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16. Abstract

The number and location of detectors on intersection approaches with actuated signal controllers and high traffic approach speeds has been studied by a variety of researchers. The relationship of detector activity to amber signal intervals and the presence of dilemma zones has likewise been investigated. Several procedures for locating multiple detectors on such problematic intersection approaches have been proposed as solutions to traffic control problems. Four multiple detector placement methods are compared, through computer simulation, with each other in a relative evaluation of their effects upon vehicular delay. Single point detection schemes are compared with multiple point detection through before and after field tests at tenttypical field sites. Measures of effectiveness studied through the field tests include vehicular delay as well as accident experience. Vehicular delay statistics produced through computer simulation are compared with those obtained through field observation. Graphical as well as statistical analyses are utilized to present research results.

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DETECTOR CONFIGURATION AND LOCATION AT SIGNALIZED INTERSECTIONS

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Research Report Number 259-1F

Detector Configuration and Location at Signalized Intersections

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March 1983

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PREFACE

The authors wish to express their appreciation for the assistance guidance and great interest of Mr. Herman Haenel and Mr. Jim Williams of the State Department of Highways and Public Transportation (D-18T). A large portion of the study was made possible through their efforts and the entire study was greatly enhanced through their suggestion.

ABSTRACT

The number and location of detectors on intersection approaches with actuated signal controllers and high traffic approach speeds has been studied by a variety of researchers. The relationship of detector activity to amber signal intervals and the presence of dilemma zones has likewise been investigated. Several procedures for locating multiple detectors on such problematic intersection approaches have been proposed as solutions to traffic control problems. Four multiple detector placement methods are compared, through computer simulation, with each other in a relative evaluation of their effects upon vehicular delay. Single point detection schemes are compared with multiple point detection through before and after field tests at ten typical field sites. Measures of effectiveness studied through the field tests include vehicular delay as well as accident experience. Vehicular delay statistics produced through computer simulation are compared with those obtained through field observation. Graphical as well as statistical analyses are utilized to present research results.

Key Words: multiple detectors, vehicular delay, accidents, traffic simulation

SUMMARY

The use of multiple detectors on approaches to at-grade intersections having actuated signal controllers and high traffic approach speeds has been prepared for solution of several traffic control problems. Within this study, four methods for placing multiple detectors are compared utilizing the TEXAS traffic simulation model and vehicular delay as the response variable. Analyses of resulting simulation data indicate the four placement methods do not produce statistically significant differences in vehicular delay.

Through a series of ten field demonstration projects multiple-point detection was compared with conventional single-point detection. Stopped time vehicular delay traffic volume and accident data were collected at each field test site before and after installation of multiple- point detection systems. Analyses of these before versus after data indicated no significant differences in vehicular delay between single and multiple-point detection systems. The accident data, however, indicated statistically significant reductions in accident experience where approach speeds were high.

Vehicular delay predictions developed by the TEXAS simulation model were compared with those measured at one of the typical field test sites. Predicted and observed vehicular delay were not found to be significantly different.

IMPLEMENTATION STATEMENT

An evaluation of the ability of multiple detector systems to reduce vehicular delay and accident at highway intersections has been conducted. These analyses which include both field and computer simulation data do not indicate that the use of multiple detectors can have any consistent impact upon vehicular delay. They indicate, however, that multiple detector systems can reduce accident experience at locations where approach speeds are 50 mph or greater. Use of such systems where there is intention of improving efficiency by reducing vehicular delay alone does not appear to be justified.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

Actuated traffic signal controllers utilize real time traffic information to vary cycle and phase lengths in response to traffic demand. Real time traffic data is acquired by detection systems which are designed to conform to particular geometric or traffic requirements.

The most widely used type of detection system is currently the inductive loop. This type of detection system is highly adaptable in that the size and shape of the in-road detection device can be designed to suit most needs. Most conventional installations have used a single loop for each inbound intersection approach. The size and shape of the single loop has typically been varied to meet requirements of the traffic stream.

The single small area (or single-point) loop detection system design has, however, been problematic on intersection approaches where speeds of approaching traffic are greater than approximately 30 mph. High approach speeds may allow very little decision time for the driver to determine whether to stop or proceed through the intersection when confronted with the appearance of a yellow signal indication. Under moderate to light traffic conditions when headways are highly variable, the single-point detection scheme may enable very short green intervals and cycle lengths, thus presenting more yellow intervals and more opportunities for wrong driver decisions.

Erratic signal controller operation associated with "gapping out" or green indications ending because of gaps in the traffic stream is frequently cited as an indication of inefficient operation. Such inefficiency may be responsible for unnecessary vehicular delay and increased accident potential.

A variety of detection schemes have been proposed for solution of these problems at intersections with high approach speeds. Within the context of this report, several of these detection schemes will be examined, and one, which is referred to as "multiple-point detection," will be examined in detail. Theoretical, simulation, and field analyses are presented to evaluate multiple-point detection methods and the capability they might provide for improved signal efficiency.

Objectives

The objectives of this study are as follows:

(1) Evaluate the effect of multiple detector systems on vehicular delay and traffic accidents on high-speed intersection approaches.

(2) Include in this evaluation a comparison of state-of-the-art placement methods and feasible modifications of these methods.

(3) Investigate the optimal inductive loop length based on the criteria of vehicular delay at low-speed, isolated intersections.

Scope and Limitations

In order to accomplish these objectives, the study was divided into the four phases described below:

(1) The TEXAS (Traffic Experiment and Analytic Simulation) Model [Ref 12, 13, 14] was used to simulate traffic situations under four different multiple-detector placement methods. The effectiveness for these four detector placement methods were evaluated based on three vehicular delay parameters.

(2) Field stopped-time delay information and accident data for ten selected problematic intersections were collected to determine comparative merit of single-point detection and multiple-point detection systems.

(3) Simulation modeling was performed for one of ten selected intersections to determine whether there were significant differences between simulation and field statistics.

(4) An experimental design considering lane volume, intersection geometry, and inductive loop length as factors and three vehicular

delay parameters as response variables was used to determine optimal loop lengths for single-point detection systems.

Fig 1-1 depicts the flow of work and illustrates the relationship of these segments. The chart indicates that the studies of detector systems for high and low speed approaches were essentially parallel efforts. The efforts were, however, not identical since the low speed portion involved an attempt to optimize one detector system concept. The high speed portion, however, was a comparison of several detector system design concepts.

The scope of the study was limited by the availability of field accident data and vehicular delay information for the different inductive loop length situations in the single-point detection systems.

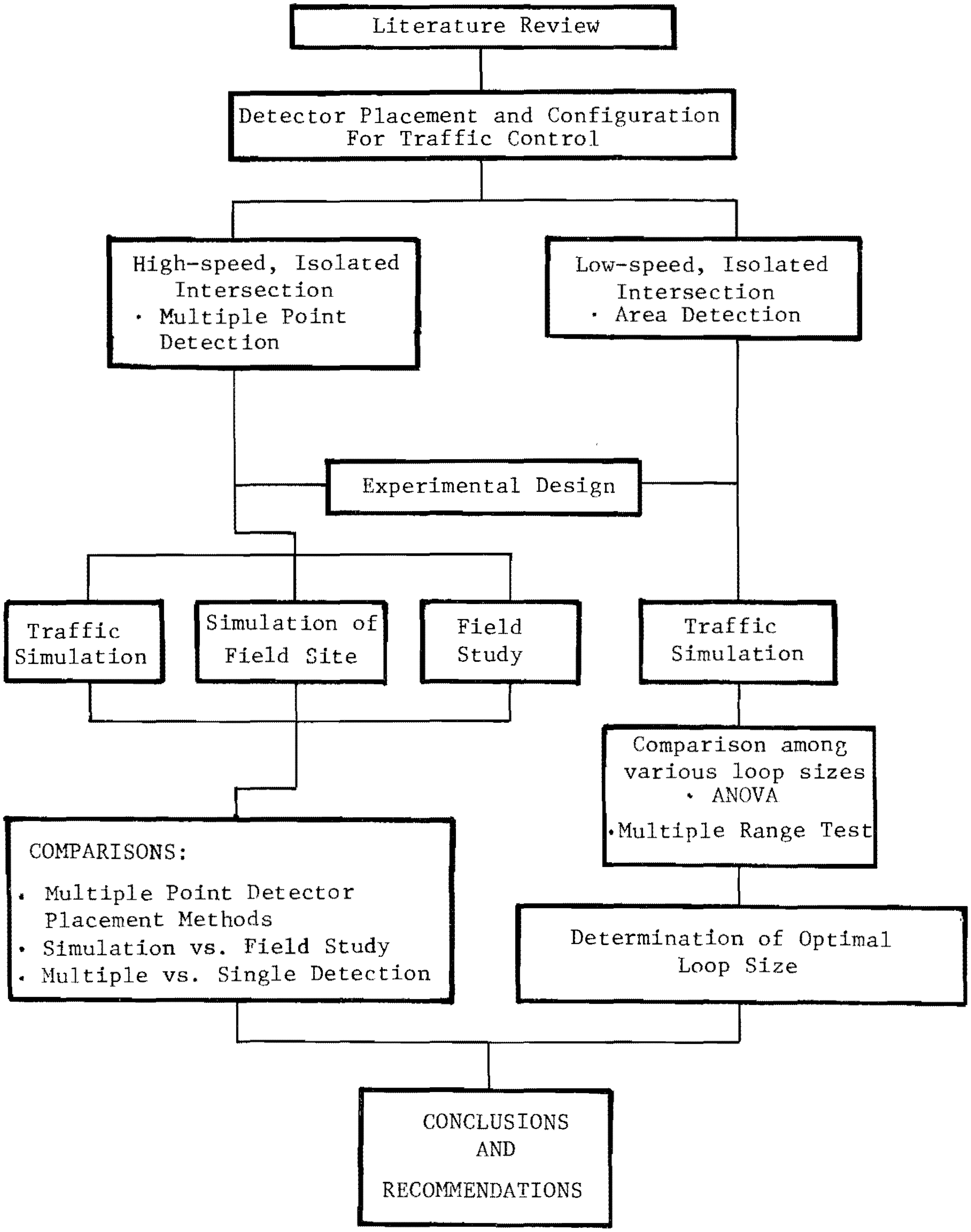


Fig 1-1. Schematic flow chart of study activities.

CHAPTER 2. IMPLICATIONS OF THE YELLOW INTERVAL

This investigation was initially motivated by problems associated with yellow traffic signal intervals. Therefore, in this chapter the effort will be concentrated on the causes of the yellow interval problem and solutions to the problem.

Since different legal interpretations regarding the yellow interval have been used in different states, there is concern about the relationship between legal definitions and operational effects. Therefore, the first step in this study is to examine the legal considerations of amber intervals.

The next step is to define the operational problem associated with yellow intervals. A qualitative description using a deterministic approach and kinematics is used instead of a complicated stochastic process. Finally, the relationship between detector placement strategy and the yellow interval problem is described.

Legal Consideration

Legal requirements and the needed duration for yellow signal intervals have been studied by a variety of researchers and practitioners. Matson and May [Refs 15 and 16] are among those who have contributed. Analyses performed by Matson have led to the recommendations of yellow durations of three to five seconds which currently appear in the Transportation and Traffic Engineering Handbook [Ref 30]. The nationwide survey conducted by May in 1968 contributed significantly to the understanding of legal specifications for yellow intervals. The survey addressed the question of whether restrictive or permissive interpretations of yellow indication regulations have significantly different effects upon intersection performance. Restrictive interpretations require that all vehicles must have cleared the intersection by the end of a yellow interval while permissive regulations allow vehicles to enter the intersection during the amber interval. Chi-Square classification tests [Ref 7] of the opinions of almost 100 traffic engineers are presented in Table 2-1. These analyses indicate that, for a five percent confidence level, there is no statistically significant difference in opinion regarding the effects of restrictive and permissive yellow interval legal specifications.

Theoretical Background

May's study and others indicated legal interpretations are not problematic, however, durations of amber intervals may be related to safety or capacity problems. In this section, a theoretical review of yellow interval estimation is developed.

Stopping Distance and Clearing Distance. A schematic plan view of an intersection with zero grade on each approach is shown in Fig 2-1. If a vehicle approaches the intersection at a speed V and is located at a position X feet from the stop line exactly at the beginning of yellow light, the driver must make a decision concerning whether to decelerate to a stop before entering the intersection or continue through. If the first decision is made, the driver will begin deceleration after a short perception-reaction time. Obviously, after the beginning of the yellow interval, the vehicle travels a distance that includes (a) the distance traveled during perception-reaction time (t_1), and (b) the distance traveled during deceleration. To ensure a safe and complete stop before the intersection, the following inequality must be maintained:

TABLE 2-1. CHI-SQUARE TEST FOR TRAFFIC ENGINEER'S OPINION ABOUT YELLOW INTERVAL

Response From	Law	Yellow Interval Problem		Chi-Square Test
		No	Yes	
State	Restrictive	14	14	Calculated χ^2 = 1.79 Table $\chi^2_{0.05,\ 2}$ = 5.99
	Permissive	6	10	
	Other	1	4	
Cities Outside California	Restrictive	5	7	Calculated χ^2 = 4.71 Table $\chi^2_{0.05,\ 2}$ = 5.99
	Permissive	6	7	
	Other	0	7	
Cities in California	Restrictive	5	12	Calculated χ^2 = 2.88 Table $\chi^2_{0.05,\ 1}$ =3.84

Source: A.D. May, "Study of Clearance Interval at Traffic Signals," Highway Research Board Record 221, 1968.

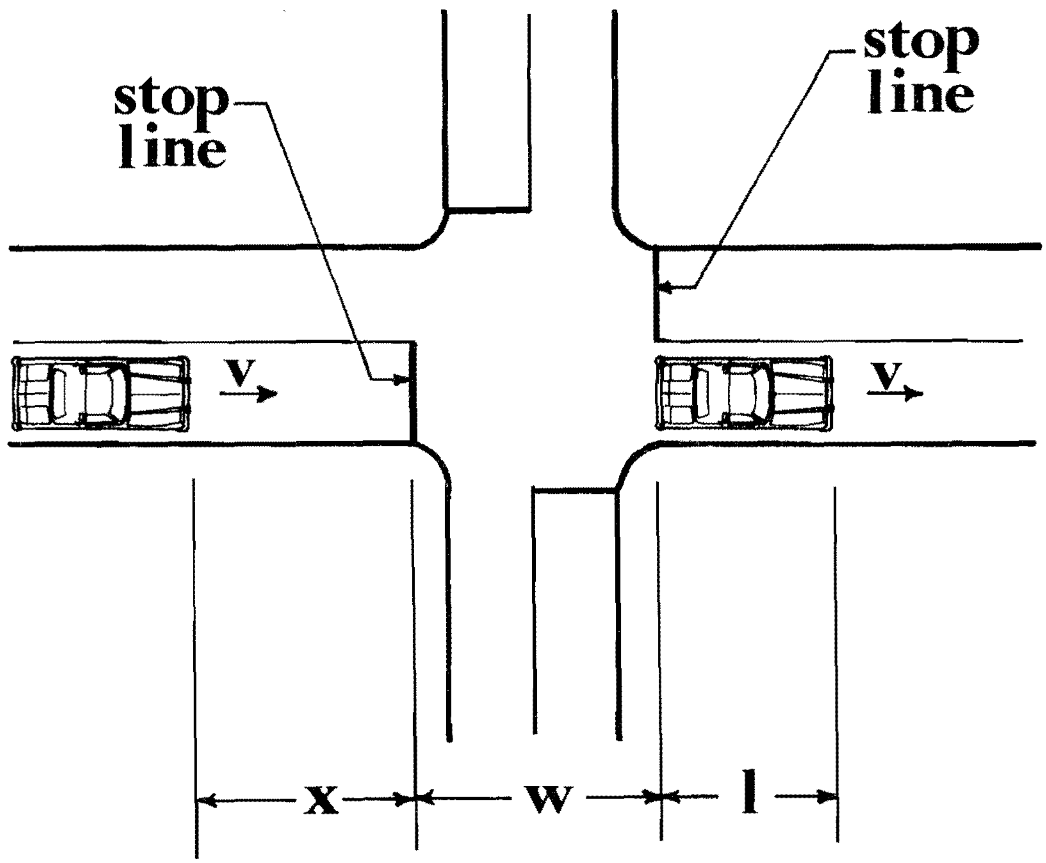


Fig 2-1. Geometry for simulated intersections.

$$X \geq Vt_1 + \frac{V^2}{2d} \tag{2-1}$$

where X = distance of a vehicle in advance of the stop line at the beginning of amber, ft,

V = approach speed, ft/sec,

t_1 = perception-reaction time, often specified as one second [Ref 3], and

d = constant deceleration rate, ft/sec^2.

Safety and comfort considerations require that the deceleration rate in (2-1) not exceed one third to one half the acceleration of gravity [Ref 8]. If d* denotes a critical deceleration rate for the concerned vehicle under prevailing roadway conditions, then the stopping distance X_s for speed V is defined by the following equation:

$$X_s = Vt_1 + \frac{V^2}{2d^*} \tag{2-2}$$

This quantity (X_s) is the minimum distance from the stop line that ensures that a vehicle running at speed V and decelerated at rate d* can stop completely before the stop line after perceiving and reacting to the beginning of the yellow signal.

If the driver decides to go through the intersection, after a short perception-reaction time, he must accelerate and clear the intersection by the end of the yellow interval. To ensure that the vehicle can pass safely through the intersection, the following inequality must be maintained:

$$X + W + L \leq Vt_1 + 1/2\, a(\,t - t_1\,)^2 + V(\,t - t_1\,)$$

or

$$X \leq Vt_1 + V(t - t_1) + 1/2\ a(t - t_1)^2 - (W + L) \qquad (2\text{-}3)$$

where t_1 = perception-reaction time often specified as one second [Ref 3],

a = constant acceleration rate, ft/sec^2,

t = amber interval, seconds,

W = intersection effective width (see Fig 2-1),

L = vehicle length, ft, and

V = speed, ft/sec.

In (2-3), the constant acceleration which might be available to the driver can be estimated through Gazi's equation [Ref 6]:

$$a = 16.0 - 0.213V$$

where V = speed, miles/hr

which indicates that higher acceleration rates can be attained when the vehicle is running at lower speeds. Clearance distance X_c for speed V can be defined by the following equation:

$$X_c = Vt_1 + V(t - t_1) + 1/2\ a(t - t_1)^2 - (W + L) \qquad (2\text{-}4)$$

This distance (X_c) is the maximum distance from the stop line from which a vehicle is able to clear the intersection if running at a speed, V, when the yellow interval begins and, after perception-reaction time, t_1, and accelerated at constant rate, a.

<u>Relationship Between X_s and X_c</u>. Previously, X_s was defined as the minimum distance from the stop line that would ensure that the vehicle can

stop before the intersection. In other words, if any vehicle is at a position closer to the stop line than X_s when yellow interval begins, then it is unable to stop safely or comfortably before the intersection. The region between the stop line and the point X_s from the stop line is therefore a region in which drivers "cannot stop." Similarly, X_c is the maximum distance in advance of the stop line from which a vehicle can clear the intersection during the yellow interval. Any vehicle positioned at a point greater than X_c from the stop line will experience great difficulty in clearing the intersection by the end of the amber interval. Therefore, the region outside the distance X_c from the stop line is considered as a region in which the driver "cannot go." Figure 2-2 depicts these two regions separately.

Since X_s and X_c are simply two measured distances from the stop line, by the inequality theorem, these two quantities should meet one of the following relationships:

(1) $X_s > X_c$
(2) $X_s = X_c$
(3) $x_s > X_c$

In the fist case where $X_s > X_c$ as shown in Fig 2-3, an overlapping region exists in which a vehicle occupying this region at the onset of the yellow can neither stop nor go safely. This is an awkward region for the driver since either possible decision is likely to be improper. This overlapping region has been called, for obvious reasons, a dilemma zone. In the real world, when a vehicle is within the dilemma zone at the beginning of the yellow interval, a decision to either stop or go will require a higher than desirable acceleration or deceleration rate. Rapid changes in vehicle speed caused by abnormal acceleration or deceleration rates may escalate the risk

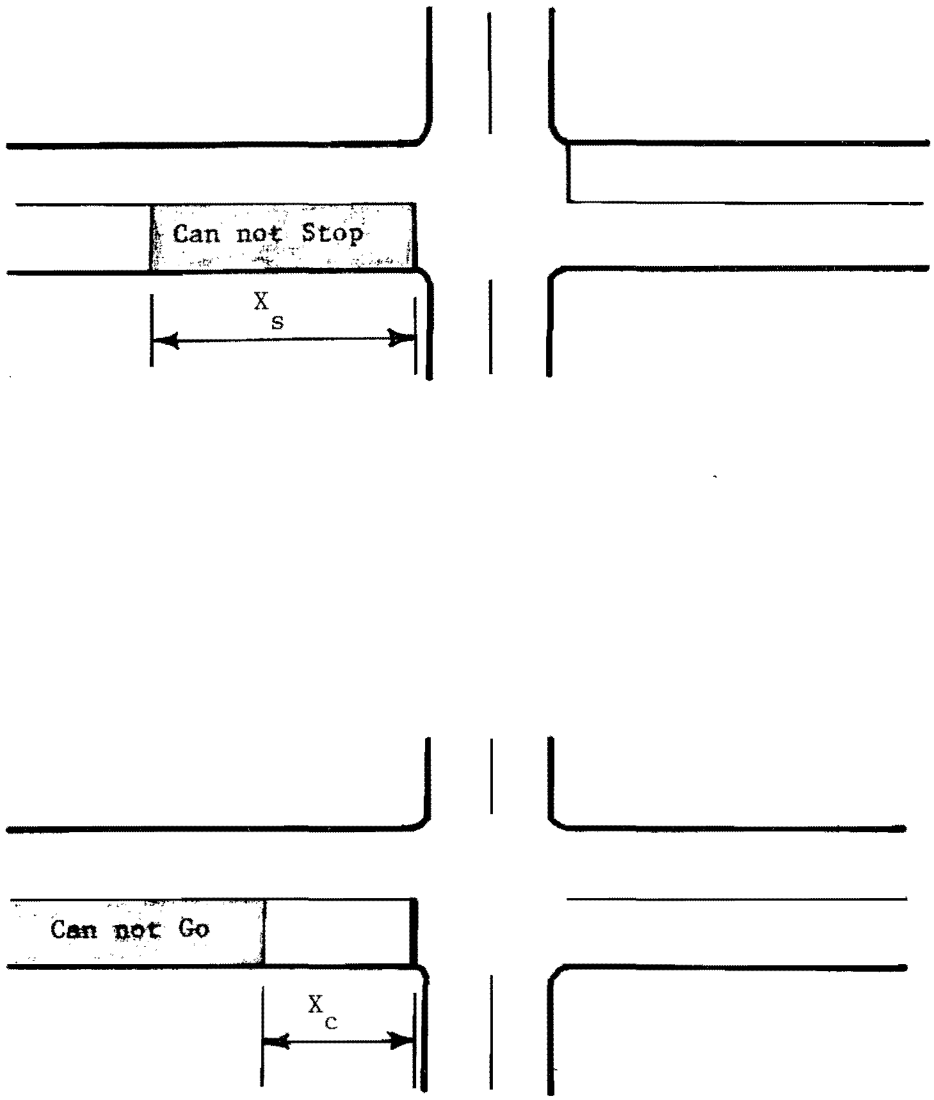


Fig 2-2. Region of 'Can not Stop' or 'Can not Go'.

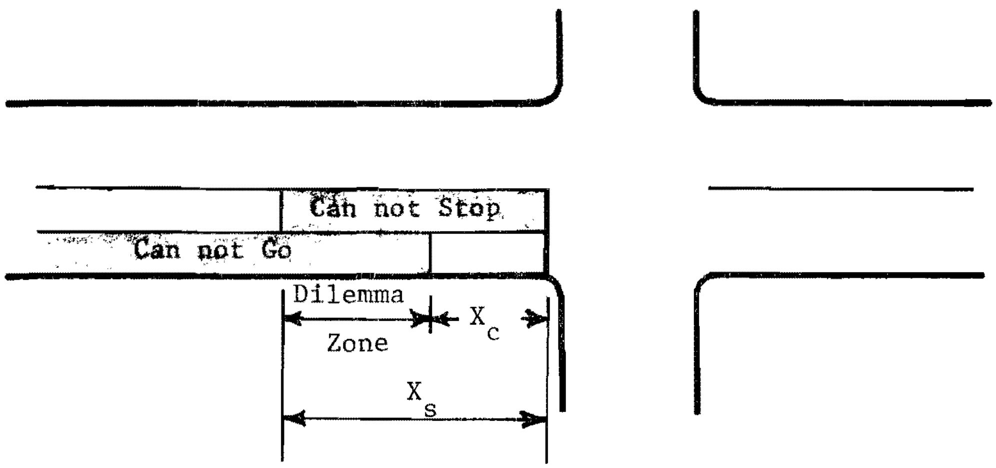


Fig 2-3. Dilemma zone ($X_s > X_c$).

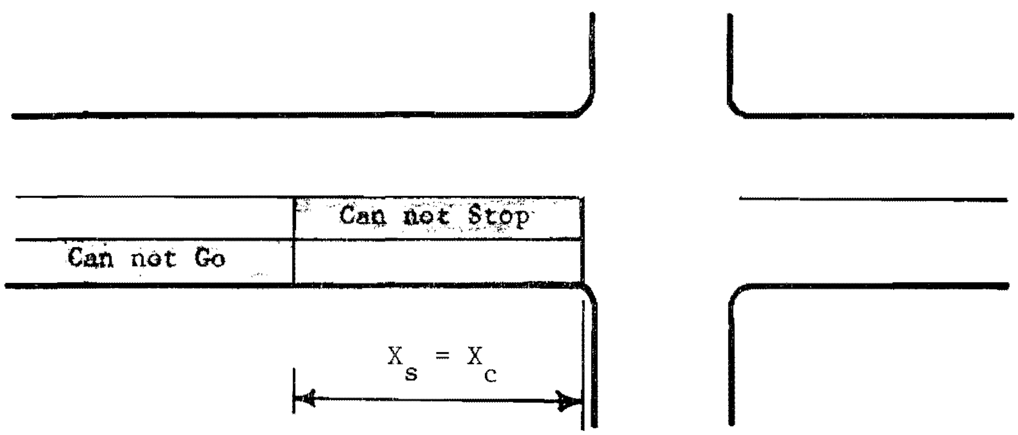


Fig 2-4. No Dilemma zone ($X_s = X_c$).

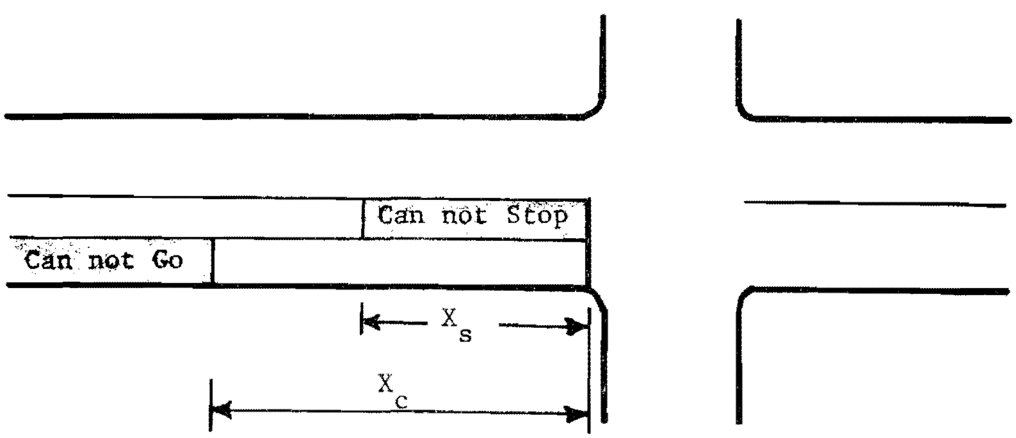


Fig 2-5. Optional zone ($X_s < X_c$).

of accidents. Changes of rear end collisions might increase if the decision "to stop" is made, right angle collisions may be caused by the decision "to go."

In the second case $X_s = X_c$ as shown in Fig 2-4, the dilemma zone shrinks to a point or vanishes and is therefore not problematic. In the third case $X_s < X_c$ as shown in Fig 2-5, the zone between X_s and X_c is not awkward because in this zone, the vehicle can either safely go or stop. Therefore, this is considered as an optional zone.

A Graphical Look at the Dilemma Zone

A dilemma zone is formed when $X_s > X_c$. As indicated in Equations (2-3 and (2-4), X_s is a function of speed, deceleration rate, and perception-reaction time while X_c is a function of speed, acceleration rate, yellow interval, perception-reaction time and effective intersection width. Tables A-1 and A-2 indicate stopping distance X_s, and clearance distance X_c for deceleration rate 10, and 16 ft/sec^2 and effective intersection width 48 and 76 feet respectively. One means of depicting how these variables affect the length of a dilemma zone is through a graphical representation.

Based on the data in Table A-1 and A-2 graphical presentations are provided in Figs A-1, A-2, A-3, and A-4. In these figures the horizontal axes represent distances from the stop line and vertical axes represent approach speeds. One curve for speed vs stopping distance and three curves for speed vs clearance distance at yellow intervals of four, five, and six seconds are included respectively. Two sets of plots included in the figures illustrate the relationship for deceleration rates of 10 [Ref 22] and 16 ft/sec^2, vehicle length of 20 ft, and intersection widths of 76 and 48 ft respectively. The deceleration rate, the vehicle length, and the effective intersection width are constant in each plot while acceleration rate is calculated by Gazi's equation a = 16.0 - 0.213V. The presence or absence of a dilemma zone and its location relative to the intersection stop line is based on the data in Table A-3 and A-4. The following generalizations can be developed from previous analyses:

(1) for a given yellow interval, as speed increases, the dilemma zone becomes longer,

(2) for a specific speed, as the yellow interval increases, the dilemma zone shrinks or vanishes,

(3) for a given speed and yellow interval, increases in deceleration or acceleration rates will result in a reduction of the dilemma zone, and

(4) increases in the effective intersection width will directly increase dilemma zone length.

<u>Solutions to the Dilemma Zone Problems</u>

The analyses of the causes of dilemma zone problems suggest two possible solutions. One of these consists of increasing the length of the yellow interval [Ref 21]. Long duration yellow intervals, however, will increase total vehicular delay and may cause some drivers to "take advantage of the long amber by treating it as part of the green" [Ref 3]. However, several studies such as those by Olson and May [Refs 2 and 16] indicate that "the increase in amber interval essentially does not change driver behavior" and thus lend no support to this last hypothesis. On the other hand, speed cannot particularly be restricted in order to eliminate a dilemma zone because speed restrictions will also increase vehicular delay.

Increasing the length of the yellow interval or restricting vehicle speeds represents the best available solutions where intersections are equipped with pre-timed signal controllers. In locations where actuated controllers are employed, however, strategic placement of detectors can offer a very much preferred solution. Detectors placed near the beginning and within the dilemma zone can allow vehicles to retain green indication and effectively overcome the dilemma zone problem in all cases except the one in which a signal phase reaches the maximum extension limit. Placement methodologies designed to accomplish this task are presented in the following sections.

Summary and Conclusion

In order to investigate the effect of different laws of the yellow interval problem, a Chi-Square test was performed on the data adapted from May's nationwide survey. The test indicated that at a five percent level of significance, there is no statistically significant difference in opinion regarding the effects of permissive and restrictive yellow interval legal specifications. Therefore, the restrictive type yellow interval regulation was adopted for use in describing the yellow interval problem.

Stopping distance and the clearance distance measured from the stop line were calculated through kinematics physics theory. The stopping distance represents the minimum distance from the stop line that ensures a vehicle running at a certain speed and decelerated at a reasonable rate can stop before the intersection stop line. On the other hand the clearance distance is the maximum distance from the stop line that ensures a vehicle running at a specific speed and accelerated at a reasonable rate can go through the intersection by the end of the yellow interval. A dilemma zone occurs when the stopping distance is greater than the clearance distance. If a vehicle within the dilemma zone at the onset of the yellow light, the driver will be confronted with a difficult decision concerning whether to stop or go through the intersection. Either of the two decisions will expose the vehicle to a higher than usual risk of rear-end or right-angle collision. Therefore, the dilemma zone problem is indeed the principal yellow interval problem. The severity of the problem increases with increasing dilemma zone lengths.

Graphical presentations indicated as the approach speed decreases or the yellow interval increases, the dilemma zone becomes shorter. In a pre-timed signal controlled intersection, the previous statement implies that limiting approach speed or increasing the yellow interval duration are two appropriate strategies for solving dilemma zone problems although these two strategies will increase vehicular delay. In actuated signal controlled intersections, detector placement before, after, and within the dilemma zone preventing entrapment of a vehicle in the dilemma zone at the onset of yellow light is a most appropriate strategy for solving the dilemma zone problems. In the following chapter, detector placement methods will be discussed.

CHAPTER 3. DETECTOR PLACEMENT METHODS

One conclusion of the last chapter was that the dilemma zone problem can be ameliorated by strategic placement of multiple vehicle detectors where actuated signal controllers are used. Through the detectors, real-time traffic information is sent to the controller which holds the green signal indication to provide safe passage for vehicles traveling through the dilemma zone. Recent innovations in detector placement techniques and controller systems are suggested as also having potential for reducing usual vehicular delay thus improving intersection operational efficiency [Ref 26]. Therefore, in this chapter, a conceptual review of the following points will be presented:

(1) choice of detector type,

(2) description of existing detector placement methods, and

(3) comparison among detector placement methods.

