ACCIDENT, TRAFFIC PERFORMANCE AND PROCEDURE EVALUATION FOR THE POSITIVE GUIDANCE DEMONSTRATION

Final Report

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16. Abstract

A cut-through circle with traffic signals at both ends (Route 38-Church Road-Coopertown Road Circle in Cherry Hill, New Jersey) was analyzed using positive guidance, an analysis technique that joins highway engineering and human factors technologies to produce an information system matched to the facility characteristics and driver attributes.

A condition of increased driver confusion may exist due to changes in signing, traffic signals, and pavement markings generated from the positive guidance analysis of the site. The speed variance increased; there was an increase in the percent of signal cycles where violation of the red occurred; and the accidents remained unchanged.

Positive guidance proved to be a time consuming, tedious procedure for the intersection studied. Although positive guidance techniques did not improve traffic performance, the methodology could prove to be a useful tool in training traffic engineers.

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SUMMARY AND CONCLUSIONS

A cut-through circle with traffic signals at both ends (Route 38-Church Road-Coopertown Road Circle) was analyzed using "positive guidance" and analysis techniques that join highway engineering and human factors technologies to produce an information system matched to the facility characteristics and driver. A condition of increased driver confusion may exist due to the changes in signing, traffic signals, and pavement markings generated from the "positive guidance" analysis of the site. statement can be inferred from the summary of the results outlined as follows:

Speed variance increased after the changes were made at all data collection sites on Route 38. There was one site at each end of the circle and one site 500' before the circle in each direction. Although only one of the increases in variance was significant at the 95 percent confidence level using the F-test, the that all had an increase is significant at a level of confidence greater than 90 percent using the Binomial Distribution

2. There was an increase in the percent of signal cycles where violation of the red occurred at the signals under study. There was also a increase in the percent of vehicles which violated the red phase at the study signals, although the analysis required use of traffic volume estimates. This data was analyzed using the ference in proportions test and the non-parametric sign test

Positive guidance the procedure used in this study, proved to be a time consuming, tedious procedure for the intersection studied. Although

positive guidance techiques did not improve traffic performance, the methodology could prove to be a useful tool in training traffic engineers.

INTRODUCTION

New Jersey was one of three states selected to demonstrate the use of "positive guidance" in the solution of Traffic Engineering problems. technique, developed by the Federal Highway Administration, is intended to be applied to locations which seem to defy improvement by use of standard traffic engineering methods. The technique involves a detailed systematic analysis of all information which confronts the motorist at a given site, analysis and ranking of hazardous situations and accidents, development of driver expectancies and information needs and determination of a "positive guidance" system to meet these needs. Included in the program is the selection and analysis of driver-traffic performance measures to help gauge the success of the system implemented. This report contains the analysis of two traffic performance measures selected for study: speeds (including mean speed and speed variance) and violations of the red phase of signals at the site as well as a detailed accident analysis and an overall evaluation of the positive guidance procedure.

The site selected for this study is the Route 38-Church Road-Coopertown Road Circle in Cherry Hill, New Jersey. The site is a cut-through circle with traffic signals at both intersections of the circle and Route 38. circle is unusual due to the addition of a third closely spaced signal before the circle in the eastbound direction at the stop line for a house. The site also has the unusual characteristics of the major route not travelling straight through the circle and the fact that it is a six-legged circle (Figure 1).

