DIAGRAMMATIC SIGN STUDY

PHASE I REPORT

by

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prepared by

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Division of Research and Evaluation
New Jersey Department of Transportation

in cooperation with the
Bureau of Public Roads

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ABSTRACT

A significant reduction in the rates of unusual maneuvers in front of a left-hand exit was found after diagrammatic signs were installed at the interchange of northbound I-287 with US 22. A mobile television surveillance unit was used to collect the data. The volumes, as well as types of unusual maneuvers, are summarized in the report by date, hour and number of axles. Studies were made of diagrammatic signs, standard signs, as well as original signs. Statistical comparisons were made between the three conditions of signing.

The use of diagrammatic signs at interchanges with left-hand exits shows good potential from both a statistical and a logical viewpoint.

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INTRODUCTION

The use of Diagrammatic Signs has been suggested as a method to reduce confusion at exits on the Interstate Highway System. In 1968 the "Blatnik Committee"[1] staff took 16mm movies and 35mm stills of traffic approaching various exits at the interchange of I-95 and I-495 in Washington, D.C. The films show a large number of vehicles swerve, stop, back, etc., in the exit gore areas. Among the committee members, it was generally assumed that the erratic behavior was a result of confusion and that inadequate signing and/or road geometry were part of the problem. The erratic or unusual maneuvers shown in the films were considered to be symptomatic of both a hazardous situation and an annoyance to many motorists. The frequency of these maneuvers, it was felt, might be reduced by the installation of signs that more adequately serve the needs of unfamiliar as well as familiar motorists.

[1] The Blatnik Committee is a short name for the "Special Subcommittee on the Federal Aid Highway Program of the Committee on Public Works of the House of Representatives, Highway Safety, Design and Operations: Freeway Signing and Related Geometrics, 90-39."

The concept of using diagrams in signs is not new. The British have installed several signs of this type with apparent success. Symbolic warning signs have been used extensively in the United States and other countries.

The BPR's Office of Traffic Engineering had diagrammatic signs installed at the I-95 and I-495 interchange in Washington, D.C. and the engineers compared the "before" and "after" effects on the frequency of unusual maneuvers. They concluded that the comparison was not valid because of a difference in the proportion of "unfamiliar" motorists in the two study periods.

The Bureau of Public Roads requested that states carry out projects similar to theirs for a more thorough evaluation of freeway-type diagrammatics. In cooperation with the BPR, the Division of Research and Evaluation of New Jersey's Department of Transportation designed and had installed a system of these signs where northbound I-287 interchanges with US 22 in north-central New Jersey.

SITE SELECTION

The particular site was chosen from a careful investigation of six interchanges on New Jersey's Interstate Highway System. Aerial and on-ground photographs, as well as construction plans, were used in the investigation.

Two interchanges were chosen for more detailed investigation. They were unique in that they both involved a left-hand exit. The interchange of northbound I-287 and US 22 was chosen because its geometric design was more conventional. At this site the exiting drivers are provided with two added, extra-long, high speed deceleration lanes.

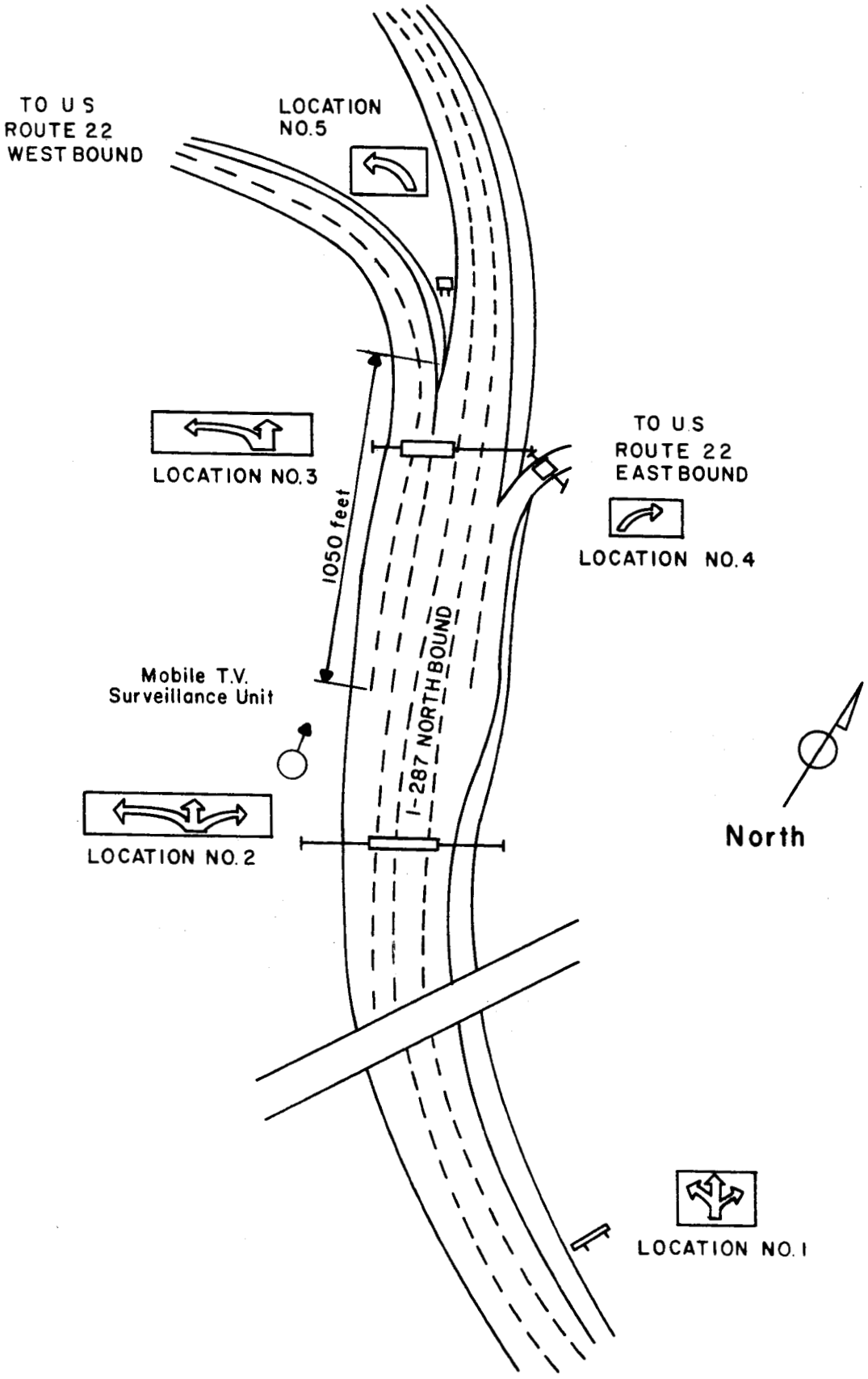
STUDY SITE LOCATION AND DESCRIPTION

The chosen site is located on I-287 in Bridgewater Township, Somerset County, approximately 10 miles northwest of New Brunswick.

