser proportion entered the mainstream when there was no vehicle in the zone. It appears that the white sign is no more restrictive than the yellow sign, and it appears that at least at one site it may be less restrictive.

CONCLUSIONS

It is realized that this study deals with only six sites and that it could not evaluate the red sign in relation to the white sign. However, it is felt that this study does give an indication of the effect of the red or white sign on the vehicles that stopped or passed the sign in relation to the vehicles that stopped or passed the yellow signs.

Since a decision has not been made or accepted as to whether a yield sign should be a "warning" device or a "regulatory" device, the results of this study cannot state which type sign is more effective. It does appear that the red yield sign is more effective in a restrictive sense than the yellow sign, in that a greater proportion of vehicles stopped before entering the mainstream when the red sign was in place than when the yellow sign was in place. It also appeared that generally, the motorist was perhaps more cautious before entering the mainstream when the red sign was in place in that a lesser proportion entered the stream when a vehicle was in the "zone of influence."

It appears that generally the white sign was no more restrictive than the yellow sign, and in some cases appeared less restrictive in that a greater proportion entered the mainstream when there was a vehicle in the "zone of influence."

If a more restrictive control is desired, it would appear that the red sign would be most effective. If a less restrictive sign is desired, it would appear that the yellow sign would be as satisfactory as a white sign.

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A P P E N D I X

T A B L E S

TABLE 1

ZONES OF INFLUENCE

<u>SITE</u>	<u>MEDIAN LAG ACCEPT. (SEC.)</u>	<u>X SPEED (F/S)</u>	<u>=</u>	<u>ZONE OF INFLUENCE (FT.)</u>
1	3.0	45.9		138'
2	3.0	58.3		175'
3	2.5	62.8		157'
4	2.5	62.2		156'
5L*	5.0	32.9		165'
R*	4.2	34.3		145'
6L	5.0	44.2		221'
R	4.2	47.8		201'

1. Arctic Parkway - Spruce Street
2. Route 535 - Route 571
3. Route 18 - Route 1
4. Route 68 - Route 206
5. Calhoun Street - Princeton Avenue
6. Arena Drive - South Olden Avenue

* L - Left zone

* R - Right zone

Table 2

Results of Statistical Tests

SITE	COLOR SIGN AFTER	Vehicle Stopped		Vehicle Passed		TOTAL STOPPED	TOTAL PASSED
		Veh. in Zone	No Veh. in Zone	Veh. in Zone	No Veh. in Zone		
1	Red	Sig. -	Sig. +	Sig. -	Sig. +	Sig. +	Sig. -
2	White	Not Sig.	Not Sig.	Not Sig.	Not Sig.	Not Sig.	Not Sig.
3	Red	Not Sig.	Not Sig.	Sig. -	Sig. +	Sig. +	Sig. -
4	White	Not Sig.	Not Sig.	Sig. +	Sig. -	Sig. +	Sig. -
5	Red	Sig. -	Sig. +	Sig. -	Sig. +	Sig. +	Sig. -
6	White	Sig. +	Sig. -	Not Sig.	Not Sig.	Sig. -	Sig. +

Significance is for 90% level of confidence; + or - indicates greater (+) or less (-) for "after" condition.

SITE

- 1 Arctic Parkway & Spruce Street
- 2 Route 535 & Route 571
- 3 Route 18 & Route 1
- 4 Route 68 & Route 206
- 5 Calhoun Street & Princeton Avenue
- 6 Arena Drive & South Olden Avenue