The detector placement methods discussed in this chapter do not include those for advanced actuated controllers such as density controllers, because those controllers are quite expensive, complicated, and are not popularly used.

Choice of Detector

The basic criteria for the choice of detectors should at least comprise the following points [Refs 2 and 10].

(1) stability - withstand environmental effects

(2) sensitivity - able to detect any size of vehicle at any reasonable speed

(3) reliability - detect every vehicle

(4) durability - practically indestructible

(5) first cost - low

(6) installation - little labor and interference to traffic

(7) maintenance - little

(8) salvage - reusable components

Among the commercial detectors, as shown in Table 3-1, the inductive loop detector meets all the criteria stated previously, therefore it is most widely preferred [Ref 31]. Inductive loop detectors are normally designed to drive a signal at approximately 100 KHZ into a parallel resonant loop circuit [Ref 18]. A vehicle within the loop area detunes the detector circuit resulting in an amplitude and phase shift. This phase shift is detected by a comparator circuit and a relay is actuated.

Generally, an inductive loop detector can operate either in pulse of presence mode. The former produces only one output pulse when a vehicle first enters the detection area. The latter produces a continuous output for as long as a vehicle is in the detection area, no matter how long the vehicle remains within the detection area. The latter produces a continuous output for as long as a vehicle is in the detection area. Since the operations of these two detector modes are quite different, the controllers to which they are connected are different. The pulse mode detector is connected to a locking controller, while the presence mode detector is normally utilized with a non-locking controller. In a locking controller, a call on a non-green phase will be remembered or held after the vehicle leaves the detection area until that call has been satisfied by the display of a green. While in a non-locking controller, a call on a non-green phase will be forgotten or dropped as soon as the vehicle leaves the detection area. Each

TABLE 3-1. TYPES OF VEHICLF DETECTORS

Detector Type \ Category	Pressure	Magnetic	Optical	Acoustic	Electro-Magnetic
Photocell			√		
Pulsed				√	
Presence				√	
Treadle	√				
Pneumatic Tube	√				
Magnetic		√			
Magnetometer		√			
Radar					√
Inductive Loop					√

Source: A Status Report On Vehicle Detectors, Final Report, 1976 [Ref 4] detection mode and type of controller may be preferable under certain circumstances.

Description of Existing Detector Placement Methods

Three generalized types of special detector placement methods are in prominent use today. Although other more exotic methods are

available, the three techniques described in the following sections are both easily installed and not excessively costly. These methods include:

(1) green extension systems [Ref 25],

(2) extended call detector systems [Ref 25], and

(3) multiple detection systems;

  (a) Beierle Method [Ref 1],

  (b) Winston-Salem Method [Ref 25], and

  (c) SSITE Method [Ref 28 and 29].

Green Extension Systems for Semi-Actuated Controllers. A green extension system (GES) is an assembly of extended call detectors and auxiliary logic. The logic can monitor the signal display, enable or disable selected call detectors, and hold the controller in green. Two inductive loops are commonly used in the system although three may be used at high speed intersections. The principal use in GES is that of detecting an approaching vehicle before it enters the dilemma zone and extending the green until the vehicle clears the dilemma zone.

In the case of two inductive loops, loop S_1 is located at a point D feet from the stop line and is on the leading edge of the dilemma zone. Loop S_2 is located at a point D_2 feet from the stop line and is on the trailing edge of the dilemma zone. A schematic representation of the placement scheme is shown as Fig 3-1. The magnitudes of D, D_1, and D_2 are calculated using the following equations:

$$D = 1.47Vt_1 + \frac{V^2}{30f} \qquad (3\text{-}1)$$

$$D_2 = 1.47V\left(\frac{V}{30} + 1\right) \qquad (3\text{-}2)$$

$$D_1 = D - D_2$$

where V = 85th percentile speed, mile/hour,

t_1 = perception-reaction time, seconds,

f = friction coefficient,

D = see Fig 3-1, feet,

D_1 = see Fig 3-1, feet, and

D_2 = see Fig 3-1, feet.

In the above, Eq 3-1 is used to calculate the stopping distance (D) for a desired perception-reaction time (t_1). The fist term in the right side of (3-1) represents the distance travelled during the perception-reaction time and the second term denotes the braking distance. Equation 3-2 is used to determine the clearing distance (as defined in Chapter 2) when one second perception-reaction time and 22 ft/sec^2 deceleration rate are assumed. The corresponding time spacings (T_1, T_2 in Fig 3-1) between loop S_1 and loop S_2 and stop line, are obtained simply dividing D_1, D_2 by V.

Obviously, in the green extension system the location of loops is governed essentially by 85th percentile speed as indicated in Eq 3-1 and 3-2. With loops positioned as shown in Fig 3-1, a vehicle passing over loop S_1,

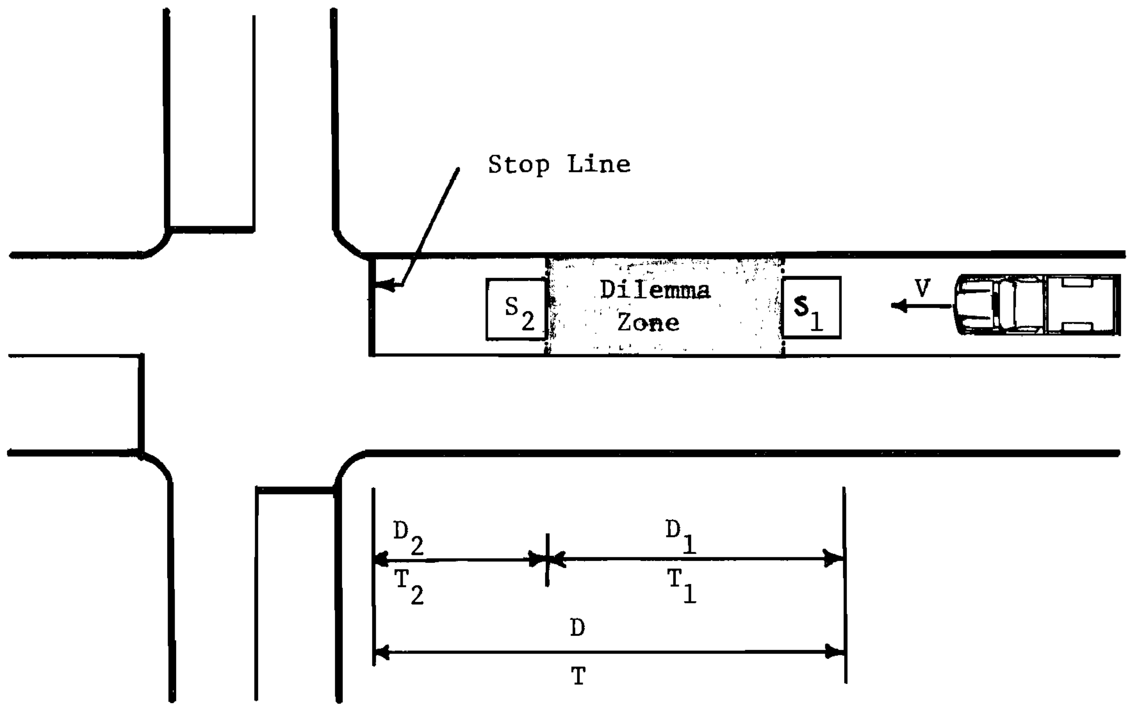


Fig 3-1. Green extension systems (two detectors).

actuates an electronic timer which will extend the green sufficiently for the vehicle to reach loop S_2 in time T_1. Similarly, when the vehicle passes over loop S_2, a second timer will maintain the green while the vehicle continues to proceed toward the intersection. The GES design does not necessarily insure that a vehicle running at a speed less than the 85th percentile speed will not be trapped in the dilemma zone.

Extended Call Detector Systems for Basic Controllers. Extended call detector systems consist of a 70 foot long presence loop extending upstream from the stop line and an extended call sensor 250 feet to 500 feet upstream from the stop line (as shown in Fig 3-2). The magnitude of D in Fig 3-2 is determined by Eq 3-1 which is based on the speed limit or the 85th percentile speed. While D_2 is set at 70 feet, both T_1 and T_2 are set equal to the magnitude of D_1 and D_2 divided by a lower limit of approach speeds which is often assumed to be the 15th percentile speed.

$$T_1 = \frac{D_1}{V_L} \tag{3-3}$$

$$T_2 = \frac{D_2}{V_L} \tag{3-4}$$

This design insures the last vehicle and those vehicles running at a speed less than the speed limit will not be trapped in the dilemma zone. Trailing vehicles, however, are likely to be trapped in the dilemma zone at the end of the maximum extension limit, which is maximum green time after an actuation on a competing phase. The 70 feet presence-type loop insures that stopped

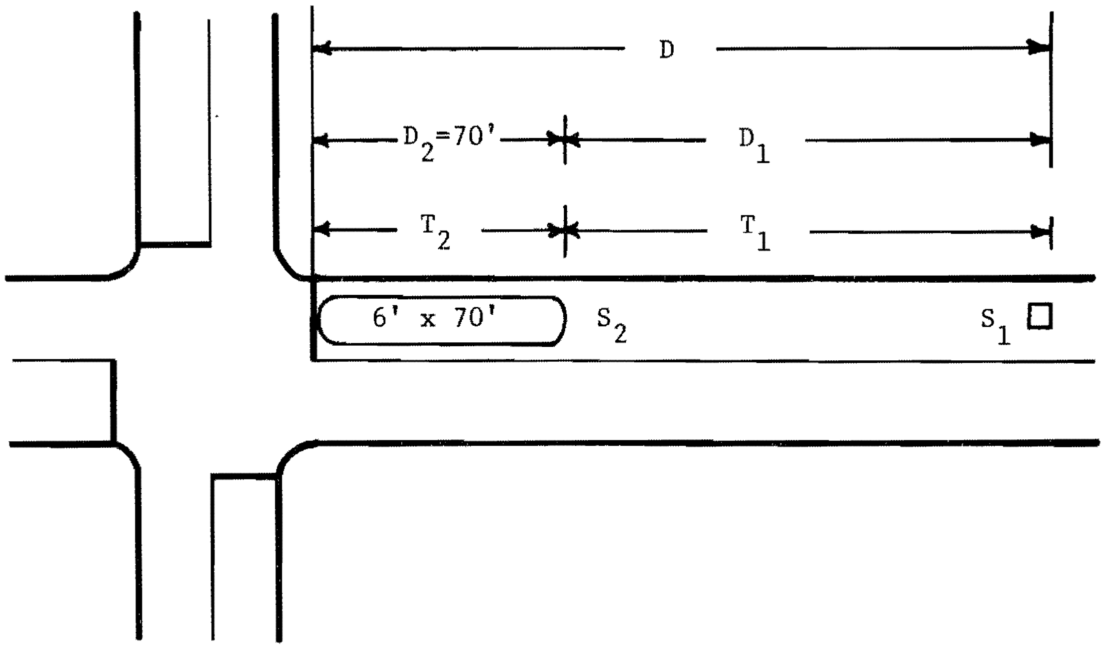


Fig 3-2. Extended-call detector system.

vehicles queued behind the stop line get into motion without a premature gap out.

Multiple-Point Detector Placement Methods. The two previously described detector placement methods deal primarily with two inductive loops and do not directly consider variations in approach speeds. These techniques are feasible when the speeds are low but may not be appropriate when the approach speeds are high. When speeds are high, the dilemma zone length becomes greater and more detectors are required to accommodate a variety of approach speeds. Detector placement methods which utilize a series of detectors attempting to accommodate a variety of high and low approach speeds are called multiple-point detection methods. At present, the Beierle, Winston-Salem, and SSITE (Southern Section of ITE) methods are recognized as the most common multiple-point detector placement methods.

The Beierle Method. The Beierle method of multiple detector placement utilizes a one-second passage (vehicle) interval setting on a controller operating in the locking detector memory mode. Each presence-mode detector is located in advance of the intersection at a distance which is at least adequate for a driver who receives a yellow indication at that point to react and stop safely from his assumed speed. Safe stopping sight distances are based on a one-second perception-reaction time plus braking distances resulting from coefficients of friction between 0.41 and 0.54 for speeds between 55 and 20 mph. The outermost, or first, detector is placed at safe stopping sight distance from the intersection for full approach speed. The next detector is tentatively located at safe stopping sight distance from the intersection for a speed assumed to be 10 mph less than that used for locating the first detector. If the travel time for a passenger car between the two presence-mode loop detectors (6 ft by 6 ft size) is greater than one second, the downstream detector is relocated to allow the vehicle to reach it during the one-second passage interval set on the controller. This location procedure is repeated for each successive detector until the last loop is within 75 feet of the approach stop line. Minimum assured green time is set on the controller to allow vehicles stored between the last detector and the intersection to enter the intersection.

The Winston-Salem Method. The Winston-Salem method was developed by Donald Holloman in 1975. The principle used in the method basically is the same as that in Beierle's method; however, the differences between them are:

(1) this method uses slightly shorter stopping distance for the outermost detector and the innermost detector, and

(2) this method is suggested for speeds up to 60 mph.

The SSITE Method. The SSITE method of detector placement was developed by the Southern Section ITE in 1976. Basically this method uses both an iterative process and engineering judgement in locating the inductive loops. Detectors are operated in presence mode implying use of a non-locking type controller. The outermost loop is positioned to provide sufficient stopping distance which is determined utilizing data from a previous SSITE report [Ref 29]. The spacing between successive loops is two seconds and the innermost detector is located at the stop line.

The Texas Method. In addition to the three basic placement methods described above, a technique developed and tested by the Texas State Department of Highways and Public Transportation (SDHPT) was also studied. The basic concept is very similar to the Beierle method, but AASHTO stopping distance criteria are utilized. By this technique an innermost detector is located 55 feet from the stop line since the next closest detector would be 110 feet. The addition of a detector at the 61 feet position has the effect of reducing the required initial interval (minimum assured green) thus improving operational efficiency.

Difference in Detector Placement Methods. Controller type, detector mode, applicable speed range, loop layouts, and allowable gap for each of the basic multiple-detector placement methods are summarized in Table 3-2. A close look at the table indicates that the major differences among these methods are:

(1) number of inductive loops used, and

(2) inductive loop spacings.

Since the length of dilemma zone becomes larger as the speed increases, more detectors are required to trace the vehicle through the dilemma zone. In addition, the longer the spacing between two inductive loops, the longer the vehicle interval and the less efficient the controller is likely to be. So, in general, multiple detection systems are more appropriate for signalized intersections with high mean approach speeds and high variability.

Summary and Conclusion

Because its particular capability of stability, sensitivity, reliability and durability in vehicular detection, and its low installation and maintenance cost, the inductive loop detector has been widely used in traffic control. Generally an inductive loop detector can operate in either pulse or presence mode. The pulse mode detector is connected to a locking type controller which will remember a call on a non-green phase until the call has been satisfied by the display of a green. The presence mode detector is normally connected to a non-locking type controller which can drop a call on non-green phase as soon as the vehicle leaves the detection area. All the

TABLE 3-2. SUMMARY OF DETECTOR PLACEMENT METHODS

Design \ Method		Green Extension Systems for Semi-actuated Control	Extended Call Detector Systems for Basic Controller	Multiple Detection Systems: Beierle Method	Multiple Detection Systems: Winston-Salem Method	Multiple Detection Systems: SSITE Method
Controller Type		Non-locking Type	Non-locking Type	Locking Type	Locking Type	Non-locking Type
Detector Type		presence	presence	presence	presence	presence
Speed Range		V = 85th percentile speed	V = 85th percentile speed	$V \leq 50$	$V \leq 60$	$V \leq 60$
Loop Layout	the outer-most loop [1]	$D=1.47Vt + \frac{V^2}{30f}$	$D=1.47t + \frac{V^2}{30f}$	use stopping distance from Intext Driver Testing Ref[1]	use stopping distance from Traffic Engr. Handbook Ref[30]	use SSITE Report Ref[29]
	the inner-most loop	$D_1=1.47V(\frac{V}{30} + 1)$	0	within 75 feet of the approach stop line	86'	0'
	spacing btwn loops [3]	$\frac{D - D_1}{V} > 2$ sec	$\frac{D - 70}{V_{low\ limit}} > 2$sec	1 second	1 second	2 second
	No. of loops [2]	2 (or 3)	2	$[\frac{V}{10}] - 1$	$[\frac{V}{10}] - 2$	≤ 6
allowable gap		5~6 seconds	5~6 seconds	2~5 seconds	2~5 seconds	5~7 seconds

1 The distance is measured from the stop line

2 $[\frac{V}{10}]$ represents the integer part of $\frac{V}{10}$ for example [3.5] = 3

3 $V_{low\ limit}$ = low speed limit for example 15th percentile speed

detector placement methods discussed previously use presence type detectors although both locking and non-locking type controllers are utilized.

Green extension systems use two or three loop detectors. In the two-detector systems, detectors are located on the leading and trailing edge of dilemma zone, the length of detection zone (dilemma zone) is governed by the 85th percentile approach speed. In extended-call detector systems, two detectors are used. The first is located at a sufficient stopping distance from the stop line based on the 85th percentile approach speed, while the second detector is located at the stop line with a length of 70 feet. Obviously, two-detector systems are not desirable when approach speeds are highly variable, since the dilemma zone size varies with approach speed.

Currently, Beierle, Winston-Salem, and SSITE methods are recognized as the most common multiple-point detector placement methods. Although they are different in the number of detectors used, location and detector spacing, they are all suggested for use in high-speed intersections with highly variable approach speeds.

CHAPTER 4. COMPARISON OF TECHNIQUES

As indicated in Chapter three, multiple-point detection systems are considered, in general, more appropriate for high-speed signalized intersections than green extension or extended-call systems. This portion of the study is directed toward high-speed signalized intersections, therefore, in this chapter the emphasis will be on multiple-point detection systems.

This analysis compares the relative effectiveness of the Beierle, Winston-Salem, and SSITE detector placement methods. Several forms of vehicular delay were utilized as primary measures of intersection operational efficiency and the basic dependent variables. An experiment design was established to collect and analyze data which was collected mainly through computer simulation using the TEXAS model. Average total delay per approach vehicle, average queue delay per approach vehicle and average stop delay per approach vehicle were the three vehicular delay parameters required.

Based on the experimental design and the choices of the above three vehicular delay parameters as dependent variables, a three-way analysis considering detector placement method, speed, and volume as factors was used.

The major subjects in this chapter will include a description of a factorial experimental design, simulation modeling and statistical analyses of simulation results.

Experiment Design

The form of experiment design used in the study was that of the multi-factorial. This design concept was chosen because of several advantages available compared to other concepts. Unlike traditional experimental approaches of manipulating only one factor at a time while holding other factors constant, a multi-factorial design provides the ability to manipulate several factors simultaneously. This advantage is very significant when the number of factors is large. A multi-factorial design not only provides the ability to assess main effects, but also enables assessment of intersection effects. A factorial study enables assessment of the significance of factors which might be of secondary importance without increasing the number of experimental units. This may permit inferences about the major factors with a greater range of validity.

In developing this design, the following steps have been utilized:

(1) choose one dependent or response variable and select the measurement unit of the variable,

(2) choose factors that are to be included in the study and decide levels of each factor - fixed or random, quantitative or qualitative,

(3) decide the number of observations to be used and the order of experimentation, and

(4) formulate a mathematical model to describe the experiment.

Choice of Dependent Variable. Since vehicular delay is an appropriate parameter for evaluating the efficiency of traffic operations in a signalized intersection, it was chosen as the dependent variable. Three experimental units which quantify vehicular delay are developed through computer simulation. These include average total delay per approach vehicle, average queue delay per approach vehicle, and average stopped delay per approach vehicle.

Choice of Factors and Levels. As indicated at the beginning of this chapter, this investigation is intended to distinguish among the effectiveness of three detector placement methods if effectiveness is quantified as vehicular delay. Naturally, placement method is considered as one of the factors in this factorial design. Beierle, Winston-Salem, and SSITE serve as the three qualitative levels of this factor "method." "Approach speed" was selected as another primary factor because with it loop layout or position varies. Approach speed levels of 30, 40, and 50 mph were selected to encompass the normal range of "high" approach speeds. An approach speed which is no less than 35 mph is considered to be high speed. Besides detector placement method and speed, traffic volume was selected as the third factor to be included in the factorial design. Volume was included as a factor to prevent possible masking of the speed and method effects. Lane volumes of 300, 500, and 700 vehicles per hour rather than approach volumes were selected to enable greater specificity in the analysis. These values cover the volumes from peak hour to off-peak hour.

Therefore, the basic factorial design consists of three factors each having three levels. A schematic presentation of the design is presented in Table 4-1(a) for a four-leg intersection and a half diamond interchange. A half diamond interchange was considered because the simulation model is only capable of dealing with one isolated intersection. In addition to the basic experiment, a modification of the Beierle method herein referred to as the Texas Method was also evaluated. The design for this portion of the study is presented in Table 4-1(b).

Numbers of Observations and Order of Experimentation. In this factorial design, the total number of treatments is 27. One observation was collected for each treatment, since the data were collected through computer simulation. The randomization restriction on the order of experimentation is not problematic because any two observations can be taken independently.

TABLE 4-1. FACTORIAL DESIGN

(a) For Diamond Interchange and Four-Leg Intersection

A Method		Beierle (1)			Winston-Salem (2)			SSITE (3)		
B Speed (MPH)		30 (1)	40 (2)	50 (3)	30 (1)	40 (2)	50 (3)	30 (1)	40 (2)	50 (3)
C Lane volume (VPHPL)[1]	300 (1)	$A_1B_1C_1$[2]	$A_1B_2C_1$	$A_1B_3C_1$	$A_2B_1C_1$	$A_2B_2C_1$	$A_2B_3C_1$	$A_3B_1C_1$	$A_3B_2C_1$	$A_3B_3C_1$
	500 (2)	$A_1B_1C_2$	$A_1B_2C_2$	$A_1B_3C_2$	$A_2B_1C_2$	$A_2B_2C_2$	$A_2B_3C_2$	$A_3B_1C_2$	$A_3B_2C_2$	$A_3B_3C_2$
	700 (3)	$A_1B_1C_3$	$A_1B_2C_3$	$A_1B_3C_3$	$A_2B_1C_3$	$A_2B_2C_3$	$A_2B_3C_3$	$A_3B_1C_3$	$A_3B_2C_3$	$A_3B_3C_3$

(b) For The Study of Optional Detector

A Option		Beierle			Texas		
B Speed (MPH)[1]		30	40	50	30	40	50
Lane volume (VPHPL)[1]	300	$A_1B_1C_1$[2]	$A_1B_2C_1$	$A_1B_3C_1$	$A_2B_1C_1$	$A_2B_2C_1$	$A_2B_3C_1$
	500	$A_1B_1C_2$	$A_1B_2C_2$	$A_1B_3C_2$	$A_2B_1C_2$	$A_2B_2C_2$	$A_2B_3C_2$
	700	$A_1B_1C_3$	$A_1B_2C_3$	$A_1B_3C_3$	$A_3B_1C_3$	$A_2B_2C_3$	$A_2B_3C_3$

1 VPHPL = vehicles per hour per lane

2 $A_1B_1C_1$ = method 1 (Beierle) when speed at the first level (30 mph) and lane volume at the first level (300 VPHPL)

Mathematical Model. Based on the factorial design in Table 4-1(a) and (b), the model for the experiment can be expressed as [Ref 2, 9, 11, and 19]:

$$Y_{ijK} = \mu + M_i + S_j + V_K + MS_{ij} + MV_{iK} + SV_{jK} + MSV_{ijK} + E_{ijK} \qquad (4\text{-}1)$$

where μ = grand mean,

M_i = placement method i = 1, 2, 3,

S_j = approach speed j = 1, 2, 3,

V_K = lane volume K = 1, 2, 3,

MV_{iK} = interaction between M and V,

SV_{jK} = interaction between S and V,

MS_{ij} = interaction between M and S,

MSV_{ijK} = interaction among M, S, v, and

E_{ijK} = error term.

Table 4-2 is an ANOVA (Analysis of Variance) table for Model (4-1). Unfortunately, no replication in each cell of Table 4-1 leaves the error term (in Table 4-2) zero degrees of freedom. At the same time, a three-way interaction is indeed hard to explain. Therefore, MSV_{ijK} in Eq (4-1) is confounded with the error term. Thus, Eq (4-1) may be changed to

$$Y_{ijK} = \mu + M_i + S_j + MS_{ij} + V_K + MV_{iK} + SV_{jK} + E_{ijK} \qquad (4\text{-}2)$$

TABLE 4-2. ANOVA FOR MODEL (4-1)

Source	Degree of Freedom	SS [1]
M_i	2	SSM
S_j	2	SSS
MS_{ij}	4	SSMS
V_k	2	SSV
MV_{ik}	4	SSMV
SV_{jk}	4	SSSV
MSV_{ijk}	8	SSMSV
Error	–	
Total	26	

1 Sums of Squares, where for example SSM = sum of squares due to M

Computer Simulation

As noted previously, simulation modeling was selected as the most feasible means of implementing the basic experiment. The TEXAS model [Ref 13, 14, and 15] for Intersection Traffic was selected as the most appropriate available traffic simulation model. The TEXAS model, which was developed in 1977 at the Center for Highway Research, The University of Texas at Austin, comprises three major component programs:

(1) Pre-Simulation Geometry Processor,

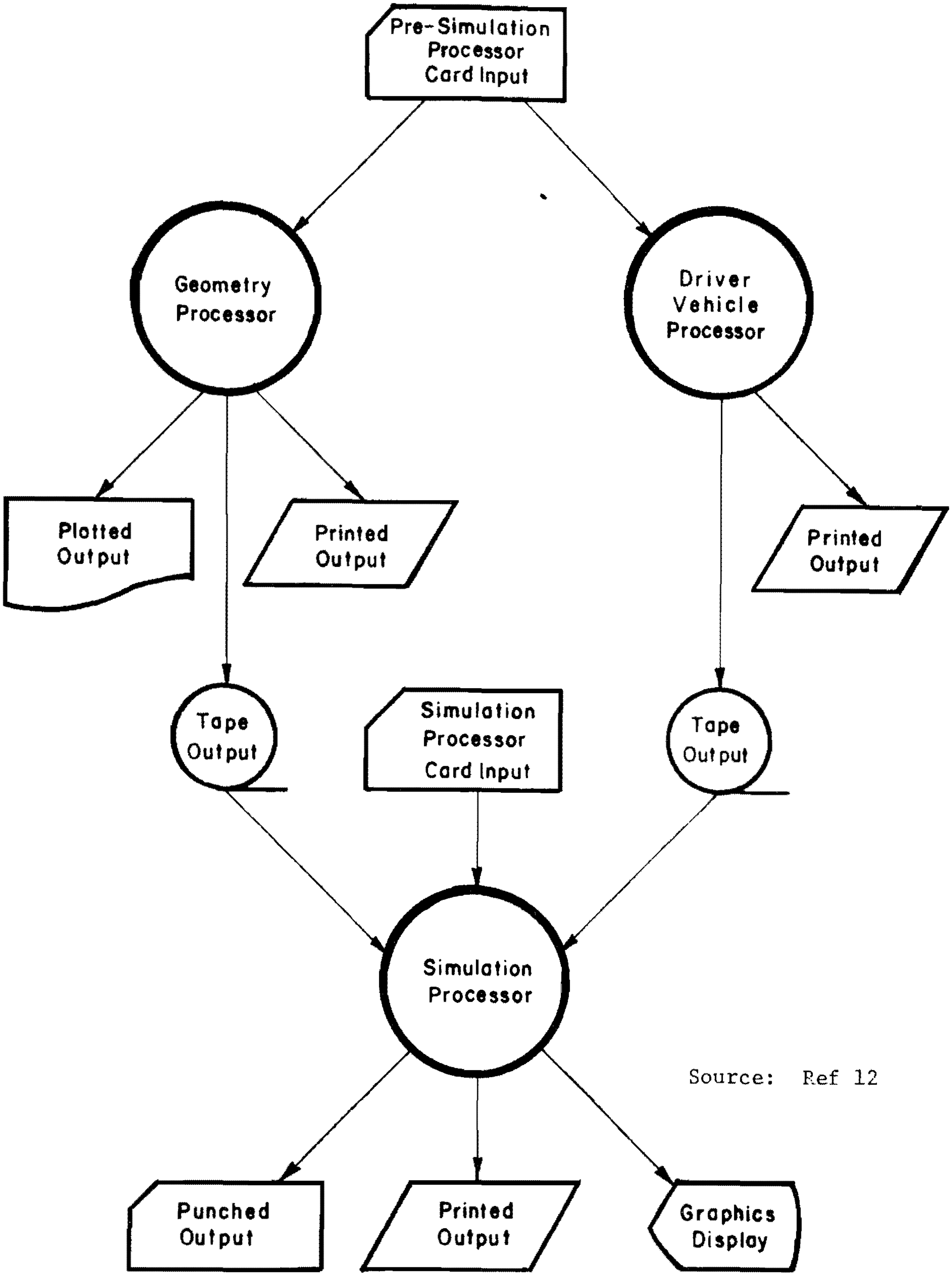
(2) Pre-Simulation Driver Vehicle Processor, and

(3) Simulation Processor.

As depicted in Fig 4-1, both the Geometry Processor and Driver Vehicle Processor are supportive programs for the Simulation Processor. The outputs from the Geometry Processor and Driver Vehicle Processor serve as input for the Simulation Processor. In the following paragraphs, a brief description of each processor will be given.

Geometry Processor and Driver Vehicle Processor. The Geometry Processor is a program for computing path geometry for all intersection paths and optionally produces a plot of the intersection. The Drive Vehicle Processor produces a list of driver-vehicle pairs to be used in the Simulation Processor. The Geometry Processor requires a characterization of intersection geometry while the Driver Vehicle Processor requires traffic volume and other information descriptive of the traffic stream. Significant elements composing the common input file utilized by both pre-processors are presented in Table 4-3.

Simulation Processor. The Simulation Processor sequentially examines each driver-vehicle unit in the intersection system allowing each to respond



Source: Ref 12

Fig 4-1. Flow process of the TEXAS Model.

TABLE 4-3. INPUT INFORMATION FOR GEOMETRIC/DRIVER-VEHICLE PROCESSOR

Category	Input Information	Input Values
Geometric Features	Number of inbound approaches	[1] 3 (or 4)
	Number of outbound approaches	[1] 3 (or 4)
	Inbound approach length on major (or minor) street, feet	800 (or 600)
	Number of lanes on major approaches	[2] 4 (or 2)
	Number of lanes on minor approaches	2
	Lane width, feet	12
	Radius of arc, feet	10
Vehicle and Driver Information	Vehicle class	10 (default)
	Driver class	3 (default)
Traffic Description	Approach volume, vehicles/hr/lane	300 (or 500, 700)
	Speed limit, miles/hr	30 (or 40, 50)
	85th percentile speed, miles/hr	28 (or 38, 48)
	Average speed, miles/hr	25 (or 35, 45)
	Percent left turns	10
	Percent right turns	10
	Name of headway distribution	Shifted negative exponential
	Parameter for headway distribution	Minimum headway 1 minute

1. Diamond interchange has three inbound (or outbound) approaches. Four-leg intersection has four inbound (or outbound) approaches.
2. In diamond interchange there are four lanes on major approach while at four-leg intersection only two lanes.
3. The simulation time was 12 minutes.

to surrounding traffic and traffic control devices and predicts their position, speed, and acceleration in the next increment of simulation time. Each unit is therefore 'stepped through' the system in small time increments. Delay, speed, and volume statistics are accumulated throughout the simulation process and reported at the end of a selected time increment. The delay measurement is of great interest here since it is chosen as one criterion to evaluate the efficiency of traffic operation. In this processor, total delay is measured as the difference between actual travel time and the travel time required if the vehicle maintained a pre-selected desired speed.

Queue delay is accumulated only when a queue exists and is maintained. A queue is said to be maintained if (1) the driver-vehicle under examination is traveling less than 3.0 ft/sec and (2) the driver-vehicle unit is less than a specified distance SQDIST (4'~40') from the stop line (for the first driver-vehicle unit in the lane) or from the lead driver-vehicle unit.

Stopped delay is accumulated when a driver-vehicle unit is part of a queue and its velocity is less than 3 ft/sec. Stop delay may be accumulated for any time increment until the simulation system logs out the driver-vehicle unit.

Input for the Simulation Processor, besides the outputs from the Geometry Processor and Drive Vehicle Processor, include (1) control parameters for the Simulation Processor and (2) specifications for the traffic control scheme at the intersection. General parameters for the Simulation Processor and their default values were shown in Table 4-4. The traffic control scheme is also described to include lane control, signal timing, and if appropriate, detector type and location. The signal timing for a full-actuated controller at least includes time specifications for initial interval, vehicle interval, yellow interval, and maximum extension.

TABLE 4-4. DEFAULT VALUES OF CONTROL PARAMETERS FOR THE SIMULATION PROCESSOR

Parameter	Default Values
1. Start-up time	2.00 min
2. Simulation time	10.00 min
3. Step increment for simulation time	1.00 sec
4. Speed below which < delay below xx mph > is gathered	10.00 mph
5. Maximum clear distance for being in a queue	30.00 ft
6. Car following equation parameters	
λ	2.80
μ	0.80
α	4000.00
7. Type of intersection control	7 (signalized)
8. Control command for print out	yes
9. Time for gap acceptance,	
lead time	2.5 sec
lag time	1.5 sec

The initial interval is determined by estimating the number of vehicles that could be queued between the stop line and the inner most inductive loop. For the Beierle and Winston-Salem method, the initial interval is set in the range of seven to twelve seconds while in the SSITE method it is set zero. The vehicle interval is estimated from the spacing between two detectors or, in the case of a single loop is estimated from travel time required between the stop line and the inductive loop. Both the Beierle and Winston-Salem method use one second, while the SSITE method uses two seconds for the vehicle interval. The amber interval is estimated based on speed, intersection width and acceleration rate. The following is a commonly utilized equation for calculation of the yellow interval [Ref 30].

$$Y = 1 + \frac{V}{2d} + \frac{W + L}{V} \qquad (4\text{-}3)$$

where
- Y = yellow interval, sec,
- V = approach speed, ft/sec,
- W = effective intersection width, ft,
- L = vehicle length, ft, and
- d = constant deceleration rate, ft/sec^2.