On the northbound roadway, three lanes continue through. One lane is added on the right for the eastbound exit. Two lanes are added on the left for the westbound exit. These and other study site characteristics may be seen in schematic form in Figure 1. The approach to the first overhead sign (sign No. 2) is on a 1-1/2° right-hand curve. From that point to the last sign (sign No. 5), the road is tangent with a 2-1/2 percent positive grade. The road then sweeps to the left on a 1-1/2° curve beyond the last sign and maintains a slight positive grade.

There are four interchanges in the four miles that precede the study site location, the last of which is less than one-half mile away. When I-287 is completed, it will encircle New York City as I-495 encircles Washington, D.C.

FIG.I. STUDY SITE CHARACTERISTICS



STUDY SITE PREPARATION

Before the site was used for the study of the effect of the diagrammatic signs, the following changes were made:

1. Electric power (115 volts) was provided in the median for our Mobile TV Surveillance Unit.

Fig. 2. Mobile TV Surveillance Unit

2. The sign messages were changed
   a. to conform with minimum Interstate highway standards, and
   b. to provide messages in standard form that were also compatible for diagrammatic signing.

The original-unmodified and the modified signs are shown in Appendix I.

PROCEDURE

Field

The study concentrated on the behavior of traffic at the exit gore from northbound I-287 to westbound Route 22. The volume of traffic using the eastbound exit was very small in comparison to the through and westbound exit movements.

Streeter-Amet hourly counters were placed to record the through volume and the left-hand exit volume. The counters were placed at considerable distances past the exit gore so that they were not readily noticed by approaching drivers.

Two Mobile TV Surveillance Unit operators recorded the traffic approaching the exit gore on video tapes. The camera was adjusted to record all lanes from 400 ft upstream to points beyond the physical gore.

An audio band on the tapes recorded the time as announced every five minutes. Separate tapes recorded each hour of traffic. The study was limited to afternoon traffic.

Office

The tapes were played back in the office under well-supervised conditions. A 15-minute count of vehicles by number of axles was made for each hour.

All unusual maneuvers that took place were noted and counted by:

1. Hour (2-3 p.m., 3-4 p.m., etc.)
2. Movement (Exit or Through)
3. Number of axles (2 or over 2)
4. Initial and final lanes used

The unusual maneuver rates are summarized in Appendix II.

Unusual Maneuvers Definition

An unusual maneuver, as defined for this study, includes any stopping, backing or crossing the gore line within a 200-ft, five lane and shoulder section of I-287 that terminates at the westbound exit gore curbing. The gore line includes both the solid striped point that is placed in front of the physical gore and the dashed line that continues upstream from this point. No more than one unusual maneuver was counted for any one vehicle. Some examples of unusual maneuvers are illustrated in Figure 3.