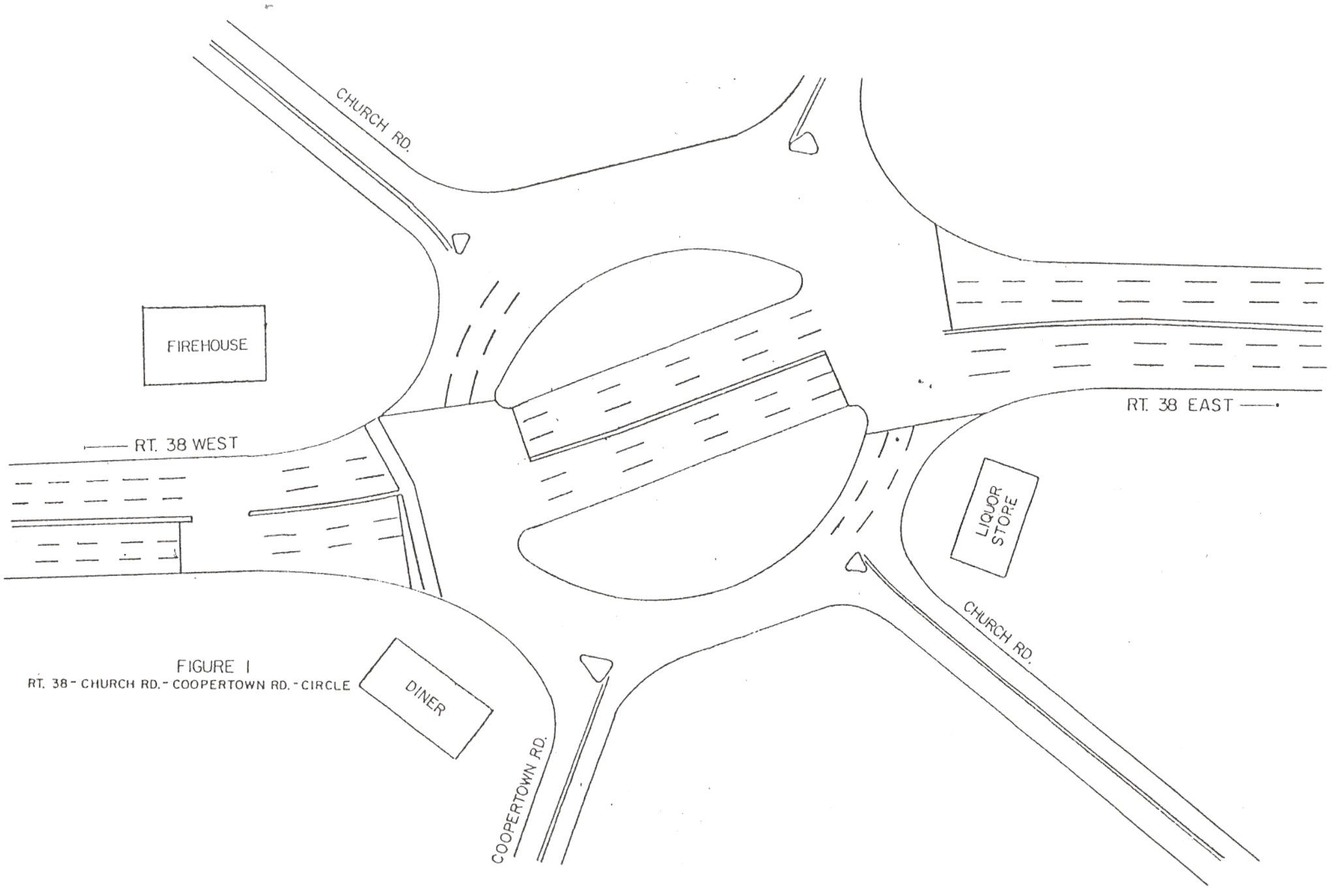


FIGURE 1
RT. 38 - CHURCH RD. - COOPERTOWN RD. - CIRCLE

IMPLEMENTATION OF POSITIVE GUIDANCE SYSTEM

Based on application of the positive guidance procedure to the Route 38 circle, the Bureau of Traffic Engineering recommended the changes at the site which were approved by the FHWA prior to implementation. Implementation of the changes occurred between November 1979 and March 1980.

Signing

Extensive changes in the signing system were made. These are diagrammed in the Interim Report submitted to FHWA on April 10, 1979. The signs were changed to improve and correct navigational information on all six approaches and at the circle. The signs were located to minimize places where the motorist was confronted with a large information load.

Signals (See Figure 2)

1 An additional signal was installed facing each of the circle approaches to Route 38 to comply with the MUTCD

2. The first signal in each direction (No. 2 EB and No. 4 WB) had the signal heads changed to 12", while the other signals retained 8" heads. This change was made to provide a visual image of longitudinal separation between the stopping points. It was thought that this improvement would reduce the high number of same direction accidents. (Fourty-four percent of total accidents from 1975 through 1977 were same direction accidents compared to 32 percent for intersections throughout the state.

3. All signal housings were changed to yellow to provide greater contrast with the surroundings.

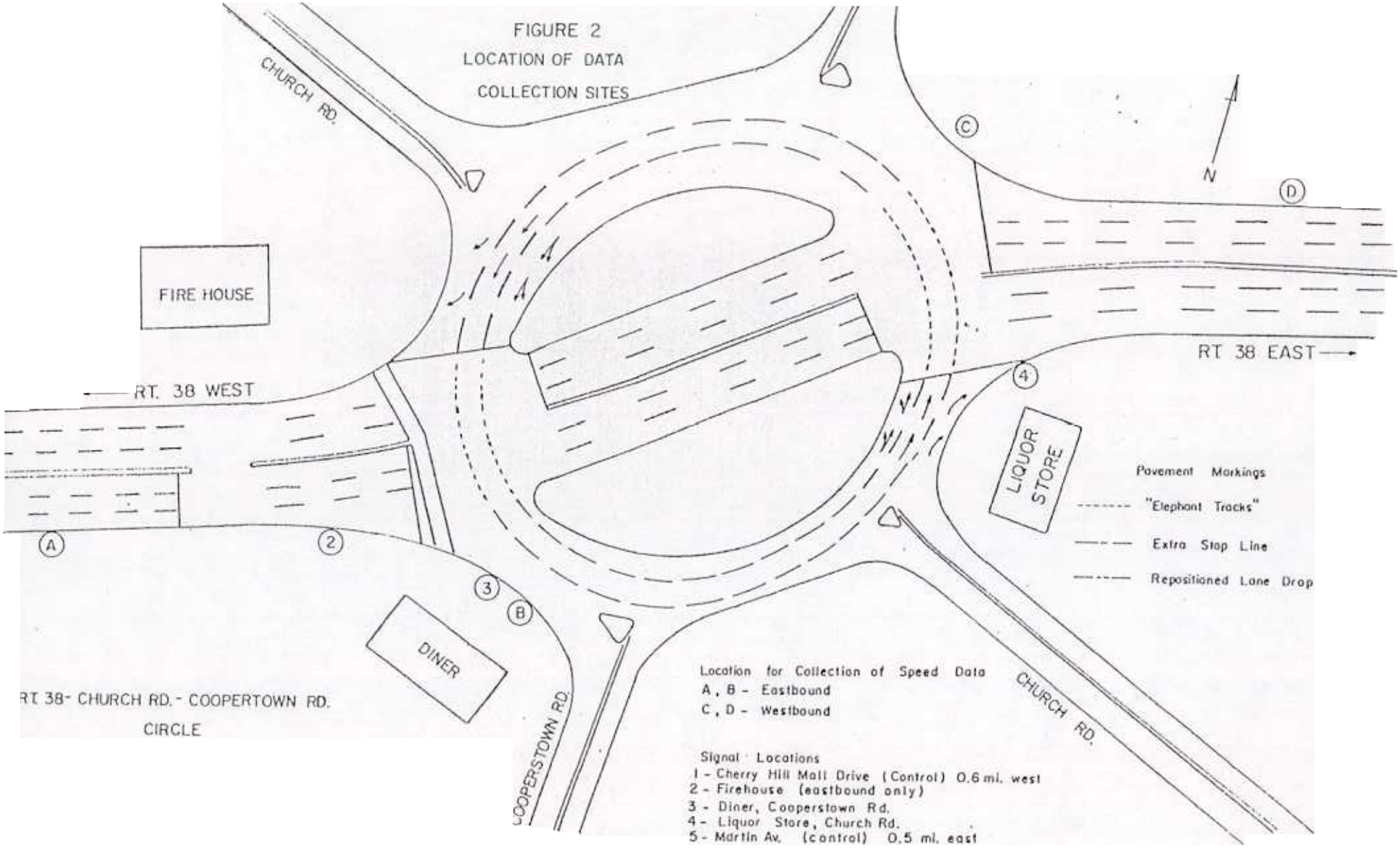


FIGURE 2
LOCATION OF DATA
COLLECTION SITES
CHURCH RD.
FIRE HOUSE
RT. 38 WEST
RT 38 EAST
LIQUOR STORE
DINER
COOPERSTOWN RD.
CHURCH RD.
N
A
B
C
D
2
3
4
Pavement Markings
"Elephant Tracks"
Extra Stop Line
Repositioned Lane Drop
Location for Collection of Speed Data
A, B - Eastbound
C, D - Westbound
Signal Locations
1 - Cherry Hill Mall Drive (Control) 0.6 mi. west
2 - Firehouse (eastbound only)
3 - Diner, Cooperstown Rd.
4 - Liquor Store, Church Rd.
5 - Martin Av. (control) 0.5 mi. east
RT 38- CHURCH RD. - COOPERTOWN RD.
CIRCLE