This question does not incorporate a grade term which when necessary is added to the second term [Ref 5]. In this simulation, amber intervals range from three to five seconds.

A maximum extension is the maximum time that an approach can hold the green interval after there is a vehicle actuation on the other street. As recommended in most traffic engineering references, maximum extensions are based on peak hour volumes and are estimated in a manner analogous to that of pretimed signals. In the peak hour, heavy traffic volume may cause an actuated signal to function like a pretimed signal. In this simulation, 60, 100, and 150 seconds were used when lane volumes were 300, 500, and 700 vehicles per hour per lane respectively.

The layouts of inductive loops for the three different methods on the major street were shown in Table 4-5. A single 50-foot loop is installed on each minor street approach.

Utilizing the Simulation Processor input and the output from both Geometry Processor and Driver Vehicle Processor, the Simulation Processor executes according to the process shown in Fig 4-2. Statistics such as speed, volume, travel time, and delay are produced for each movement (U or left turn, straight, right turn).

A total of 24 sets of delay data were collected of which Table 4-6 is an example. This table clearly indicates the average total delay, average queue delay and average stopped delay per approach vehicle under different treatments of method, speed, and lane volume. (See Appendix B for a complete listing of simulation data.)

Statistical Analysis of Simulation Results

Based on the selected model as shown in (4-2), the EMS (expected mean square values) analysis for fixed effects model were shown in Table C-1.

$$x_{ijKr} = \mu + M_i + S_j + MS_{ij} + V_K + MV_{iK} + SV_{jK} + E_{r(ijK)} \qquad (4\text{-}2)$$

where $i = 1, 2, 3,$

$j = 1, 2, 3,$

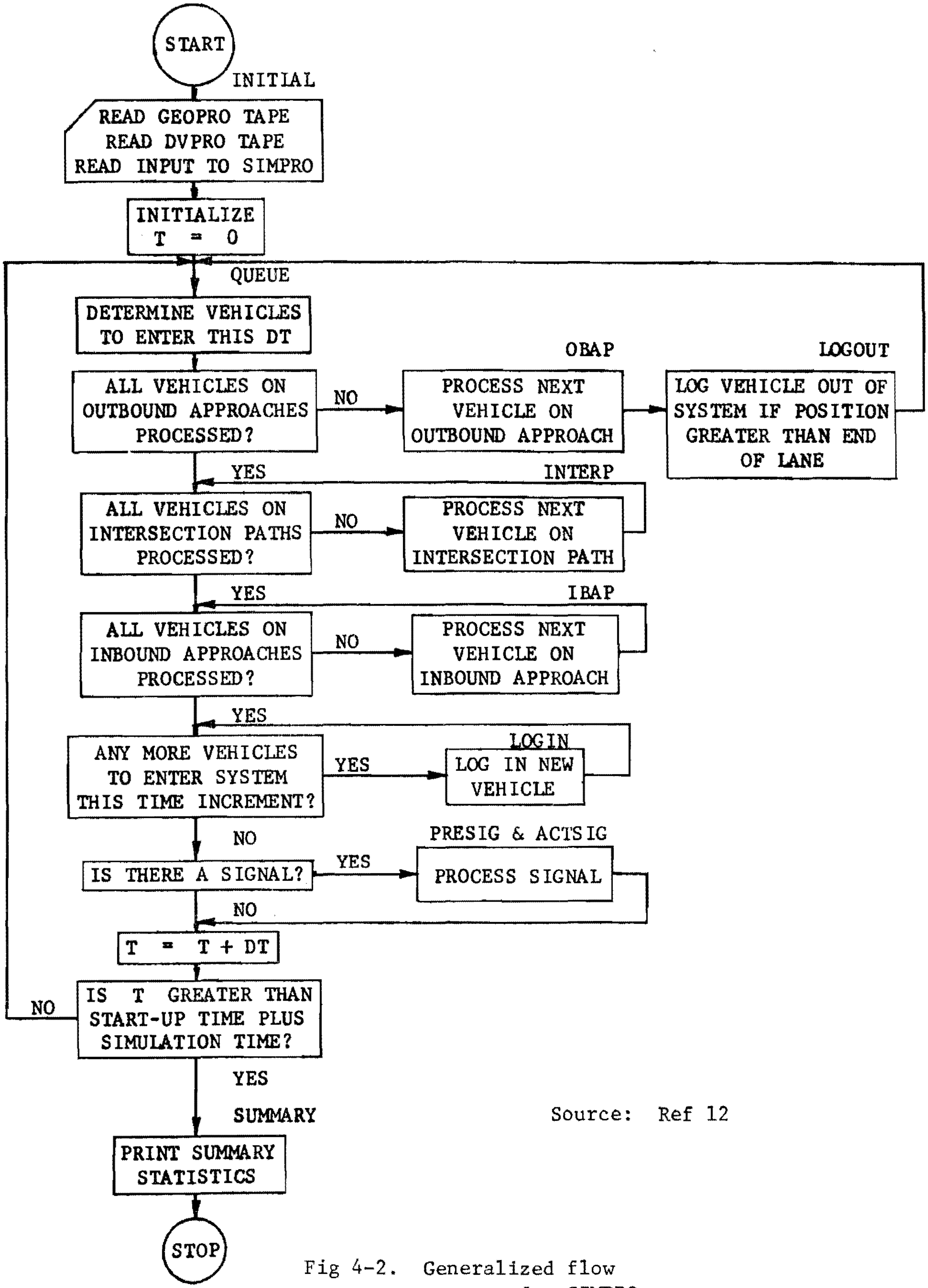
$K = 1, 2, 3,$ and

$r = 1.$

TABLE 4-5. DETECTOR SPACING FOR MULTIPLE-POINT DETECTION METHODS

Speed (mph) \ Method	Beierle	Winston-Salem	SSITE
30	45, 48	86	80, 49, 37, 21
40	64, 45, 48	73, 86	112, 80, 31, 21
50	72, 68, 54, 52	81, 73, 86	130, 111, 51, 31, 21

* All loop sizes are 6 feet by 6 feet.



Source: Ref 12

Fig 4-2. Generalized flow process for SIMPRO.

TABLE 4-6. EXAMPLE OF SIMULATION DELAY INFORMATION, ALL APPROACHES, FOUR-LEG INTERSECTION

DELAY ANALYSIS FOR FOUR-LEG INTERSECTION

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSITE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.2	11.6	13.6	11.9	12.3	12.8	17.3	16.8	16.8
. 500	76.7	78.4	87.2	81.0	78.5	84.5	95.4	99.7	87.2
V 700	105.7	135.0	140.8	135.9	157.0	134.5	137.0	135.0	140.8

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSITE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	8.0	7.2	9.1	7.6	7.7	8.0	14.0	12.9	12.7
. 500	72.2	73.0	83.2	75.5	71.7	75.8	88.7	92.4	83.2
V 700	96.9	128.9	130.8	130.7	150.6	125.8	131.1	128.9	130.8

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSITE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	6.5	5.9	7.5	6.4	6.3	6.7	11.4	10.8	10.8
. 500	52.6	54.6	59.4	56.4	52.8	57.2	65.5	68.5	59.4
V 700	72.9	101.6	103.6	99.0	120.4	101.1	101.9	101.6	103.6

From the EMS analysis, an ANOVA (Analysis of Variance) table (Table C-2) can be set up to test the main effects of the three factors and three two-way interactions among these factors. The calculations of sum of squares are summarized in Table C-3.

Explanation of Results of Analyses. In this study, all statistical analyses are conducted using the SPSS (Statistical Package for the Social Sciences) computer package [Ref 20]. The Analysis of Variance program of SPSS can perform analyses for as many as five main effects. In this study, 24 statistical tests (as shown in Table 4-7) are required. An example of one of these tests is shown in Table 4-8 and it includes sums of squares, degrees of freedom, mean squares, calculated F values and significance of F. The details concerning calculations of the former four columns are shown in Table 4-8(a) and Table 4-8(b). The significance of F in the last column of Table 4-8(a) is interpreted by comparing the calculated F with the table F value at a selected significance level such as five percent. A test statistic falling within this five percent rejection region indicates that the null hypothesis (means of all levels of that treatment are equal) must be rejected. Therefore, if the probability value (associated with the F ratio) in the fifth column is less than 0.05 the effect for which the F ratio is computed, had a significant effect upon the delay response variable.

The example of Table 4-8 indicates the main effect of the factor "volume" is significant at a five percent level while the other two effects of "method" and "speed" are not significant at a five percent level of significance. Since the interaction effects are insignificant, a multiple classification analysis as shown in Table 4-8(b), may be utilized to determine the extent of the variation of the dependent variable explained by each factor. The first column unadjusted deviation is obtained by comparing

TABLE 4-7. LIST OF STATISTICAL ANALYSIS FOR SIMULATION RESULTS

Alternatives A / Approach B	1 Diamond Interchange		2 Four-Leg Intersection			3 Texas		
	1 All*	2 Major** 1	1 All	2 Major** 1	3 Major 3	1 All	2 Major 1	3 Major 3
C_1 Average Total Delay Per Approach Vehicle	$A_1B_1C_1$	$A_1B_2C_1$	$A_2B_1C_1$	$A_2B_2C_1$	$A_2B_3C_1$	$A_3B_1C_1$	$A_3B_2C_1$	$A_3B_3C_1$
C_2 Average Queue Delay Per Approach Vehicle	$A_1B_1C_2$	$A_1B_2C_2$	$A_2B_1C_2$	$A_2B_2C_2$	$A_2B_3C_2$	$A_3B_1C_2$	$A_3B_2C_2$	$A_3B_3C_2$
C_3 Average Stop Delay Per Approach Vehicle	$A_1B_1C_3$	$A_1B_2C_3$	$A_2B_1C_3$	$A_2B_2C_3$	$A_2B_3C_3$	$A_3B_1C_3$	$A_3B_2C_3$	$A_3B_3C_3$

* All - consider all approaches

* Major - consider only major approach(es) where multiple detection system is implemented

TABLE 4-8. EXAMPLE OF SPSS ANALYSIS - FOUR-LEG INTERSECTION, AVERAGE TOTAL DELAY PER APPROACH VEHICLE AND ALL APPROACHES

(a) ANOVA

ANALYSIS OF VARIANCE

	Delay	Average Delay Per Approach Vehicle
BY	Method	Beierle or Winston or SSITE
	Speed	Approach speeds 30, 40, or 50 mph
	Volume	300 vphl or 500 vphl or 700 vphl

Source of Variation			Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects			68027.880	6	11337.980	185.413	.001
Method		SSM =	401.209	2	200.604	3.281	.091
Speed		SSS =	173.802	2	86.901	1.421	.296
Volume		SSV =	67452.869	2	33726.434	551.536	.001
2-Way Interactions			893.487	12	74.457	1.218	.401
Method	Speed	SSMS =	282.516	4	70.629	1.155	.398
Method	Volume	SSMV =	248.242	4	87.061	1.424	.310
Speed	Volume	SSSV =	262.729	4	65.682	1.074	.430
Explained			68921.367	18	3828.965	62.616	.001
Residual			489.200	8	61.150		
Total		SSTO =	69410.567	26	2669.637		

TABLE 4-8(b). MULTIPLE CLASSIFICATION ANALYSIS

MULTIPLE CLASSIFICATION ANALYSIS

	Delay	Average Delay Per Approach Vehicle
BY	Method	Beierle or Winston or SSITE
	Speed	30 mph or 40 mph or 50 mph
	Volume	300 vphl or 500 vphl or 700 vphl

Grand Mean = 78.36

Variable Category	N	Unadjusted DEV=N (1)	Unadjusted ETA (2)	Adjusted For Independents DEV=N (3)	Adjusted For Independents BETA (4)	Adjusted For Independents + Covariates DEV=N (5)	Adjusted For Independents + Covariates BETA (6)
Method							
1 Bierele	9	- 4.89		- 4.89			
2 Winston	9	.36		.36			
3 SSITE	9	4.53		4.53			
			.08		.08		
Speed							
1 30mph	9	- 3.57		- 3.57			
2 40mph	9	2.12		2.12			
3 50mph	9	1.44		1.44			
			.05		.05		
Volume							
1 300vphl	9	-64.43		-64.43			
2 500vphl	9	7.04		7.04			
3 700vphl	9	57.39		57.39			
			.99		.99		
Multiple R Squared					0.99		
Multiple R					0.98		

the mean each level for the factor with the grand mean. The grand mean is obtained by summing all observations and dividing by the total number of observations. In the example of Table 4-8(b) the grand mean is 78.36. The mean of the first level 'Beierle' is 74.37 which is a deviation of -4.89 from the grand mean. Eta in column (2) is the square root (SSM/SSTO) in Table 4-5(a). The square of eta for a factor represents the portion of variation explained by the factor. Column (3), (4) or (5), and (6) will change. Otherwise, they should have the same values as column (1) and (2). Then R^2 is the sum of the $(eta)^2$ or $(beta)^2$ and represents the portion of variation explained by the main effects. In this example, R^2 is 0.99.

Percentage of Vehicles Stopped

Differences among detector placement methods regarding their effects upon the percentage of the traffic stream required to stop were also evaluated. Utilizing the simulation data of the previously discussed experiment, the percentages of vehicles stopped for each case were cross-classified by detector placement method, approach speed, volume and approach number. An analysis of variance was conducted of this four-way classification separately for the diamond and four-leg intersection. Results of these analyses are shown in Tables 4-9 and 4-10. These analyses indicate that effects due to placement method are very minimal and are certainly not statistically significant with F ratios of 0.351 and 0.072 for the diamond and four-leg respectively.

These analyses indicate that there is no significant difference among placement methods regarding their effects upon percentages of vehicular stops.

TABLE 4-9. ANALYSIS FOR PERCENTAGE OF VEHICLES STOPPING FOR FOUR-LEG INTERSECTION

ANALYSIS OF VARIANCE

PER STOP By: METHOD TYPE OF DETECTOR PLACEMENT
SPEED SPEED OF VEHICLES
VOLUME VOLUME OF VEHICLES
APPROACH THE APPROACH NUMBER

Source of Variance		Sum of Squares	Degrees of Freedom	Mean Square	F	Significance Of F
Main Effects		2.442	9	.271	40.275	.001
Method		.001	2	.000	.072	.930
Speed		.008	2	.004	.628	.537
Volume		1.518	2	.759	112.648	.001
Approach		.915	3	.305	42.258	.001
Two-Way Intersections		.381	30	.013	1.886	.016
Method	Speed	.009	4	.002	.346	.846
Method	Volume	.039	4	.010	1.464	.223
Method	Approach	.071	6	.012	1.753	.122
Speed	Volume	.038	4	.009	1.401	.243
Speed	Approach	.013	6	.002	.327	.921
Volume	Approach	.211	6	.035	5.208	.001
Explained		2.824	39	.072	10.745	.001
Residual		.458	68	.007		
Total		3.282	107	.031		

TABLE 4-10. ANALYSIS FOR PERCENTAGE OF VEHICLES STOPPING FOR DIAMOND INTERCHANGE

ANALYSIS OF VARIANCE

PER STOP By: METHOD TYPE OF DETECTOR PLACEMENT
SPEED SPEED OF VEHICLES
VOLUME VOLUME OF VEHICLES
APPROACH THE APPROACH NUMBER

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance Of F
Main Effects	1.845	8	.231	28.400	.001
Method	.006	2	.003	.351	.706
Speed	.052	2	.026	3.230	.048
Volume	.523	2	.261	32.198	.001
Approach	1.251	2	.625	77.025	.001
Two-Way Approach	.590	24	.025	3.025	.001
Method Speed	.033	4	.008	1.027	.403
Method Volume	.010	4	.002	.307	.872
Method Approach	.127	4	.032	3.897	.008
Speed Volume	.027	4	.007	.836	.509
Speed Approach	.109	4	.027	3.346	.017
Volume Approach	.272	4	.068	8.379	.001
Explained	2.434	32	.076	9.369	.001
Residual	.390	48	.008		
Total	2.824	80	.035		

Summary

The summary of Table 4-11 may be interpreted to produce the following statements.

(1) In both the diamond interchange and four-leg intersection:

(a) neither detector placement method nor approach speed have significant effects on the average delay per approach vehicle at a five percent level of significance,

(b) lane volume has a significant effect on both the average delay per approach vehicle at a five percent level of significance, and

(c) neither detector placement method nor approach speed have significant effects on the number of vehicular stops at a five percent level of significance.

(2) The Texas placement method in a four-leg intersection produces the following:

(a) the method does not produce significant effects on the average delay per approach vehicle at a five percent level of significance,

(b) approach speed has no significant effects on the average delay per approach vehicle at a five percent level of significance,

(c) approach speed has no significant effect on the average delay per approach vehicle when all approaches are analyzed together. However, it produces significant effects at five percent level of significance when individual approaches are tested, and

(d) lane volume produces significant effects on the average delay per approach vehicle at a five percent level of significance.

Analyses described in this chapter have compared multiple detection methods with each other. Based upon this section of the study there appears to be no significant difference, in terms of vehicular delay, among the methods tested for the range of variables used. The only variable included which had a consistently significant effect upon delay was lane volume. Approach speed was observed to have significant effects upon delay in

TABLE 4-11. LIST OF SIGNIFICANCE

Delay Measure (per approach vehicle)		Intersection Geometry					[4] Texas		
		Diamond Interchange		Four-Leg Intersection					
		[1] All Approaches	Major Approaches	All Approaches	Major Approach 1	Major Approach 2	[1] All Approaches	Major Approach 1	Major Approach 2
Average Total Delay	M[3]	0.103	0.133	0.091	0.251	0.353	0.828	0.199	0.949
	S	0.191	0.433	0.269	0.400	0.473	0.231	0.076	0.002
	V	0.007	0.001	0.007	0.001	0.001	0.001	0.002	0.001
Average Queue Delay	M	0.119	0.145	0.080	0.209	0.614	0.219	0.108	0.324
	S	0.189	0.430	0.340	0.362	0.384	0.230	0.008	0.001
	V	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Average Stop Delay	M	0.119	0.282	0.089	0.246	0.285	0.878	0.339	0.338
	S	0.598	0.459	0.220	0.363	0.353	0.715	0.023	0.001
	V	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

1 Only major street approaches receive multiple detectors

2 PAV signifies delay per approach vehicle

3 M, S, and V represent detection method, speed, and lane volume respectively, as main treatment effects

4 Simulation conducted only for four-leg intersection

isolated cases when the "Texas" placement method was tested. This is likely due to the different stopping distance criteria utilized in this technique.

The next chapter will provide a comparison, in terms of vehicular delay and accident rate of multiple-point and single-point detection. While analyses of this chapter have been simulation based, that of the following chapter will be primarily based upon field data.

CHAPTER 5. FIELD INVESTIGATIONS

During early 1978 and 1979, multiple detector configurations were studied by SDHPT personnel through a series of field demonstration projects. Ten test sites having actuated signal controllers and relatively high approach speeds were selected. Basic data which is descriptive of these intersections is presented in Table D-1.

At each test site, existing single detectors were replaced by multiple units on selected approaches which were deemed to be most problematic. The placement method used to design the multiple installations was the Beierle technique complemented by AASHTO stopping distances. Placement and spacing of multiple detectors on approaches receiving them are indicated in Table D-2.

Traffic volume and stopped time delay data were collected by observers at each test site before and after installation of multiple detector systems. Comparisons of the before and after stopped time delay and traffic data were utilized as a means of evaluating the multiple detector systems.

Field Data Collection

Stopped time delay and traffic volume data were collected at each test site using procedures specified in A Technique for Measurement of Delay at Intersections [Ref 32]. At each location data were acquired during both peak and off-peak traffic volume conditions with and without multiple detection systems. Data collection for multiple detector systems was conducted a minimum of one year after system installations, thus providing time for driver reaction and signal timing fine tuning.

An overview of dates and times of data collection efforts is provided in Table D-3. Data were summarized by five, and 60 minute intervals and are presented in Appendix E. Graphical presentations of the time wise variation in vehicular delay are presented for selected time periods in Appendix F.

Data Analyses

The field data analysis was designed to test a general hypothesis that multiple detection systems would produce a reduction in stopped delay when compared with conventional single detector systems. Conventional parametric analysis of variance testing was used to examine this hypothesis.

The generalized factorial experiment used is shown in Table 5-1. Application of this experiment to all ten test sites was slightly impeded by the fact that in all cases complete before and after data were not collected.

Utilizing stopped time vehicular delay as the dependent variable, three-way analysis of variance testing was applied independently to each test site. In order to normalize differences in before and after vehicular delay data due to variations in traffic volume, all delay statistics were divided by appropriate traffic volume totals. Therefore, the dependent variable was actually "mean stopped time delay per vehicle passing through the intersection approach."

A summary of the analysis of variance testing is presented in Table 5-2. Probability values indicating the likelihood that observed effects could be due to chance alone are presented. For example, the probability that effects (presumably) due to the detector scheme at S.H. 174 and F.M. 917 could have occurred due to chance alone is almost zero (0.004). On the other hand, there is an extremely large probability (0.429) that detector effects at F.M. 1220 and Boat Club are indeed due to chance alone. Also included are analogous assessments for effects due to intersection approach and times of

TABLE 5-1. FACTORIAL DESIGN FOR THE STUDY OF SINGLE DETECTION SYSTEM VERSUS MULTIPLE DETECTION SYSTEM

Detector Configuration / Approach	A Multiple (1)		Original (2)	
	B Peak (1)	Off-Peak (2)	Peak (1)	Off-Peak (2)
C 1	$A_1B_1C_1$	$A_1B_2C_1$	$A_2B_1C_1$	$A_2B_2C_1$
2	$A_1B_1C_2$	$A_1B_2C_2$ *	$A_2B_1C_2$	$A_2B_2C_2$
3	$A_1B_1C_3$	$A_1B_2C_3$	$A_2B_1C_3$	$A_2B_2C_3$
4	$A_1B_1C_4$	$A_1B_2C_4$	$A_2B_1C_4$	$A_2B_2C_4$

* $A_1B_2C_2$ = Second approach in multiple detection system in peak hour

TABLE 5-2. SUMMARY OF SIGNIFICANCE OF F RATIO FROM ANALYSIS OF VARIANCE SINGLE VERSUS MULTIPLE DETECTOR INSTALLATIONS

Test Site	Source of Variation[1]			
	Main Effects	Before Versus After (Single Versus Multiple Point Detection)	Intersection Approach	Time (AM, PM or Off Peak)
SH 174 and FM 917	0.003	0.004	0.007	0.031
FM 1220 and Boat Club Drive	0.214	0.429	0.073	0.128
SH 183 and Roaring Springs	0.062	0.236	0.865	0.015
SH 361 and FM 1069	0.001	0.052	0.001	0.661
SH 6 and Jackson Street	0.001	0.001	0.003	0.001
SH 146 and Crest Lane	0.001	0.084	0.276	0.001
US 290 and FM 1960	0.260	0.222	0.122	0.364
US 84 and SH 317	0.556	0.892	0.326	0.468
SH 199 and Fire Hall Drive	0.001	0.002	0.001	0.034
SH 199 and Roberts Cut Off	0.042	0.405	0.019	0.089

1 Numbers in each cell can be interpreted as the proportion of all possible chances that differences of the size observed could have occurred due to chance alone. Minimum cell value is 0.0 and maximum is 1.0

observation, as well as, all main effects taken together. A probability value of 0.05 is frequently assumed to be small enough to guarantee acceptable confidence that effects are not chance occurrences. If this policy is adopted, statistically significant effects due to detector scheme, were observed at three of the ten test sites. This statement does not imply, however, that in all these significant cases multiple detection reduced vehicular delay. In fact, Table 5-3 demonstrates that in one of these three, there was a significant increase in vehicular delay.

Another view of the comparison between single and multiple-point detection is presented in Table 5-3. Arithmetic mean values of stopped time delay per vehicle, including all observations, both for single and multiple-point detection schemes are presented. The statistical significance of differences between before and after observations at a confidence level of 0.05 and an indication of which detector scheme produced smaller delay values are included. As already noted, effects attributable to detection scheme were significant in only three cases and of these only two indicated greater efficiency under multiple-point detection.

A generalized comparison of before and after means indicates that, six of the ten test sites did have at least marginal decreases in delay under multiple detection schemes. Conversely, four of ten performed more efficiently under the original single-point detection schemes. A conventional "T" test was performed to evaluate the hypothesis that all means of before and after conditions were drawn from the same population or are equivalent. This test produced a "T" statistic of 0.65 with 18 degrees of freedom which when compared with a table value of 2.10 (for a 0.05 confidence level) is obviously not significant. In fact, this value is not significant at a 0.50 confidence level. Therefore, if stopped time delay is a measure of

TABLE 5-3. OVERVIEW OF FIELD COMPARISONS OF MULTIPLE VERSUS SINGLE-POINT DETECTION

Test Site	[1]Arithmetic Mean Stopped Vehicular Delay		Statistically Significant (0.05 Alpha level)	Detector Configuration Producing Least Delay
	Before (Single Point)	After (Multiple Point)		
SH 174 and FM 917	5.80	9.12	Yes	Single
FM 1220 and Boat Club	16.00	14.42	No	Multiple
SH 183 and Roaring Springs	7.56	5.98	No	Multiple
SH 361 and FM 1069	5.70	5.16	No	Multiple
SH 6 and Jackson Street	16.32	8.14	Yes	Multiple
SH 146 and Crest Lane	11.44	13.71	No	Single
US 290 and FM 1960	19.61	29.24	No	Single
US 84 and SH 317	5.05	4.98	No	Multiple
SH 199 and Fire Hall Drive	16.95	10.43	Yes	Multiple
SH 199 and Roberts Cut Off	14.58	18.52	No	Single

1 Includes all approaches

operational efficiency, data gathered at these ten test sites, do not demonstrate any significant difference in operational efficiency for single and multiple-point detection system.

Simulation of Field Sites

Within Chapter 4, computer simulation analyses utilized to compare multiple-point detector placement methods were documented. Within previous sections of this Chapter, a field experiment comparing multiple and single-point detection has been described. Although the simulation model which was utilized has been previously verified through field studies, additional verification was deemed desirable.

Therefore, a typical field test site was selected for comparing delay statistics produced by the simulation model with those field counted. The intersection of S.H. 174 and F.M. 917 was selected for this experiment in which known geometry, signal timing, detector placement, and traffic characteristics were input to the simulation model. Conditions both before and after installation of multiple detectors were simulated and both peak and off-peak traffic volumes were utilized.

A factorial experiment was designed to test for statistically significant differences among treatment effects. Three main effects were studied and these included time (either peak or off-peak), intersection approach and data source (field versus simulation). The analysis of variance table demonstrating results of this experiment is illustrated in Table 5-4.

The table indicates that differences between simulation and field delay statistics are not statistically significant at an alpha level of 0.05. Differences due to the other two main effects are, likewise, not significant at the corresponding alpha level. Although this limited experiment cannot be

TABLE 5-4. ANALYSIS OF VARIANCE OF FIELD VERSUS SIMULATION DATA

Source of Variation	Sum of Squares	D.F.	Mean Square	F Ratio	Significance of F Ratio
Field Versus Simulation Delay Statistics	20.48	1	20.48	3.76	0.08
Intersection Approach	10.06	3	3.35	0.62	0.62
Time of Day	1.63	1	1.63	0.30	0.60
Residual	54.39	10	5.44	1.18	0.38
Total	86.55	15	5.77		

completely generalized, it does strengthen the assumption that the simulation technique does a reasonable job of reproducing real world delay information.

Accident Analysis

In order to assess the effect of multiple detectors upon accident experience, both accident and volume data were acquired for each of the ten test sites. In all cases, accident data were collected for at least one year following multiple detector installation. Data for one to three years before the installation of multiple-point detection systems were utilized as a basis for comparison. The details concerning the date the multiple detection system was implemented and the times for accident data collection for each of the test sites were shown in Table 5-5. The applicable accident data which excludes non-intersection related accidents for each of the ten test sites were shown in Table 5-6.

Before and after cases were obtained through automatic traffic recorder (ATR) counts. Numbers of axles counted on each approach at each test site during the years 1977, 1978, 1979, and 1980 (see Table G-1) were converted to vehicle counts utilizing an axle to vehicle to conversion factor and are illustrated in Table G-2. The estimated annual traffic was produced from the numbers in Table G-2 simply by multiplying by 365 (as shown in Table 5-7). In general, traffic volumes did not vary greatly during the study period.

Annual accident rates expressed as numbers of accidents per million vehicles for the test sites are presented in Table 5-8. Since traffic volume did not vary greatly between before and after periods, the accident rate was not counter balanced by the traffic volume effect. Statistical significance of changes in numbers of accidents and rates was evaluated using both parametric and nonparametric tests. Classical parametric Poisson and Chi-Square tests were utilized along with the nonparametric sign test

TABLE 5-5. DATE FOR THE IMPLEMENTATION OF MULTIPLE DETECTION SYSTEM AND ACCIDENT DATA COLLECTION

Test Site	Date Installed	Before Study Accident Recorded	After Study Accident Recorded
S.H. 199 and Fire Hall Drive	11/1979	1977 - 79	1980
F.M. 1220 and Boat Club Road	11/1979	1977 - 79	1980
S.H. 199 and Roberts Cut-off	11/1979	1977 - 79	1980
S.H. 183 and Roaring Springs Road	11/1979	1977 - 79	1980
S.H. 174 and F.M. 917	9/1979	1977 - 79	1980
U.S. 290 and S.H. 6[1] and F.M. 1960	3/1979	1977	4/1979-4/1980
S.H. 6 and Jackson	3/1979	1977	4/1979-4/1980
S.H. 146 and Crest Lane	3/1979	1977	4/1979-4/1980
S.H. 361 and F.M. 1069	8/1979	1977 - 79	1/1980-11/1980
U.S. 84 and S.H. 317[1]	10/1978	7/1977-6/1978	1979

[1] Intersections deleted from study due to changes in before and after conditions

TABLE 5-6. APPLICABLE ACCIDENTS FOR TEN TEST SITES

Test Site	Year			
	1977	1978	1979	1980
S.H. 199 and Fire Hall	8	12	7	7
F.M. 1220 and Boat Club Road	16	6	6	3
S.H. 199 and Roberts Cut-off	30	20	20	27
S.H. 183 and Roaring Springs Road	35	29	20	22
S.H. 174 and F.M. 917	4	7	8	7
U.S. 290 and S.H. 6 [1] and F.M. 1960	27	-	-	31*
S.H. 6 and Jackson	5	-	-	2*
S.H. 146 and Crest Lane	6	-	-	0*
S.H. 361 and F.M. 1069	4	-	-	6**
U.S. 84 and S.H. 317 [1]	-	13***	14.0	-

* From May 1979 to April 1980

** From December 1979 to November 1980

*** From July 1977 to June 1978

[1] Intersections deleted from study due to changes in before and after conditions

TABLE 5-7. ESTIMATED ANNUAL TRAFFIC VOLUMES FOR TEN TEST INTERSECTIONS

Test Site	Average Annual Traffic ($x\ 10^6$ vehicles)			
	1977	1978	1979	1980
S.H. 199 and Fire Hall	9.16*	10.20	10.20	10.28
F.M. 1220 and Boat Club Road	3.84	3.93	4.12	4.28
S.H. 199 and Roberts Cut-off	10.40	11.50	11.20	11.30
S.H. 183 and Roaring Springs Road	11.70	12.00	11.90	11.90
S.H. 174 and F.M. 917	5.58	6.04	6.54	7.10
U.S. 290 and S.H. 6 F.M. 1960 [1]	11.90	14.4	14.4	16.10
S.H. 6 and Jackson	4.94	4.91	4.46	4.49
S.H. 146 and Crest Lane	8.46	9.55	9.74	11.60
S.H. 361 and F.M. 1069	3.75	4.12	2.95	4.44
U.S. 84 and S.H. 317 [1]	2.68	2.74	2.81	-

Estimated Annual Volume = Estimated Daily Volume x 365

* $9.16 \times 10^6 \approx (11720 + 13170 + 100 + 100) \cdot 365$
(From Table G-2) · 365

[1] Intersections deleted from study due to changes in before and after conditions

TABLE 5-8. ACCIDENT ANALYSIS PARAMETERS

Intersection	Total Traffic Volume[1] (x 10^6 vehicles)		Total Accidents[1]		Accident Rate (accidents/million vehicles)			Speed (mph)
	[2]Before	After	Before	After	Before	After	Sign[4]	
S.H. 199 and Fire Hall Drive	29.36 [3]	10.2	27	7	0.92	0.69	-	45
F.M. 1220 and Boat Club Road	11.89	4.28	28	3	2.35	0.70	-	45
S.H. 199 and Roberts Cut-off	33.10	11.30	70	27	2.11	2.39	+	45
S.H. 183 and Roaring Springs Road	35.60	11.90	84	22	2.36	1.85	-	40
S.H. 174 and F.M. 917	18.16	7.10	19	7	1.02	0.99	-	55
U.S. 290 and S.H. 6 and F.M. 1960 [5]	11.90	16.10	27	31	2.27	1.93	-	55
S.H. 6 and Jackson	4.94	4.49	5	2	1.01	0.45	-	55
S.H. 146 and Crest Lane (Barbours Cut)	8.46	11.60	6	0	0.71	0.00	-	55
S.H. 361 and F.M. 1069	3.75	4.40	4	6	1.07	1.36	+	40
U.S. 84 and S.H. 317 [5]	2.74	2.81	13	14	4.74	4.98	+	45

1. "Total" represents the summation of annual volume (or accident) data available before and after the implementation of multiple detection systems.
2. Before the implementation of multiple detection systems.
3. 29.36 = 9.16 + 10.20 + 10.20 from Table 5-11.
4. A positive sign means the accident rate is higher in the after case.
5. Intersection deleted due to change in traffic environment

[Ref 27]. Both Poisson and Chi-Square tests assume the number of accidents and rates before the installation of multiple-point detection systems as the expected number of accidents and rate for each selected intersection in the after period. The critical number of accidents and rate which marks a significant change from the expected values are estimated for a given level of significance. If the number of accidents and rate after the installation of multiple-point detection systems is less than the critical values, it is said a significant difference at a given level of significance exists between the before case and after case. As indicated in Fig 5-1, the Poisson test is somewhat more liberal and can be used to minimize the chance of calling an accident reduction not significant when in fact it is. The Chi-Square test is more conservative and can be used to minimize the chance of calling an accident reduction significant when in fact it is not.