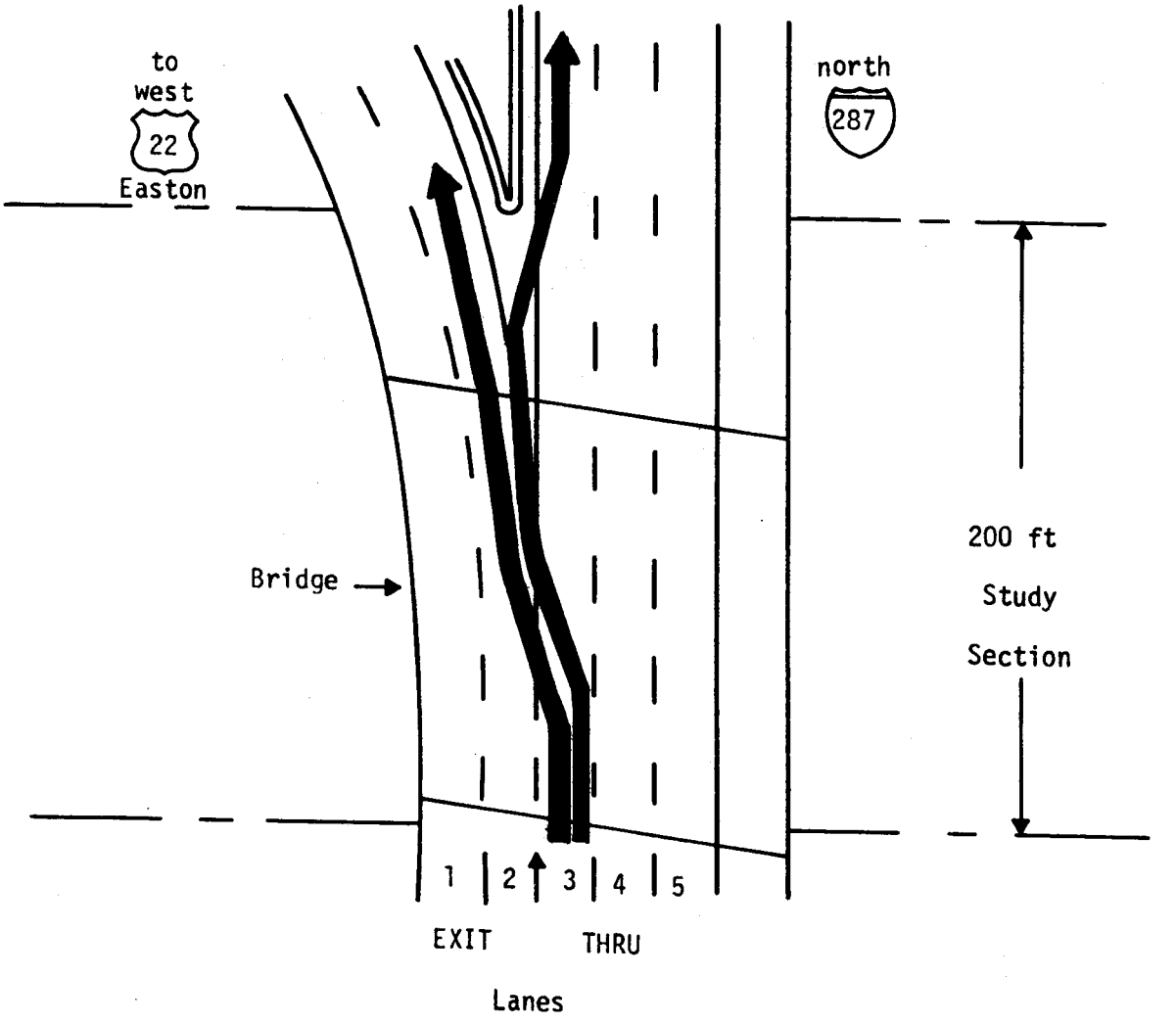
Data Correction

Several corrections to hourly data were necessary. These corrections are listed below:

1. Volume corrections

   a. Clock inaccuracy. Corrections were made to nearest 60th of a unit on a linear basis.

Fig. 3. Identification of Unusual Maneuvers



b. Missing counts. Some missing "through" volumes were estimated on the basis of a linear regression analysis. The data for the regression was obtained from a study of volumes from prior weeks that were equivalent in day of week and time of day.

c. The equation, $V = \frac{C}{X + 1.56y}$, was used to estimate the number of vehicles given the machine counts (C) and the sample proportions of two axle (X) and three or more axle (y) vehicles in each hour. The constant 1.56 is based upon a sample of 3 or more axle vehicles taken from earlier studies of hourly axle distributions.

2. Unusual maneuver frequency corrections

In cases where the television apparatus failed to yield a recording for short periods of time, the periods of failure were totaled for a given hour and a linear correction was made to the unusual maneuver frequency totals.

RESULTS

Two comparisons were made in relation to the first phase of the study. Data on the original-unmodified signs were collected in addition to the primary data on the modified and diagrammatic signs. The comparisons were made statistically[2] and account for all the changes that were made to the signs:

[2]The Wilcoxon matched-pairs, signed-ranks method was used to test the significance of differences found in the comparisons (p.361 of Reference 2). The pairs were matched by hour, day, and number of axles.

1. Original-Unmodified to Modified Signs
2. Modified to Diagrammatic Signs

As stated, modification of the signs was necessary so that the diagrammatic signs could be compared to standard signs with messages that were compatible with the study's diagrammatic concept. The sign differences between the three conditions may be seen by comparing the photographs in Appendix I.

Comparisons of the hourly, exit, 2-axle categories were the only ones made because these categories consistently represented the vast majority of unusual maneuvers that occurred at the gore.

Comparison of Unmodified with Modified Signs

This comparison showed no significant difference in the rates of unusual maneuvers. A significant difference was not found at the 95 percent level of confidence. By chance, the rates were found to be slightly higher after the modification. A reduced rate of unusual maneuvers for the more standard, modified signs was expected because of (a) a lower assumed percentage of unfamiliar drivers, and (b) an assumed improvement in signing and subsequent improvement in driver performance at the exit gore.

The lack of significance may have been due to (a) too short a time difference between modification and subsequent study, thus not allowing a sufficient

period for motorist adjustment (refer to Figure 4), and (b) an insufficient amount of data.

Comparison of Modified with Diagrammatic Signs

This comparison showed a significant reduction (95 percent level of confidence) in the rates of unusual maneuvers with the diagrammatic signs.

The specific changes made on the signs were (a) the exchange of diagrammatic with conventional arrows and subsequent repositioning of messages, and (b) the addition of one US Route 22 shield on the first sign (refer to Appendix I).

The reduction in the rates may be partially attributed to these changes, but they may also be partially attributed to (a) the greater attention value from the uniqueness of the signs within the I-287 system, and (b) the motorist's feeling that greater importance has been put on his needs at this particular location.