4. The cycles of all signals, including the control signals, were not altered.

Pavement Markings (See Figure 2)

1. Lane lines were extended all around the circle including "elephant track" markings across Route 38.

2. Turning and straight through arrows were added at the two circle approaches to Route 38

3. The lane drop on Route 38 eastbound, just east of the circle, was repositioned 800' further east

STUDY DESIGN

The following three traffic performance measures were selected for study based on observations at the site by two engineers:

1. Speeds, including mean and variance.

2. Violations of the red phase of the signals, both percent of vehicles which violate and percent of signal cycles which have a violation.

3. Accidents

Since the positive guidance analysis indicated driver confusion with the inaccurate and overloaded signing system, the closeness of signals and the lack of pavement markings around the circle, the above measures were chosen. It was believed that the changes made at the circle would reduce driver confusion and this would be reflected in a reduction of speed variance and a reduction of red light violations.

Data was collected in May and June of 1979 (the before condition) and 1980 (the after condition). Collection was limited to Tuesday, Wednesday and Thursday to avoid non-commuter travel patterns on the weekend, Monday morning and Friday evening.

Speed data was collected between 12 Noon and 2:30 in order to gather 100 free-flowing speed samples at each point. The locations where speed data was collected were: (Figure 2)

A - 500' West of Circle in east direction.

B - At beginning of Circle in east direction.

C - At beginning of Circle in west direction.

D - 500' East of Circle in west direction.

A hand-held radar unit, commonly employed by Traffic Engineering for speed analysis, was used.

Data on violations of the red phase was collected at five signals (Figure 2):

No.	Location	Type of Site	Cycle Length
1	Cherry Hill Mall Drive (0.6 miles west of circle)	Control	120 sec
2	Fire House (Eastbound traffic only)	Study	90 sec.
3	Diner, Coopertown Road	Study	90 sec
4	Liquor Store, Church Road	Study	90 sec
5	Martin Avenue (0.5 miles east of circle)	Control	90 sec

Data was collected at each location for Route 38 traffic for both the eastbound and westbound directions, during the morning and evening peak periods: Morning - 7 to 10, Evening - 3 to 6. The data collectors counted the number of vehicles which passed through the red phase of each signal cycle (120 cycles in three hours for No. 2 to No. 5; 90 cycles in three hours for No. 1). Traffic volume data was not collected at this time but estimated as explained in the Appendix

An extra stop line was mistakenly painted during implementation of the changes about 20' west of the existing stop line for the No. 2 - Fire House signal (Figure 2). Observations by the data collectors led to the belief

that this induced many motorists to violate this red signal. The data from this signal, although collected and included in the Results Section for completeness, was not used in discussion of the results or generation of the conclusions

Before-after accident data was collected from computer runoffs of accidents supplied by the Bureau of Accident Records

Once the study was completed the positive guidance procedure was evaluated. The project engineer from Traffic Engineering filled out a questionnaire on each of the positive guidance activities, mentioning what he liked or disliked about each activity and why. Questionnaire results are summarized in Tables 7 and 8. Also positive guidance was monitored as far as time spent and costs

RESULTS

Violations of the Red Phase of Signals

The data of red phase violations was analyzed in two ways. The first method attempted to determine whether any differences existed in the percentage of cycles where a violation of the red phase occurred between 1979 and 1980. For this analysis, a cycle was considered to have had a violation of the signal when the front wheels of one or more cars crossed the stop line. The second method tested for significance in the differences of percentage of vehicles which violated the red between 1979 and 1980 However, since traffic volumes were not collected at the time of data collection, estimates of the volumes were generated as shown in the Appendix and used in this analysis.

The results of the first method are given in Tables 1 and 2. These tables list the number of cycles studied, the number of cycles where violation of the red occurred, and the percentage of cycles where the red was violated for 1979 and 1980. The change in these percentages from 1979 to is also listed along with a determination of statistical significance of these changes at the 95 percent level of confidence using a test for the Difference in Proportions.(1)

Seven of the eight control situations had changes not found to be significant. The one control site where a significant change did occur (Martin Avenue, AM, Eastbound), this change was a reduction in the percent of cycles where red violations occurred.

Of the eight study sites, excluding Site #2 for the reasons already stated, five exhibited significant increases in the percent of cycles where

TABLE 1

% OF CYCLES WHERE VIOLATION OF THE RED PHASE OCCURRED

AM PEAK PERIOD

EASTBOUND

Location of Signal	1979 # Cycles	1979 # Cycles With Red Violation	1979 %	1980 # Cycles	1980 # Cycles With Red Violation	1980 %	Change 1979 to 80	Diff. Signif. at 95% Confidence Level
#1-Cherry Hill Mall Drive (Control)	80	9	11.3	90	17	18.9	+7.6	No
#2-Fire House	122	27	22.1	121	111	91.7	+69.6	Yes
#3-Diner, Coopertown Road	118	33	28.0	120	37	30.8	+2.8	No
#4-Liquor Store, Church Road	104	6	5.8	120	32	26.7	+21.9	Yes
#5-Martin Ave. (Control)	118	37	31.4	120	23	19.2	-12.2	Yes

WESTBOUND

Location of Signal	1979 # Cycles	1979 # Cycles With Red Violation	1979 %	# Cycles			Change 1979 to 80	Diff. Signif. at 95% Confidence Level
#1-Cherry Hill Mall Drive (Control)	87	58	66.7	90	63	70.0		
#3-Diner, Coopertown Road	120	25	20.8	120	58	48.3		Yes
#4-Liquor Store, Church Road			20.2					
#5-Martin Ave. (Control)	118	55	46.6	120	53	44.2	-1.6	No