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P H O T O S

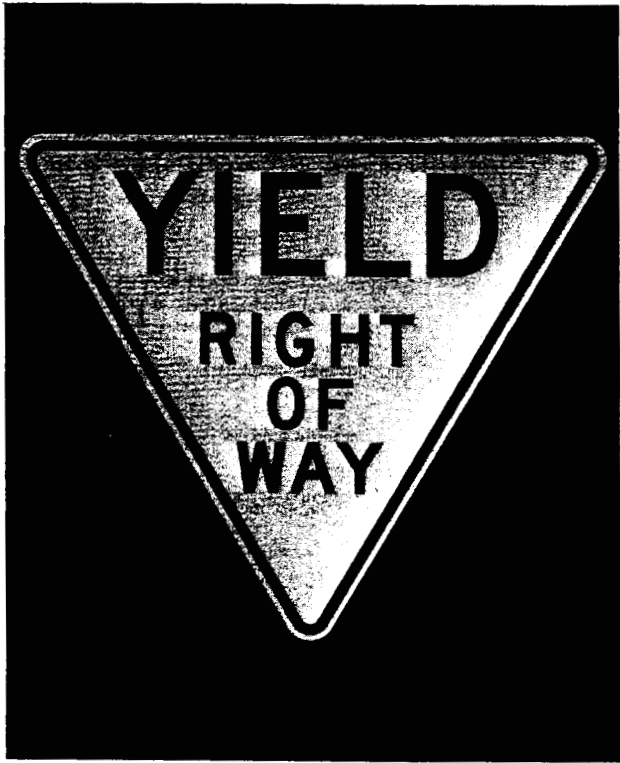


PHOTO 1

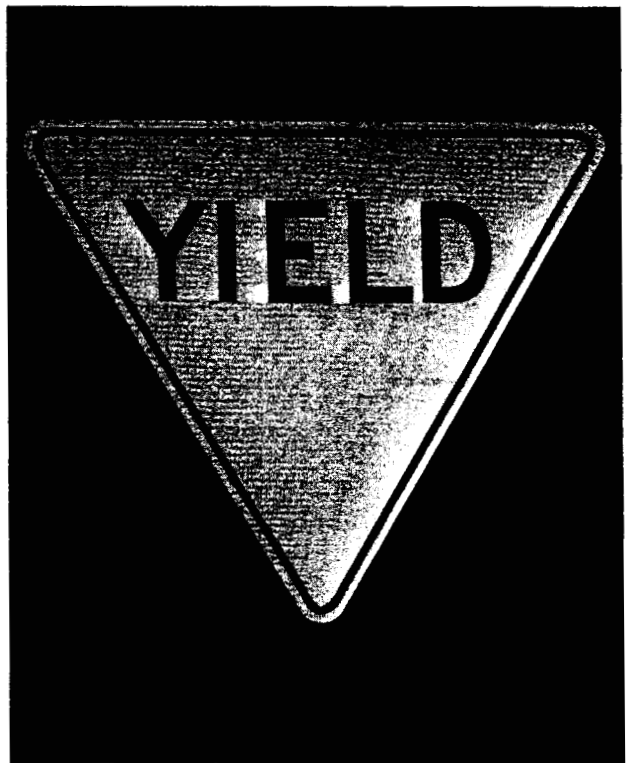