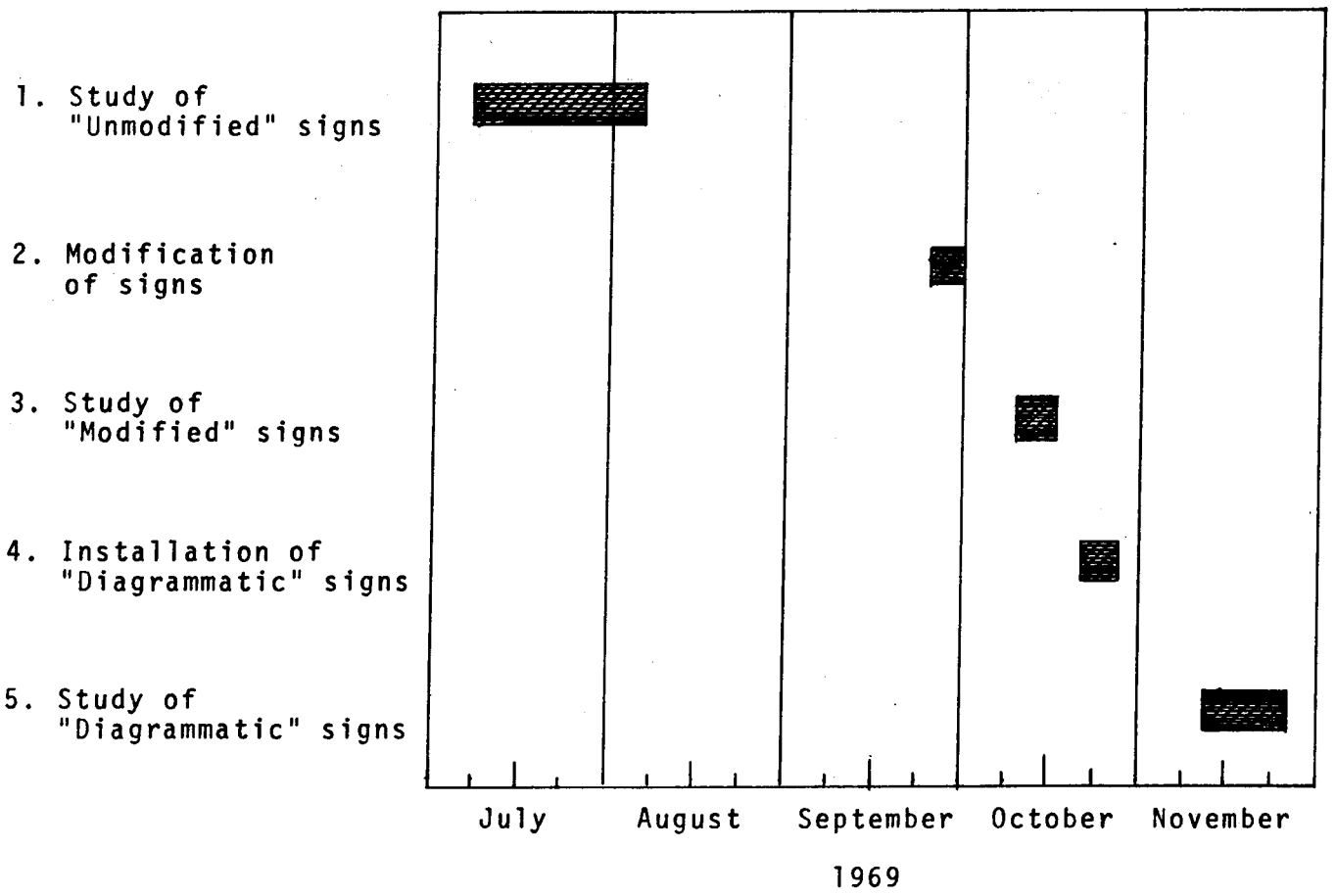
CONCLUSIONS

Observation of the diagrammatic signs points out some obvious improvements over standard signing since the signs offer several advantages to the motorist in comparison to conventional signs:

1. The exit directions are more clearly communicated for all exits at more advanced locations, as well as at the most advanced location, which is at

Fig. 4

Study Activity - Time Sequence



the first sign.

2. The number of lanes for a movement are communicated at the most advanced point. This is done by displaying different arrow stem thicknesses.

3. The destination and route information is more meaningful because it is matched with the major diagrammatic components of the interchange on all signs. The motorist does not therefore have to infer the match in advance because this is done for him.

4. The relative position of the sign within the interchange is more adequately communicated. Arrow stem connections and lengths show the choices left to the motorist at the sign locations.

5. The attention value of the diagrammatic signs in this study seems greater than the conventional signs, perhaps because the arrows add more white area.

Although a statistically significant reduction in the rate of unusual maneuvers was found after the diagrammatic signs were installed, an "ideal" application was not made. Due to the restriction upon the study that the present structures be used, the following observations were made:

1. The sign at location No. 3 was not referenced on the lane line that divides exit from through movements. A more ideal placement -- 8 ft to the left and at a more advanced point -- was not possible because of the overhead structures' wind-load capacity and its constructed position.

2. In the mind of the motorist the sign at location No. 5 does not entirely eliminate the possibility that its exit ramp may be farther down the highway. The sign may have been better placed over the exit ramp on a cantilever structure with its support on the outside of the ramp.

RECOMMENDATIONS

It is recommended that further evaluation of diagrammatic signing under basic conditions be carried out for:

1. "Cloverleaf" geometry
2. "Diamond" geometry
3. Whole series of interchanges

Serious consideration should be made that new standards include the diagrammatic concept.

FUTURE PLANS

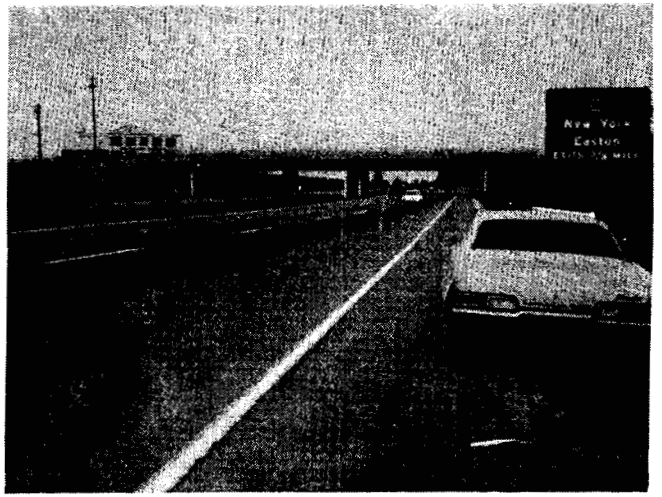
The Bureau of Safety and Traffic plans two more phases of study on the study location:

1. Phase II - "Lane Lines" for the arrows in the spring of 1970
2. Phase III - Reinstallation of standard signs in the summer of 1970.

APPENDIX I

SIGN LOCATION PHOTOGRAPHS

SIGN LOCATIONS: ORIGINAL - UNMODIFIED SIGNS



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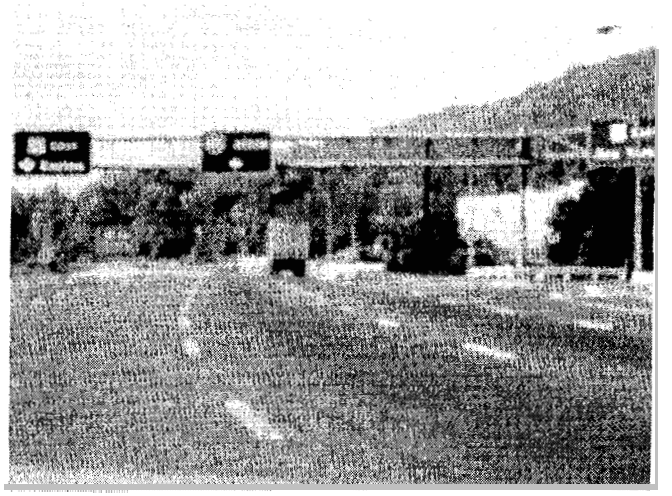
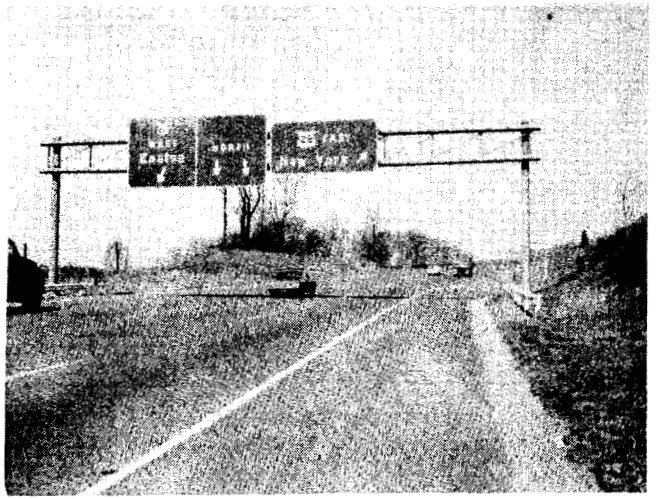