The intersections of U.S. 290 - S.H. 6 and U.S. 84 - S.H. 317 were deleted from the analysis because of changes in the traffic environment during the data collection period which could not be controlled and would likely bias results. The remaining eight intersections were grouped by approach speeds into a 40 to 45 mph class and a 50 to 55 mph class. Both parametric and nonparametric tests were applied to each of the two groups and to the aggregate.

Test by both statistical tests indicated that changes in accidents and rates were statistically significant at a 95 percent confidence level for the high approach speed (50-55 mph) group. Changes in numbers of accidents and rates for the low approach speed (40-45 mph) group and the aggregate of all eight intersections did not indicate statistical significance at 95 percent confidence level.

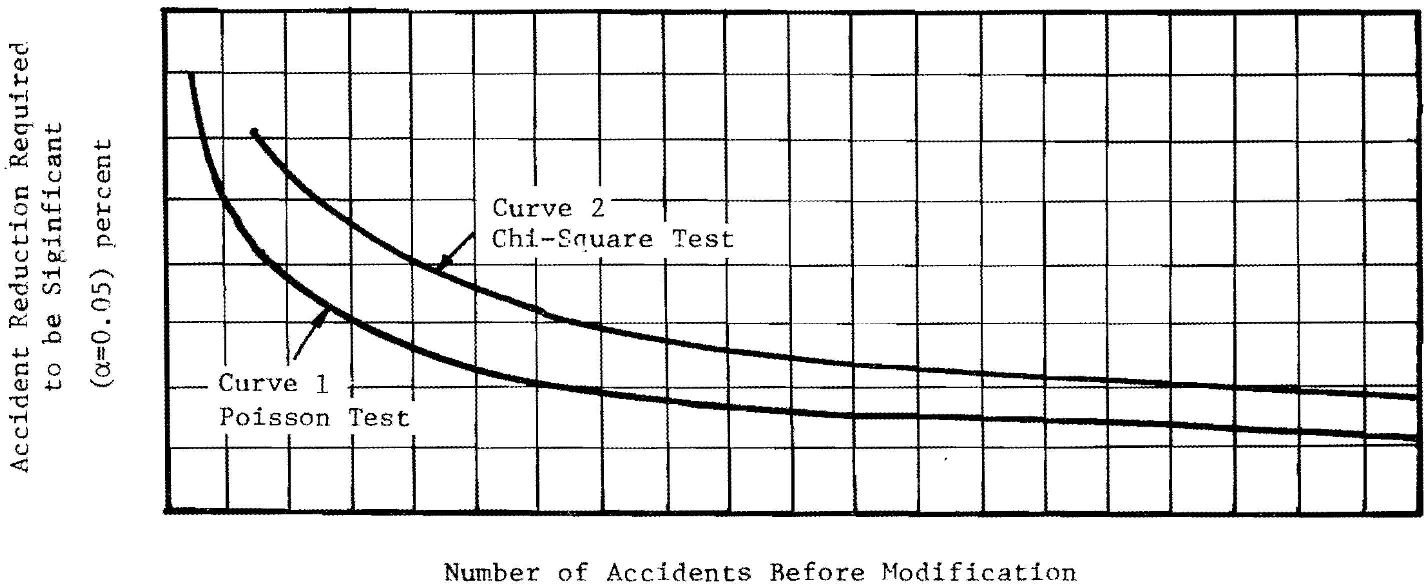


Fig 5-1. Poisson Test and Chi-Square Test

Source: Michaels, Richard M., "Two Simple Techniques for Determining the Significance of Accident-Reducing Measures," Traffic Engin-ering, September, 1966

Summary and Conclusion

Within this chapter a field study of single and multiple-point detection schemes has been presented. The study compared the two detection methods in a before versus after format with stopped time vehicular delay and accident rates as the response variables. A limited comparison of vehicular delay statistics produced by the TEXAS simulation model and those collected through field measurement was also presented.

Based upon these data and analyses, the following statements can be made:

(1) A statistically significant difference in vehicular delay due to single versus multiple-point detection was not found.

(2) A statistically significant difference in accident rate in the high speed class (50-55 mph) due to single versus multiple- point detection was found. However, no such significant effect was found in low speed class (40-45 mph) or the aggregate.

(3) Differences among vehicular delay data predicted by the TEXAS simulation model and that measured in field tests were not found to be statistically significant at a confidence level of 0.05.

CHAPTER 6. DETECTOR LOCATION AND CONFIGURATION FOR LOW-SPEED CONDITIONS

Previous sections of this report have presented analyses of methodologies for locating multiple detectors on approaches to intersections having high traffic approach speeds. The speed of traffic approaching many intersections in heavily developed portions of urban areas is, however, less than 35 mph. At these locations, dilemma zones and other operational problems related to high approach speeds do not require multiple detector installations. In each lane or approach to such intersections, a single detector is most often utilized.

Location and configuration of single detectors has a very pronounced effect upon operational efficiency of the intersection. Within this chapter, operational effects of single detector location and configuration and their interaction with the single controllers are evaluated.

Selection of Detector and Operating Mode

In this study an inductive loop detector operating in presence mode was chosen in order to maximize controller capability and flexibility in responding to real-time traffic situations. When operating in presence mode, the detector registers a continuous call to the signal controller if one or more vehicles are occupying the detection zone. This action tends to retain a green indication until the detection zone is no longer occupied. The time after the detection zone is unoccupied in which green can be retained is variable and is controlled by the maximum extension dial setting of the controller. More capability for the controller means that more traffic information can be obtained between the stop line and the loop detector.

More flexibility for the controller, means that, the length of green interval is determined primarily by the length of the time the detection area is occupied and only secondarily by the settings of the controller.

Detector Location

When a green signal indication is returned to an approach having a waiting queue, an amount of time will be required for the queue to begin moving. With the consideration of furnishing the traffic controller more flexibility and avoid non-vehicular detection near the stop line, the inductive loop is located at a point 10 feet from the stop line and the allowable queue start-up time is extended using the initial interval dial setting of the signal controller. The amount of time actually required, however, depends upon the number of vehicles in the queue which will vary from one green phase to the next.

The controller, however, will provide the amount of start-up time specified on its initial dial for every queue. This constant start-up time will obviously reduce efficiency. If a presence mode inductive loop detector is located within one vehicle length of the approach stop line, the initial interval is set near zero, the continuous call activity of the detector can be used to effectively vary start-up time in response to queue length. Therefore in this study, the downstream edge of presence mode inductive loop detectors were located within 10 feet of the stop line and the initial interval controller setting was quite small.

Determination of Inductive Loop Length

A graphical presentation relating headway, inductive loop length, loop location, and vehicle length is shown in Fig 6-1. Equations (6-1) and (6-1a) are mathematical expressions of the relationships of the parameters.

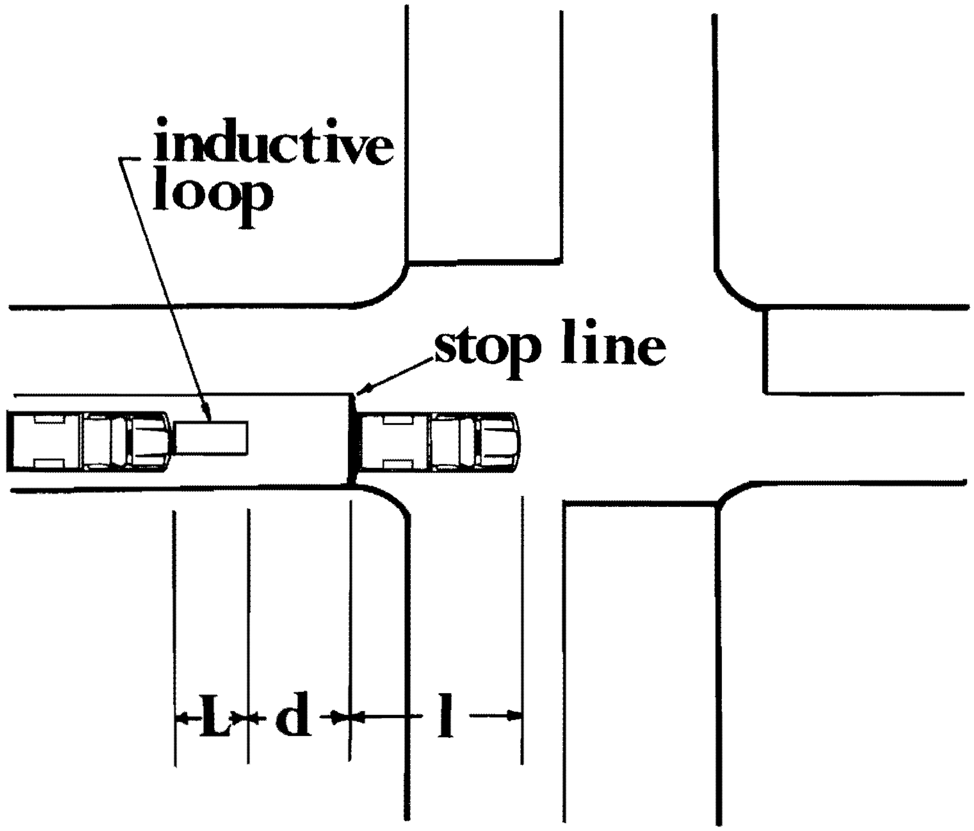


Fig 6-1. Relationships among headway, inductive loop length, loop location and vehicle length.

$$H * V = L + d + l \tag{6-1}$$

or

$$H = \frac{L}{V} + \frac{d}{V} + \frac{l}{V} \tag{6-1a}$$

where H = headway, sec,

V = speed, ft/sec,

L = inductive loop length, ft,

d = loop location from the stop line, ft, and

l = vehicle length, ft .

In equation (6-1a), L/V represents the portion of green time during which a vehicle occupies the detection area of the inductive loop. The portion of green time needed for a vehicle to enter the intersection after leaving the detection area is indicated by d/V. This quantity of time should be the vehicle extension interval setting of the controller. If VI is adopted as the notation for vehicle interval, then

$$VI = \frac{d}{V} \tag{6-2}$$

and equation (6-1a) can be re-written as equation (6-3)

$$H = \frac{L}{V} + VI + \frac{l}{V} \tag{6-3}$$

Obviously, the vehicle interval is governed by the loop location, and since the downstream loop edge is 10 feet from the stop line, the calculated vehicle interval will be very small.

For given headway, speed, and vehicle interval, the inductive loop length can be developed from equation (6-3), as

$$L = (H - VI) * V - l \tag{6-3a}$$

If speed, vehicle length, and vehicle interval are constant, a loop of length L as determined by Equation (6-3a) would retain the green indication until the appearance of a headway greater than H. Long loops are needed to retain the green indication if headways are large. Figure 6-2 is a graphical presentation describing this relationship.

Headway, however, is a function of traffic volume which varies with time. In other words, headway in equation (6-3a) cannot be well represented by single value, but rather, headways vary with time according to a certain distribution. One method for determining optimal loop length is to experimentally measure the performance of various loop lengths under a variety of different traffic which gives the conditions as headway distributions.

Experimental Design

In order to provide efficiency and sufficiency of experimental results, an experiment design was developed prior to data acquisition. Three delay based measures of efficiency were chosen as potential dependent variables.

(1) average total delay per approach vehicle,

(2) average queue delay per approach vehicle, and

(3) average stop delay per approach vehicle.

Independent variables chosen for the experiment were lane volume, speed, and loop length. The lane volume used in this design ranges from 200 vehicles to 500 vehicles per lane per hour with an increment of 100. The lane volumes comprise the practical range of traffic volume that may occur in peak periods. The speed used in the design ranges from 25 to 40 miles per hour with an increment of 5. Detector lengths ranging from six feet to lengths equivalent to the distance travelled by a vehicle at the approach

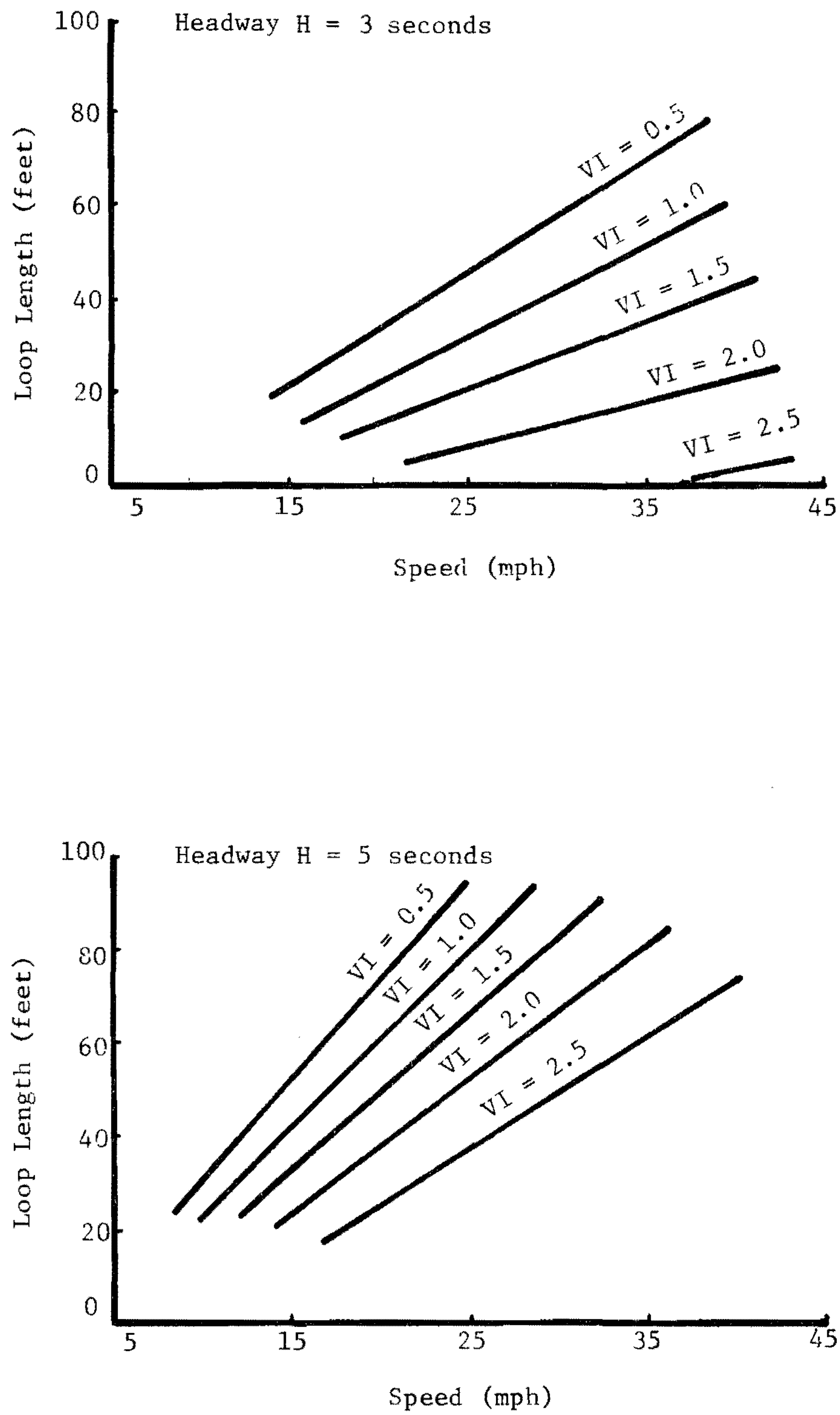


Fig 6-2. The relationship between inductive loop length and speed for given headway and vehicle intervals.

speed in times of one to 2.5 seconds with an increment of 0.5. Table 6-1 is a list of the loop lengths used in the design. Obviously, it is a fair coverage for the length of inductive loops used in practice.

A schematic representation of the experimental design for this part of study is shown in Table 6-2. Loop length, lane volume, and speed are the three factors considered in the design.

Computer Simulation

Data were obtained through computer simulation utilizing the TEXAS Model as described in previous sections.

Geometry of the simulated intersection was a typical four lane by two lane, four-leg at-grade configuration shown schematically in Fig 6-1. A two-phase actuated traffic signal controller was utilized and there were no special turn phases or bays. Lane control and signal timing for all approaches were identical.

The simulation time, which includes start-up time and simulated observation time, controls the quantity and stability of statistics gathering from traffic simulation. During the start-up time, no statistics are gathered, but rather the simulation environment is loaded with traffic and allowed to stabilize. When traffic flow approaches a stable condition, summary statistics can be gathered and timing for simulated observation can be started. In heavy traffic flow conditions, a minimum simulation time of ten minutes is sufficient, however, a longer simulation time is recommended for light traffic flow conditions because of greater variability in low volume traffic statistics. Table 6-3 is a list of simulation time for various study lane volumes. The values for lane volumes, 200 and 300, as shown in Table 6-3 were obtained after several trials. While the values for

TABLE 6-1. SUMMARY FOR INDUCTIVE LOOP LENGTH

Speed (mph)	Loop Length (feet)*				
	A	B	C	D	E
25	6	37	55	74	92
30	6	44	66	88	110
35	6	51	77	103	129
40	6	59	88	118	147

* the width for all inductive loop is 6'

A, B, C, D, and E have the same explanation as that in Table 6-2

TABLE 6-2. EXPERIMENTAL DESIGN FOR THE STUDY OF OPTIMAL LOOP LENGTH

Lane Volume (VPHPL)	Speed (mph)	Loop Length (feet)*, LL				
		A	B	C	D	E
200	25					
	30					
	35					
	40					
300	25					
	30					
	35					
	40					
400	25					
	30					
	35					
	40					
500	25					
	30					
	35					
	40					

* The width for all loop is 6 feet

A LL = 6'

B LL = 1.47 x speed x 1, in feet

C LL = 1.47 x speed x 1.5, in feet

D LL = 1.47 x speed x 2.0, in feet

E LL = 1.47 x speed x 2.5, in feet

TABLE 6-3. SUMMARY FOR SIMULATION TIME

Lane Volume (VPLPH)	Simulation Time (min)		
	Start-up	Simulation	Total
200	5	90	95
300	5	60	65
400	5	10	15
500	5	10	15

lane volume 400 and 500 were chosen as the default value of ten minutes. All simulation statistics were collected using a one second increment time.

Signal Timing Specifications

The vehicle interval (VI) for each experimental condition was estimated using equation (6-2). For a design vehicle length of 20 feet and detector downstream edge located ten feet from the stop line, the calculated vehicle intervals would be 0.8, 0.7, 0.6, and 0.5 seconds for speeds of 25, 30, 35, and 40 mph respectively.

The initial interval (II) can be calculated using Greenshield's empirical formula:

$$II = (n * 2.1 + 3.7) - VI \qquad (6\text{-}4)$$

where n = number of vehicles in a waiting queues in this case, between detector and stop line.

As noted earlier, since the leading edge of the detector was located only ten feet from the stop line and the detectors were operating in presence mode, n would be less than one and the vehicle interval could be set almost to zero.

In the TEXAS Model, for full actuated control, the simulation time increment at which all vehicle positions are updated is recommended as one second. Moreover, both the initial interval and the vehicle interval should be equal to or greater than the simulation time increment. Therefore, one second was utilized for both initial and vehicle intervals. Three-second amber intervals were used for each of the two signal phases. Based upon the decision that each traffic volume level should represent peak hour conditions, maximum extensions were estimated by the same principle as that of pretimed signal control. For each selected minimum extension, a simulation run was executed to determine the number of max-outs on each competing phase. Table 6-4 is a summary of maximum extensions for various peak lane volumes.

Data developed through implementation of the experiment design and the simulation model were shown in Appendix H. From the data in Appendix H no general tendency between vehicular delay and inductive loop length is apparent. Vehicular delay seems to have less dispersion under low speed than under high speed conditions.

Because delay increases significantly with lane volume, effects due to loop length could be masked by the volume effect. Such apparent masking does, in fact, occur because an actuated signal controller tends to behave as a pretimed controller under high volume conditions. The duration of the maximum green for each phase is normally established so that during the peak hour most phases will extend to the limit. Thus, under peak hour, high volume conditions detector length cannot effect phase length or delay because phase lengths are controlled by the maximum extension controller dial setting. Additionally, under very heavy volume conditions, all traffic lane space may become occupied by vehicles and, of course, a detector of any length at any position would produce the same effect. A two-way analysis with loop length and approach width as factors, may be more appropriate than using a four-way analysis, which has lane volume, speed, loop length and approach width as factors.

Analysis of Variance

In order that the loop length effect would not be masked by the volume, speed and approach effects, a two-way analysis using loop length and approach on major or minor streets as two factors was chosen to determine if the loop length effect on vehicular delay was significant at five percent significance level. Analyses were performed for major or minor approaches separately

TABLE 6-4. SUMMARY FOR SIGNAL TIMING

Lane Volume (VPLPH)	Signal Timing (seconds)			
	Initial Interval	Vehicle Interval	Amber Interval	Maximum Extension
200	1.0	1.0	3.0	27.0
300	1.0	1.0	3.0	27.0
400	1.0	1.0	3.0	37.0
500	1.0	1.0	3.0	50.0

under specific speed and approach volume conditions. By using SPSS and the data in Appendix H, 96 two-way analyses were performed. The significance of F for the loop length effect on average total delay, average queue delay, and average stop delay were summarized in Table 6-5. Graphical presentations indicating significance of the loop length effect at the five percent level were also shown in Figs 6-3, 6-4, and 6-5. On the major approach, the loop length effect was not significant in the cases of speed 30 and 40 mph or approach volume 800 vph for the three different vehicular delay measures. In general, there was no specific trend for the effect of loop length on average total delay, average queue delay, and average stop delay which could be traced on either the minor or major street.

Summary

Analyses of the effects of detector length upon vehicular delay produced generaly mixed results. Tests of conditions in which traffic volumes and approach speeds were low (200 vph and 25 mph) indicated that the longest tested detector length clearly produced least delay. For all other conditions, however, results were quite inconsistent.

Several theories may be cited as possible causes of this variability. High volume conditions (400 or 500 vph per lane) tend to produce small gaps between arriving vehicles which means that lane traffic density is rather high. Higher densities cause any detection area to be occupied for a higher percentage of time likely negating some potential effects of detection area size. Additionally, tests utilizing volumes of 300 vph per lane may have been influenced by the fact that for this volume condition many green phases were terminated due to phases reaching the maximum allowed green time (or "maxed out") (see Table 6-6). This could mean that if the controller had not been constrained by the maximum interval dial setting, it would have provided

TABLE 6-5. SIGNIFICANCE OF F FOR LOOP LENGTH EFFECT ON VEHICULAR DELAYS

Speed (MPH)	Major or Minor Approach	Approach Volume (VPH)	Significance of F for Loop Length Effect on		
			ATDV	AQDV	ASDV
25	Minor	200	0.098	0.150	0.181
		300	0.002*	0.004*	0.005*
		400	0.761	0.564	0.516
		500	0.051*	0.064	0.031
	Major	400	0.350	0.147	0.170
		600	0.023*	0.046*	0.038*
		800	0.419	0.324	0.297
		1000	0.860	0.850	0.891
30	Minor	200	0.744	0.307	0.364
		300	0.999	0.878	0.733
		400	0.123	0.136	0.090
		500	0.841	0.890	0.760
	Major	400	0.078	0.148	0.131
		600	0.944	0.312	0.269
		800	0.365	0.406	0.386
		1000	0.898	0.839	0.870
35	Minor	200	0.814	0.120	0.066
		300	0.207	0.159	0.138
		400	0.021*	0.025*	0.035*
		500	0.598	0.623	0.593
	Major	400	0.039*	0.010*	0.023*
		600	0.201	0.118	0.096
		800	0.703	0.659	0.592
		1000	0.026*	0.011*	0.016*
40	Minor	200	0.024*	0.004*	0.004*
		300	0.102	0.050*	0.030*
		400	0.098	0.047*	0.196
		500	0.966	0.970	0.949
	Major	400	0.850	0.085	0.120
		600	0.641	0.112	0.158
		800	0.531	0.742	0.707
		1000	0.054	0.090	0.208

ATDV = Average Total Delay per Approach Vehicle
AQDV = Average Queue Delay per Approach Vehicle
ASDV = Average Stopped Time Delay per Approach Vehicle

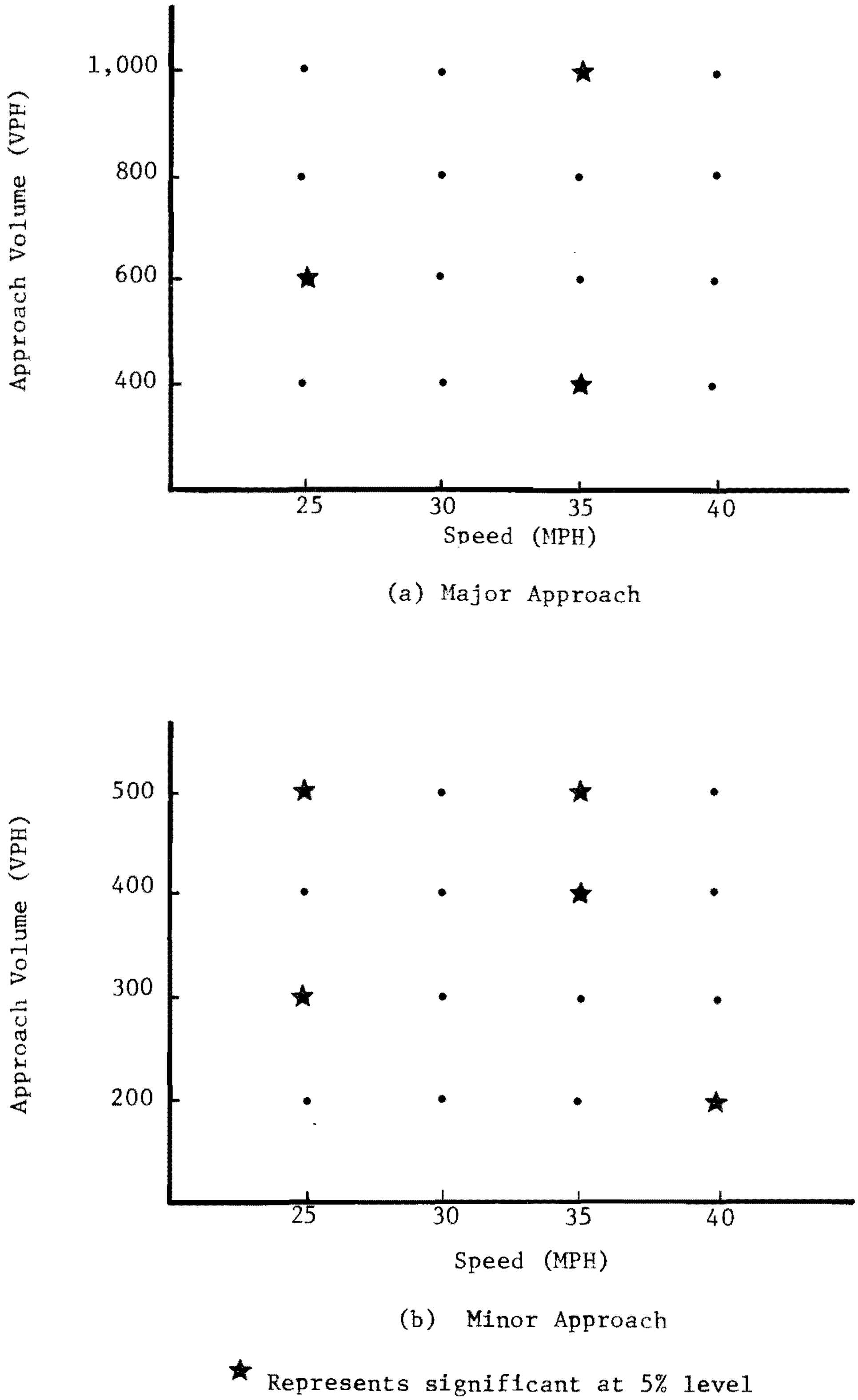


Fig 6-3. Significance of loop length on average total delay per approach vehicle.

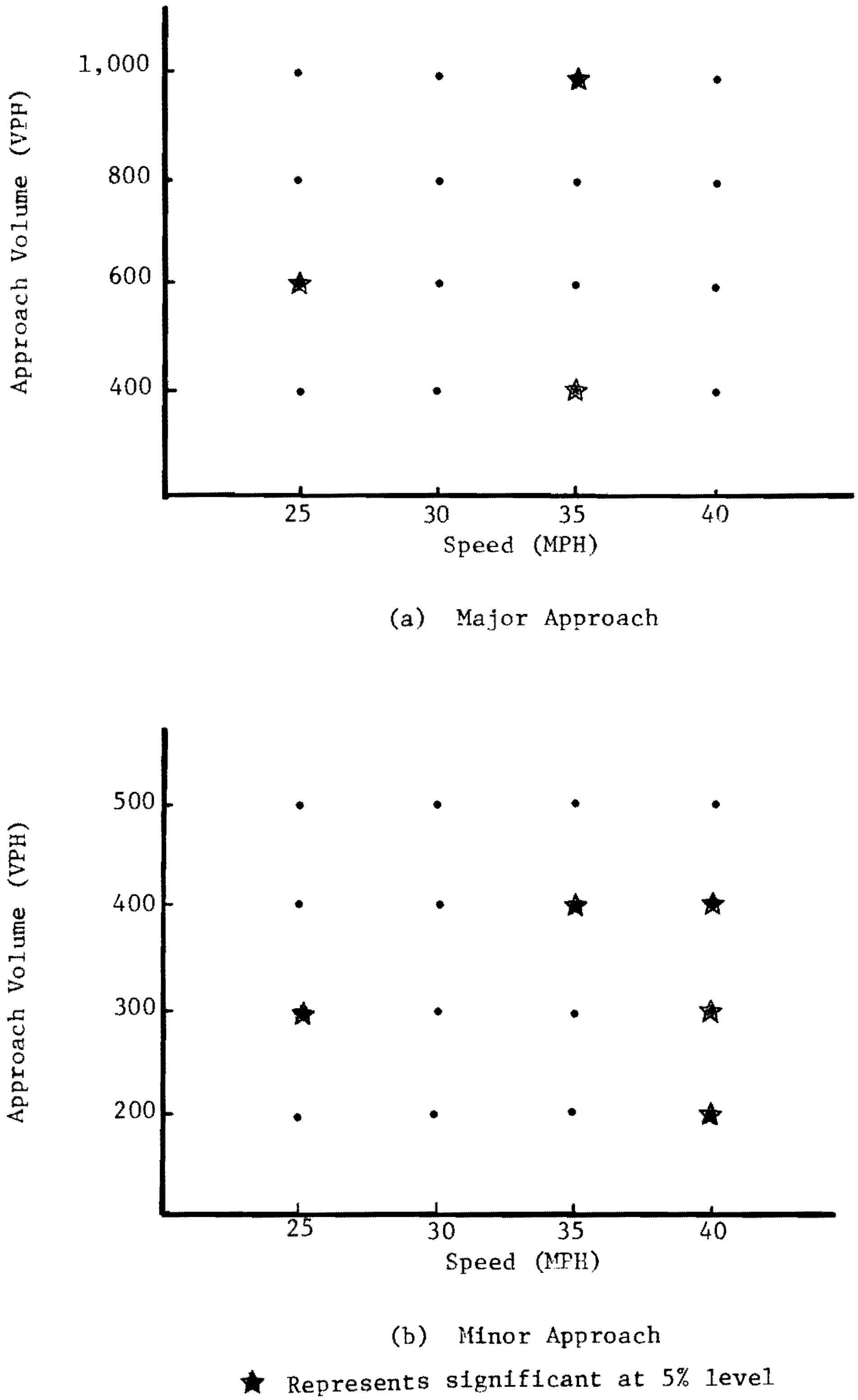
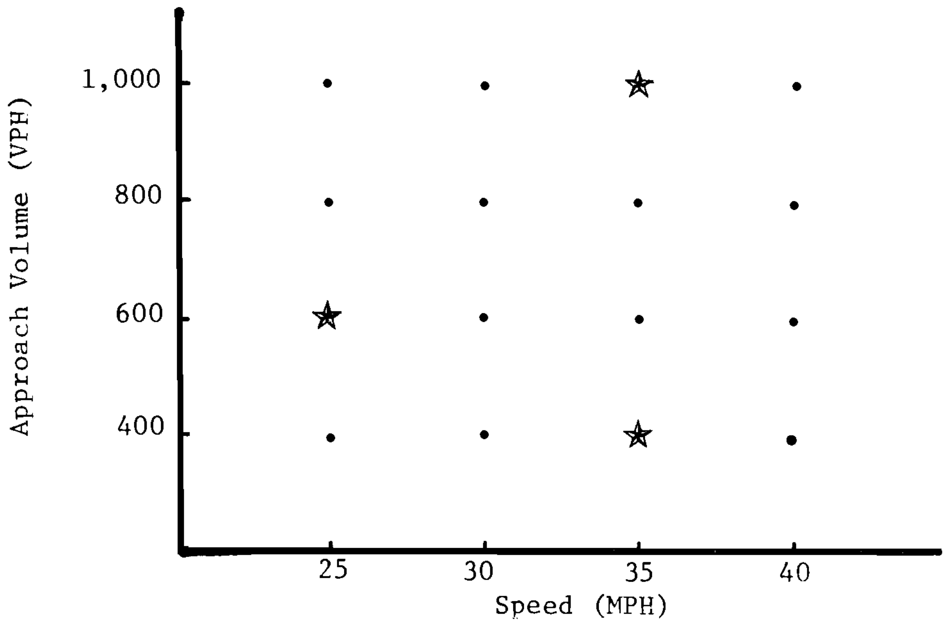
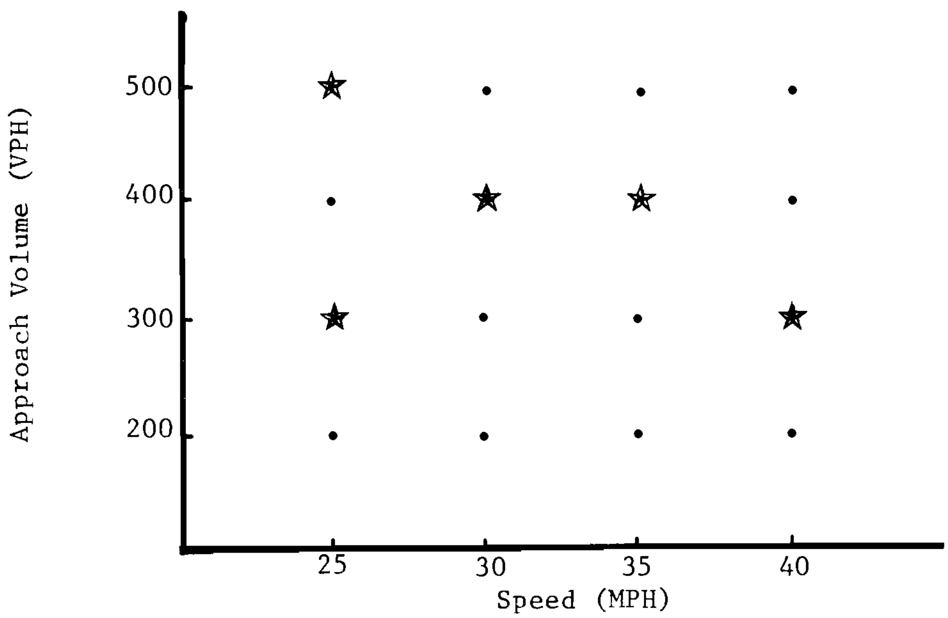


Fig 6-4. Significance of loop length on average queue delay per approach vehicle.