PHOTO 2

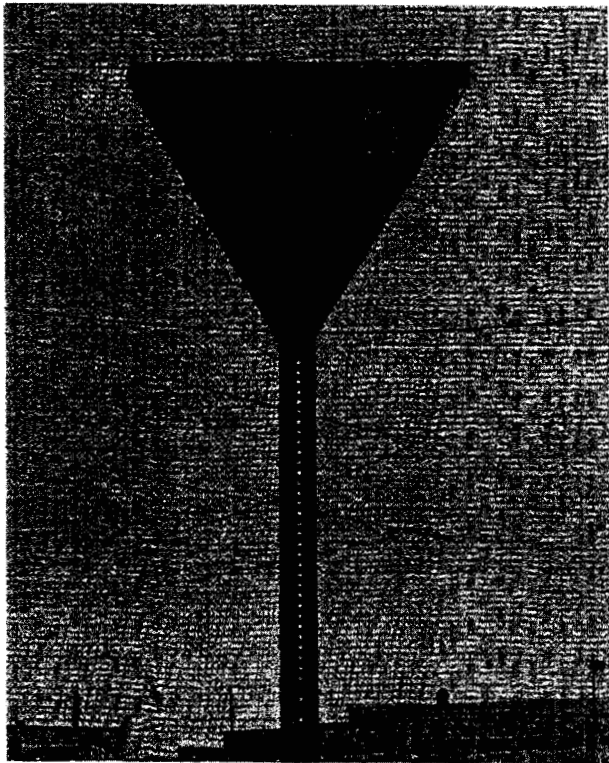


PHOTO 3

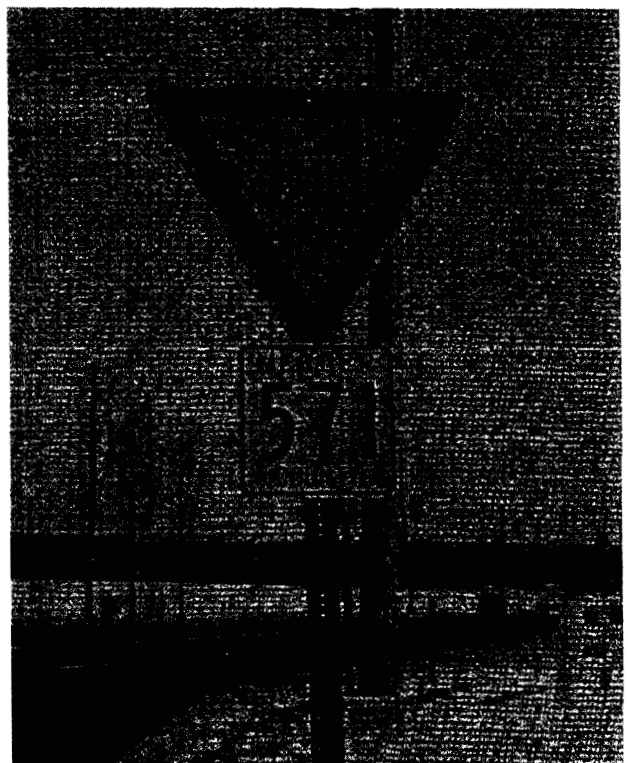


PHOTO 4