No. 3 and No. 4



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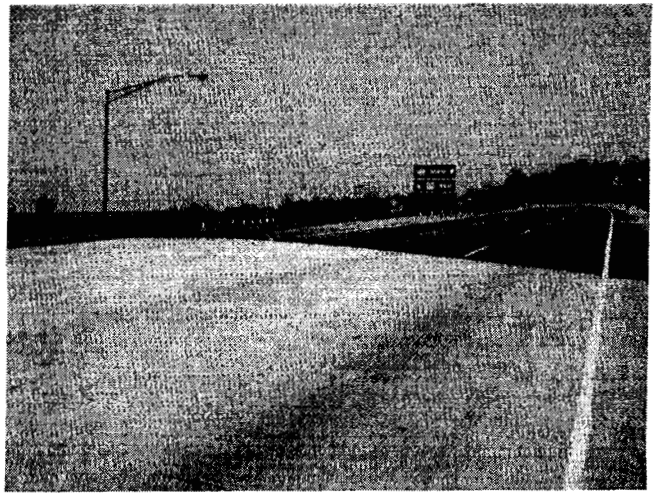
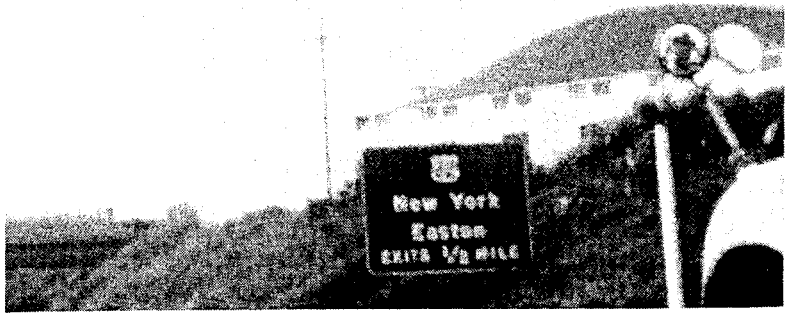


No. 5

SIGN LOCATIONS: PHASE I - SIGNS

BEFORE - MODIFIED



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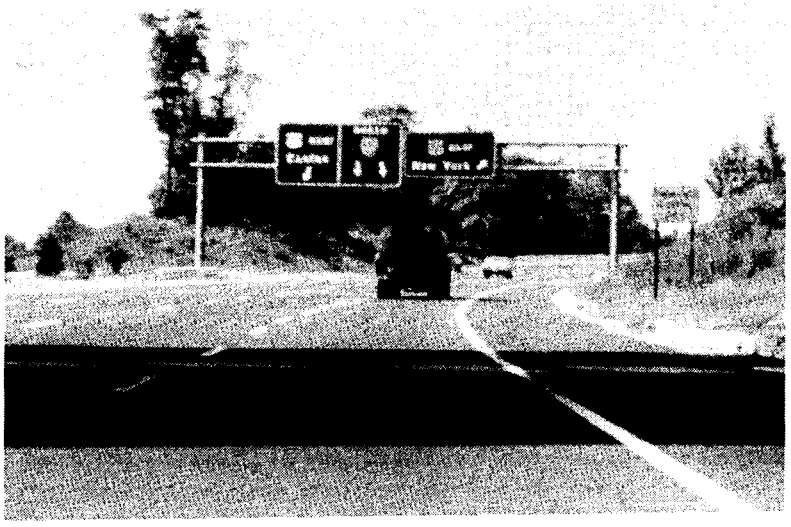

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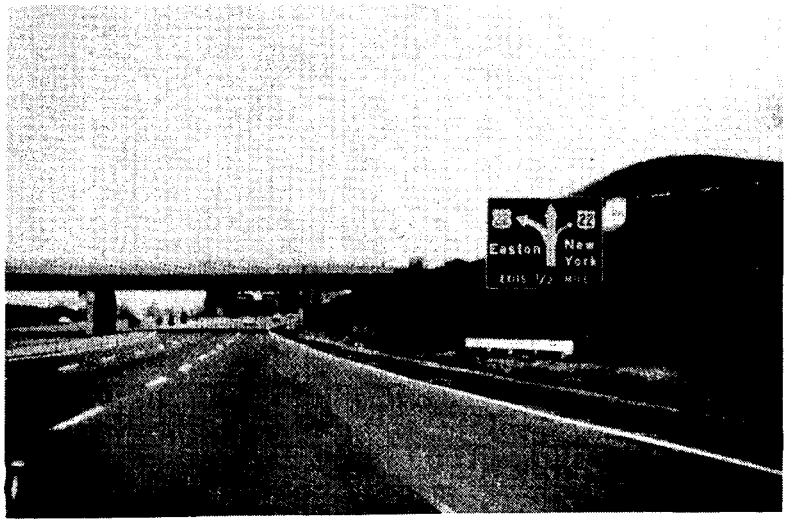
AFTER - DIAGRAMMATIC



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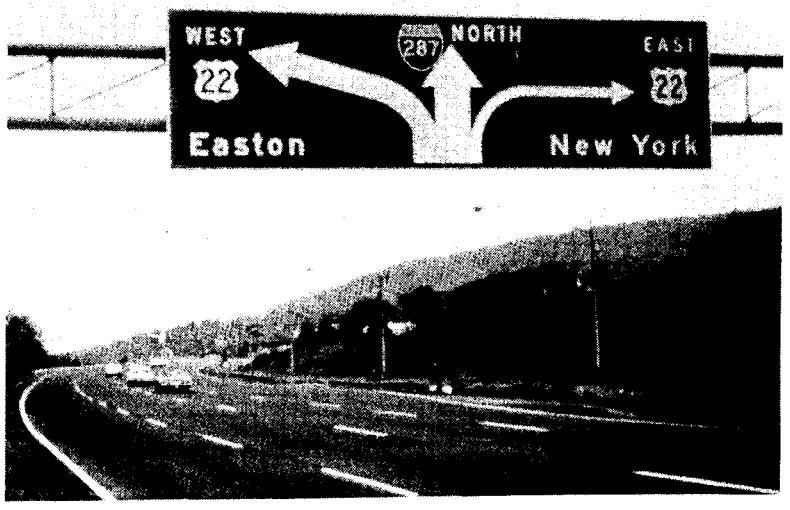