TABLE 2

% OF CYCLES WHERE VIOLATION OF THE RED PHASE OCCURRED

PM PEAK PERIOD

EASTBOUND

Location of Signal	1979			1980			Change 1979 to 80	Diff. Signif. at 95% Confidence Level
	# Cycles	# Cycles With Red Violation	%	# Cycles	# Cycles With Red Violation	%		
#1-Cherry Hill Mall Drive (Control)	89	35	39.3	90	35	38.9	-0.4	No
#2-Fire House	122	57	46.7	120	100	83.3	+36.6	Yes
#3-Diner, Coopertown Road	118	55	46.6	120	68	56.6	+10.0	No
#4-Liquor Store, Church Road	123	17	13.8	120	59	49.2	+35.4	Yes
#5-Martin Ave. (Control)	120	37	30.8	120	46	38.3	+7.5	No

WESTBOUND

Location of Signal	1979			1980			Change 1979 to 80	Diff. Signif. at 95% Confidence Level
	# Cycles	# Cycles With Red Violation	%	# Cycles	# Cycles With Red Violation	%		
#1-Cherry Hi Mall Drive (Control)	76	60	78.9	90	66	73.3	-5.6	No
#3-Diner, Coopertown Road	104	25	24.0	120	46	38.3	+14.3	Yes
#4-Liquor Store, Church Road	99	9	9.1	120	36	30.0	+20.9	Yes
#5-Martin Ave. (Control)	104	41	39.4	120	37	30.8	-8.6	No

red violations occurred, while the other three had increases not found to be significant. None of the study sites showed a decrease in the percent of cycles with violation of the red phase

If the direction of change alone is considered, and not the magnitude the non-parametric sign test can be applied.(2) Since three control situations increased while five decreased, the hypothesis that the 1979 and 1980 populations, from which the data was taken, are the same is not rejected at the 95 percent confidence level. For the eight study sites, all which exhibited increases in the percent of cycles where violations of the red occurred, the hypothesis that 1979 and 1980 data come from the same populations is rejected at a level of confidence greater than 99 percent.

The second method of analysis of the red phase violation data determined whether changes in the percent of vehicles which violated the red were statistically significant from the before 1979) to the after (1980) condition. The estimated 1979 traffic volumes used in this analysis are:

	Eastbound	Westbound
7 AM - 10 AM	3000	7700
3 PM - 6 PM	7000	4800

The methods for generation of these volumes are given in the Appendix. Due to the ±2 percent variation in traffic volume between 1979 and 1980 at a nearby traffic count station for the month of data collection, the data was anlayzed assuming a ±5 percent change in traffic from 1979 to 1980. The intent of this anlaysis was to see whether the results remain consistent over this range of volumes, which, for the reasons outlined in the Appendix, probably encompasses the actual percent change experienced at the study site. The 1980 traffic volume estimates are:

	Eastbound		Westbound	
	1979+5%	1979-5%	1979+5%	1979-5%
10 AM	3200	2900	8100	7300
6 PM	7400	6700	5000	4600

Tables 3 and 4 summarize the results of this analysis. The numbers of vehicles which violated the red signal in 1979 and 1980 are listed along with the estimated volumes. Adjustments in these volumes reflect lost or additional time of data collection at many of the sites in 1979. Twelve sites had less than the full three hours of data collection, while four sites had slightly more than three hours of collection time. Percentages of vehicles which ran the red light are calculated for each of the 1980 conditions and compared to 1979 for statistical significance of any differences. The previously mentioned test for differences in proportions at the 95 percent confidence level was used here again. Also listed on these tables is the direction of the difference, to be used in the running of the non-parametric sign test

The results for all eight control sites were consistent over the ±5% volume range. That is, the differences between the extremes of the 1980 volume range and the 1979 data are both found siginficant or both found not significant. Similar to the percent of cycles with red violation analysis previously discussed, only the Martin Avenue, AM, Eastbound control site exhibited significant change, and again this change was a reduction. The eight study sites, excluding Site #2, also had consistent results over the ±5% volume range with two exceptions: Site #4, AM, Westbound and Site #3, PM, Westbound. Each of these sites exhibited significant change at the 1979-5% volume and non-signifiance at the 1979+5% volume. Overall, for the

TABLE 3

% OF VEHICLES WHICH VIOLATED THE RED PHASE

AM PEAK PERIOD

EASTBOUND

Location of Signal	1979 # Veh Running Red	1979 Volume (A)	1979 %	1980 # Veh Running Red	1980 1979 Volume +5%	1980 %	1980 Dir. of Diff. + Signif. (B)	1980 1979 Volume -5%	1980 %	1980 Dir. of Diff. + Signif. (B)
#1-Cherry Hill Mall Drive (Control)	12	2700	0.44	19	3200	0.59	+ No	2900	0.66	+ No
#2-Fire House	38	3100	1.23	302	3200	9.43	+ Yes	2900	10.40	+ Yes
#3-Diner, Coopertown Road	44	2900	1.52	43	3200	1.34	- No	2900	1.48	+ No
#4-Liquor Store, Church Road	7	2600	0.27	40	3200	1.25	+ Yes	2900	1.38	+ Yes
#5-Martin Avenue (Control)	46	2900	1.59	26	3200	0.81	- Yes	2900	0.90	- Yes

WESTBOUND

Location of Signal	1979 # Veh Running Red	1979 Volume (A)	1979 %	1980 # Veh Running Red	1980 1979 Volume +5%	1980 %	1980 Dir. of Diff. + Signif. (B)	1980 1979 Volume -5%	1980 %	1980 Dir. of Diff. + Signif. (B)
#1-Cherry Hi Mall Drive (Control)	111	7400	1.50	116	8000	1.45	- No	7300	1.59	+ No
#3-Diner, Coopertown Road	30	7700	0.39	85	8000	1.06	+ Yes	7300	1.16	+ Yes
#4-Liquor Store, Church Road	27	8000	0.34	41	8000	0.51	+ No	7300	0.56	+ Yes
#5-Martin Avenue (Control)	75	7600	.99	76	8000	0.95	- No	7300	1.04	+ No

(A) Volumes are adjusted to reflect lost or additional time of data collection.

(B) Significance of change using test of proportions at 95% level of confidence.