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FIGURES

FIGURE I

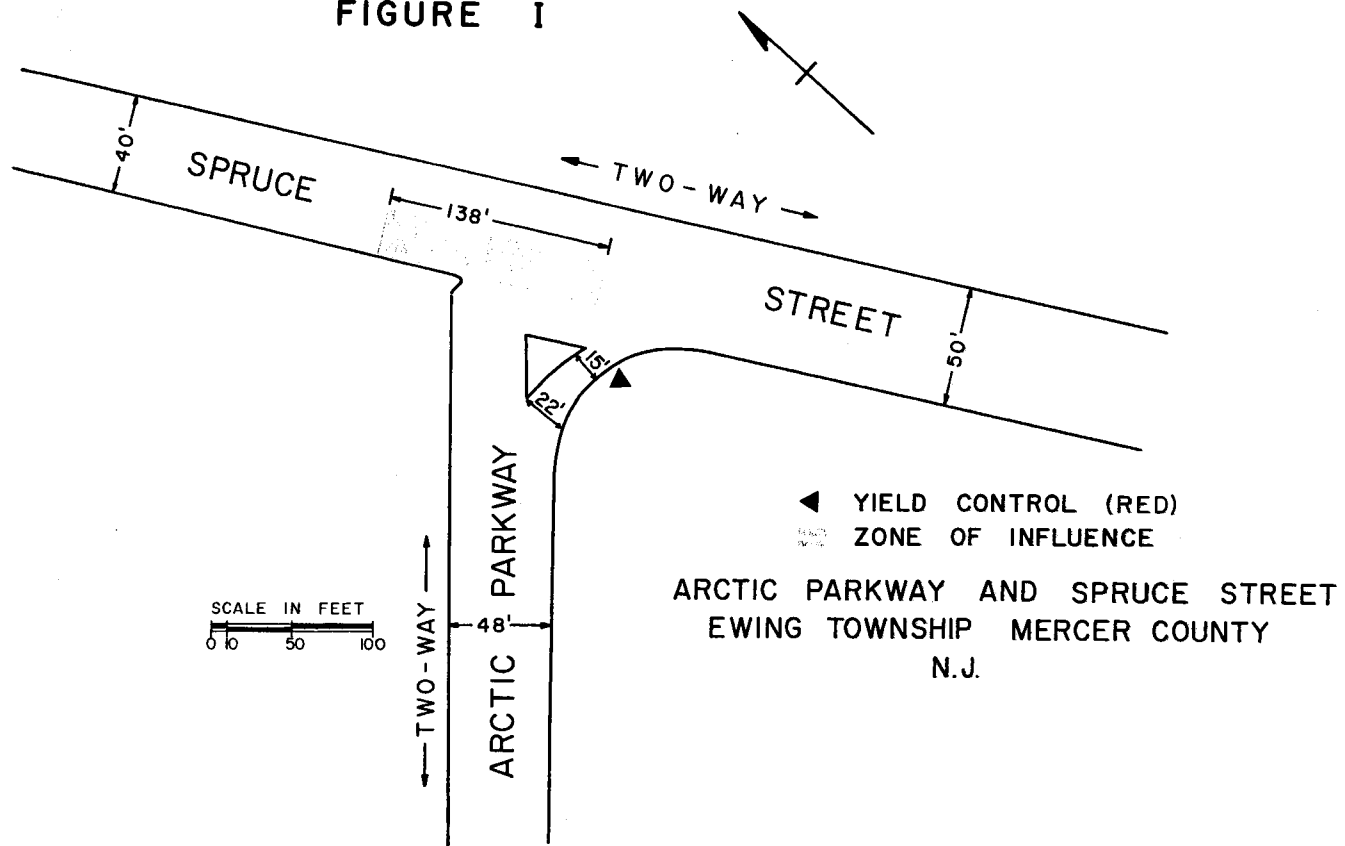
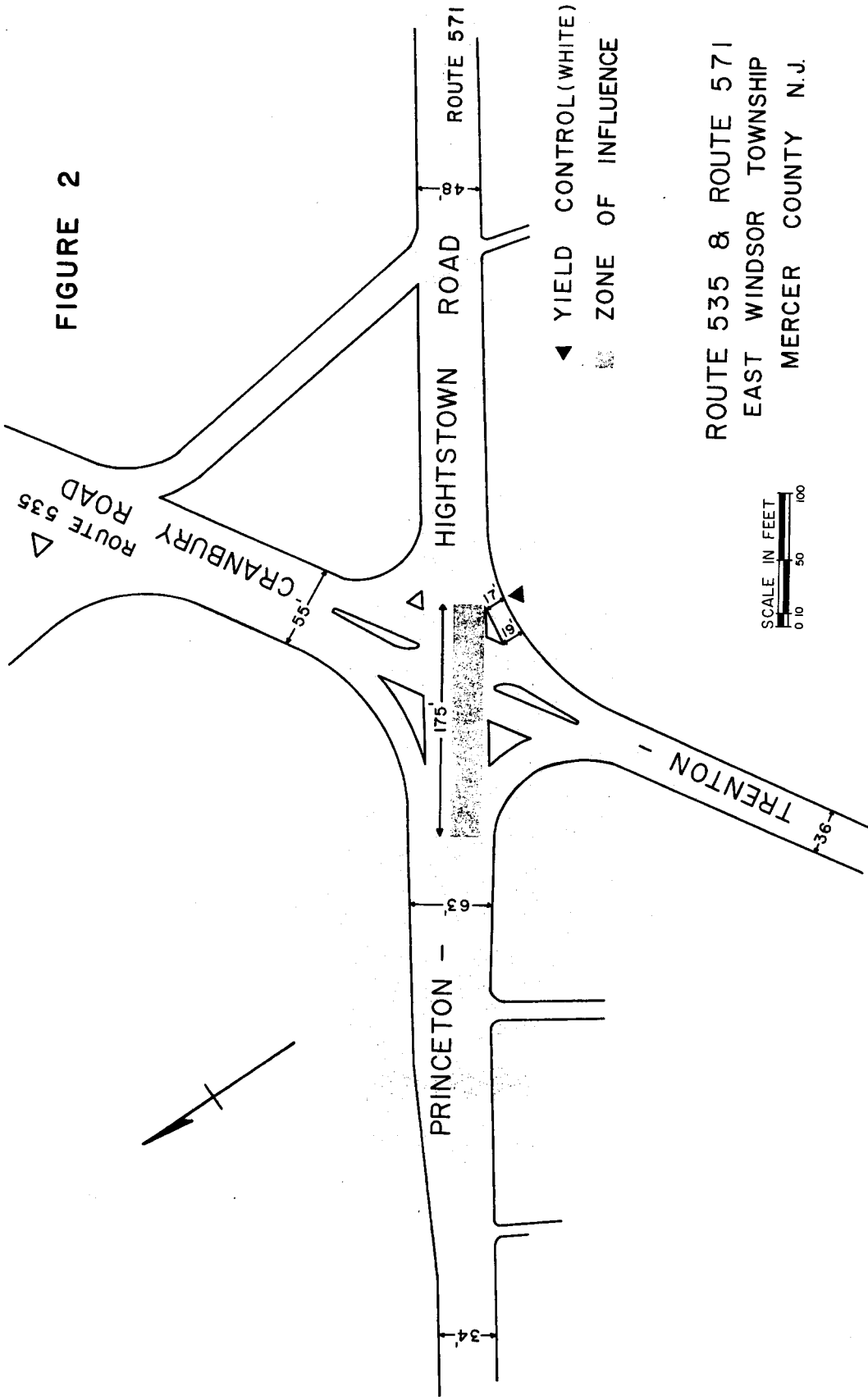