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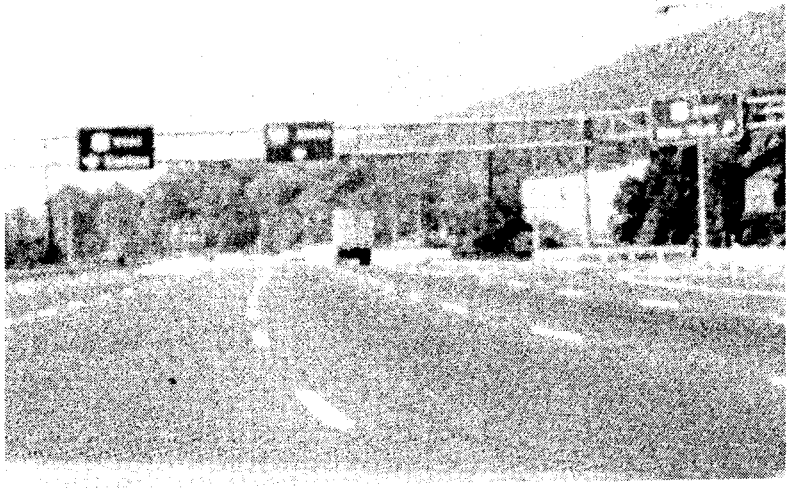
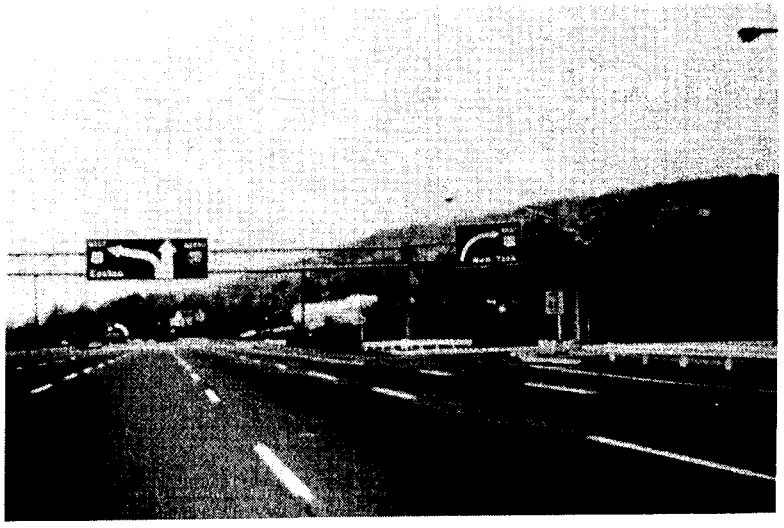
SIGN LOCATIONS: PHASE I - SIGNS

BEFORE - MODIFIED



No. 3 and No. 4

AFTER - DIAGRAMMATIC



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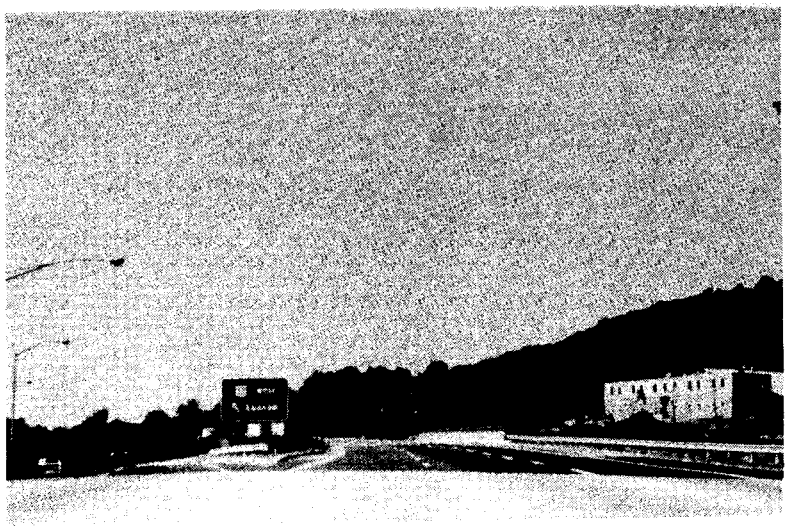
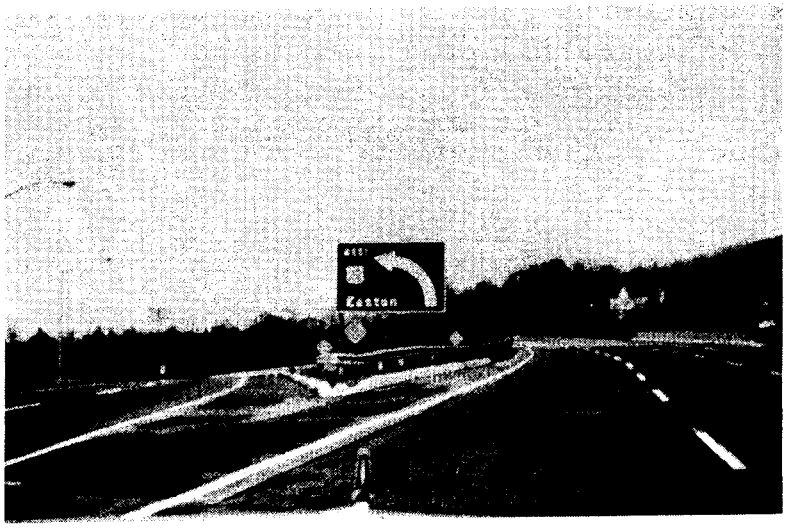