(a) Major Approach



(b) Minor Approach

★ Represents significant at 5% level

Fig 6-5. Significance of loop length on average stop delay per approach vehicle.

TABLE 6-6. NUMBER OF MAX-OUT FOR VARIOUS VOLUMES, SPEEDS AND LOOP SIZES

Lane Volume (VPLPH)	Maximum Extension (SEC)	Speed (MPH)	Phase	No. of Max-Out for Loop Size				
				L1	L2	L3	L4	L5
200.	27.0	25	1	0	0	0	0	0
			2	0	0	0	0	0
		30	1	0	1	2	0	0
			2	0	0	0	0	0
		35	1	0	4	0	0	1
			2	1	3	0	0	0
		40	1	1	0	0	1	2
			2	0	0	0	1	2
300.	27.0	25	1	2	2	0	3	6
			2	3	2	2	2	4
		30	1	15	17	26	8	10
			2	3	7	9	4	7
		35	1	19	32	7	13	20
			2	5	9	5	7	9
		40	1	23	5	13	17	25
			2	10	4	8	9	10
400.	37.0	25	1	-	4	5	5	5
			2	-	0	0	3	3
		30	1	-	5	5	5	5
			2	-	3	3	3	3
		35	1	-	3	5	5	6
			2	-	1	5	3	3
		40	1	-	4	4	4	4
			2	-	3	1	3	3
500.	50.0	25	1	-	6	6	6	5
			2	-	5	5	5	5
		30	1	-	5	6	5	5
			2	-	4	5	5	5
		35	1	-	5	6	6	6
			2	-	5	5	5	5
		40	1	-	5	6	5	5
			2	-	5	5	6	5

LEGEND: L1 = 6 ft
L2 = 1.0 * 1.47 * Speed, Speed in MPH
L3 = 1.5 * 1.47 * Speed, Speed in MPH
L4 = 2.0 * 1.47 * Speed, Speed in MPH
L5 = 2.5 * 1.47 * Speed, Speed in MPH
The width of inductive loop is 6 feet

\- Data is not available

longer green phases. Longer phases could, in turn, have allowed the detectors to produce more nearly optimal cycle lengths.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

Within previous sections, a comparative evaluation of vehicle detector systems for use in actuated signal control has been presented. The evaluation has compared detection systems using single and multiple detectors and has compared three techniques of placing multiple detectors. Vehicular delay statistics predicted by the TEXAS simulation model have been compared with those measured through a field test. Additionally, optimal inductive loop length for area detection systems, based on vehicular delay, was studied using the TEXAS simulation model.

Conclusions

Based upon these analyses the following conclusions may be stated.

(1) The Beierle, Winston-Salem and SSITE detector placement methods were not observed to produce statistically significant differences in vehicular delay.

(2) Vehicular delay predicted by the TEXAS traffic simulation model was not shown to be significantly different from that which was measured at a selected field test site.

(3) A comparison of single and multiple detector installations at ten test sites indicated no significant difference in stopped time vehicular delay. If the above statements could be generalized they would indicate that multiple detection systems do not appear to be effective in reducing vehicular delay.

(4) Both parametric and nonparametric statistical tests indicate that multiple detection systems do appear to be effective in reducing accident

rates in intersections with high speed approaches (50-55 mph), but not effective for low speed situations (40-25 mph).

(5) Analyses of the effects upon vehicular delay of lengths of single long loops produced mixed results. Vehicular delay for approaches with low volumes (200 vph) and low approach speeds (25 mph) indicated a clear tendency to become smaller as detectors length increased. All other combinations of volume and approach speed produced inconsistent results.

Recommendations

Based on the conclusions stated previously, the following recommendations can be stated.

(1) Multiple detection systems are suggested for implementation on intersection approaches having traffic speeds of 50 mph or greater as a means of reducing accident experience. They are not suggested for use as a means of reducing vehicular delay or as an accident reduction measure if approach speeds are less than 50 mph.

(2) If multiple detectors are to be implemented, the method selected for detector placement can be any of the four placement methods (Beierle, Winston-Salem, SSITE and TEXAS).

(3) The speed of traffic approaching many intersections, especially in heavily developed portions of urban areas is less than 35 mph. At these intersections, dilemma zones and other operational problems related to high approach speeds do not require multiple detector installations. In order to enhance efficiency, an area detection system is indeed appropriate. In this study, some mixed results concerning the optimal inductive loop sizes were obtained from computer simulation. Additional field studies are suggested in order to verify area detection study results.

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APPENDIX A

THE CALCULATION OF STOPPING DISTANCE AND CLEARANCE DISTANCE AND THE DETERMINATION OF DILEMMA ZONE

APPENDIX A

In Appendix A, the stopping distance (X_s) and clearance distance (X_c) were calculated based on the following equations:

$$X_s = v \cdot t_1 + 1/2 \frac{V^2}{2d} \quad (2\text{-}2)$$

$$X_c = vt_1 + v(t - t_1) + 1/2a(t - t_1)^2 - (W + L) \quad (2\text{-}4)$$

Table A-1 and A-2 indicate the calculated stopping distance and the clearance distances when the yellow intervals are four, five, and six seconds. The intersection width are 48 feet and 76 feet for Table A-1 and A-2 respectively. The deceleration rate 10 ft/sec^2 and 16 ft/sec^2 were used. In addition, the following quantities were assumed.

(1) perception-reaction time : one second [Ref 3]

(2) design vehicle length : 20 feet [Ref 30]

(3) acceleration rate : 16.0 - 0.213 · V [Ref 6]

Table A-3 and A-4 were obtained from Table A-1 and A-2 respectively for those cases having stopping distance greater than clearance distance.

Based on the data in Table A-1 and A-2, Figs A-1, A-2, A-3 and A-4 were plotted. The vertical axis is the approach speed and the horizontal axis is the distance from the stop line. In each plot, one curve is for the stopping distance, and three curves are for clearance distances when yellow intervals are four, five and six seconds respectively. The shaded area represents the situations when stopping distance is greater than the clearance distance. In other words, the shaded area stands for the dilemma zone for the given speed and yellow interval. The beginning and ending of the dilemma zone are based on the information in Table A-3 and A-4.

TABLE A-1. STOPPING AND CLEARANCE DISTANCE FOR INTERSECTION WIDTH 48 FEET

DECELERATION (FT/SEC**2)	SPEED (MPH)	STOPPING DISTANCE (FEET)	CLEARANCE DISTANCE (FEET)		
			T=4 SEC	T=5 SEC	T=6 SEC
10	5.00	10.05	28.6	88.2	162.8
	10.00	25.50	53.2	116.5	193.6
	15.00	46.36	77.8	144.7	224.4
	20.00	72.62	102.4	172.9	255.1
	25.00	104.28	127.0	201.1	285.9
	30.00	141.34	151.6	229.4	316.7
	35.00	183.81	176.3	257.6	347.5
	40.00	231.67	200.9	285.8	378.3
	45.00	284.94	225.5	314.1	409.1
	50.00	343.61	250.1	342.3	439.9
	55.00	407.69	274.7	370.5	470.7
	60.00	477.16	299.3	398.8	501.4
16	5.00	9.04	28.6	88.2	162.8
	10.00	21.45	53.2	116.5	193.6
	15.00	37.24	77.8	144.7	224.4
	20.00	56.41	102.4	172.9	255.1
	25.00	78.96	127.0	201.1	285.9
	30.00	104.88	151.6	229.4	316.7
	35.00	134.17	176.3	257.6	347.5
	40.00	166.84	200.9	285.8	378.3
	45.00	202.89	225.5	314.1	409.1
	50.00	242.32	250.1	342.3	439.9
	55.00	285.12	274.7	370.5	470.7
	60.00	331.30	399.3	398.8	501.4

REMARKS:

1. All distances are measured from stop line in the upstream direction.
2. Vehicle length, 20 feet.
3. Acceleration rate, a=16.0-0.213*speed, ft/sec**2
4. Perception-reaction time = 1 second.

TABLE A-2. STOPPING AND CLEARANCE DISTANCE FOR INTERSECTION WIDTH 76 FEET

DECELERATION (FT/SEC**2)	SPEED (MPH)	STOPPING DISTANCE (FEET)	CLEARANCE DISTANCE (FEET)		
			T=4 SEC	T=5 SEC	T=6 SEC
10	5.00	10.05	.6	60.2	134.8
	10.00	25.50	25.2	88.5	165.6
	15.00	46.36	49.8	116.7	196.4
	20.00	72.62	74.4	144.9	227.1
	25.00	104.28	99.0	173.1	257.9
	30.00	141.34	123.6	201.4	288.7
	35.00	183.81	148.3	229.6	319.5
	40.00	231.67	172.9	257.8	350.3
	45.00	284.94	197.5	286.1	381.1
	50.00	343.61	222.1	314.3	411.9
	55.00	407.69	246.7	342.5	442.7
	60.00	477.16	271.3	370.8	473.4
16	5.00	9.04	.6	60.2	134.8
	10.00	21.45	25.2	88.5	165.6
	15.00	37.24	49.8	116.7	196.4
	20.00	56.41	74.4	144.9	227.1
	25.00	78.96	99.0	173.1	257.9
	30.00	104.88	123.6	201.4	288.7
	35.00	134.17	148.3	229.6	319.5
	40.00	166.84	172.9	257.8	350.3
	45.00	202.89	197.5	286.1	381.1
	50.00	242.32	222.1	314.3	411.9
	55.00	285.12	246.7	342.5	442.7
	60.00	331.30	371.3	370.8	473.4

REMARKS:

1. All distances are measured from stop line in the upstream direction.
2. Vehicle length, 20 feet.
3. Acceleration rate, a=16.0-0.213*speed, ft/sec**2
4. Perception-reaction time = 1 second

TABLE A-3. THEORETICAL DILEMMA ZONE LOCATIONS

$\overline{W}$ (=W+L) feet	Speed V mph	Deceleration = 10 ft/sec^2				Deceleration = 16 ft/sec^2			
		End of Dilemma Zone[1] Duration of Amber (Sec)			Beginning[1] of Dilemma Zone	End of Dilemma Zone[1] Duration of Amber (Sec)			Beginning[1] of Dilemma Zone
		4	5	6		4	5	6	
68	25	-	-	-	-	-	-	-	-
	30	-	-	-	-	-	-	-	-
	35	176	-	-	184	-	-	-	-
	40	201	-	-	232	-	-	-	-
	45	226	-	-	285	-	-	-	-
	50	250	342	-	344	-	-	-	-
	55	275	371	-	408	275	-	-	285
	60	299	399	-	477	299	-	-	331

REMARKS:

1. All distance is measured from stop line in the upstream direction.
2. Any cell having "-" indicates dilemma zone does not exist under that condition.
3. W = effective intersection width, 48 feet.
4. L = vehicle length, 20 feet.
5. Acceleration rate, $a = 16.0 - 0.213 \cdot V$, ft/sec^2.
6. Perception-reaction time = 1 second.

TABLE A-4. THEORETICAL DILEMMA ZONE LOCATIONS

$\overline{W}$ (=W+L) feet	Speed V mph	Deceleration = 10 ft/sec^2				Deceleration = 16 ft/sec^2			
		End of Dilemma Zone[1] Duration of Amber (Sec)			Beginning[1] of Dilemma Zone	End of Dilemma Zone[1] Duration of Amber (Sec)			Beginning[1] of Dilemma Zone
		4	5	6		4	5	6	
96	25	99	-	-	104	-	-	-	-
	30	124	-	-	141	-	-	-	-
	35	148	-	-	184	-	-	-	-
	40	173	-	-	232	-	-	-	-
	45	198	-	-	285	198	-	-	203
	50	222	314	-	344	222	-	-	242
	55	247	343	-	408	247	-	-	285
	60	271	571	473	477	271	-	-	331

REMARKS:

1. All distance is measured from stop line in the upstream direction.
2. Any cell having "-" indicates dilemma zone does not exost under that condition.
3. W = effective intersection width, 76 feet.
4. L = vehicle length, 20 feet.
5. Acceleration rate, $a = 16.0 - 0.213 \cdot V$, ft/sec^2.
6. Perception-reaction time = 1 second.

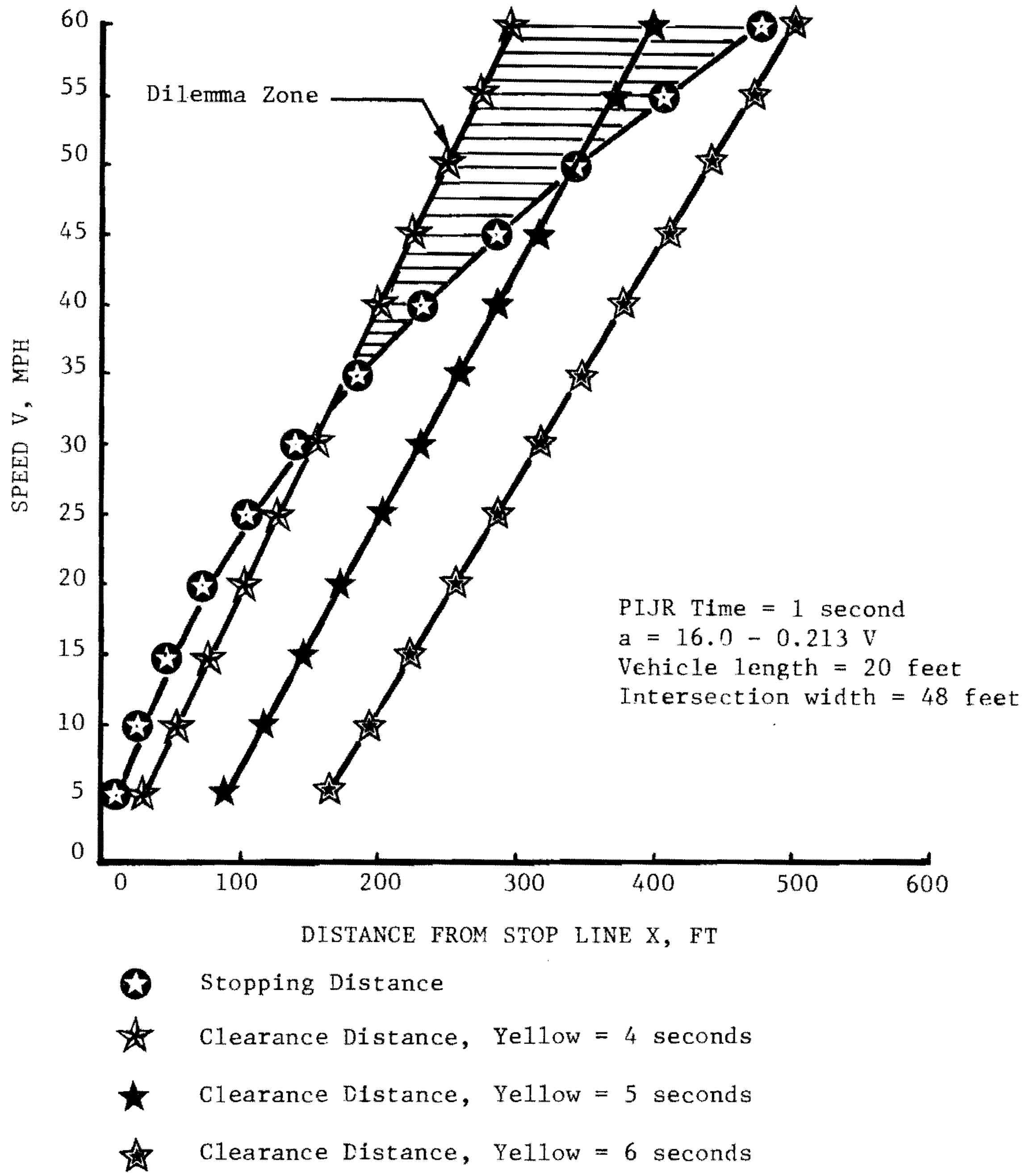


Fig A-1. Graphical illustration of dilemma zone for d = 10 ft/sec^2 w = 48 feet.

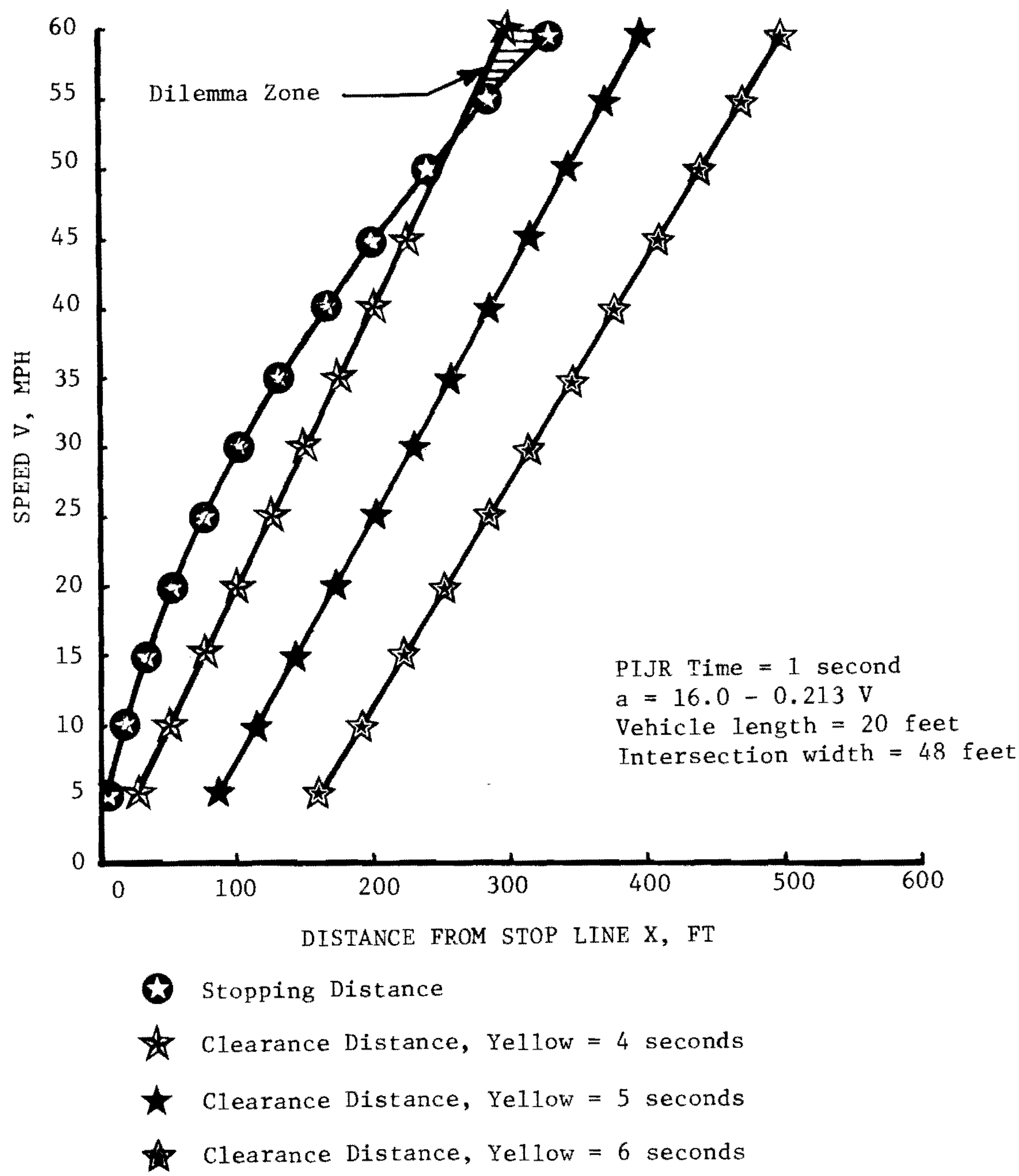


Fig A-2. Graphical illustration of dilemma zone for $d = 16$ ft/sec^2 $w = 48$ feet.

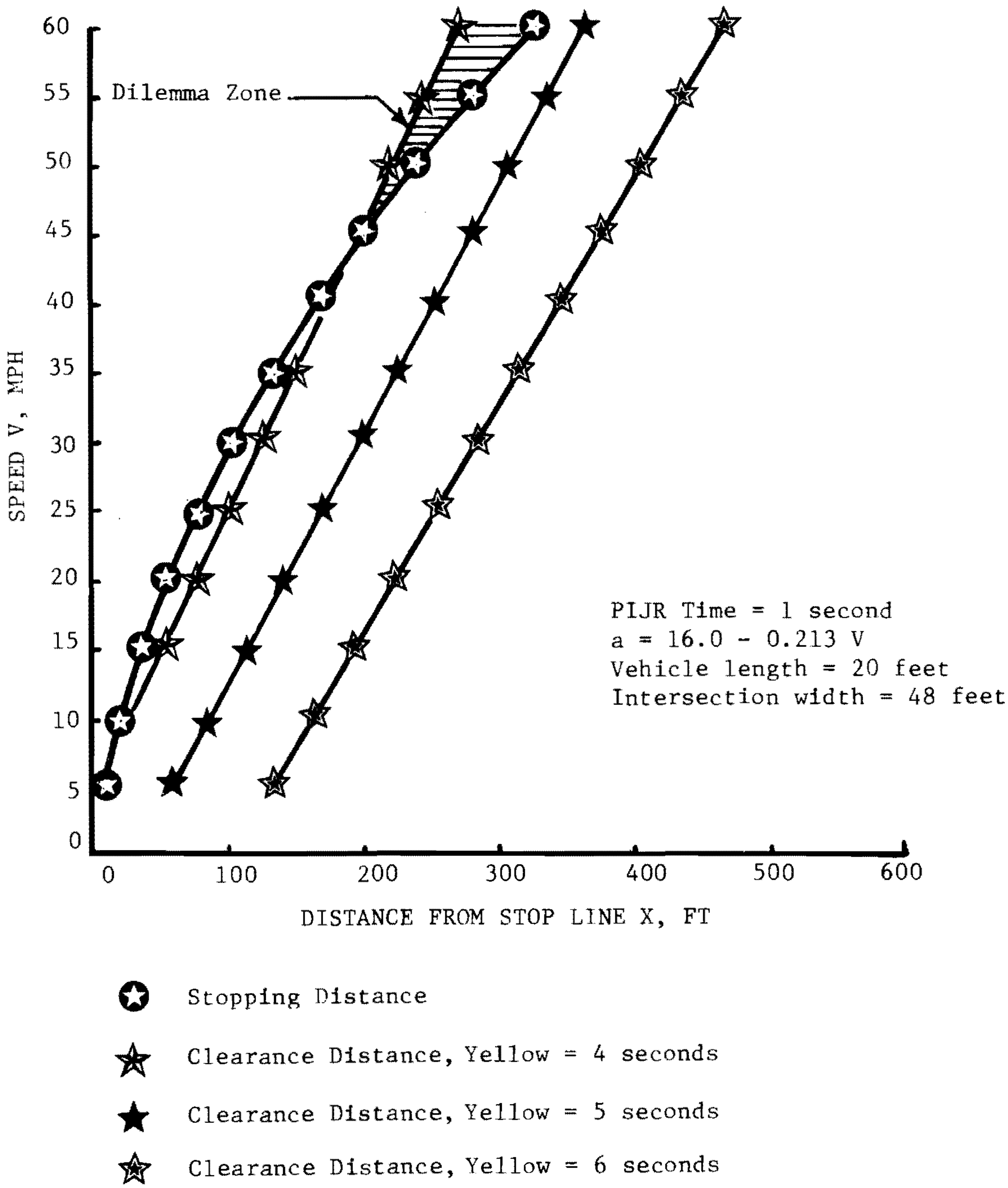


Fig A-3. Graphical illustration of dilemma zone for $d = 10$ ft/sec^2 $w = 76$ feet.

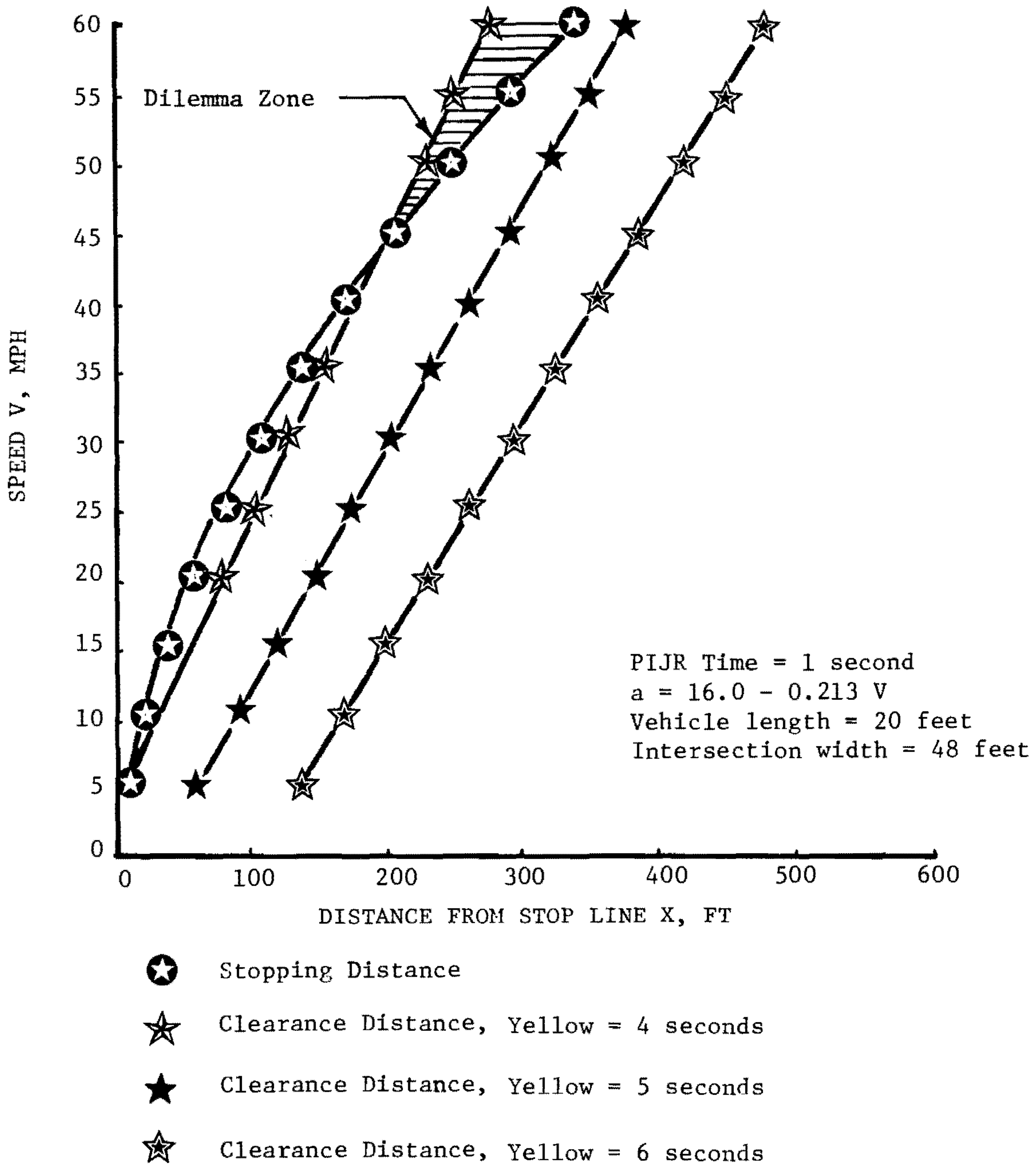


Fig A-4. Graphical illustration of dilemma zone for d = 16 ft/sec^2 w = 76 feet.