TABLE 4

% OF VEHICLES WHICH VIOLATED THE RED PHASE

PM PEAK PERIOD

EASTBOUND

Location of Signal	1979			1980						
	# Veh Running Red	1979 Volume (A)	%	# Veh Running Red	1979 Volume +5%	%	Dir. of Diff. + Signif. (B)	1979 Volume -5%	%	Dir. of Diff. + Signif. (B)
#1-Cherry Hill Mall Drive (Control)	45	6900	0.65	48	7400	0.65	No Diff. No	6700	0.72	+ No
#2-Fire House	93	7100	1.31	251	7400	3.40	+ Yes	6700	3.75	+ Yes
#3-Diner, Coopertown Road	75	6900	1.09	110	7400	1.49	+ Yes	6700	1.64	+ Yes
#4-Liquor Store, Church Road	20	7200	0.28	73	7400	0.99	+ Yes	6700	1.09	+ Yes
#5-Martin Avenue (Control)	44	7000	0.63	57	7400	0.77	+ No	6700	0.85	+ No

WESTBOUND

Location of Signal	1979			1980						
	# Veh Running Red	1979 Volume (A)	%	# Veh Running Red	1979 Volume +5%	%	Dir. of Diff. + Signif. (B)	1979 Volume -5%	%	Dir. of Diff. + Signif. (B)
#1-Cherry Hill Mall Drive (Control)	118	4100	2.87	113	5000	2.26	- No	4600	2.46	- No
#3-Diner, Coopertown Road	31	4200	0.74	53	5000	1.06	+ No	4600	1.15	+ Yes
#4-Liquor Store, Church Road	10	4000	0.25	45	5000	0.90	+ Yes	4600	0.98	+ Yes
#5-Martin Avenue (Control)	55	4200	1.31	49	5000	0.98	- No	4600	1.07	- No

(A) Volumes are adjusted to reflect any lost or additional time of data collection.

(B) Significance of change using test of proportions at 95% level of confidence

+5% condition, five of the study sites had significant increases, two had non-siginificant increases and one had a non-significant decrease. For the -5% condition, seven had significant increases and one had a non-significant increase. If the change in volume between 1979 and 1980 was as high as +25%, four out of eight study sites still exhibit significant increases in the percentage of vehicles which violated the red signal.

Use of the sign test on the direction of the changes parallels the results of the previous analysis. The control site data can be said to come from the same population when comparing 1979 to both 1980 conditions. However, the study sites analysis rejects this hypothesis, i.e., that 1979 and 1980 data were taken from the same population, at the 95 percent confidence level for both the ±5% volume conditions.

Speed Data

Initially, all eight groups of speed data (four from 1979 and four from 1980) were subjected to the X^2 (chi-square) goodness of fit test.(3) The results of this test were that at the 95 percent confidence level, all the speed distributions gathered can be assumed normal and tests for the differences between the means and differences between variances (F-test) could be applied to the data.

The information in Table 5 shows decreases in the mean speed from 1979 to 1980 for three of the sites, both sites at the circle and the site in the eastbound lane -- 500' before the circle. The fourth site, in the westbound lane -- 500' before the circle, had an increase in mean speed. All differences in the means were found to be statistically significant at the 95 percent confidence level using the t-test.(4)

TABLE 5

ANALYSIS OF MEAN SPEEDS AND SPEED VARIANCE

Direction and Location	Measure	1979	1980	Change	Significance at 95% Level
Eastbound-500' West of Circle (Location A)	$\bar{x}$	49.6	45.5	-4.1	Yes
	σ	5.62	6.54	--	--
	σ^2	31.58	42.77	+11.19	No
	n	100	100	--	--
Eastbound at Beginning of Circle (Location B)	$\bar{x}$	46.0	42.4	-3.6	Yes
	σ	3.99	5.28	--	--
	σ^2	15.92	27.88	+11.96	Yes
	n	100	100	--	--
Westbound at Beginning of Circle (Location C)	$\bar{x}$	41.4	39.7	-1.7	Yes
	σ	4.39	5.12	--	--
	σ^2	19.27	26.21	+6.94	No
	n	100	100	--	--
Westbound-500' East of Circle (Location D)	$\bar{x}$	44.5	46.4	+1.9	Yes
	σ	6.47	6.67	--	--
	σ^2	41.86	44.49	+2.63	No
	n	100	100	--	--