FIGURE 2

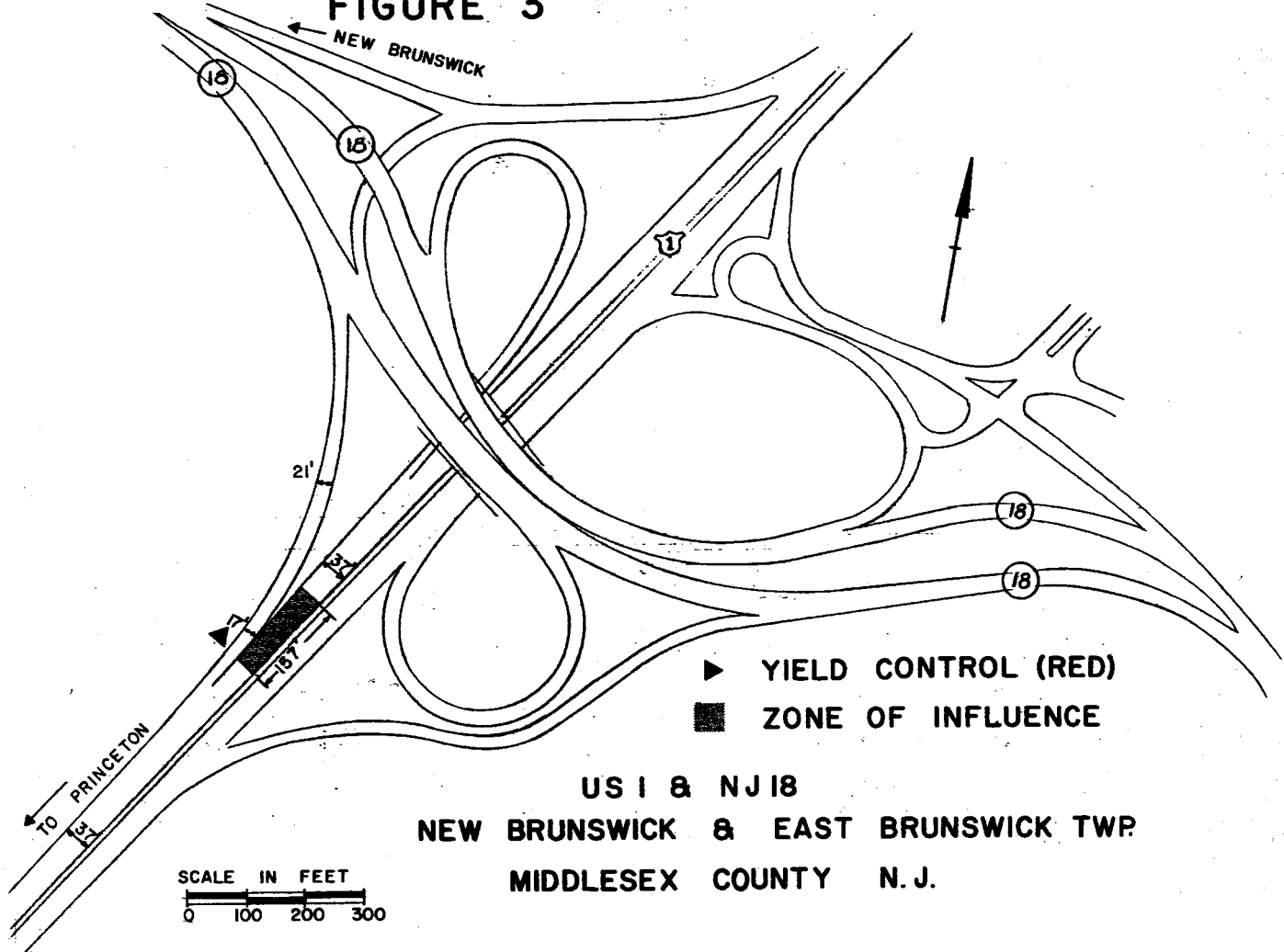


ROUTE 535 & ROUTE 571
EAST WINDSOR TOWNSHIP
MERCER COUNTY N.J.