APPENDIX B

SIMULATION STATISTICS FOR DIAMOND AND FOUR-LEG INTERSECTIONS

DELAY ANALYSIS FOR FOUR-LEG INTERSECTION

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.2	11.6	13.6	11.9	12.3	12.8	17.3	16.8	16.8
. 500	76.7	78.4	87.2	81.0	78.5	84.5	95.4	99.7	87.2
V 700	105.7	135.0	140.8	135.9	157.0	134.5	137.0	135.0	140.8

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	8.0	7.2	9.1	7.6	7.7	8.0	14.0	12.9	12.7
. 500	72.2	73.0	83.2	75.5	71.7	75.8	88.7	92.4	83.2
V 700	96.9	128.9	130.8	130.7	150.6	125.8	131.1	128.9	130.8

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	6.5	5.9	7.5	6.4	6.3	6.7	11.4	10.8	10.8
. 500	52.6	54.6	59.4	56.4	52.8	57.2	65.5	68.5	59.4
V 700	72.9	101.6	103.6	99.0	120.4	101.1	101.9	101.6	103.6

DELAY ANALYSIS FOR FOUR-LEG INTERSECTION

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR 1ST APPROACH

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	8.9	8.4	11.4	11.5	10.8	10.3	12.8	10.1	12.3
. 500	69.6	60.5	76.0	94.0	82.4	66.9	107.4	91.6	76.0
V 700	202.0	148.8	175.8	268.5	319.0	142.3	173.3	148.8	175.8

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR 1ST APPROACH

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	6.0	5.2	6.8	8.0	7.3	5.8	10.1	7.2	8.5
. 500	64.3	54.6	70.4	87.8	75.9	58.8	103.8	85.3	70.4
V 700	174.8	139.5	162.6	267.6	312.9	129.6	164.5	139.5	162.6

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR 1ST APPROACH

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	5.1	4.4	5.6	6.8	6.2	4.6	8.6	6.2	7.1
. 500	49.1	41.8	54.5	72.5	58.3	44.1	78.5	61.1	54.5
V 700	154.0	112.7	132.9	213.7	265.8	103.3	136.8	112.7	132.9

DELAY ANALYSIS FOR FOUR-LEG INTERSECTION

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR 3RD APPROACH

METHOD	BEIERLE'S			WINSTON'S			SOTTE'S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	11.3	10.6	8.7	13.7	12.7	11.0	14.4	12.5	11.6
. 500	52.8	69.2	89.7	49.1	66.7	108.8	97.7	123.4	89.7
V 700	166.0	131.0	113.8	235.2	303.5	96.9	101.9	131.0	113.8

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR 3RD APPROACH

METHOD	BEIERLE'S			WINSTON'S			SOTTE'S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	19.0	15.5	11.7	22.7	19.7	15.1	28.4	25.2	21.5
. 500	102.7	124.9	95.8	78.4	104.9	118.9	104.1	142.1	95.8
V 700	88.1	124.6	108.0	158.9	111.5	119.6	108.2	124.6	108.0

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR 3RD APPROACH

METHOD	BEIERLE'S			WINSTON'S			SOTTE'S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	6.1	5.4	4.2	7.5	6.8	5.5	8.9	7.0	6.4
. 500	33.9	47.7	56.2	31.9	43.1	74.1	61.2	88.2	56.2
V 700	134.0	95.5	73.8	186.7	255.5	67.8	67.0	95.5	73.8

DELAY ANALYSIS FOR DIAMOND INTERCHANGE

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.6	12.8	14.6	10.9	10.4	12.0	20.9	21.9	19.1
. 500	39.4	58.1	59.6	45.7	54.8	56.3	56.3	58.0	59.4
V 700	90.0	92.3	97.1	113.9	111.8	98.4	91.6	100.6	97.1

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	8.7	8.7	10.4	7.0	6.8	7.8	18.0	18.5	15.6
. 500	32.8	52.6	54.6	37.2	48.1	50.2	51.6	52.4	54.6
V 700	87.6	89.9	93.8	110.4	111.4	94.2	89.1	97.2	93.8

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR ALL APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	7.3	7.3	8.5	5.8	5.7	6.5	14.9	14.9	12.6
. 500	23.6	39.3	39.9	26.3	34.6	36.5	38.9	38.6	39.8
V 700	63.7	62.3	70.5	81.5	71.6	63.9	66.9	75.0	70.5

DELAY ANALYSIS FOR DIAMOND INTERCHANGE

AVERAGE TOTAL DELAY PER APPROACH VEHICLE FOR 2ND APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	11.5	10.1	10.6	10.6	8.8	9.3	14.2	16.3	14.3
. 500	39.0	42.0	51.2	58.4	51.3	44.0	45.4	49.2	50.6
V 700	87.5	91.2	88.7	232.4	128.7	93.6	82.8	91.8	88.7

AVERAGE QUEUE DELAY PER APPROACH VEHICLE FOR 2ND APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	8.1	7.2	7.4	7.1	5.7	6.2	11.8	13.8	11.5
. 500	32.4	35.3	45.5	49.5	43.0	37.3	39.7	42.4	45.1
V 700	85.0	87.5	84.6	230.6	129.4	87.7	79.7	87.7	84.6

AVERAGE STOP DELAY PER APPROACH VEHICLE FOR 2ND APPROACHES

METHOD	BEIERLE#S			WINSTON#S			SSTTE#S		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	7.0	6.2	6.3	6.0	5.8	5.3	9.8	11.6	9.5
. 500	23.6	25.4	32.8	34.8	32.6	27.6	29.1	31.1	32.7
V 700	59.9	61.6	62.7	178.3	83.2	57.8	59.7	66.1	62.7

DELAY STUDY FOR OPTIONAL DETECTOR ALTERNATIVE

AVERAGE TOTAL DELAY PER DELAYED VEHICLE FOR ALL APPROACHES

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	13.0	14.1	14.6	13.8	14.1	16.4
. 500	103.4	78.7	112.4	93.1	86.4	91.3
V 700	142.8	137.8	132.7	150.3	138.6	138.8

AVERAGE QUEUE DELAY PER QUEUE DELAYED VEHICLE FOR ALL APPROACHES

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	13.1	15.7	15.7	13.8	15.4	17.7
. 500	118.6	87.3	113.2	111.8	92.2	101.9
V 700	159.5	168.5	142.0	162.0	157.9	150.4

AVERAGE STOP DELAY PER STOP DELAYED VEHICLE FOR ALL APPROACHES

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	10.6	13.4	12.6	11.8	12.4	14.0
. 500	88.4	63.5	85.8	78.5	69.3	73.8
V 700	119.1	136.6	108.1	129.7	122.4	120.2

DELAY STUDY FOR OPTIONAL DETECTOR ALTERNATIVE

AVERAGE TOTAL DELAY PER DELAYED VEHICLE FOR 1ST APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.1	13.4	9.2	12.6	10.8	10.2
. 500	121.9	65.6	113.1	84.1	82.4	76.3
V 700	265.0	162.6	175.4	256.5	153.7	32.5

AVERAGE QUEUE DELAY PER QUEUE DELAYED VEHICLE FOR 1ST APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.6	16.4	12.2	14.1	13.3	13.1
. 500	137.0	81.7	110.7	114.4	93.4	97.5
V 700	271.0	207.5	181.1	265.6	172.5	132.5

AVERAGE STOP DELAY PER STOP DELAYED VEHICLE FOR 1ST APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	10.7	13.9	10.4	12.2	10.9	10.9
. 500	105.9	63.2	82.9	87.1	74.7	73.7
V 700	215.4	175.0	145.9	225.3	138.5	127.0

DELAY STUDY FOR OPTIONAL DETECTOR ALTERNATIVE

AVERAGE TOTAL DELAY PER DELAYED VEHICLE FOR 3RD APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	12.2	13.4	15.1	13.0	14.6	17.6
. 500	100.8	90.5	142.3	101.1	73.3	107.7
V 700	232.8	103.3	131.7	256.5	131.8	124.0

AVERAGE QUEUE DELAY PER QUEUE DELAYED VEHICLE FOR 3RD APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	13.9	15.7	16.2	13.9	17.0	16.9
. 500	126.9	84.6	136.1	130.5	76.9	118.3
V 700	239.2	135.1	129.1	258.7	161.3	130.2

AVERAGE STOP DELAY PER STOP DELAYED VEHICLE FOR 3RD APPROACH

METHOD	WITHOUT			WITH		
SPEED	30MPH	40MPH	50MPH	30MPH	40MPH	50MPH
L 300	11.8	13.7	12.9	12.0	14.0	13.3
. 500	100.8	59.8	104.3	93.4	54.0	85.4
V 700	187.0	104.2	92.1	217.5	118.1	100.7

APPENDIX C

THE ANALYSES OF EXPECTED MEAN SQUARES VARIANCE AND THE CALCULATION OF SUM OF SQUARES

TABLE C-1. EXPECTED MEAN SQUARES

(a) For Alternative (1) and (2) - Diamond Interchange / Four-Leg Intersection

Source (1)	3 F i	3 F j	3 F k	1 R l (2)	Expected Mean Squares (EMS)
M_i	0	3	3	1	$\sigma_\varepsilon^2 + 9\phi_M$
S_j	3	0	3	1	$\sigma_\varepsilon^2 + 9\phi_S$
MS_{ij}	0	0	3	1	$\sigma_\varepsilon^2 + 3\phi_{MS}$
V_K	3	3	0	1	$\sigma_\varepsilon^2 + 9\phi_R$
MV_{iK}	0	3	0	1	$\sigma_\varepsilon^2 + 3\phi_{MV}$
SV_{jK}	3	0	0	1	$\sigma_\varepsilon^2 + 3\phi_{SV}$
$E_{\ell(ijK)}$	1	1	1	1	

(b) For Alternative (3) - Optional Detector

Source	2 F i	3 F j	3 F K	1 R ℓ	Expected Mean Squares (EMS)
M_i	0	3	3	1	$\sigma_\varepsilon^2 + 9\phi_M$
S_j	2	0	3	1	$\sigma_\varepsilon^2 + 6\phi_S$
MS_{ij}	0	0	3	1	$\sigma_\varepsilon^2 + 3\phi_{MS}$
V_K	2	3	0	1	$\sigma_\varepsilon^2 + 6\phi_V$
MV_{iK}	0	3	0	1	$\sigma_\varepsilon^2 + 3\phi_{MV}$
SV_{jK}	2	0	0	1	$\sigma_\varepsilon^2 + 2\phi_{SV}$
$E_{\ell(ijK)}$	1	1	1	1	σ_ε^2

(1) M_i, S_i, V_K, refer to main effects of Placement Method, Speed, and Traffic volume

(2) For R refer to fixed or randomly set levels of main effects while the indeces i, j or K, indicate number of levels of each main effect.

TABLE C-2. ANOVA FOR DELAY ANALYSIS

Source	df	SS	MS	F
Method (M_i)	3-1 = 2	SSM	SSM/2 = MSM	MSM/MSE
Speed (S_j)	3-1 = 2	SSS	SSS/2 = MSS	MSS/MSE
Method x Speed (MS_{ij})	(3-1)(3-1) = 4	SSMS	SSMS/4 = MSMS	MSMS/HSE
Volume (V_K)	3-1 = 2	SSV	SSV/2 = MSV	MSV/MSE
Method x Volume (MV_{iK})	(3-1)(3-1) = 4	SSMV	SSMV/4 = MSMV	MSMV/MSE
Speed x Volume (SV_{jK})	(3-1)(3-1) = 4	SSSV	SSSV/4 = MSSV	MSSV/MSE
Error	8	SSE	SSE/8 = MSE	
Total	27-1 = 26	SSTO		

SS = sum of squares

MS = mean squares

df = degree of freedom

F = estimated F value

TABLE C-3. CALCULATION FOR SUMS OF SQUARES

$i = 1, 2, 3$ (For Alternative 3 $i = 1, 2$)
$j = 1, 2, 3$
$K = 1, 2, 3$
$r = 1$

SS	Formula
SSM =	$\dfrac{\sum_{i}(\sum_{j}\sum_{K}\sum_{r} X_{ijKr})^2}{3 \times 3 \times 1} - C$
SSS =	$\dfrac{\sum_{j}(\sum_{i}\sum_{K}\sum_{r} X_{ijKr})^2}{3 \times 3 \times 1} - C$
SSMS =	$\dfrac{\sum_{i}\sum_{j}(\sum_{K}\sum_{r} X_{ijKr})^2}{3 \times 1} - SSM - SSS - C$
SSV =	$\dfrac{\sum_{K}(\sum_{i}\sum_{j}\sum_{r} X_{ijKr})^2}{3 \times 3 \times 1} - C$
SSMV =	$\dfrac{\sum_{i}\sum_{K}(\sum_{j}\sum_{r} X_{ijKr})^2}{3 \times 1} - SSM - SSV - C$
SSSV =	$\dfrac{\sum_{j}\sum_{K}(\sum_{i}\sum_{r} X_{ijKr})^2}{3 \times 1} - SSS - SSV - C$
SSE =	SSTO - SSM - SSS - SSMV - SSV - SSMV - SSSV
SSTO =	$\sum_{i}\sum_{j}\sum_{K}\sum_{r} X^2_{ijKr} - C$
C =	$\dfrac{(\sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{K=1}^{3}\sum_{r=1}^{1} X_{ijKr})^2}{3 \times 3 \times 3 \times 1}$

Source: Clark, C.T., Schkade, L.L., Statistical Analysis for Administrative Decisions, 3rd Edition, South-Western Publishing Co., 1978.

APPENDIX D

THE INTERSECTION, DETECTOR LOCATION AND THE DATE AND TIME FOR DATA COLLECTION

TABLE D-1. FIELD SITE LOCATIONS AND CHARACTERISTICS

Intersection	District	Multiple Detectors Located On
S.H. 183 and Roaring Springs Rd.	Ft. Worth (2)	S.H. 183
S.H. 174 and F.M. 917	Ft. Worth (2)	S.H. 174
F.M. 1220 and Boat Club Rd.	Ft. Worth (2)	F.M. 1220
S.H. 199 and Fire Hall Rd.	Ft. Worth (2)	S.H. 199
S.H. 199 and Roberts Cut-off	Ft. Worth (2)	S.H. 199
S.H. 361 and F.M. 1069	Corpus Christi (16)	S.H. 361
U.S. 84 and S.H. 317 [1,2]	Waco (9)	U.S. 84 East & West-bound S.H. 317 South-bound
U.S. 290 and F.M. 1960 [1]	Houston (12)	All Approaches
S.H. 6 and Jackson St.	Houston (12)	S.H. 6
S.H. 146 and Crest Lane	Houston (12)	S.H. 146

[1] Not used in delay field study or accident study

[2] Not used in accident study

TABLE D-2. LOCATION AND SPACING OF MULTIPLE DETECTORS

Intersection/Approach	Detector Spacing[1] (measured upstream from stop line feet)			
	Stop Line to 1st Detector	1st to 2nd Detector	2nd to 3rd Detector	3rd to 4th Detector
SH 183 and Roaring Springs				
Northbound SH 183	80	64	80	97
Southbound SH 183	55	53	70	89
SH 174 and FM 917				
Northbound SH 174	55	53	70	89
Southbound SH 174	108	64	83	-
FM 1220 and Boat Club Road				
Westbound FM 1220	80	64	80	97
Southbound Boat Club	80	64	80	97
SH 199 and Fire Hall Drive				
Northbound SH 199	80	61	79	-
Southbound SH 199	80	61	79	-
SH 199 and Roberts Cut Off				
Westbound SH 361	55	53	70	89
Eastbound SH 199	55	53	70	89
FM 361 and FM 1069				
Westbound SH 361	108	70	89	-
Eastbound SH 361	108	70	89	-
US 84 and SH 317[2]				
Westbound US 84	141	79	-	-
Eastbound US 84	141	79	-	-
Southbound US 84	141	79	-	-
US 290 and FM 1960[3]				
Westbound US 290	108	70	89	-
Eastbound US 290	108	70	89	-
Northbound SH 6	108	70	-	-
Southbound FM 1960	108		89	-

1 All loop detectors are configured 6 x 6 ft square

2 Not used in delay field study or accident study

3 Not used in accident study

(continued)

TABLE D-2. (Continued)

Intersection/Approach	Detector Spacing[1] (measured upstream from stop line feet)			
	Stop Line to 1st Detector	1st to 2nd Detector	2nd to 3rd Detector	3rd to 4th Detector
SH 6 and Jackson				
Westbound SH 6	144	80	97	-
Eastbound SH 6	144	80	97	-
SH 146 and Crest Lane				
Northbound SH 146	108	70	89	103
Southbound SH 146	144	80	97	-

1 All loop detectors are configured 6 x 6 ft square

TABLE D-3. DATES AND TIMES OF DATA COLLECTION

Intersection	Date	Time
SH 183 and Roaring Springs	10/26/78	0700 - 0800
		1030 - 1130
		1650 - 1750
	04/10/80	0700 - 0800
		1030 - 1130
		1645 - 1745
SH 174 and FM 917	10/05/78	0730 - 0830
		1030 - 1130
		1630 - 1730
	04/03/80	0730 - 0830
		1030 - 1130
		1630 - 1730
FM 1220 and Boat Club	10/24/78	0730 - 0830
		1030 - 1130
		1630 - 1730
	04/08/80	0730 - 0830
		1030 - 1130
		1630 - 1730
SH 199 and Fire Hall Road	10/31/78	0715 - 0815
		1030 - 1130
		1645 - 1745
	04/15/80	0715 - 0815
		1030 - 1130
		1645 - 1745
SH 199 and Roberts C.O.	11/02/78	0715 - 0815
		1030 - 1130
		1645 - 1745
	04/17/80	0715 - 0815
		1030 - 1130
		1645 - 1745
SH 361 and FM 1069	08/15/78	0700 - 1730
	08/16/78	0700 - 1700
	08/21/79	0700 - 0900
		0930 - 1130
		1530 - 1730
	08/22/79	0700 - 0900
		0930 - 1130
		1530 - 1730

(continued)

TABLE D-3. (Continued)

Intersection	Date	Time
US 84 and SH 317	10/11/78	0730 - 0830
		0930 - 1030
		1630 - 1730
	10/12/78	0730 - 0830
		0930 - 1030
		1630 - 1730
	10/10/79	0730 - 0830
		0930 - 1030
	10/11/79	0730 - 0830
		0930 - 1030
		1630 - 1730
FM 1960 and US 290	09/26/78	1440 - 1540
	09/27/78	0900 - 1030
		1350 - 1520
	10/18/79	1445 - 1545
	10/31/79	0900 - 1030
SH 6 and Jackson Street	07/31/78	1430 - 1530
		1630 - 1730
	08/01/78	1430 - 1530
		1630 - 1730
	08/03/78	0715 - 0815
	08/07/78	0715 - 0815
	10/22/79	1430 - 1530
		1630 - 1730
	10/23/79	1430 - 1530
		1630 - 1730
	10/24/79	0715 - 0815
SH 146 and Crest Lane	08/07/78	1545 - 1645
	08/09/78	0700 - 0800
		0900 - 1000
	08/10/78	0700 - 0800
	08/17/78	1545 - 1645
	10/29/79	1200 - 1300
		1545 - 1645
	10/31/79	0715 - 0815
		0900 - 1000
	11/01/79	0700 - 0800
		1545 - 1645

APPENDIX E

BEFORE AND AFTER FIELD DATA

(INCLUDES ALL FIELD SITES AND ALL AVAILABLE DATA)

LOCATION= SH 183 + ROARING SPRING
TIME= 0700-0800
DATE= 10/26/78(BEFORE)-04/10/80(AFTER)
FILES= B09-A06

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	41.0	79.0	12.0	2.0	42.0	97.0	15.0	3.0
B 2	60.0	50.0	11.0	4.0	41.0	136.0	14.0	5.0
B 3	56.0	62.0	14.0	2.0	53.0	138.0	10.0	2.0
B 4	57.0	109.0	27.0	11.0	54.0	153.0	30.0	7.0
B 5	88.0	87.0	33.0	1.0	79.0	132.0	34.0	3.0
B 6	81.0	98.0	42.0	2.0	75.0	144.0	35.0	4.0
B 7	93.0	50.0	15.0	7.0	93.0	106.0	27.0	8.0
B 8	70.0	45.0	19.0	8.0	90.0	83.0	24.0	7.0
B 9	74.0	87.0	30.0	19.0	98.0	134.0	26.0	14.0
B 10	73.0	111.0	26.0	12.0	82.0	119.0	23.0	6.0
B 11	33.0	105.0	28.0	8.0	80.0	144.0	21.0	10.0
B 12	20.0	58.0	6.0	0.0	51.0	102.0	17.0	0.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	37.0	89.0	3.0	1.0	37.0	89.0	3.0	1.0
A 2	31.0	61.0	8.0	2.0	43.0	128.0	11.0	1.0
A 3	28.0	66.0	19.0	6.0	57.0	135.0	14.0	1.0
A 4	42.0	63.0	33.0	1.0	44.0	119.0	27.0	3.0
A 5	25.0	44.0	12.0	0.0	51.0	131.0	15.0	1.0
A 6	24.0	46.0	9.0	0.0	65.0	120.0	16.0	3.0
A 7	11.0	16.0	8.0	0.0	84.0	69.0	17.0	1.0
A 8	25.0	44.0	11.0	0.0	77.0	99.0	11.0	0.0
A 9	34.0	44.0	20.0	3.0	85.0	96.0	24.0	2.0
A 10	43.0	106.0	17.0	5.0	91.0	116.0	30.0	3.0
A 11	18.0	45.0	12.0	4.0	80.0	88.0	8.0	1.0
A 12	18.0	22.0	8.0	3.0	90.0	105.0	12.0	3.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	14.64	15.00	12.22	15.00	12.00	15.00	10.00	15.00	12.80	15.00
2	21.95	10.81	5.51	7.15	11.79	10.91	12.00	30.00	9.57	8.36
3	15.85	7.37	6.74	7.33	21.00	20.36	15.00	90.00	9.00	8.62
4	15.83	14.32	10.69	7.94	13.50	18.33	23.57	5.00	12.54	10.80
5	16.71	7.35	9.89	5.00	14.56	12.00	5.00	0.00	12.64	6.14
6	16.20	5.54	10.21	5.75	18.00	8.44	7.50	0.00	12.97	5.81
7	15.00	1.96	7.08	3.48	8.33	7.06	13.13	0.00	10.58	3.07
8	11.67	4.87	8.13	6.67	11.88	15.00	17.14	I	10.44	6.42
9	11.33	6.00	9.74	6.88	17.31	12.50	20.36	22.50	11.58	7.32
10	13.35	7.09	13.99	13.71	16.96	8.50	30.00	25.00	14.48	10.69
11	6.19	3.38	10.94	7.67	20.00	22.50	12.00	60.00	10.24	6.69
12	5.88	3.00	8.53	3.14	5.29	10.00	I	15.00	7.41	3.64

LOCATION= SH 183 + ROARING SPRING
TIME= 1030-1130
DATE= 10/26/78(BEFORE)-04/10/80(AFTER)
FILES= B10-A07

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	22.0	22.0	1.0	3.0	80.0	70.0	1.0	2.0
B 2	10.0	13.0	4.0	0.0	58.0	65.0	8.0	0.0
B 3	5.0	6.0	2.0	1.0	58.0	60.0	7.0	2.0
B 4	15.0	11.0	6.0	0.0	61.0	45.0	10.0	0.0
B 5	57.0	14.0	7.0	2.0	87.0	47.0	15.0	5.0
B 6	20.0	14.0	1.0	0.0	63.0	65.0	5.0	1.0
B 7	3.0	4.0	0.0	0.0	88.0	53.0	0.0	0.0
B 8	47.0	32.0	6.0	1.0	115.0	68.0	5.0	6.0
B 9	23.0	16.0	4.0	1.0	108.0	71.0	6.0	4.0
B 10	24.0	12.0	6.0	5.0	90.0	53.0	11.0	6.0
B 11	24.0	22.0	5.0	8.0	87.0	56.0	5.0	7.0
B 12	23.0	19.0	5.0	5.0	77.0	52.0	10.0	9.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	11.0	10.0	4.0	5.0	63.0	62.0	8.0	5.0
A 2	28.0	39.0	1.0	8.0	68.0	91.0	6.0	9.0
A 3	21.0	21.0	2.0	3.0	71.0	61.0	7.0	2.0
A 4	42.0	18.0	3.0	1.0	76.0	87.0	6.0	1.0
A 5	23.0	26.0	1.0	6.0	83.0	77.0	7.0	8.0
A 6	35.0	29.0	4.0	1.0	91.0	76.0	8.0	4.0
A 7	20.0	20.0	5.0	2.0	88.0	86.0	13.0	2.0
A 8	10.0	14.0	2.0	0.0	79.0	67.0	2.0	0.0
A 9	20.0	15.0	2.0	1.0	70.0	67.0	10.0	2.0
A 10	25.0	13.0	6.0	0.0	77.0	70.0	13.0	1.0
A 11	28.0	14.0	2.0	2.0	100.0	61.0	8.0	1.0
A 12	21.0	20.0	0.0	4.0	80.0	73.0	2.0	3.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	4.13	2.62	4.71	2.42	15.00	7.50	22.50	15.00	4.71	3.26
2	2.59	6.18	3.00	6.43	7.50	2.50	I	13.33	3.09	6.55
3	1.29	4.44	1.50	5.16	4.29	4.29	7.50	22.50	1.65	5.00
4	3.69	8.29	3.67	3.10	9.00	7.50	I	15.00	4.14	5.65
5	9.83	4.16	4.47	5.06	7.00	2.14	6.00	11.25	7.79	4.80
6	4.76	5.77	3.23	5.72	3.00	7.50	0.00	3.75	3.92	5.78
7	.51	3.41	1.13	3.40	I	5.77	I	15.00	.74	3.73
8	6.13	1.90	7.06	3.13	18.00	15.00	2.50	I	6.65	2.64
9	3.19	4.29	3.38	3.36	10.00	3.00	3.75	7.50	3.49	3.83
10	4.00	4.87	3.40	2.79	8.18	6.92	12.50	0.00	4.41	4.10
11	4.14	4.20	5.89	3.44	15.00	3.75	17.14	30.00	5.71	4.06
12	4.48	3.94	5.48	4.11	7.50	0.00	8.33	20.00	5.27	4.27

LOCATION= SH 183 + ROARING SPRING
TIME= 1645-1745
DATE= 10/26/78(BEFORE)-04/10/80(AFTER)
FILES= B11-A08

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	51.0	81.0	12.0	2.0	147.0	92.0	13.0	7.0
B 2	26.0	63.0	23.0	8.0	116.0	100.0	19.0	10.0
B 3	56.0	61.0	9.0	10.0	118.0	101.0	8.0	10.0
B 4	31.0	61.0	5.0	6.0	129.0	106.0	10.0	8.0
B 5	74.0	83.0	8.0	13.0	167.0	98.0	10.0	13.0
B 6	87.0	90.0	25.0	16.0	162.0	130.0	16.0	5.0
B 7	72.0	49.0	16.0	0.0	161.0	96.0	12.0	1.0
B 8	44.0	48.0	14.0	6.0	132.0	95.0	12.0	5.0
B 9	55.0	39.0	14.0	5.0	135.0	101.0	14.0	4.0
B 10	48.0	25.0	10.0	0.0	95.0	83.0	12.0	2.0
B 11	52.0	26.0	8.0	1.0	144.0	82.0	20.0	2.0
B 12	34.0	43.0	9.0	4.0	118.0	85.0	14.0	8.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	42.0	40.0	1.0	7.0	140.0	117.0	13.0	8.0
A 2	43.0	24.0	8.0	5.0	136.0	76.0	10.0	7.0
A 3	44.0	44.0	6.0	6.0	111.0	99.0	11.0	4.0
A 4	46.0	79.0	11.0	1.0	135.0	104.0	15.0	0.0
A 5	33.0	64.0	4.0	12.0	141.0	120.0	7.0	1.0
A 6	44.0	68.0	16.0	9.0	128.0	122.0	13.0	7.0
A 7	63.0	49.0	18.0	1.0	95.0	93.0	16.0	0.0
A 8	53.0	46.0	3.0	3.0	187.0	87.0	31.0	2.0
A 9	79.0	36.0	15.0	1.0	131.0	80.0	18.0	6.0
A 10	34.0	47.0	10.0	4.0	121.0	93.0	11.0	3.0
A 11	82.0	73.0	12.0	3.0	111.0	88.0	11.0	2.0
A 12	36.0	56.0	8.0	0.0	98.0	104.0	7.0	4.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	5.20	4.50	13.21	5.13	13.85	1.15	4.29	13.13	8.46	4.86
2	3.36	4.74	9.45	4.74	18.16	12.00	12.00	10.71	7.35	5.24
3	7.12	5.95	9.06	6.67	16.88	8.18	15.00	22.50	8.61	6.67
4	3.60	5.11	8.63	11.39	7.50	11.00	11.25	0	6.11	8.09
5	6.65	3.51	12.70	8.00	12.00	8.57	15.00	*****	9.27	6.30
6	8.06	5.16	10.38	8.36	23.40	18.46	48.00	19.20	10.45	7.61
7	6.71	9.95	7.66	7.90	20.00	16.88	0.00	0	7.61	9.63
8	5.00	4.25	7.58	7.93	17.50	1.45	18.00	22.50	6.89	5.13
9	6.11	9.05	5.79	6.75	15.00	12.50	18.75	2.50	6.67	8.36
10	7.58	4.21	4.52	7.58	12.50	13.64	0.00	20.00	6.48	6.25
11	5.42	11.08	4.76	12.44	6.00	16.36	7.50	22.50	5.26	12.03
12	4.32	5.51	7.50	8.08	9.64	17.14	7.50	0.00	6.00	7.04

LOCATION= SH174 + FM 917
TIME= 0730-0830
DATE= 05/10/78(BEFORE)-04/03/80(AFTER)
FILES= B06-A15

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	4.0	3.0	4.0	4.0	39.0	59.0	6.0	6.0
B 2	9.0	10.0	19.0	8.0	20.0	46.0	5.0	5.0
B 3	18.0	23.0	26.0	1.0	51.0	65.0	13.0	6.0
B 4	23.0	0.0	11.0	0.0	44.0	36.0	21.0	4.0
B 5	23.0	21.0	24.0	7.0	37.0	54.0	34.0	12.0
B 6	23.0	11.0	13.0	2.0	55.0	57.0	27.0	5.0
B 7	31.0	20.0	18.0	1.0	52.0	55.0	26.0	7.0
B 8	39.0	29.0	31.0	1.0	30.0	41.0	41.0	5.0
B 9	54.0	30.0	30.0	14.0	52.0	61.0	22.0	15.0
B 10	38.0	38.0	14.0	12.0	42.0	69.0	23.0	13.0
B 11	20.0	30.0	24.0	14.0	40.0	54.0	14.0	12.0
B 12	9.0	20.0	8.0	9.0	26.0	81.0	8.0	9.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	28.0	30.0	13.0	6.0	42.0	43.0	20.0	9.0
A 2	16.0	23.0	9.0	3.0	30.0	51.0	17.0	8.0
A 3	19.0	8.0	10.0	8.0	38.0	39.0	21.0	9.0
A 4	39.0	16.0	20.0	5.0	43.0	47.0	13.0	12.0
A 5	39.0	17.0	29.0	5.0	51.0	43.0	38.0	7.0
A 6	18.0	9.0	17.0	3.0	48.0	38.0	30.0	5.0
A 7	39.0	13.0	25.0	8.0	50.0	36.0	32.0	12.0
A 8	45.0	15.0	104.0	4.0	61.0	40.0	32.0	9.0
A 9	29.0	19.0	45.0	4.0	45.0	49.0	43.0	17.0
A 10	26.0	18.0	13.0	12.0	33.0	45.0	16.0	12.0
A 11	28.0	13.0	10.0	12.0	31.0	41.0	14.0	20.0
A 12	32.0	9.0	8.0	5.0	39.0	32.0	10.0	13.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	1.54	10.00	.00	10.47	10.00	9.75	10.00	10.00	2.23	10.13
2	6.75	8.00	3.26	6.76	57.00	7.94	24.00	5.63	9.08	7.22
3	5.29	7.50	5.31	3.08	30.00	7.14	2.50	13.33	7.56	6.31
4	7.84	13.60	0.00	5.11	7.86	23.08	0.00	6.25	4.86	10.43
5	9.32	11.47	5.83	5.93	10.59	11.45	8.75	10.71	8.21	9.71
6	6.27	5.63	2.89	3.55	7.22	8.50	6.00	9.00	5.10	5.83
7	8.94	11.70	5.45	5.42	10.38	11.72	2.14	10.00	7.50	9.81
8	19.50	11.07	10.61	5.63	11.34	48.75	3.00	6.67	12.82	17.75
9	15.58	9.67	7.38	5.82	20.45	15.70	14.00	3.53	12.80	9.45
10	13.57	11.82	8.26	6.00	9.13	12.19	13.85	15.00	10.41	9.76
11	7.50	13.55	8.33	4.76	25.71	10.71	17.50	9.00	11.00	8.92
12	5.19	12.31	3.70	4.22	15.00	12.00	15.00	5.77	5.56	8.62

LOCATION= SH174 + FM 917
TIME= 1030-1130
DATE= 05/10/78(BEFORE)-04/03/80(AFTER)
FILES= B07-A17

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	13.0	19.0	11.0	3.0	43.0	45.0	16.0	5.0
B 2	11.0	9.0	8.0	1.0	34.0	32.0	6.0	4.0
B 3	11.0	13.0	3.0	0.0	43.0	27.0	2.0	6.0
B 4	3.0	3.0	1.0	9.0	27.0	29.0	5.0	8.0
B 5	20.0	11.0	5.0	2.0	34.0	49.0	6.0	5.0
B 6	11.0	7.0	15.0	4.0	28.0	46.0	5.0	10.0
B 7	13.0	21.0	8.0	1.0	29.0	51.0	10.0	4.0
B 8	8.0	17.0	1.0	2.0	26.0	64.0	3.0	7.0
B 9	14.0	6.0	4.0	1.0	43.0	45.0	5.0	4.0
B 10	9.0	6.0	6.0	2.0	32.0	44.0	8.0	5.0
B 11	12.0	5.0	1.0	1.0	30.0	46.0	5.0	3.0
B 12	8.0	5.0	6.0	6.0	26.0	59.0	2.0	7.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	26.0	9.0	13.0	12.0	42.0	16.0	9.0	12.0
A 2	20.0	27.0	9.0	7.0	25.0	41.0	10.0	10.0
A 3	14.0	12.0	4.0	6.0	55.0	34.0	4.0	6.0
A 4	18.0	35.0	9.0	4.0	28.0	58.0	9.0	4.0
A 5	23.0	6.0	5.0	11.0	36.0	25.0	11.0	13.0
A 6	20.0	17.0	5.0	16.0	30.0	37.0	11.0	21.0
A 7	23.0	14.0	2.0	9.0	36.0	39.0	3.0	8.0
A 8	17.0	12.0	5.0	1.0	32.0	32.0	7.0	2.0
A 9	21.0	12.0	8.0	13.0	40.0	33.0	10.0	13.0
A 10	19.0	13.0	7.0	4.0	28.0	48.0	11.0	11.0
A 11	28.0	18.0	2.0	8.0	30.0	39.0	9.0	15.0
A 12	14.0	7.0	4.0	3.0	32.0	22.0	9.0	11.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	4.53	9.29	6.33	8.44	10.31	21.67	9.00	15.00	6.33	11.39
2	4.85	12.00	4.22	9.88	20.00	13.50	3.75	10.50	5.72	10.99
3	3.84	3.82	7.22	5.29	22.50	15.00	0.00	15.00	5.19	5.45
4	1.67	9.64	1.55	9.05	3.00	15.00	16.88	15.00	3.48	10.00
5	8.82	9.58	3.37	3.60	12.50	6.82	6.00	12.60	6.06	7.94
6	5.89	10.00	2.28	6.80	45.00	6.82	6.00	11.43	6.24	8.79
7	6.72	9.58	6.18	5.38	12.00	10.00	3.75	16.88	6.86	8.37
8	4.62	7.97	3.98	5.63	5.00	10.71	4.29	7.50	4.20	7.19
9	4.88	7.88	2.00	5.45	12.00	12.00	3.75	15.00	3.87	8.44
10	4.22	10.18	2.05	4.06	11.25	9.55	6.00	5.45	3.88	6.58
11	6.00	14.00	1.63	6.92	3.00	3.33	5.00	8.00	3.39	9.03
12	4.62	6.56	1.27	4.77	45.00	6.67	12.86	4.00	3.99	5.68