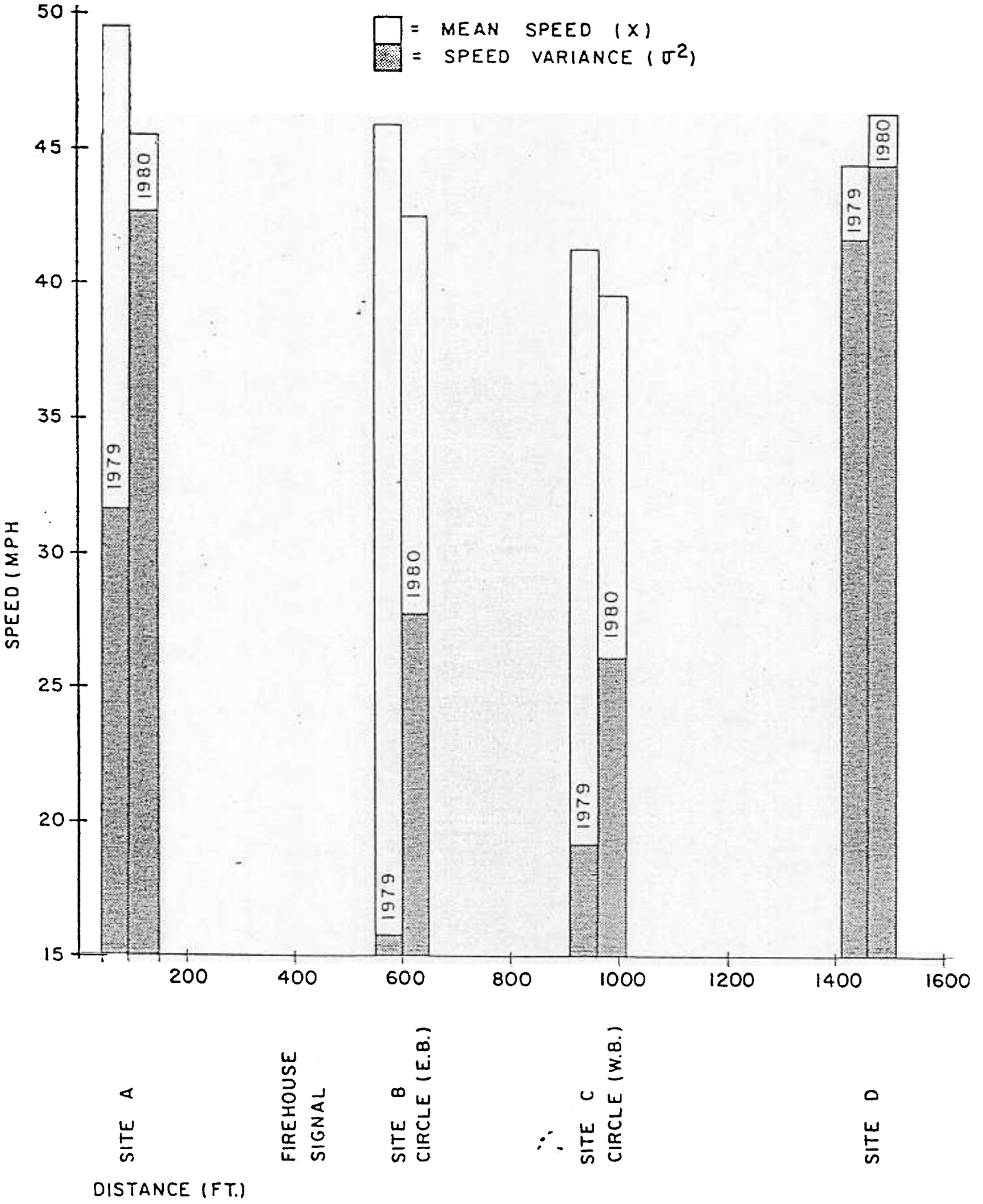
$\bar{x}$ = Mean Speed
σ = Standard Deviation
σ^2 = Variance
n = Number of Samples

Speed variance increased at all the locations between 1979 and 1980. However, for only one location was this difference significant, at the beginning of the circle in the eastbound direction. The f-test at the 95 percent confidence level was applied to this data.(5)

Application of the binomial distribution to the direction of change for speed variances leads to a rejection of the hypothesis that the 1979 1980 speed variances come from the same population at the 90 percent confidence level.

Figure 3 graphically shows the differences in the mean speeds and speed variances between the before and after conditions. It also illustrates the decrease in mean speed and speed variance as cars approach the circle from the westbound and eastbound directions for each year.

Figure 3 MEAN SPEED AND SPEED VARIANCE



Accident Analysis

Before and after police reported accidents were collected on the dates shown below.

Condition	Date
Before	April 1, 1976 to March 31, 1979
Implementation	November 1979 to March 1980
After	April , 1980 to March 31, 1981

In Table 6, the accidents considered to be most sensitive to the treatment are listed. Accident were collected from within the circle as well as up to .10 miles east of the circle and up to .12 miles west of the circle to account for traffic backups. The before data was adjusted for time and volume differences. The time adjustment was a factor of 1/3 since three years of before data were compared with one year of after data. The volume adjustment was derived from the weekly May counts at the nearby counting station, assuming the change in the volume at the count station reflects the change in volume at the study site (see Appendix).

Year	Weekly Total
	136,481
	130,536
	142,520
	139,371

The 1980 volume of 139,37 increased 2.1 percent over the 1976, 1977, and 1978 average volume of 136,512. So, the volume adjustment was a factor of 139,371/136,512. As a sample, there were 82 same direction accidents

TABLE 6

ACCIDENT ANALYSIS

Accident Category	Accidents Before	Expected Accidents After	Observed Acc Accidents After	% Change	% Change Required for 95% Confidence	Is Change Significant?
Total	137	47	36	-26	36	No
Fatal	0	0	0	0	*	*
Injury	59	20	15	-25	55	No
PDO	78	27	21	-22	47	No
Same Direction	82	28	25	-11	46	No
All Others	55	19	11	-47	55	No
Day	81	28	20	-29	46	No
Night	50	17	16	- 6	61	No
Dawn/Dusk	6	2	0	*	*	*
Dry	107	36	29	-19	42	No
Wet	28	10	7	-30	67	No
Icy	1	0	0	*	*	*
Unknown	1	0	0	*	*	*

*Too small to test

during the three years prior to the positive guidance treatment. Using the above factors, the expected number of same direction accidents for the one year after the treatment would be:

82 (1/3) 139,371/136,512) = 28

There were 25 same direction accidents after the treatment, a decrease of 11 percent below the expected amount. This difference is not significant at the 95 percent level of confidence using the chi-square distribution.(6)

DISCUSSION

As outlined previously in this report, the positive guidance analysis performed on the existing signing revealed the need for more accurate navigational signing and spreading out of the sign informational load. results of the speed data analysis tend to indicate that the sign changes, which attempted to correct the existing deficiencies, worsened situation. The increase in the speed variance at all four data collection points may indicate more confusion on the motorists' part during the after condition. Explanation of this phenomena through motorist unfamiliarity may be discounted since the after data collection occurred six to seven months after the sign changes were made. This should be sufficient time for driver acclimation to the sign changes.

The changes in the traffic signals attempted to improve the signal visibility by making all the housing units yellow, rather than green and by installing 12" heads, instead of 8" heads, on the first set of signals in each direction of traffic. This second change was made to provide a visual image of longitudinal separation between the first 12") and second (still 8") sets of signals in each direction. It was believed that this improvement would reduce the high number of same direction accidents. Since running closely spaced red lights could account for some of the same direction accidents as rear-enders, violations of the red signal were measured before and after.