No. 5



No. 5

APPENDIX II

UNUSUAL MANEUVERS RATE TABLES

TABLE 1
ORIGINAL - UNMODIFIED SIGNS
DATA SUMMARY

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS Exiting Vehicles 3to2[a]	4to2	5to2	2to2	Thru Vehicles 2to3	3to3	TOTAL[b] Exit	Thru	VOLUME Exit	Thru[c]	RATE Exit	Thru
Mon.	7/7/69	2-3	2	11	2			1		13	1	395		.033	
			3+	0	0			0		0	1	25		.000	
		3-4	2	11	1					12	0	476		.025	
			3+	2	0					2	0	25		.080	
		4-5	2	10	2	2		1		14	2	662		.021	
			3+	0	0	0		0		0	0	50		.000	
		5-6	2	16	1			2	1	17	3	772		.022	
			3+	2	0			0	0	2	0	16		.125	
		6-7	2	5	1				1	6	1	452		.013	
			3+	1	1				0	2	0	56		.036	
Tues.	7/8/69	2-3	2	7				0	1	7	1	409		.017	
			3+	1				1	0	1	1	4		.250	
		3-4	2	8	4	1		1		13	2	467		.028	
			3+	0	1	0		0		1	0	58		.017	
		4-5	2	17	5				1	22	1	764		.029	
			3+	3	0				0	3	0	57		.053	
		5-6	2	10	3			1	1	13	2	516		.025	
			3+	2	0			0	0	2	0	243		.008	
		6-7	2	13	2	1				16	0	541		.030	
			3+	1	1	0				2	0	22		.091	
Wed.	7/9/69	2-3	2	8	5					13	1	341		.038	
			3+	2	1					3	0	70		.043	
		3-4	2	15	6					21	0	437		.048	
			3+	1	0					1	0	71		.014	
		4-5	2	15	4			2		19	2	543		.035	
			3+	0	0			1		0	1	53		.000	
		5-6	2	18.0			4.0			22.0	0	560		,039	
			3+	0			0			0	0	63		.000	
		6-7	2	21	4			1		25	1	555		.045	
			3+	0	0			0		0	0	23		.000	

[a]Refer to Figure 1
[b]Sometimes totals reflect miscellaneous categories that are not shown
[c]Volumes were unavailable

TABLE 1 (Cont.)

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS Exiting Vehicles 3to2	4to2	5to2	2to2	Thru Vehicles 2to3	3to3	TOTAL Exit	Thru	VOLUME Exit	Thru	RATE Exit	Thru
Thurs.	7/10/69	2-3	2	18.0	4.0					22	2	573		.038	
			3+	4.0	2.0					6	0	162		.037	
		3-4	2	6				2		6	2	495		.012	
			3+	1				0		1	0	29		.034	
		4-5	2	11.8	1.4			2.4		13.2	2.4	456		.029	
			3+	1.2	0			0		1.2	0	62		.019	
		5-6	2	18	2			1		20	1	506		.040	
			3+	0	0			0		0	0	50		.000	
		6-7	2	10	1	1		2		12	2	606		.020	
			3+	1	0	0		0		1	0	46		.022	
Sat.	8/2/69	2-3	2	20	4	2	1			29.7	0	450		.066	
			3+	0	0	0	0			0	0	5		.000	
		3-4	2	20	3	1		1	1	24	4	416		.058	
			3+	0	0	0		0	0	0	0	22		.000	
		4-5	2	18	2	1			2	21	2	389		.054	
			3+	0	0	0			0	0	0	21		.000	
		5-6	2	27	12					39	0	430		.091	
			3+	1	0					1	0	9		.111	
		6-7	2	16	7	1		1		24	1	388		.062	
			3+	0	0	0		0		0	0	16		.000	
Sun.	8/3/69	2-3	2	33	8	2		2	1	43	3	495		.087	
			3+	0	0	0		0	0	0	0	15		.000	
		3-4	2	6	1					7	1	411		.017	
			3+	0	0					1	0	4		.250	
		4-5	2	29	6	1		2		36	3	340		.106	
			3+	1	0	0		0		1	0	4		.250	
		5-6	2	24	5	2		3		31	3	347		.089	
			3+	0	0	0		0		0	0	0		.000	
		6-7	2	14	3	1				18	0	350		.051	
			3+	0	0	1				1	0	4		.250	

TABLE 2
PHASE I - BEFORE - MODIFIED SIGNS
DATA SUMMARY

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS						TOTAL		VOLUME		RATE	
				Exiting Vehicles				Thru Vehicles		Exit	Thru	Exit	Thru	Exit	Thru
				3to2	4to2	5to2	2to2	2to3	3to3						
Mon.	10/13/69	2-3	2	11		1		1		12	1	390	256	.031	.004
			3+	2		0		0		2	0	34	132	.059	.000
		3-4	2	12			1	1		13	1	555	343	.023	.003
			3+	1			0	0		1	0	48	86	.021	.000
		4-5	2	27	2			1		29	1	713	578	.041	.002
			3+	1	0			0		1	0	54	86	.019	.000
		5-6	2	16						16	0	725	657	.022	.000
			3+	0						0	0	15	42	.000	.000
Tues.	10/14/69	2-3	2	8	1			1		9	1	303	280	.030	.004
			3+	0	0			0		0	0	71	103	.000	.000
		3-4	2	14	1			3		15	3	535	330	.028	.009
			3+	1	0			0		1	0	40	122	.025	.000
		4-5	2	21	1	1			1	23	1	742	593	.031	.002
			3+	2	0	0			0	2	0	64	113	.031	.000
		5-6	2	19	4			2		23	2	788	633	.029	.003
			3+	0	0			0		0	0	33	58	.000	.000
Wed. 1	10/8/69	2-3	2	13						13	0	365	224	.036	.000
			3+	3						3	0	45	121	.067	.000
		3-4	2	11	1					12	0	546	304	.022	.000
			3+	2	0					2	0	89	118	.022	.000
		5-6	2	15	2					17	0	792	602	.021	.000
			3+	0	0					0	0	25	115	.000	.000
Thurs.	10/9/69	2-3	2	13	1	1				15	0	349	201	.043	.000
			3+	1	2	0				3	0	43	108	.070	.000
		3-4	2	12	7	1		2		20	2	505	381	.040	.005
			3+	2	0	0		0		2	0	44	108	.045	.000
		4-5	2	28	1	1				30	0	730	691	.041	.000
			3+	1	0	0				1	0	47	44	.021	.000
		5-6	2	12	5	1				18	0	937	628	.019	.000
			3+	0	1	0				1	0	19	55	.053	.000

TABLE 2 (Cont.)