LOCATION= SH174 + FM 917
TIME= 1630-1730
DATE= 05/10/78(BEFORE)-04/03/80(AFTER)
FILES= 808-A16

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	33.0	20.0	8.0	7.0	60.0	73.0	6.0	7.0
B 2	41.0	53.0	3.0	11.0	49.0	61.0	3.0	15.0
B 3	40.0	12.0	9.0	4.0	62.0	57.0	6.0	5.0
B 4	19.0	12.0	8.0	5.0	48.0	55.0	7.0	4.0
B 5	34.0	14.0	1.0	10.0	69.0	66.0	2.0	6.0
B 6	30.0	13.0	29.0	6.0	62.0	48.0	3.0	5.0
B 7	28.0	22.0	6.0	9.0	55.0	56.0	4.0	8.0
B 8	24.0	14.0	15.0	9.0	52.0	48.0	6.0	11.0
B 9	18.0	13.0	8.0	11.0	71.0	71.0	7.0	10.0
B 10	36.0	16.0	10.0	7.0	67.0	65.0	8.0	9.0
B 11	19.0	32.0	56.0	7.0	70.0	61.0	7.0	7.0
B 12	32.0	10.0	14.0	12.0	62.0	57.0	9.0	13.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	42.0	21.0	3.0	24.0	55.0	48.0	5.0	20.0
A 2	56.0	23.0	43.0	19.0	59.0	43.0	26.0	12.0
A 3	32.0	33.0	17.0	10.0	53.0	48.0	17.0	8.0
A 4	56.0	31.0	30.0	14.0	65.0	57.0	20.0	12.0
A 5	27.0	42.0	9.0	13.0	40.0	63.0	15.0	15.0
A 6	49.0	24.0	10.0	22.0	48.0	38.0	9.0	16.0
A 7	63.0	28.0	29.0	15.0	48.0	46.0	9.0	15.0
A 8	42.0	27.0	18.0	21.0	60.0	36.0	14.0	12.0
A 9	63.0	25.0	4.0	21.0	66.0	48.0	16.0	18.0
A 10	59.0	37.0	15.0	44.0	66.0	44.0	3.0	12.0
A 11	55.0	37.0	20.0	22.0	81.0	37.0	14.0	15.0
A 12	76.0	34.0	11.0	9.0	66.0	30.0	8.0	16.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	8.25	11.45	4.11	6.56	20.00	9.00	15.00	18.00	6.99	10.55
2	12.55	14.24	13.03	8.02	15.00	24.81	11.00	23.75	12.66	15.11
3	9.68	9.06	3.16	10.31	22.50	15.00	12.00	18.75	7.50	10.95
4	5.94	12.92	3.27	8.16	17.14	22.50	18.75	17.50	5.79	12.76
5	7.39	10.13	3.18	10.00	7.50	9.00	25.00	13.00	6.19	10.26
6	7.26	15.31	4.06	9.47	*****	16.67	18.00	20.63	9.92	14.19
7	7.64	19.69	5.89	9.13	22.50	48.33	16.88	15.00	7.93	17.16
8	6.92	10.50	4.38	11.25	37.50	19.29	12.27	26.25	7.95	13.28
9	3.80	14.32	2.75	7.81	17.14	3.75	16.50	17.50	4.72	11.45
10	8.06	13.41	3.69	12.61	18.75	75.00	11.67	55.00	6.95	18.60
11	4.07	10.19	7.87	15.00	*****	21.43	15.00	22.00	11.79	13.67
12	7.74	17.27	2.63	17.00	23.33	20.63	13.85	8.44	7.23	16.25

LOCATION= FM 1220 + BOAT CLUB RD
TIME= 0730-0830
DATE= 10/24/78(BEFORE)-04/08/80(AFTER)
FILES= B15-A10

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	95.0	7.0	3.0	29.0	84.0	8.0	9.0	22.0
B 2	66.0	5.0	6.0	23.0	65.0	5.0	4.0	24.0
B 3	249.0	2.0	3.0	27.0	76.0	4.0	20.0	40.0
B 4	173.0	0.0	18.0	39.0	70.0	3.0	17.0	33.0
B 5	51.0	8.0	24.0	41.0	60.0	9.0	20.0	31.0
B 6	37.0	3.0	15.0	23.0	51.0	6.0	21.0	24.0
B 7	34.0	12.0	9.0	16.0	46.0	10.0	13.0	13.0
B 8	28.0	2.0	13.0	18.0	49.0	3.0	17.0	15.0
B 9	31.0	2.0	9.0	23.0	43.0	1.0	13.0	20.0
B 10	29.0	5.0	17.0	25.0	41.0	6.0	16.0	25.0
B 11	25.0	6.0	14.0	25.0	32.0	3.0	21.0	19.0
B 12	27.0	2.0	11.0	23.0	37.0	2.0	14.0	28.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	44.0	7.0	8.0	25.0	63.0	8.0	14.0	45.0
A 2	114.0	7.0	10.0	53.0	60.0	11.0	6.0	42.0
A 3	100.0	11.0	10.0	46.0	60.0	11.0	11.0	29.0
A 4	64.0	1.0	14.0	33.0	100.0	0.0	12.0	34.0
A 5	48.0	5.0	14.0	22.0	77.0	7.0	23.0	35.0
A 6	34.0	12.0	15.0	14.0	53.0	10.0	18.0	52.0
A 7	38.0	1.0	11.0	10.0	42.0	2.0	9.0	29.0
A 8	45.0	11.0	9.0	16.0	41.0	5.0	10.0	28.0
A 9	28.0	0.0	9.0	11.0	38.0	3.0	17.0	28.0
A 10	64.0	0.0	13.0	19.0	46.0	2.0	21.0	32.0
A 11	16.0	5.0	5.0	6.0	35.0	3.0	14.0	32.0
A 12	39.0	5.0	7.0	8.0	47.0	15.0	9.0	18.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	16.96	10.48	13.13	13.13	5.00	8.57	19.77	8.33	16.34	9.69
2	15.23	28.50	15.00	9.55	22.50	25.00	14.38	18.93	15.31	23.19
3	49.14	25.00	7.50	15.00	2.25	13.64	10.13	23.79	30.11	22.57
4	37.07	9.60	0.00	0	15.88	17.50	17.73	14.56	28.05	11.51
5	12.75	9.35	13.33	10.71	18.00	9.13	19.84	9.43	15.50	9.40
6	10.88	9.62	7.50	18.00	10.71	12.50	14.38	4.00	11.47	8.46
7	11.09	13.57	18.00	7.50	10.38	18.33	18.46	5.17	12.99	10.98
8	8.57	16.46	10.00	33.00	11.47	13.50	18.00	8.57	10.89	14.46
9	10.81	11.05	30.00	0.00	10.38	7.94	17.25	5.80	12.66	8.37
10	10.61	20.87	12.50	0.00	15.94	9.29	15.00	8.91	12.95	14.26
11	11.72	6.86	30.00	25.00	10.00	5.36	19.74	2.81	14.00	5.71
12	10.95	12.45	15.00	5.00	11.79	11.67	12.32	6.67	11.67	9.94

LOCATION= FM 1220 + BOAT CLUB RD
TIME= 1030-1130
DATE= 10/24/78(BEFORE)-04/08/80(AFTER)
FILES= B16-A09

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	20.0	5.0	14.0	13.0	33.0	9.0	13.0	8.0
B 2	25.0	0.0	5.0	10.0	18.0	0.0	13.0	10.0
B 3	28.0	1.0	8.0	6.0	22.0	6.0	7.0	12.0
B 4	17.0	6.0	9.0	17.0	10.0	7.0	16.0	10.0
B 5	15.0	9.0	15.0	8.0	30.0	8.0	12.0	7.0
B 6	9.0	1.0	17.0	4.0	21.0	4.0	20.0	9.0
B 7	28.0	4.0	12.0	11.0	20.0	3.0	13.0	13.0
B 8	14.0	6.0	8.0	8.0	13.0	8.0	13.0	13.0
B 9	15.0	5.0	7.0	19.0	16.0	4.0	12.0	14.0
B 10	11.0	5.0	16.0	30.0	23.0	3.0	15.0	18.0
B 11	9.0	5.0	7.0	24.0	20.0	5.0	10.0	21.0
B 12	20.0	4.0	18.0	20.0	33.0	4.0	14.0	21.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	16.0	17.0	12.0	22.0	20.0	13.0	12.0	26.0
A 2	10.0	14.0	10.0	12.0	6.0	14.0	16.0	25.0
A 3	12.0	8.0	7.0	12.0	22.0	19.0	14.0	14.0
A 4	9.0	8.0	2.0	2.0	12.0	14.0	11.0	14.0
A 5	24.0	13.0	28.0	16.0	16.0	8.0	24.0	15.0
A 6	21.0	3.0	8.0	11.0	24.0	6.0	20.0	19.0
A 7	18.0	3.0	4.0	4.0	11.0	9.0	19.0	14.0
A 8	12.0	5.0	8.0	13.0	12.0	4.0	16.0	15.0
A 9	16.0	12.0	7.0	16.0	15.0	10.0	23.0	12.0
A 10	18.0	9.0	4.0	16.0	24.0	17.0	11.0	23.0
A 11	24.0	7.0	10.0	21.0	21.0	5.0	24.0	19.0
A 12	6.0	8.0	10.0	8.0	14.0	20.0	13.0	26.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	9.09	12.00	8.33	19.62	16.15	15.00	24.38	12.69	12.38	14.15
2	20.83	25.00	T	15.00	5.77	9.38	15.00	7.24	14.63	11.31
3	19.00	8.18	2.50	6.32	17.14	7.50	7.50	12.86	13.72	8.48
4	25.50	11.25	12.86	8.57	8.44	2.73	25.50	2.14	17.09	6.18
5	7.50	22.50	16.88	24.38	18.75	17.50	17.14	16.00	12.37	19.29
6	6.43	13.13	3.75	7.50	12.75	6.00	6.67	8.68	8.61	9.35
7	21.00	24.55	20.00	5.00	13.85	3.16	12.69	4.20	16.84	8.21
8	16.15	15.00	11.25	18.75	9.23	7.50	9.23	13.00	11.49	12.13
9	14.06	16.00	18.75	18.00	8.75	4.57	20.36	20.00	15.00	12.75
10	7.17	11.25	25.00	7.94	16.00	5.45	25.00	10.43	15.76	9.40
11	6.75	17.14	15.00	21.00	10.50	6.25	17.14	16.50	12.05	13.48
12	9.09	6.43	15.00	6.00	19.29	11.54	14.29	4.62	12.92	6.58

LOCATTON= FM 1220 + ROAT CLUR RD
TIME= 1630-1730
DATE= 10/24/78(BEFORE)-04/08/80(AFTER)
FILES= B17-A11

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	36.0	6.0	38.0	27.0	40.0	5.0	30.0	25.0
B 2	29.0	14.0	20.0	21.0	31.0	14.0	28.0	23.0
B 3	31.0	21.0	37.0	27.0	39.0	13.0	22.0	27.0
B 4	49.0	18.0	32.0	25.0	41.0	12.0	39.0	25.0
B 5	6.0	10.0	44.0	24.0	22.0	8.0	51.0	22.0
B 6	33.0	15.0	81.0	34.0	27.0	9.0	39.0	15.0
B 7	19.0	20.0	39.0	51.0	20.0	18.0	38.0	35.0
B 8	27.0	14.0	68.0	40.0	30.0	11.0	48.0	33.0
B 9	15.0	14.0	48.0	18.0	32.0	13.0	47.0	18.0
B 10	22.0	19.0	71.0	49.0	24.0	13.0	45.0	31.0
B 11	24.0	34.0	66.0	33.0	32.0	20.0	42.0	32.0
B 12	44.0	61.0	70.0	54.0	28.0	24.0	45.0	33.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	14.0	28.0	18.0	56.0	8.0	22.0	35.0	15.0
A 2	43.0	30.0	59.0	45.0	25.0	21.0	43.0	10.0
A 3	27.0	14.0	75.0	63.0	25.0	12.0	42.0	26.0
A 4	57.0	21.0	56.0	33.0	27.0	14.0	58.0	21.0
A 5	41.0	45.0	46.0	25.0	27.0	20.0	57.0	22.0
A 6	31.0	47.0	23.0	20.0	40.0	29.0	51.0	23.0
A 7	30.0	19.0	30.0	28.0	33.0	23.0	62.0	17.0
A 8	27.0	48.0	26.0	20.0	14.0	21.0	33.0	29.0
A 9	31.0	46.0	27.0	51.0	34.0	33.0	59.0	17.0
A 10	57.0	33.0	48.0	38.0	19.0	32.0	51.0	24.0
A 11	32.0	28.0	48.0	49.0	19.0	35.0	57.0	31.0
A 12	19.0	43.0	33.0	27.0	16.0	12.0	52.0	25.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	13.50	26.25	18.00	19.09	19.00	7.71	16.20	56.00	16.05	21.75
2	14.03	25.80	15.00	21.43	10.71	20.58	13.70	67.50	13.13	26.82
3	11.92	16.20	24.23	17.50	25.23	26.79	15.00	36.35	17.23	25.57
4	17.93	31.67	22.50	22.50	12.31	14.48	15.00	23.57	15.90	20.88
5	4.09	22.78	18.75	33.75	12.94	12.11	16.36	17.05	12.23	18.69
6	18.33	11.62	25.00	24.31	31.15	6.76	34.00	13.04	27.17	12.69
7	14.25	13.64	16.67	12.39	15.39	7.26	21.86	24.71	17.43	11.89
8	13.50	28.93	19.09	34.29	21.25	11.82	18.18	10.34	18.32	18.71
9	7.03	13.68	16.15	20.91	15.32	6.86	15.00	45.00	12.95	16.26
10	13.75	45.00	21.92	15.47	23.67	14.12	23.71	23.75	21.37	20.95
11	11.25	25.26	25.50	12.00	23.57	12.63	15.47	23.71	18.69	16.58
12	23.57	17.81	38.13	53.75	23.33	9.52	24.55	16.20	26.42	17.43

SH199 AND FIRE HALL 10/31/78-04/15/80, 0715-0815

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	19.0	36.0	2.0	14.0	20.0	163.0	3.0	10.0
B 2	20.0	127.0	12.0	21.0	34.0	182.0	8.0	19.0
B 3	25.0	124.0	19.0	12.0	35.0	204.0	7.0	14.0
B 4	24.0	99.0	19.0	18.0	34.0	150.0	14.0	8.0
B 5	20.0	134.0	33.0	13.0	43.0	182.0	11.0	15.0
B 6	23.0	96.0	18.0	32.0	31.0	190.0	8.0	7.0
B 7	34.0	79.0	14.0	26.0	36.0	154.0	14.0	10.0
B 8	52.0	196.0	17.0	34.0	42.0	139.0	6.0	24.0
B 9	12.0	88.0	14.0	28.0	38.0	119.0	15.0	16.0
B 10	43.0	105.0	11.0	36.0	41.0	148.0	8.0	30.0
B 11	27.0	76.0	45.0	29.0	45.0	123.0	26.0	23.0
B 12	26.0	80.0	24.0	33.0	28.0	91.0	16.0	34.0

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	17.0	171.0	10.0	3.0	27.0	160.0	1.0	16.0
A 2	12.0	112.0	11.0	18.0	23.0	169.0	3.0	15.0
A 3	7.0	98.0	12.0	17.0	29.0	190.0	0.0	23.0
A 4	22.0	178.0	39.0	48.0	36.0	190.0	3.0	21.0
A 5	21.0	200.0	24.0	20.0	30.0	156.0	2.0	17.0
A 6	9.0	79.0	19.0	18.0	42.0	185.0	1.0	37.0
A 7	9.0	36.0	19.0	7.0	29.0	150.0	0.0	27.0
A 8	17.0	106.0	6.0	17.0	29.0	131.0	1.0	17.0
A 9	24.0	173.0	8.0	26.0	29.0	125.0	1.0	16.0
A 10	22.0	67.0	12.0	25.0	48.0	107.0	1.0	8.0
A 11	19.0	81.0	16.0	24.0	31.0	76.0	1.0	8.0
A 12	23.0	86.0	13.0	26.0	31.0	92.0	1.0	15.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVNBB	DVNBA	DVSBB	DVSBA	DVEBB	DVEBA	DVWBB	DVWBA	TDVB	TDVA
1	14.3	9.4	3.3	16.0	10.0	150.0	21.0	2.8	5.4	14.8
2	8.8	7.8	10.5	9.9	22.5	55.0	16.6	18.0	11.1	10.9
3	10.7	3.6	9.1	7.7	40.7	R	12.9	11.1	10.4	8.3
4	10.6	9.2	9.9	14.1	20.4	105.0	33.8	34.3	11.7	17.2
5	7.0	10.5	11.0	27.9	45.0	180.0	13.0	17.6	12.0	26.0
6	11.1	3.2	7.6	6.4	33.8	285.0	68.6	7.3	10.7	7.1
7	14.2	4.7	7.7	3.6	15.0	R	27.9	3.9	10.5	5.2
8	18.6	8.8	21.2	12.1	42.5	90.0	21.3	15.0	21.3	12.3
9	4.7	12.4	11.1	20.8	14.0	130.0	26.3	24.4	11.3	20.3
10	15.7	6.9	10.6	9.4	20.6	180.0	18.0	46.9	12.9	11.5
11	9.0	9.2	9.3	16.0	26.0	240.0	18.9	45.0	12.2	18.1
12	13.9	11.1	13.2	14.0	22.5	105.0	14.6	26.0	14.8	16.0

SH199 & FIRE HALL,10/?1/78-04/15/80,1030-1130

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	28.0	18.0	2.0	12.0	43.0	57.0	6.0	15.0
B 2	40.0	19.0	7.0	17.0	48.0	42.0	11.0	20.0
B 3	10.0	20.0	8.0	17.0	57.0	59.0	9.0	27.0
B 4	20.0	23.0	4.0	9.0	52.0	50.0	7.0	12.0
B 5	25.0	33.0	8.0	15.0	50.0	65.0	7.0	14.0
B 6	17.0	19.0	4.0	15.0	48.0	62.0	8.0	16.0
B 7	22.0	14.0	9.0	18.0	46.0	58.0	8.0	16.0
B 8	12.0	20.0	9.0	8.0	42.0	61.0	5.0	15.0
B 9	25.0	17.0	13.0	6.0	58.0	59.0	11.0	15.0
B 10	19.0	20.0	14.0	4.0	60.0	51.0	6.0	10.0
B 11	15.0	26.0	11.0	10.0	36.0	48.0	10.0	11.0
B 12	15.0	12.0	14.0	8.0	58.0	63.0	15.0	14.0

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	38.0	24.0	7.0	22.0	34.0	60.0	0.0	22.0
A 2	6.0	19.0	5.0	9.0	50.0	38.0	0.0	8.0
A 3	19.0	24.0	5.0	14.0	47.0	60.0	1.0	17.0
A 4	24.0	25.0	10.0	12.0	48.0	63.0	0.0	14.0
A 5	24.0	38.0	11.0	5.0	58.0	60.0	0.0	7.0
A 6	18.0	24.0	10.0	8.0	58.0	50.0	1.0	10.0
A 7	25.0	33.0	6.0	18.0	66.0	59.0	0.0	25.0
A 8	30.0	30.0	14.0	15.0	59.0	56.0	0.0	10.0
A 9	36.0	28.0	3.0	13.0	75.0	69.0	0.0	12.0
A 10	22.0	25.0	7.0	11.0	69.0	70.0	1.0	15.0
A 11	21.0	30.0	7.0	16.0	46.0	64.0	0.0	22.0
A 12	28.0	39.0	9.0	12.0	46.0	66.0	0.0	14.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVNBB	DVNBA	DVSBB	DVSBA	DVEBB	DVEBA	DVWBB	DVWBA	TDVB	TDVA
1	9.8	16.8	4.7	6.0	5.0	R	12.0	15.0	7.4	11.8
2	12.5	1.8	6.8	7.5	9.5	R	12.8	16.9	10.3	6.1
3	2.6	6.1	5.1	6.0	13.3	75.0	9.4	12.4	5.4	7.4
4	5.8	7.5	6.9	6.0	8.6	R	11.3	12.9	6.9	8.5
5	7.5	6.2	7.6	9.5	17.1	R	16.1	10.7	8.9	9.4
6	5.3	4.7	4.6	7.2	7.5	150.0	14.1	12.0	6.2	7.6
7	7.2	5.7	3.6	8.4	16.9	R	16.9	10.8	7.4	8.2
8	4.3	7.6	4.9	8.0	27.0	R	8.0	22.5	6.0	10.7
9	6.5	7.2	4.3	6.1	17.7	R	6.0	16.3	6.4	7.7
10	4.8	4.8	5.9	5.4	35.0	105.0	6.0	11.0	6.7	6.3
11	6.3	6.8	8.1	7.0	16.5	R	13.6	10.9	8.9	8.4
12	3.9	9.1	2.9	8.9	14.0	R	8.6	12.9	4.9	10.5

SH199 A FIRE HALL 10/31/78-04/15/80,1640-1740

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	168.0	120.0	7.0	130.0	138.0	63.0	6.0	36.0
B 2	117.0	49.0	13.0	54.0	110.0	57.0	7.0	47.0
B 3	261.0	95.0	17.0	63.0	160.0	66.0	7.0	32.0
B 4	160.0	62.0	11.0	40.0	160.0	62.0	11.0	40.0
B 5	408.0	83.0	38.0	75.0	119.0	88.0	17.0	56.0
B 6	298.0	42.0	76.0	102.0	146.0	74.0	23.0	51.0
B 7	249.0	85.0	23.0	60.0	127.0	37.0	19.0	63.0
B 8	246.0	65.0	22.0	88.0	121.0	77.0	11.0	52.0
B 9	254.0	56.0	55.0	92.0	169.0	47.0	22.0	56.0
B 10	317.0	115.0	46.0	56.0	176.0	72.0	16.0	37.0
B 11	231.0	95.0	29.0	79.0	164.0	74.0	15.0	37.0
B 12	91.0	59.0	12.0	40.0	114.0	85.0	13.0	48.0

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	227.0	125.0	25.0	46.0	132.0	61.0	0.0	38.0
A 2	251.0	75.0	34.0	45.0	132.0	64.0	3.0	34.0
A 3	223.0	58.0	27.0	40.0	131.0	77.0	0.0	42.0
A 4	152.0	70.0	43.0	33.0	151.0	60.0	1.0	27.0
A 5	280.0	146.0	40.0	39.0	148.0	76.0	2.0	34.0
A 6	193.0	24.0	40.0	26.0	143.0	67.0	0.0	30.0
A 7	211.0	39.0	43.0	28.0	166.0	54.0	0.0	33.0
A 8	130.0	21.0	22.0	68.0	134.0	42.0	0.0	33.0
A 9	178.0	83.0	34.0	50.0	105.0	55.0	0.0	27.0
A 10	140.0	36.0	22.0	28.0	138.0	73.0	1.0	24.0
A 11	362.0	99.0	76.0	45.0	101.0	46.0	2.0	22.0
A 12	117.0	92.0	37.0	47.0	128.0	89.0	0.0	18.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVNBB	DVNBA	DVSBB	DVSBA	DVEBB	DVEBA	DVWBB	DVWBA	TDVB	TDVA
1	18.3	25.8	28.6	30.7	17.5	R	54.2	18.2	26.2	27.5
2	16.0	28.5	12.9	17.6	27.9	170.0	17.2	19.9	15.8	26.1
3	24.5	25.5	21.6	11.3	36.4	R	29.5	14.3	24.7	20.9
4	15.0	15.1	15.0	17.5	15.0	645.0	15.0	18.3	15.0	18.7
5	51.4	28.4	14.1	28.8	33.5	300.0	20.1	17.2	32.4	29.1
6	30.6	20.2	8.5	5.4	49.6	R	30.0	13.0	26.4	17.7
7	29.4	19.1	34.5	10.8	18.2	R	14.3	12.7	25.4	19.0
8	30.5	14.6	12.7	7.5	30.0	R	25.4	30.9	24.2	17.3
9	22.5	25.4	17.9	22.6	37.5	R	24.6	27.8	23.3	27.7
10	27.0	15.2	24.0	7.4	43.1	330.0	22.7	17.5	26.6	14.4
11	21.1	53.8	19.3	32.3	29.0	570.0	32.0	30.7	22.4	51.1
12	12.0	13.7	10.4	15.5	13.8	R	12.5	39.2	11.7	18.7

BS199RY:SH109 AND ROBERTS CUTOFF:11/02/78:1030-1130

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	28.0	38.0	22.0	6.0	*****	*****	*****	*****
B 2	12.0	13.0	8.0	14.0	*****	*****	*****	*****
B 3	21.0	59.0	26.0	3.0	*****	*****	*****	*****
B 4	25.0	26.0	23.0	16.0	*****	*****	*****	*****
B 5	51.0	40.0	26.0	4.0	*****	*****	*****	*****
B 6	25.0	26.0	18.0	9.0	*****	*****	*****	*****
B 7	20.0	57.0	28.0	4.0	*****	*****	*****	*****
B 8	28.0	37.0	24.0	4.0	*****	*****	*****	*****
B 9	21.0	26.0	23.0	6.0	*****	*****	*****	*****
B 10	24.0	29.0	21.0	13.0	*****	*****	*****	*****
B 11	24.0	31.0	12.0	5.0	*****	*****	*****	*****
B 12	19.0	16.0	16.0	7.0	*****	*****	*****	*****
			HOURLY VOLUME=		531.0	657.0	2320.0	300.0

AS199RY:SH109 AND ROBERTS CUTOFF:04/17/80:1030-1

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	31.0	42.0	17.0	10.0	*****	*****	*****	*****
A 2	76.0	49.0	18.0	6.0	*****	*****	*****	*****
A 3	34.0	60.0	9.0	4.0	*****	*****	*****	*****
A 4	44.0	38.0	23.0	4.0	*****	*****	*****	*****
A 5	45.0	42.0	10.0	4.0	*****	*****	*****	*****
A 6	48.0	38.0	9.0	11.0	*****	*****	*****	*****
A 7	37.0	45.0	31.0	4.0	*****	*****	*****	*****
A 8	37.0	57.0	12.0	10.0	*****	*****	*****	*****
A 9	34.0	45.0	36.0	7.0	*****	*****	*****	*****
A 10	32.0	58.0	22.0	4.0	*****	*****	*****	*****
A 11	33.0	73.0	23.0	8.0	*****	*****	*****	*****
A 12	37.0	49.0	23.0	1.0	*****	*****	*****	*****
			HOURLY VOLUME=		419.0	895.0	266.0	115.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	420.0	465.0	570.0	630.0	330.0	255.0	90.0	150.0
2	180.0	1140.0	195.0	735.0	120.0	270.0	210.0	90.0
3	315.0	510.0	885.0	900.0	390.0	135.0	45.0	60.0
4	375.0	660.0	390.0	570.0	345.0	345.0	240.0	60.0
5	765.0	675.0	600.0	630.0	390.0	150.0	60.0	60.0
6	375.0	720.0	390.0	570.0	270.0	135.0	135.0	165.0
7	300.0	555.0	855.0	675.0	420.0	465.0	60.0	60.0
8	420.0	555.0	555.0	855.0	360.0	180.0	60.0	150.0
9	315.0	510.0	390.0	675.0	345.0	540.0	90.0	105.0
10	360.0	480.0	435.0	870.0	315.0	330.0	195.0	60.0
11	360.0	495.0	465.0	1095.0	180.0	345.0	75.0	120.0
12	285.0	555.0	240.0	735.0	240.0	345.0	105.0	15.0

* REPRESENTS DATA NOT AVAILABLE
P REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BS199RX:SH 199 AND ROBERTS CUTOFF:11/02/78:0715-0815

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	20.0	37.0	7.0	13.0	*****	*****	*****	*****
B 2	12.0	42.0	7.0	3.0	*****	*****	*****	*****
B 3	17.0	40.0	25.0	23.0	*****	*****	*****	*****
B 4	12.0	76.0	59.0	27.0	*****	*****	*****	*****
B 5	4.0	71.0	29.0	7.0	*****	*****	*****	*****
B 6	4.0	73.0	25.0	16.0	*****	*****	*****	*****
B 7	34.0	86.0	38.0	21.0	*****	*****	*****	*****
B 8	27.0	37.0	25.0	13.0	*****	*****	*****	*****
B 9	13.0	18.0	27.0	9.0	*****	*****	*****	*****
B 10	23.0	53.0	21.0	14.0	*****	*****	*****	*****
B 11	14.0	12.0	16.0	15.0	*****	*****	*****	*****
B 12	14.0	27.0	4.0	8.0	*****	*****	*****	*****
			HOURLY VOLUME=		422.0	2557.0	258.0	220.0

AS199RX:SH199 AND ROBERTS CUTOFF:04/17/80:0715-0815

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	33.0	68.0	9.0	11.0	*****	*****	*****	*****
A 2	20.0	59.0	13.0	13.0	*****	*****	*****	*****
A 3	20.0	114.0	11.0	8.0	*****	*****	*****	*****
A 4	16.0	53.0	13.0	1.0	*****	*****	*****	*****
A 5	19.0	47.0	11.0	13.0	*****	*****	*****	*****
A 6	30.0	124.0	31.0	4.0	*****	*****	*****	*****
A 7	32.0	61.0	29.0	9.0	*****	*****	*****	*****
A 8	15.0	115.0	29.0	12.0	*****	*****	*****	*****
A 9	22.0	52.0	20.0	7.0	*****	*****	*****	*****
A 10	15.0	60.0	10.0	10.0	*****	*****	*****	*****
A 11	12.0	37.0	8.0	2.0	*****	*****	*****	*****
A 12	29.0	55.0	10.0	5.0	*****	*****	*****	*****
			HOURLY VOLUME=		268.0	1414.0	530.0	169.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	300.0	495.0	555.0	1020.0	105.0	135.0	195.0	165.0
2	180.0	300.0	630.0	885.0	105.0	195.0	45.0	195.0
3	255.0	300.0	600.0	1710.0	375.0	165.0	345.0	120.0
4	180.0	240.0	1140.0	795.0	885.0	195.0	405.0	15.0
5	60.0	285.0	1065.0	705.0	435.0	165.0	105.0	195.0
6	60.0	450.0	1095.0	1860.0	375.0	465.0	240.0	60.0
7	510.0	480.0	1290.0	915.0	570.0	435.0	315.0	135.0
8	405.0	225.0	555.0	1725.0	375.0	435.0	195.0	180.0
9	195.0	330.0	270.0	780.0	405.0	300.0	135.0	105.0
10	345.0	225.0	795.0	900.0	315.0	150.0	210.0	150.0
11	210.0	180.0	180.0	555.0	240.0	120.0	225.0	30.0
12	210.0	435.0	405.0	825.0	60.0	150.0	120.0	75.0

* REPRESENTS DATA NOT AVAILABLE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BS199RZ:SH169 AND ROBERTS CUTOFF:11/02/78:1645-1

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	188.0	50.0	55.0	27.0	*****	*****	*****	*****
B 2	112.0	31.0	71.0	17.0	*****	*****	*****	*****
B 3	132.0	108.0	90.0	23.0	*****	*****	*****	*****
B 4	112.0	105.0	78.0	13.0	*****	*****	*****	*****
B 5	89.0	123.0	144.0	4.0	*****	*****	*****	*****
B 6	134.0	137.0	178.0	7.0	*****	*****	*****	*****
B 7	143.0	88.0	136.0	20.0	*****	*****	*****	*****
B 8	112.0	89.0	71.0	3.0	*****	*****	*****	*****
B 9	72.0	54.0	64.0	18.0	*****	*****	*****	*****
B 10	106.0	56.0	65.0	28.0	*****	*****	*****	*****
B 11	192.0	68.0	72.0	4.0	*****	*****	*****	*****
B 12	87.0	119.0	212.0	22.0	*****	*****	*****	*****
			HOURLY	VOLUME=	1309.0	1021.0	510.0	153.0

AS199RZ:SH169 AND ROBERTS CUTOFF:04/17/80:1645-1

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	207.0	43.0	348.0	13.0	*****	*****	*****	*****
A 2	173.0	78.0	238.0	15.0	*****	*****	*****	*****
A 3	86.0	47.0	258.0	7.0	*****	*****	*****	*****
A 4	244.0	76.0	121.0	9.0	*****	*****	*****	*****
A 5	190.0	81.0	143.0	15.0	*****	*****	*****	*****
A 6	185.0	53.0	269.0	16.0	*****	*****	*****	*****
A 7	220.0	66.0	124.0	10.0	*****	*****	*****	*****
A 8	312.0	25.0	143.0	23.0	*****	*****	*****	*****
A 9	217.0	58.0	179.0	8.0	*****	*****	*****	*****
A 10	236.0	30.0	183.0	18.0	*****	*****	*****	*****
A 11	242.0	48.0	159.0	8.0	*****	*****	*****	*****
A 12	155.0	49.0	69.0	3.0	*****	*****	*****	*****
			HOURLY	VOLUME=	1016.0	891.0	414.0	118.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	2820.0	3105.0	750.0	645.0	825.0	5220.0	405.0	195.0
2	1680.0	2595.0	465.0	1170.0	1065.0	3570.0	255.0	225.0
3	1980.0	1290.0	1620.0	705.0	1350.0	3870.0	345.0	105.0
4	1680.0	3660.0	1575.0	1140.0	1170.0	1815.0	195.0	135.0
5	1335.0	2850.0	1845.0	1215.0	2160.0	2145.0	60.0	225.0
6	2010.0	2775.0	2055.0	795.0	2670.0	4035.0	105.0	240.0
7	2145.0	3300.0	1320.0	990.0	2040.0	1860.0	300.0	150.0
8	1680.0	4680.0	1335.0	375.0	1065.0	2145.0	45.0	345.0
9	1080.0	3255.0	810.0	870.0	960.0	2685.0	270.0	120.0
10	1590.0	3540.0	840.0	450.0	975.0	2745.0	420.0	270.0
11	2880.0	3630.0	1020.0	720.0	1080.0	2385.0	60.0	120.0
12	1305.0	2325.0	1785.0	735.0	3180.0	1035.0	330.0	45.0