SCALE IN FEET
0 10 50 100

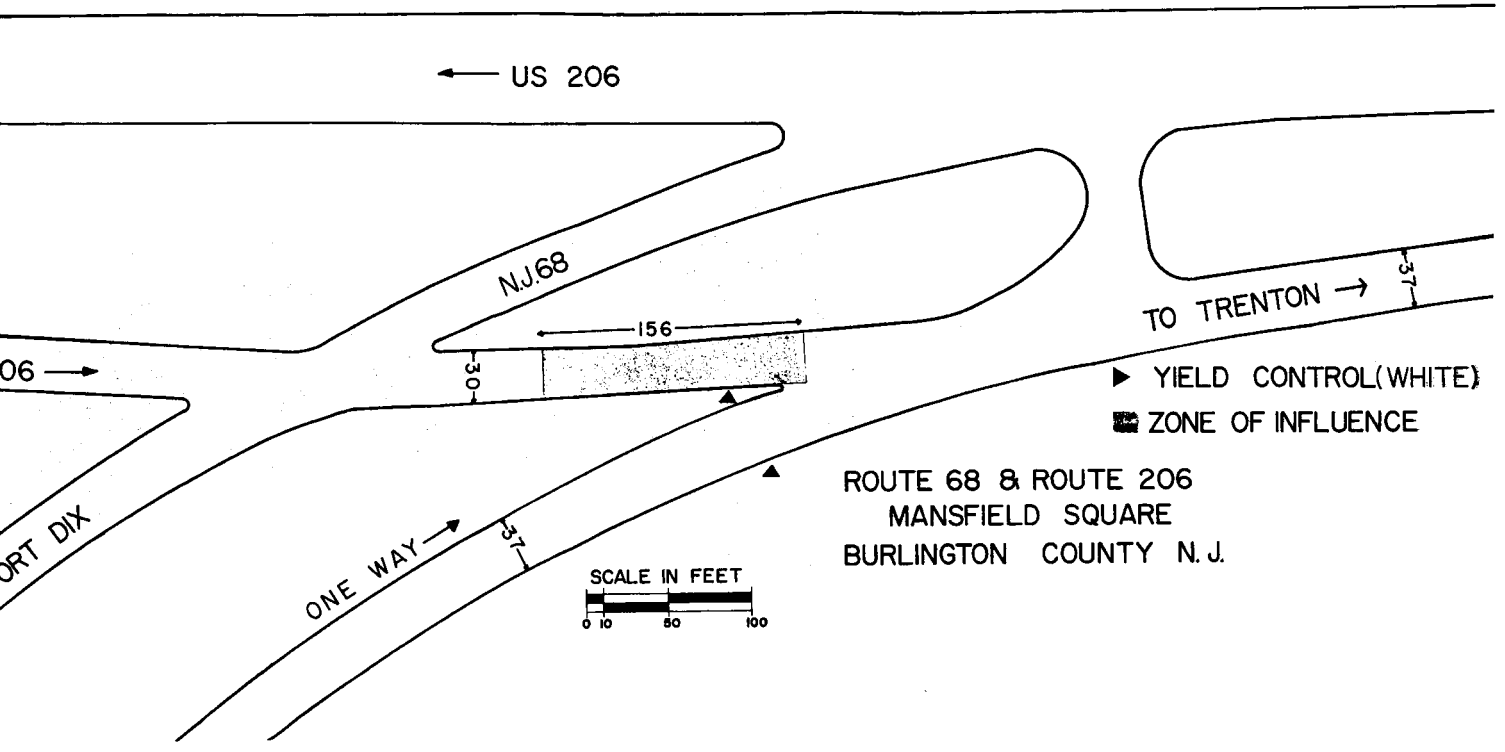
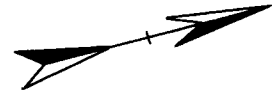
◀ YIELD CONTROL (WHITE)
▨ ZONE OF INFLUENCE