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS						TOTAL		VOLUME		RATE	
				Exiting Vehicles				Thru Vehicles		Exit	Thru	Exit	Thru	Exit	Thru
				3to2	4to2	5to2	2to2	2to3	3to3						
Fri.	10/10/69	2-3	2	9	1		1		1	11	1	386	356	.028	.003
			3+	1	0		0		0	1	0	74	132	.014	.000
		3-4	2	14	1	1				16	0	609	682	.026	.000
			3+	2	0	0				2	0	19	102	.105	.000
		4-5	2	16				2		16	2	842	1043	.019	.002
			3+	1				0		1	0	26	91	.038	.000
		5-6	2	30	5	1		5		36	5	983	1111	.037	.005
			3+	1	0	0		0		1	0	30	71	.033	.000
Sat.	10/11/69	2-3	2	17	5	1	1	1		24	1	423	411	.057	.002
			3+	1	0	0	0	0		1	0	4	31	.250	.000
		3-4	2												
			3+												
		4-5	2												
			3+												
		5-6	2												
			3+												
Sun.	10/12/69	2-3	2	36	14			4		50	4	632	801	.079	.005
			3+	0	0			0		0	0	0	0	.000	.000
		3-4	2	35	7			7	1	42	8	454	560	.093	.014
			3+	0	0			0	0	0	0	0	6	.000	.000
		4-5	2	26	5				1	31	1	383	473	.081	.002
			3+	0	1				0	1	0	12	10	.083	.000
		5-6	2	26	5			2		31	3	337	504	.092	.006
			3+	0	0			0		0	0	7	16	.000	.000

TABLE 3
PHASE I - AFTER - DIAGRAMMATIC SIGNS
DATA SUMMARY

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS Exiting Vehicles 3to2	4to2	5to2	2to2	Thru Vehicles 2to3	3to3	TOTAL Exit	Thru	VOLUME Exit	Thru	RATE Exit	Thru
Mon.	11/24/69	2-3	2	15						15	0	383	297	.039	.000
			3+	1						1	0	20	147	.050	.000
		3-4	2	12	2			1		14	1	482	325	.029	.003
			3+	2	0			0		2	0	85	168	.024	.000
		4-5	2	10.3						10.3	0	605	584	.017	.000
			3+	1.7						1.7	0	115	174	.015	.000
Tues.	11/11/69	2-3	2	16	3			1		19	1	457	248	.042	.004
			3+	1	0			0		1	0	40	111	.025	.000
		3-4	2	18				1		18	1	778	344	.023	.003
			3+	3				0		3	0	24	97	.125	.000
		4-5	2	12.0						12.0	0	489	511	.025	.000
			3+	2.2						2.2	0	163	112	.013	.000
Wed.	11/12/69	2-3	2	9	1					10	0	451	344	.022	.000
			3+	2	0					2	0	79	134	.025	.000
		3-4	2	14				1		14	1	615	544	.023	.002
			3+	4				1		4	1	100	182	.040	.005
		4-5	2												
			3+												
Thurs.	11/20/69	2-3	2	11	1					12	0	383	267	.031	.000
			3+	4	1					5	0	29	126	.172	.000
		3-4	2	10	2					12	0	485	363	.025	.000
			3+	2	0					2	0	79	103	.025	.000
		4-5	2	18	1.2					19.2	0	719	562	.027	.000
			3+	1.2	1.2					2.4	0	89	150	.027	.000

TABLE 3 (Cont.)

DAY	DATE	HOUR P.M.	AXLES NO.	LANE CHANGE OF UNUSUAL MANEUVERS Exiting Vehicles 3to2	4to2	5to2	2to2	Thru Vehicles 2to3	3to3	TOTAL Exit	Thru	VOLUME Exit	Thru	RATE Exit	Thru
Fri.	11/14/69	2-3	2	7				2		7	2	370	248	.019	.008
			3+	0				0		0	0	51	111	.000	.000
		3-4	2	8.0						8.0	0	572	485	.014	.000
			3+	2.7						2.7	0	43	61	.063	.000
		4-5	2	17	2			2		19	2	771	685	.025	.003
			3+	2	0			1		2	1	76	140	.026	.007
Sat.	11/22/69	2-3	2	15	4	1		1		20	1	465	389	.043	.003
			3+	0	0	0		0		0	0	30	38	.000	.000
Sun.	11/23/69	2-3	2	35	2				2	37	2	628	667	.059	.003
			3+	0	0				0	0	0	0	28	.000	.000
		3-4	2	42	1			1	1	43	2	470	490	.091	.004
			3+	1	0			0	0	1	0	5	5	.200	.000
		4-5	2	8.7					1.1	8.7	1.1	327	410	.027	.003
			3+	0					0	0	0	3	8	.000	.000

REFERENCES

1. Highway Safety, Design and Operations: Freeway Signing and Related Geometrics (90-39), Hearings before the Special Subcommittee on the Federal-Aid Highway Program of the Committee on Public Works, House of Representatives, Ninetieth Congress, Second Session, U.S. Government Printing Office, Washington, D.C., 1968.

2. Statistical Analysis in Psychology and Education, George A. Ferguson, McGraw-Hill Book Company, 1966, Lib. of Cong., Cat. Card No. 65-25541

BIBLIOGRAPHY

1. Some Principles of Freeway Directional Signing Based on Motorists' Experiences, David W. Schoppert, Karl Moskowitz, Slade F. Hulbert and Albert Burg, Highway Research Board Bulletin 244, "Effects of Traffic Control Devices," Highway Research Board, 1960.

2. Motorists' Reactions to Signing on a Beltway, Stephen G. Peterson and David W. Schoppert. Not published.

3. Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways, American Association of State Highway Officials, Washington, D.C., 1961.

4. Development of Information Requirements and Transmission Techniques for Highway Users, G.J. Alexander, G.F. King, M.S. Warskow. Research Report Number 606-1, Diagnostic Studies of Highway Visual Communication Systems, Research Project Number HPR-2(108), Contract Number FH-11-7031, Texas Transportation Institute, 1969.