The results clearly indicate that the incidence of running the phase increased at all the study sites. The increase in vehicles running the red phase might be in part due to the visual image of signal separation

inducing motorists to violate the first light, sensing enough distance exists to stop for the second and causing same direction, rear-end type accidents when insufficient distance existing to stop for the next signal. However, the magnitude of the increases is generally greater for the last signal in each direction. In the eastbound direction, the misplaced stop line at the first signal (Fire House) caused the very large increase in red violations at that light and may be said to have affected the other eastbound signals. It cannot, however, be used to account for the similar findings in the westbound direction. The "elephant track" pavement markings in the two intersections of the circle and Route 38 may have distracted motorists' attention from the signal and stop line, causing violation of the red. The increased driver confusion indicated by the greater speed variances could have played a large part in the increases of red signal violations. However, a positive guidance analysis of the current set-up would be needed to generate convincing reasons for this confusion. The accident analysis showed no significant changes

Since no data was gathered on the side street traffic, the signing signal and pavement marking changes made in these areas cannot be discussed

EVALUATION OF POSITIVE GUIDANCE PROCEDURE

Positive guidance for the most part was a new method of coming up with solutions to traffic engineering problems.(7) Most of Function A was a standard procedure for the Traffic Engineering Bureau. However, driver performance data was not normally collected due to a lack of personnel. Functions B and C took too much time for the information yielded. Function D was useful in improving sign locations. Positive guidance devices selection under Function E were influenced by the thinking and input of several superiors. Before-after studies are not a standard traffic engineering procedure, especially when driver performance factors are used since the staff is not available. Although positive guidance was not a useful tool in improving the complicated intersection chosen, positive guidance could be used as a training tool for new traffic engineers since it outlines in detail many of the steps experienced engineers follow automatically. Table 7 summarizes the results of a questionnaire filled out by the project engineer who performed the positive guidance procedure, and Table 8 lists the project engineer's comments on positive guidance

TABLE 7

POSITIVE GUIDANCE QUESTIONNAIRE RESULTS

Collect Data	Activity	Performed?	Variations, Modifications, Omissions?	Understandable?	Inputs Useful and Applicable?	Practical in View of Time Spent and Results Obtained?	Person-Days Spent	Over a ___ Day Period
Review all historical data	A-1	Yes	Yes	Yes	Yes	Yes	4	15
Conduct site survey and operations review	A-2	Yes	Yes	Yes	NC	NC	3¼	180
Collect performance data	A-3	Yes	No	Yes	Yes	NC	3	30
Describe location characteristics	A-4	No	Yes	NC	Yes	NC	0	0
Specify problem								
Identify, describe and rank hazards	B-1	Yes	Yes	Yes	Yes	No	4	5
Define driver performance factors								
Analyze speed and path	C-1	No	NC	NC	NC	NC	0	0
Characterize expectancies	C-2	Yes	No	No	NC	Yes	4½	10
Assess selection and recognition factors	C-3	Yes	Yes	Yes	Yes	Yes	1	3
Analyze information load	C-4	Yes	No	Yes	Yes	Yes	2½	4

TABLE 7

POSITIVE GUIDANCE QUESTIONNAIRE RESULTS
(Continued)

Collect Data	Activity	Performed?	Variations, Modifications, Omissions?	Understandable?	Inputs Useful and Applicable?	Practical in View of Time Spent and Results Obtained?	Person-Days Spent	Over a Day Period
Define information requirements								
Determine information handling zone	D-1	Yes	No	Yes	Yes	Yes	1	3
Determine information needs	D-2	Yes	No	Yes	Yes	Yes	1	3
Assign primacies to needs	D-3	Yes	Yes	Yes	Yes	Yes	1½	3
Assess current information system	D-4	Yes	No	Yes	Yes	Yes	½	1
Determine positive guidance information								
Identify applicable control devices	E-1	Yes	No	Yes	Yes	Yes	2	3
Design positive guidance plan	E-2	Yes	Yes	Yes	Yes	Yes		
Evaluation								
Develop evaluation plan	F-1	Yes	No	No	Yes	No		
Conduct evaluation	F-2	Yes	No	Yes	Yes	No		

TABLE 8

COMMENTS FROM POSITIVE GUIDANCE QUESTIONNARIE

Function A - Collect Data

Activity 1 - Review All Historical Data

A standard traffic engineering procedure. Step 5 was omitted as impractical.

Activity 2 - Conduct Site Survey and Operations Review

A standard traffic engineering procedure, done simultaneously other activities.

Activity 3 - Collect Performance Data

Not a standard traffic engineering procedure, required more data usually collected. Usually the squeaky wheel gets the grease. If there are no complaints, then the treatment is deemed a success.

Activity 4 - Prepare Site File

A necessary activity. However, the study site had an existing file from previous investigations. The performance data was incomplete and was not summarized.

Function B - Specify Problem

Activity 1 - Identify, Describe and Rank Hazards

All three steps were done simultaneously. Identification of hazards (Step) can be very tedious as some items may be listed as hazards without ever being a problem. Hazard ranking (Step 3) should have more

emphasis on engineering judgement and accident number and severity. The listing of situation hazards (Step 1) proved very useful.

Function C - Definition of Driver Performance Factors

Activity 1 - Analyze Speed and Paths

Not performed due to a lack of time and personnel.

Activity 2 - Characterize Guidance and Navigational Expectancies

The expectancy violation characterization sheet was not easily understood, as the column headings were vague. Add a location column. The results from the characterization sheet appeared to be very useful.

Activity 3 - Assess Detection and Recognition Factors

Detection and recognition differences were difficult to understand. Activity 4 was heavily dependent on Activities A2 and A3 and so was used as an input.

Activity 4 - Analyze Information Load

The condition diagram did not contain enough information to complete the Information Load Diagram. Procedure could be time consuming

Function D - Definition of Information Requirements

Activity - Determine Information Handling Zones

Useful in determining if and where signs are needed without relying on engineering judgement. Consider combining with drive through.

Activity 2 - Determine Information Needs

Hazard Descriptions (B-1) used very little because of uncertain accident locations.

Activity 3 - Assign Primacies to Information Needs

Used results from observations (Function A) and hazards (Function B).

Activity 4 - Assess Current Information System

The inadequacy of the current system was already known.

Function E - Determination of Positive Guidance Information

Activity 1 - Identify Traffic Control Devices Applicable to Information Needs

No comment.

Activity 2 - Design Positive Guidance Plan

Design was influenced by the thinking and input of several superiors

Function F - Evaluation

Activity 1 - Develop Evaluation Plan

Improvements not normally evaluated with before-after studies. Data requirements were unknown. The squeaky wheel gets the grease. If there are no complaints, the improvement is deemed successful.