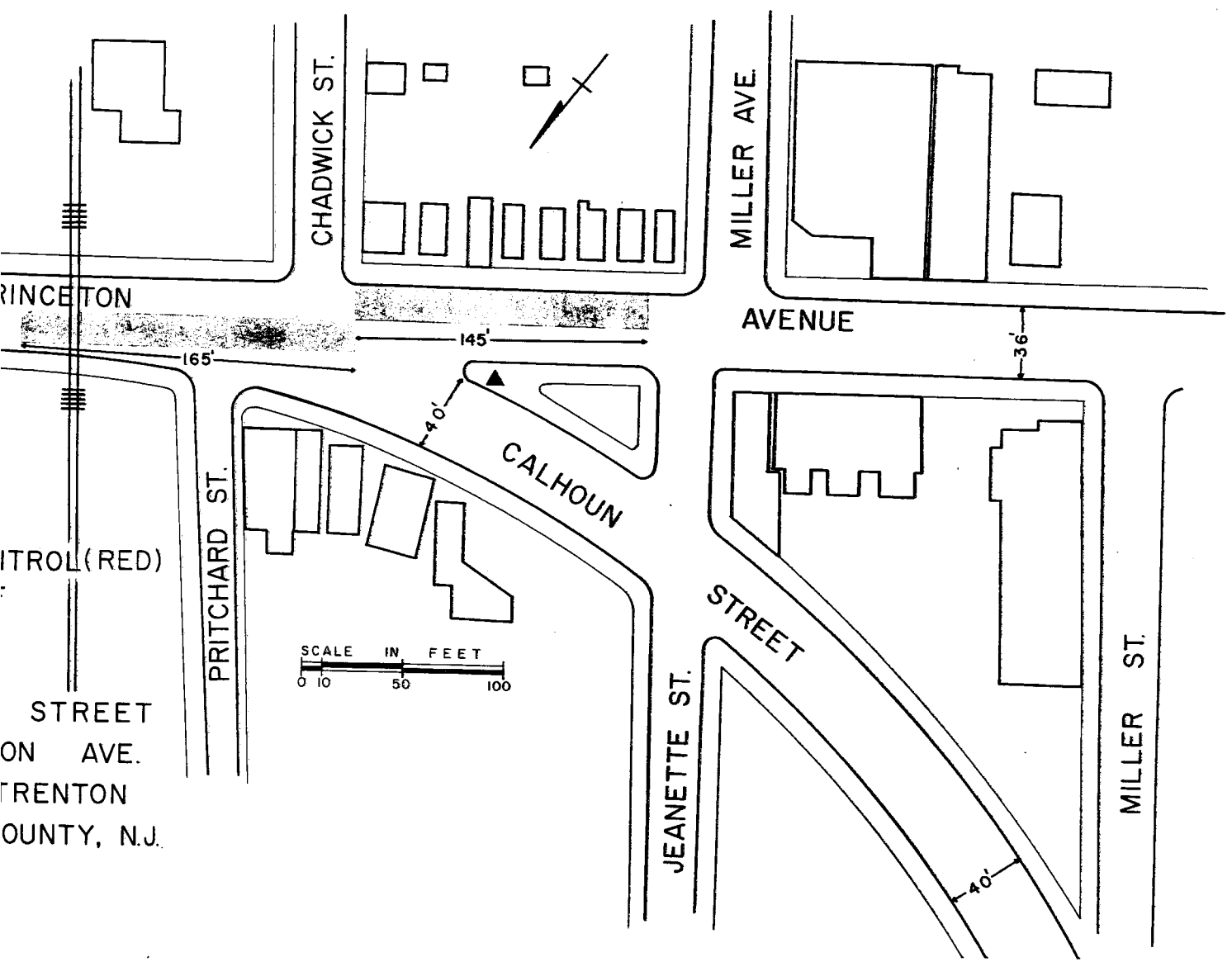
FIGURE 3



**US 1 & NJ 18
NEW BRUNSWICK & EAST BRUNSWICK TWP
MIDDLESEX COUNTY N. J.**

FIGURE 4





RINCETON

CHADWICK ST.

MILLER AVE.

AVENUE

PRITCHARD ST.

CALHOUN

STREET

JEANETTE ST.

MILLER ST.

TROL (RED)

STREET
ON AVE.
TRENTON
COUNTY, N.J.