Activity 2 - Conduct Evaluation

No Comment.

Time Spent

Positive guidance was performed over a two-year period, and the time can be broken down as follows:

Organization	Man-Days
Traffic Engineering	
Research	119
Maintenance	
TOTAL	

Costs

Traffic Engineering applied positive guidance to come up with solutions to a difficult intersection. The role of Research was to monitor and evaluate the project and prepare the interim and final report. Maintenance crews installed the positive guidance devices. There were also expenses for vehicles used in installing traffic devices and expenses for materials used to implement positive guidance. Project expenses can be broken down as follows:

Organization	
Traffic Engineering	$10,932
Research	16,584
Maintenance	2,653
Supplies	
Travel	531
TOTAL	$35,337

APPENDIX

Traffic volumes were not collected at the circle under study during the collection of the traffic performance data. In order to determine whether the percent of vehicles which violated the red changed between the before and after conditions (1979 and 1980) estimates of the traffic volume were generated as follows:

A major count station (which counts traffic one week out of four in same direction) exists at M.P. 4.97 on Route 38. The study site is at 3.9 (Figure 4). The first assumption made is that changes in the traffic at this count station reflect changes in the traffic at the circle under study. This assumption may be considered acceptable due to the lack of any major highways between the count station and the circle, and due to the nature of the traffic which uses the road: commuters to and from the Camden-Philadelphia area.

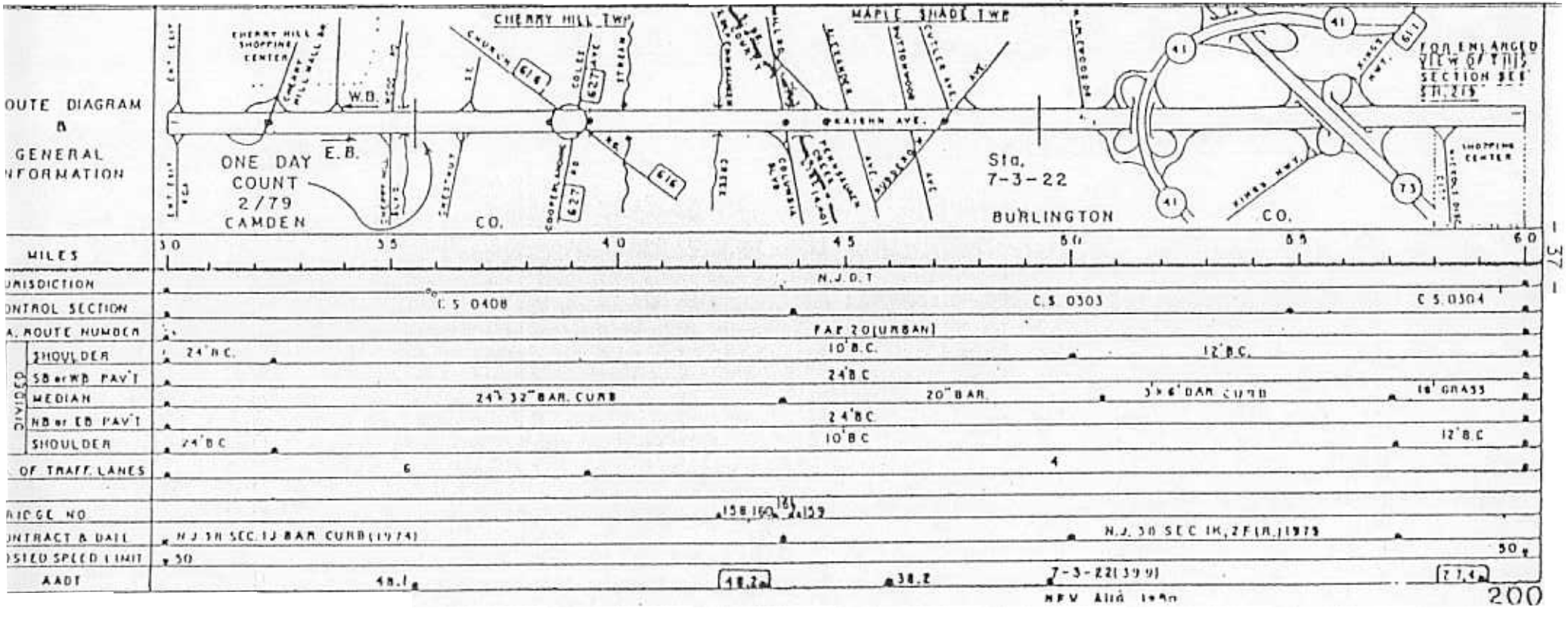
The following data from the count station comprises one week of traffic counts during May for the years 1978, 1979, and 1980

	1978	1979	% Change	1980	% Change
7 AM - 10 AM	26,519	26,142	-1.4	26,675	+2.0
6 PM	29,216	29,125	-0.3	28,570	-1.9
Daily Total	142,520	40,406	-1.5	139,371	-0

Since the peak period volumes, which were time periods when data was collected, and the daily totals changed from 1979 to 1980 by no more than the $\pm 2\%$, and based on the previous assumption, a decision was made to analyze the percent of vehicles which violated the red under the conditions

Figure 4 LOCATIONS TRAFFIC VOLUME

ROUTE NJ 38



of a 5% increase and 5% decrease in 1980 traffic over 1979. The intent of this sensitivity analysis is to see whether the results remain consistent over this volume range, a range which, based on the available data, can reasonably be assumed to encompass the actual change at the study site

The traffic volumes at the study site were estimated as follows. A one-day count in February 1979 at M.P. 3.55 of Route 38 (Figure 4) provided the following counts for the study area.

	ONE DAY COUNT 2/79		ADJUSTED TO 5/79	
	EB	WB	EB	WB
7 AM - 10AM	2,688	6,812	3,037	7,697
3 PM - 6PM	6,23	4,253	7,041	4,806

A ratio of volumes from the May 1979 and February 1979 counts at the count station yielded a factor of 1.13 (February 1979) = May 1979. Using the assumption that the study site traffic variations reflect the count station variations, the one-day count data from February 1979 was multiplied by 1.13 and used as the May 1979 traffic volumes at the study site.

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