SCALE IN FEET
0 10 50 100

40'

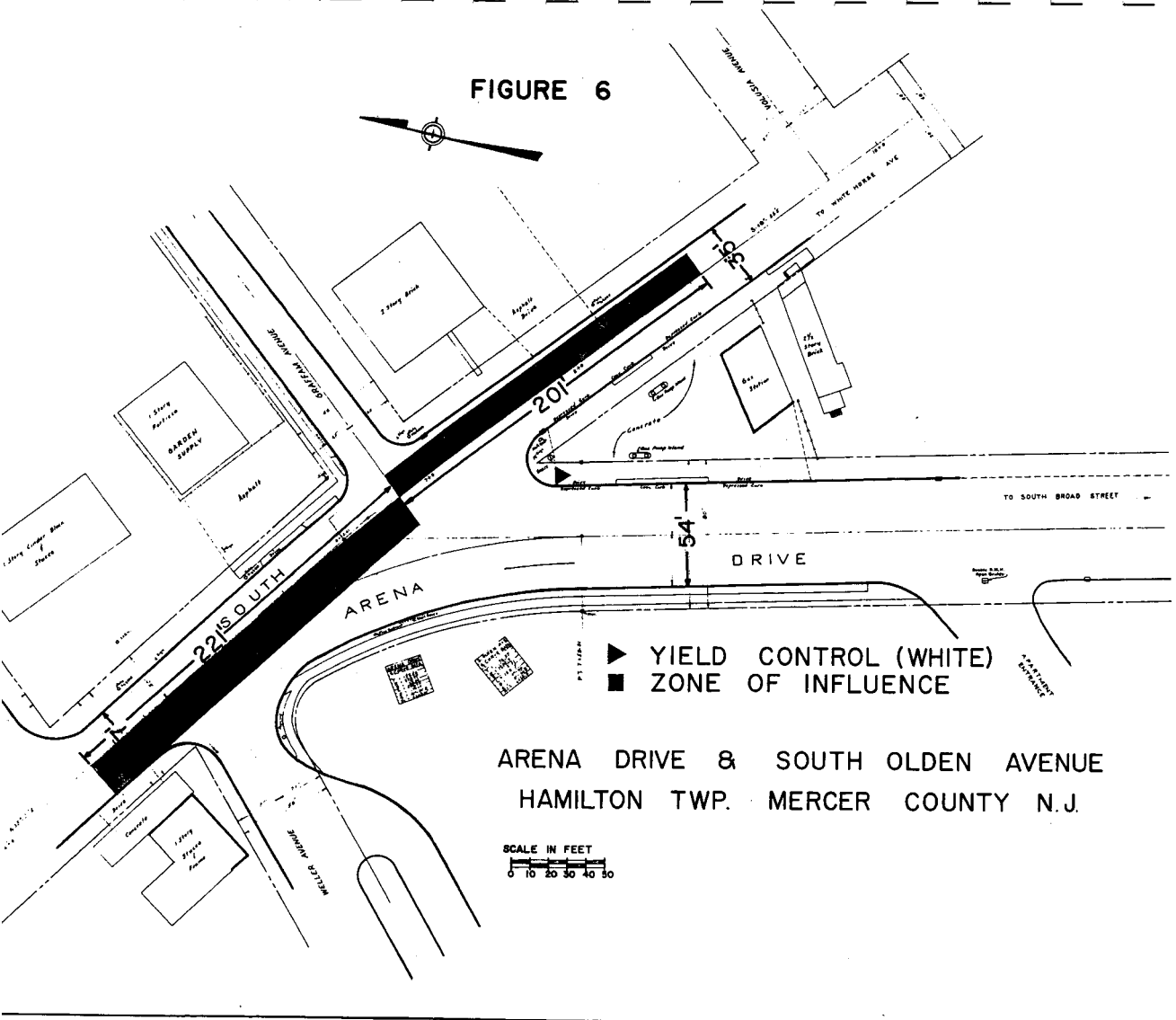
36'

40'

165'

145'

FIGURE 6



ARENA DRIVE & SOUTH OLDEN AVENUE
HAMILTON TWP. MERCER COUNTY N.J.

SCALE IN FEET
0 10 20 30 40 50

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Figure 7

DATA COLLECTION SHEET

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Vehicle No.	Vehicle Stopped	Vehicle Stopped in Line	Vehicle Passed	Entered with Vehicle in Zone	
				Left	Right
1	X				
2			X	X	