* REPRESENTS DATA NOT AVAILBLE
B REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

LOCATION= SH361 + FM 1069
TIME= 0700-0900
DATE= 08/15/78(BEFORE)-08/21/79(AFTER)
FILES= B25-A31

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	20.0	13.0	10.0	14.0	38.0	53.0	38.0	64.0
B 2	5.0	19.0	13.0	9.0	59.0	27.0	31.0	40.0
B 3	12.0	34.0	16.0	13.0	54.0	36.0	49.0	50.0
B 4	7.0	34.0	15.0	7.0	55.0	35.0	35.0	52.0
B 5	15.0	38.0	6.0	9.0	64.0	32.0	49.0	33.0
B 6	4.0	22.0	11.0	8.0	62.0	21.0	48.0	34.0
B 7	1.0	39.0	16.0	10.0	62.0	30.0	46.0	35.0
B 8	7.0	19.0	7.0	10.0	48.0	23.0	45.0	29.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	11.0	27.0	16.0	13.0	44.0	45.0	49.0	75.0
A 2	8.0	19.0	9.0	13.0	52.0	33.0	45.0	44.0
A 3	12.0	27.0	18.0	9.0	55.0	48.0	53.0	43.0
A 4	13.0	47.0	20.0	25.0	62.0	27.0	47.0	53.0
A 5	10.0	27.0	12.0	8.0	55.0	31.0	52.0	43.0
A 6	3.0	19.0	11.0	13.0	56.0	24.0	48.0	36.0
A 7	12.0	27.0	21.0	16.0	56.0	18.0	46.0	47.0
A 8	11.0	27.0	20.0	4.0	56.0	30.0	41.0	35.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	7.80	3.75	3.68	9.00	3.95	4.90	3.28	2.60	4.43	4.72
2	1.27	2.31	10.56	8.64	6.29	3.00	3.38	4.43	4.39	4.22
3	3.33	3.27	14.17	8.44	4.00	5.09	3.90	3.14	5.95	4.97
4	1.91	3.15	14.57	26.11	6.43	6.38	2.02	7.08	5.34	8.33
5	3.52	2.73	17.81	13.06	1.84	3.46	4.09	2.79	5.73	4.72
6	.97	.80	15.71	11.88	3.44	3.44	3.53	5.42	4.09	4.21
7	.24	3.21	19.50	22.50	5.22	6.85	4.29	5.11	5.72	6.83
8	2.19	2.95	12.39	13.50	2.33	7.32	5.17	1.71	4.45	5.74

LOCATION= SH361 + FM 1069
TIME= 0700-0900
DATE= 08/16/78(BEFORE)-08/22/79(AFTER)
FILES= B28-A20

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	2.0	14.0	9.0	17.0	43.0	31.0	27.0	62.0
B 2	7.0	22.0	11.0	12.0	61.0	34.0	36.0	34.0
B 3	9.0	30.0	10.0	13.0	71.0	42.0	38.0	47.0
B 4	9.0	16.0	21.0	15.0	62.0	32.0	66.0	59.0
B 5	8.0	21.0	21.0	11.0	57.0	27.0	45.0	35.0
B 6	18.0	29.0	17.0	5.0	59.0	33.0	54.0	37.0
B 7	8.0	46.0	8.0	9.0	65.0	24.0	37.0	40.0
B 8	11.0	27.0	19.0	5.0	69.0	30.0	50.0	41.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	9.0	6.0	16.0	15.0	40.0	32.0	49.0	77.0
A 2	5.0	34.0	19.0	15.0	51.0	36.0	39.0	51.0
A 3	12.0	22.0	11.0	12.0	69.0	41.0	54.0	49.0
A 4	12.0	35.0	4.0	17.0	62.0	40.0	38.0	56.0
A 5	7.0	12.0	20.0	14.0	46.0	25.0	44.0	42.0
A 6	4.0	11.0	15.0	17.0	46.0	25.0	42.0	44.0
A 7	2.0	24.0	9.0	9.0	77.0	16.0	33.0	38.0
A 8	3.0	16.0	11.0	6.0	53.0	24.0	39.0	35.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	.70	3.38	6.77	2.81	5.00	4.90	4.11	2.92	3.87	3.48
2	1.72	1.47	9.71	14.17	4.58	7.31	5.29	4.41	4.73	6.19
3	1.90	2.61	10.71	8.05	3.95	3.06	4.15	3.67	4.70	4.01
4	2.18	2.90	7.50	13.13	4.77	1.58	3.81	4.55	4.18	5.20
5	2.11	2.28	11.67	7.20	7.00	6.82	4.71	5.00	5.58	5.06
6	4.58	1.30	13.18	6.60	4.72	5.36	2.03	5.80	5.66	4.49
7	1.85	.39	28.75	22.50	3.24	4.09	3.38	3.55	6.42	4.02
8	2.30	.85	13.50	10.00	5.70	4.23	1.83	2.57	4.89	3.58

LOCATION= SH361 + FM 1069
TIME= 0930-1130
DATE= 08/15/78(BEFORE)-08/21/79(AFTER)
FILES= B24-A30

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	12.0	45.0	15.0	11.0	71.0	30.0	46.0	43.0
B 2	9.0	35.0	10.0	9.0	74.0	37.0	51.0	46.0
B 3	10.0	40.0	21.0	17.0	74.0	26.0	62.0	48.0
B 4	11.0	25.0	4.0	16.0	72.0	29.0	34.0	46.0
B 5	14.0	23.0	13.0	10.0	55.0	26.0	57.0	37.0
B 6	14.0	25.0	23.0	13.0	51.0	43.0	45.0	37.0
B 7	25.0	45.0	26.0	8.0	65.0	34.0	43.0	55.0
B 8	15.0	46.0	25.0	7.0	88.0	37.0	59.0	42.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	8.0	25.0	8.0	12.0	69.0	25.0	26.0	42.0
A 2	13.0	20.0	20.0	23.0	58.0	36.0	36.0	59.0
A 3	13.0	37.0	22.0	5.0	51.0	37.0	49.0	37.0
A 4	13.0	30.0	12.0	11.0	73.0	44.0	51.0	40.0
A 5	11.0	37.0	20.0	10.0	74.0	37.0	62.0	49.0
A 6	16.0	38.0	16.0	2.0	65.0	30.0	49.0	24.0
A 7	8.0	47.0	7.0	10.0	65.0	41.0	55.0	46.0
A 8	8.0	33.0	19.0	14.0	68.0	27.0	49.0	52.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	2.54	1.74	22.50	15.00	4.89	4.62	3.84	4.29	6.55	4.91
2	1.82	3.36	14.19	8.33	2.94	8.33	2.93	5.85	4.54	6.03
3	2.03	3.82	23.08	15.00	5.08	6.73	5.31	2.03	6.29	6.64
4	2.29	2.67	12.93	10.23	1.76	3.53	5.22	4.13	4.64	4.76
5	3.82	2.23	13.27	15.00	3.42	4.84	4.05	3.06	5.14	5.27
6	4.12	3.69	8.72	19.00	7.67	4.90	5.27	1.25	6.39	6.43
7	5.77	1.85	19.85	17.20	9.07	1.91	2.18	3.26	7.92	5.22
8	2.56	1.76	18.65	18.33	6.36	5.82	2.50	4.04	6.17	5.66

LOCATION= SH361 + FM 1069
TIME= 0930-1130
DATE= 08/16/78(BEFORE)-08/22/79(AFTER)
FILES= B27-A21

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	11.0	28.0	14.0	8.0	73.0	31.0	46.0	33.0
B 2	12.0	28.0	17.0	16.0	57.0	32.0	55.0	38.0
B 3	20.0	33.0	16.0	15.0	65.0	35.0	53.0	42.0
B 4	6.0	23.0	17.0	20.0	58.0	33.0	42.0	53.0
B 5	10.0	26.0	17.0	9.0	74.0	20.0	56.0	45.0
B 6	15.0	32.0	14.0	8.0	60.0	42.0	39.0	45.0
B 7	25.0	44.0	25.0	12.0	85.0	35.0	52.0	45.0
B 8	18.0	57.0	11.0	9.0	78.0	36.0	74.0	54.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	4.0	33.0	7.0	6.0	67.0	30.0	39.0	36.0
A 2	6.0	26.0	10.0	14.0	66.0	29.0	42.0	49.0
A 3	7.0	33.0	17.0	17.0	60.0	38.0	48.0	53.0
A 4	6.0	40.0	20.0	18.0	68.0	28.0	54.0	51.0
A 5	8.0	27.0	8.0	12.0	61.0	44.0	52.0	42.0
A 6	8.0	24.0	22.0	16.0	59.0	37.0	80.0	36.0
A 7	11.0	30.0	18.0	17.0	63.0	42.0	56.0	44.0
A 8	5.0	25.0	7.0	27.0	71.0	26.0	55.0	54.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	2.26	.90	13.55	16.50	4.57	2.69	3.64	2.50	5.00	4.36
2	3.16	1.36	13.13	13.45	4.64	3.57	6.32	4.29	6.02	4.52
3	4.62	1.75	14.14	13.03	4.53	5.31	5.36	4.81	6.46	5.58
4	1.55	1.32	10.45	21.43	6.07	5.56	5.66	5.29	5.32	6.27
5	2.03	1.97	19.50	9.20	4.55	2.31	3.00	4.29	4.77	4.15
6	3.75	2.03	11.43	9.73	5.38	4.13	2.67	6.67	5.56	4.95
7	4.41	2.62	18.86	10.71	7.21	4.82	4.00	5.80	7.33	5.56
8	3.46	1.06	23.75	14.42	2.23	1.91	2.50	7.50	5.89	4.66

LOCATION= SH361 + FM 1069
TIME= 1530-1730
DATE= 08/15/78(BEFORE)-08/21/79(AFTER)
FILES= B23-A29

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	8.0	41.0	23.0	19.0	70.0	32.0	65.0	57.0
B 2	18.0	45.0	28.0	22.0	80.0	26.0	74.0	67.0
B 3	19.0	41.0	25.0	38.0	77.0	34.0	74.0	86.0
B 4	28.0	112.0	21.0	17.0	94.0	43.0	69.0	93.0
B 5	11.0	40.0	21.0	21.0	57.0	39.0	54.0	63.0
B 6	13.0	43.0	14.0	14.0	91.0	48.0	53.0	62.0
B 7	20.0	45.0	21.0	14.0	72.0	61.0	103.0	67.0
B 8	19.0	51.0	40.0	19.0	64.0	44.0	72.0	104.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	11.0	46.0	36.0	29.0	79.0	35.0	108.0	96.0
A 2	10.0	45.0	29.0	20.0	81.0	40.0	69.0	72.0
A 3	19.0	38.0	32.0	25.0	87.0	38.0	82.0	95.0
A 4	8.0	40.0	20.0	45.0	87.0	37.0	73.0	77.0
A 5	8.0	30.0	30.0	25.0	74.0	36.0	56.0	87.0
A 6	7.0	33.0	40.0	24.0	75.0	36.0	67.0	72.0
A 7	14.0	37.0	39.0	28.0	66.0	42.0	96.0	73.0
A 8	12.0	24.0	43.0	16.0	49.0	44.0	76.0	82.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	1.71	2.09	19.22	19.71	5.31	5.00	5.00	4.53	6.09	5.75
2	3.38	1.85	25.96	16.88	5.68	6.30	4.93	4.17	6.86	5.95
3	3.70	3.28	18.09	15.00	5.07	5.85	6.63	3.95	6.81	5.66
4	4.47	1.38	39.07	16.22	4.57	4.11	2.74	8.77	8.93	6.19
5	2.89	1.62	15.38	12.50	5.83	8.04	5.00	4.31	6.55	5.51
6	2.14	1.40	13.44	13.75	3.96	8.96	3.39	5.00	4.96	6.24
7	4.17	3.18	11.07	13.21	3.06	6.09	3.13	5.75	4.95	6.39
8	4.45	3.67	17.39	8.18	8.33	8.49	2.74	2.93	6.81	5.68

LOCATION= SH361 + FM 1069
TIME= 1530-1730
DATE= 08/16/78(BEFORE)-08/22/79(AFTER)
FILES= B26-A22

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
B 1	9.0	39.0	27.0	29.0	68.0	31.0	57.0	76.0
B 2	20.0	36.0	34.0	19.0	112.0	32.0	60.0	57.0
B 3	26.0	66.0	36.0	26.0	91.0	36.0	84.0	82.0
B 4	18.0	51.0	34.0	18.0	87.0	46.0	70.0	94.0
B 5	21.0	27.0	30.0	21.0	66.0	32.0	62.0	95.0
B 6	14.0	38.0	14.0	27.0	71.0	37.0	58.0	88.0
B 7	25.0	41.0	47.0	15.0	73.0	48.0	92.0	65.0
B 8	18.0	35.0	30.0	18.0	69.0	47.0	72.0	72.0

PERIOD	DELAYED VEH-SB	DELAYED VEH-NB	DELAYED VEH-WB	DELAYED VEH-EB	VOLUME SB	VOLUME NB	VOLUME WB	VOLUME EB
A 1	10.0	34.0	36.0	43.0	69.0	29.0	107.0	96.0
A 2	1.0	24.0	15.0	16.0	65.0	27.0	73.0	62.0
A 3	8.0	49.0	23.0	35.0	70.0	33.0	81.0	88.0
A 4	16.0	43.0	28.0	41.0	79.0	34.0	61.0	99.0
A 5	11.0	30.0	24.0	23.0	74.0	37.0	62.0	75.0
A 6	22.0	21.0	15.0	25.0	55.0	34.0	60.0	71.0
A 7	13.0	27.0	44.0	27.0	76.0	34.0	64.0	116.0
A 8	11.0	25.0	16.0	16.0	56.0	46.0	57.0	65.0

AVERAGE DELAY PER APPROACHING VEHICLE

PERIOD	DVSBB	DVSBA	DVNBB	DVNBA	DVWBB	DVWBA	DVEBB	DVEBA	TDVB	TDVA
1	1.99	2.17	18.87	17.59	7.11	5.05	5.72	6.72	6.72	6.13
2	2.68	.23	16.88	13.33	8.50	3.08	5.00	3.87	6.26	3.70
3	4.29	1.71	27.50	22.27	6.43	4.26	4.76	5.97	7.88	6.34
4	3.10	3.04	16.63	18.97	7.29	6.89	2.87	6.21	6.11	7.03
5	4.77	2.23	12.66	12.16	7.26	5.81	3.32	4.60	5.82	5.32
6	2.96	6.00	15.41	9.26	3.62	3.75	4.60	5.28	5.49	5.66
7	5.14	2.57	12.81	11.91	7.66	10.31	3.46	3.49	6.91	5.74
8	3.91	2.95	11.17	8.15	6.25	4.21	3.75	3.69	5.83	4.55

BUS84Y:US 84 AND SH 317;10/12/78;0730-0830

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	4.0	4.0	17.0	9.0	*****	*****	*****	*****
B 2	5.0	8.0	8.0	13.0	*****	*****	*****	*****
B 3	4.0	7.0	11.0	14.0	*****	*****	*****	*****
B 4	5.0	11.0	2.0	6.0	*****	*****	*****	*****
B 5	2.0	4.0	3.0	6.0	*****	*****	*****	*****
B 6	1.0	5.0	10.0	4.0	*****	*****	*****	*****
B 7	5.0	3.0	6.0	7.0	*****	*****	*****	*****
B 8	4.0	6.0	9.0	14.0	*****	*****	*****	*****
B 9	2.0	2.0	0.0	3.0	*****	*****	*****	*****
B 10	5.0	4.0	5.0	5.0	*****	*****	*****	*****
B 11	7.0	2.0	3.0	6.0	*****	*****	*****	*****
B 12	7.0	6.0	6.0	13.0	*****	*****	*****	*****
			HOURLY	VOLUME=	196.0	216.0	262.0	237.0

AUS84Y:US84 AND SH317;10/11/79;0730-0830

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	3.0	3.0	14.0	7.0	*****	*****	*****	*****
A 2	8.0	4.0	13.0	11.0	*****	*****	*****	*****
A 3	3.0	2.0	13.0	19.0	*****	*****	*****	*****
A 4	2.0	3.0	2.0	7.0	*****	*****	*****	*****
A 5	2.0	2.0	6.0	5.0	*****	*****	*****	*****
A 6	7.0	8.0	5.0	11.0	*****	*****	*****	*****
A 7	0.0	4.0	6.0	5.0	*****	*****	*****	*****
A 8	8.0	6.0	13.0	4.0	*****	*****	*****	*****
A 9	5.0	10.0	3.0	1.0	*****	*****	*****	*****
A 10	9.0	7.0	1.0	6.0	*****	*****	*****	*****
A 11	4.0	2.0	8.0	3.0	*****	*****	*****	*****
A 12	4.0	1.0	7.0	3.0	*****	*****	*****	*****
			HOURLY	VOLUME=	177.0	192.0	270.0	199.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	60.0	45.0	60.0	45.0	255.0	210.0	135.0	105.0
2	75.0	120.0	120.0	60.0	120.0	195.0	195.0	165.0
3	60.0	45.0	105.0	30.0	165.0	195.0	210.0	285.0
4	75.0	30.0	165.0	45.0	30.0	30.0	90.0	105.0
5	30.0	30.0	60.0	30.0	45.0	90.0	90.0	75.0
6	15.0	105.0	75.0	120.0	150.0	75.0	60.0	165.0
7	75.0	0.0	45.0	60.0	90.0	90.0	105.0	75.0
8	60.0	120.0	90.0	90.0	135.0	195.0	210.0	60.0
9	30.0	75.0	30.0	150.0	0.0	45.0	45.0	15.0
10	75.0	135.0	60.0	105.0	75.0	15.0	75.0	90.0
11	105.0	60.0	30.0	30.0	45.0	120.0	90.0	45.0
12	105.0	60.0	90.0	15.0	90.0	105.0	195.0	45.0

* REPRESENTS DATA NOT AVAILABLE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BUS84W;US 84 AND SH317;10/12/78;0930 -1030

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	2.0	2.0	2.0	10.0	*****	*****	*****	*****
B 2	3.0	5.0	8.0	7.0	*****	*****	*****	*****
B 3	4.0	1.0	9.0	12.0	*****	*****	*****	*****
B 4	2.0	3.0	4.0	1.0	*****	*****	*****	*****
B 5	8.0	8.0	4.0	3.0	*****	*****	*****	*****
B 6	5.0	0.0	7.0	11.0	*****	*****	*****	*****
B 7	6.0	5.0	3.0	1.0	*****	*****	*****	*****
B 8	5.0	9.0	2.0	7.0	*****	*****	*****	*****
B 9	9.0	5.0	8.0	2.0	*****	*****	*****	*****
B 10	2.0	8.0	5.0	8.0	*****	*****	*****	*****
B 11	10.0	4.0	5.0	8.0	*****	*****	*****	*****
B 12	7.0	5.0	10.0	1.0	*****	*****	*****	*****
			HOURLY	VOLUME=	170.0	111.0	221.0	163.0

AUS84W;US 84 AND SH317,10/11/79,0930-1030

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	7.0	0.0	4.0	5.0	*****	*****	*****	*****
A 2	6.0	1.0	3.0	4.0	*****	*****	*****	*****
A 3	12.0	0.0	7.0	3.0	*****	*****	*****	*****
A 4	8.0	3.0	4.0	6.0	*****	*****	*****	*****
A 5	4.0	1.0	4.0	6.0	*****	*****	*****	*****
A 6	2.0	1.0	7.0	6.0	*****	*****	*****	*****
A 7	10.0	2.0	5.0	12.0	*****	*****	*****	*****
A 8	9.0	5.0	4.0	2.0	*****	*****	*****	*****
A 9	0.0	0.0	1.0	1.0	*****	*****	*****	*****
A 10	2.0	2.0	2.0	9.0	*****	*****	*****	*****
A 11	5.0	3.0	4.0	3.0	*****	*****	*****	*****
A 12	4.0	0.0	3.0	5.0	*****	*****	*****	*****
			HOURLY	VOLUME=	185.0	84.0	211.0	159.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	30.0	105.0	30.0	0.0	30.0	60.0	150.0	75.0
2	45.0	90.0	75.0	15.0	120.0	45.0	105.0	60.0
3	60.0	180.0	15.0	0.0	135.0	105.0	180.0	45.0
4	30.0	120.0	45.0	45.0	60.0	60.0	15.0	90.0
5	120.0	60.0	120.0	15.0	60.0	60.0	45.0	90.0
6	75.0	30.0	0.0	15.0	105.0	105.0	165.0	90.0
7	90.0	150.0	75.0	30.0	45.0	75.0	15.0	180.0
8	75.0	135.0	135.0	75.0	30.0	60.0	105.0	30.0
9	135.0	0.0	75.0	0.0	120.0	15.0	30.0	15.0
10	30.0	30.0	120.0	30.0	75.0	30.0	120.0	135.0
11	150.0	75.0	60.0	45.0	75.0	60.0	120.0	45.0
12	105.0	60.0	75.0	0.0	150.0	45.0	15.0	75.0

* REPRESENTS DATA NOT AVAILABLE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BUSB4S:US 80 AND SH 317:10/12/78:1630 -1730

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	12.0	11.0	5.0	10.0	*****	*****	*****	*****
B 2	8.0	5.0	13.0	12.0	*****	*****	*****	*****
B 3	13.0	4.0	8.0	25.0	*****	*****	*****	*****
B 4	8.0	4.0	12.0	14.0	*****	*****	*****	*****
B 5	18.0	9.0	8.0	7.0	*****	*****	*****	*****
B 6	21.0	4.0	8.0	14.0	*****	*****	*****	*****
B 7	21.0	8.0	10.0	6.0	*****	*****	*****	*****
B 8	7.0	12.0	13.0	21.0	*****	*****	*****	*****
B 9	12.0	4.0	9.0	19.0	*****	*****	*****	*****
B 10	5.0	9.0	13.0	16.0	*****	*****	*****	*****
B 11	9.0	4.0	16.0	23.0	*****	*****	*****	*****
B 12	16.0	2.0	7.0	23.0	*****	*****	*****	*****
			HOURLY VOLUME=		307.0	152.0	331.0	404.0

AUSB4T:US 80 AND SH317:10/11/79:1630-1730

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	8.0	3.0	17.0	-0.0	*****	*****	*****	*****
A 2	8.0	3.0	4.0	-0.0	*****	*****	*****	*****
A 3	7.0	5.0	9.0	-0.0	*****	*****	*****	*****
A 4	10.0	4.0	28.0	-0.0	*****	*****	*****	*****
A 5	12.0	6.0	3.0	-0.0	*****	*****	*****	*****
A 6	7.0	4.0	4.0	-0.0	*****	*****	*****	*****
A 7	11.0	13.0	18.0	-0.0	*****	*****	*****	*****
A 8	12.0	7.0	8.0	-0.0	*****	*****	*****	*****
A 9	16.0	5.0	16.0	-0.0	*****	*****	*****	*****
A 10	6.0	8.0	8.0	-0.0	*****	*****	*****	*****
A 11	5.0	4.0	5.0	-0.0	*****	*****	*****	*****
A 12	8.0	5.0	8.0	-0.0	*****	*****	*****	*****
			HOURLY VOLUME=		2870.0	1420.0	3460.0	3920.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	180.0	120.0	165.0	45.0	75.0	255.0	150.0	0.0
2	120.0	120.0	75.0	45.0	195.0	60.0	180.0	0.0
3	195.0	105.0	60.0	75.0	120.0	135.0	375.0	0.0
4	120.0	150.0	60.0	60.0	180.0	420.0	210.0	0.0
5	270.0	180.0	135.0	90.0	120.0	45.0	105.0	0.0
6	315.0	105.0	60.0	60.0	120.0	60.0	210.0	0.0
7	315.0	165.0	120.0	195.0	150.0	270.0	90.0	0.0
8	105.0	180.0	180.0	105.0	195.0	120.0	315.0	0.0
9	180.0	240.0	60.0	75.0	135.0	240.0	285.0	0.0
10	75.0	90.0	135.0	120.0	195.0	120.0	240.0	0.0
11	135.0	75.0	60.0	60.0	240.0	75.0	345.0	0.0
12	240.0	120.0	30.0	75.0	105.0	120.0	345.0	0.0

* REPRESENTS DATA NOT AVAILABLE
B REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BUS290Y;US200,FM1960;09/26/78;1400 -1500

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	69.0	97.0	75.0	86.0	*****	*****	*****	*****
B 2	59.0	115.0	114.0	52.0	*****	*****	*****	*****
B 3	64.0	107.0	59.0	47.0	*****	*****	*****	*****
B 4	27.0	69.0	53.0	102.0	*****	*****	*****	*****
B 5	65.0	77.0	64.0	54.0	*****	*****	*****	*****
B 6	0.0	73.0	123.0	0.0	*****	*****	*****	*****
B 7	60.0	0.0	0.0	155.0	*****	*****	*****	*****
B 8	49.0	65.0	149.0	48.0	*****	*****	*****	*****
B 9	57.0	71.0	99.0	39.0	*****	*****	*****	*****
B 10	23.0	66.0	97.0	121.0	*****	*****	*****	*****
B 11	123.0	43.0	118.0	87.0	*****	*****	*****	*****
B 12	113.0	64.0	159.0	47.0	*****	*****	*****	*****
			HOURLY VOLUME=		475.0	465.0	295.0	715.0

AUS290Y;US200,FM1960;10/18/79;1445-1545

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	70.0	50.0	52.0	74.0	*****	*****	*****	*****
A 2	62.0	70.0	69.0	63.0	*****	*****	*****	*****
A 3	46.0	184.0	71.0	55.0	*****	*****	*****	*****
A 4	42.0	76.0	74.0	47.0	*****	*****	*****	*****
A 5	86.0	87.0	67.0	50.0	*****	*****	*****	*****
A 6	84.0	96.0	70.0	69.0	*****	*****	*****	*****
A 7	91.0	176.0	79.0	43.0	*****	*****	*****	*****
A 8	49.0	89.0	71.0	63.0	*****	*****	*****	*****
A 9	51.0	81.0	80.0	20.0	*****	*****	*****	*****
A 10	129.0	73.0	70.0	79.0	*****	*****	*****	*****
A 11	59.0	90.0	74.0	69.0	*****	*****	*****	*****
A 12	120.0	93.0	103.0	88.0	*****	*****	*****	*****
			HOURLY VOLUME=		475.0	465.0	295.0	715.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	1035.0	1185.0	1455.0	750.0	1125.0	780.0	1290.0	1110.0
2	885.0	930.0	1725.0	1050.0	1710.0	1035.0	780.0	945.0
3	960.0	600.0	1005.0	2760.0	885.0	1065.0	705.0	825.0
4	425.0	630.0	1035.0	1140.0	795.0	1110.0	1530.0	705.0
5	975.0	1290.0	1155.0	1305.0	960.0	1005.0	810.0	750.0
6	0.0	1260.0	1095.0	1400.0	1845.0	1050.0	0.0	1035.0
7	900.0	1365.0	0.0	2640.0	0.0	1185.0	2325.0	645.0
8	735.0	735.0	975.0	1335.0	2235.0	1065.0	720.0	945.0
9	855.0	765.0	1065.0	1215.0	1485.0	1200.0	585.0	300.0
10	345.0	1935.0	990.0	1095.0	1455.0	1050.0	1815.0	1185.0
11	1845.0	885.0	645.0	1350.0	1770.0	1110.0	1305.0	1035.0
12	1695.0	1800.0	960.0	1395.0	2385.0	1545.0	705.0	1320.0

* REPRESENTS DATA NOT AVAILBLE
0 REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BUS290X;US290;FM1960;09/27/78;0900 -1030

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	18.0	*****	*****	86.0	*****	*****	*****	*****
B 2	46.0	*****	*****	27.0	*****	*****	*****	*****
B 3	25.0	*****	*****	118.0	*****	*****	*****	*****
B 4	38.0	*****	*****	17.0	*****	*****	*****	*****
B 5	24.0	*****	*****	125.0	*****	*****	*****	*****
B 6	24.0	*****	*****	49.0	*****	*****	*****	*****
B 7	38.0	*****	*****	81.0	*****	*****	*****	*****
B 8	21.0	*****	*****	72.0	*****	*****	*****	*****
B 9	32.0	*****	*****	83.0	*****	*****	*****	*****
B 10	35.0	*****	*****	35.0	*****	*****	*****	*****
B 11	55.0	*****	*****	55.0	*****	*****	*****	*****
B 12	7.0	*****	*****	47.0	*****	*****	*****	*****
B 13	18.0	*****	*****	47.0	*****	*****	*****	*****
B 14	40.0	*****	*****	66.0	*****	*****	*****	*****
B 15	50.0	*****	*****	39.0	*****	*****	*****	*****
B 16	20.0	*****	*****	74.0	*****	*****	*****	*****
B 17	27.0	*****	*****	27.0	*****	*****	*****	*****
B 18	28.0	*****	*****	24.0	*****	*****	*****	*****
			HOURLY VOLUME=		605.0	630.0	535.0	810.0

AUS290X;US290;FM 1960;10/31/79;0900 - 1030

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	34.0	65.0	78.0	89.0	*****	*****	*****	*****
A 2	37.0	79.0	38.0	85.0	*****	*****	*****	*****
A 3	33.0	32.0	136.0	52.0	*****	*****	*****	*****
A 4	55.0	57.0	94.0	49.0	*****	*****	*****	*****
A 5	55.0	83.0	65.0	18.0	*****	*****	*****	*****
A 6	31.0	98.0	60.0	40.0	*****	*****	*****	*****
A 7	46.0	51.0	94.0	60.0	*****	*****	*****	*****
A 8	31.0	57.0	100.0	96.0	*****	*****	*****	*****
A 9	80.0	50.0	96.0	119.0	*****	*****	*****	*****
A 10	27.0	67.0	65.0	43.0	*****	*****	*****	*****
A 11	26.0	66.0	92.0	94.0	*****	*****	*****	*****
A 12	24.0	63.0	80.0	76.0	*****	*****	*****	*****
A 13	30.0	62.0	52.0	45.0	*****	*****	*****	*****
A 14	22.0	57.0	105.0	61.0	*****	*****	*****	*****
A 15	33.0	50.0	53.0	55.0	*****	*****	*****	*****
A 16	45.0	70.0	98.0	147.0	*****	*****	*****	*****
A 17	35.0	49.0	116.0	65.0	*****	*****	*****	*****
A 18	42.0	45.0	85.0	33.0	*****	*****	*****	*****
			HOURLY VOLUME=		605.0	630.0	535.0	810.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	270.0	510.0	0.0	975.0	0.0	1170.0	1290.0	1335.0
2	690.0	555.0	0.0	1185.0	0.0	570.0	405.0	1275.0
3	375.0	405.0	0.0	480.0	0.0	2040.0	1770.0	780.0
4	570.0	825.0	0.0	855.0	0.0	1410.0	255.0	735.0
5	360.0	825.0	0.0	1245.0	0.0	975.0	1875.0	270.0
6	360.0	465.0	0.0	1470.0	0.0	900.0	735.0	600.0
7	570.0	690.0	0.0	765.0	0.0	1410.0	1215.0	900.0
8	315.0	465.0	0.0	855.0	0.0	1500.0	1080.0	1440.0
9	480.0	1200.0	0.0	750.0	0.0	1440.0	1245.0	1785.0
10	525.0	405.0	0.0	1095.0	0.0	975.0	525.0	645.0
11	825.0	390.0	0.0	990.0	0.0	1380.0	825.0	1410.0
12	195.0	360.0	0.0	945.0	0.0	1200.0	705.0	1140.0
13	270.0	450.0	0.0	930.0	0.0	780.0	705.0	675.0
14	600.0	330.0	0.0	855.0	0.0	1575.0	990.0	915.0
15	750.0	495.0	0.0	750.0	0.0	795.0	585.0	825.0
16	360.0	675.0	0.0	1110.0	0.0	1470.0	1110.0	2275.0
17	405.0	525.0	0.0	735.0	0.0	1740.0	405.0	975.0
18	420.0	630.0	0.0	675.0	0.0	1275.0	360.0	495.0

* REPRESENTS DATA NOT AVAILBLE
P REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BSH6JX:SH6 AND JACKSON:08/02/78:0715 -0815

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	9.0	23.0	10.0	0.0	*****	*****	*****	*****
B 2	7.0	11.0	7.0	0.0	*****	*****	*****	*****
B 3	3.0	2.0	11.0	3.0	*****	*****	*****	*****
B 4	8.0	10.0	9.0	0.0	*****	*****	*****	*****
B 5	2.0	8.0	8.0	0.0	*****	*****	*****	*****
B 6	4.0	8.0	8.0	3.0	*****	*****	*****	*****
B 7	9.0	2.0	6.0	6.0	*****	*****	*****	*****
B 8	17.0	4.0	13.0	2.0	*****	*****	*****	*****
B 9	2.0	7.0	2.0	0.0	*****	*****	*****	*****
B 10	7.0	6.0	8.0	0.0	*****	*****	*****	*****
B 11	3.0	3.0	1.0	6.0	*****	*****	*****	*****
B 12	0.0	13.0	3.0	0.0	*****	*****	*****	*****
			HOURLY VOLUME=		280.0	485.0	110.0	15.0

ASH6JX:SH6 AND JACKSON:10/24/79:0715 -0815

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	7.0	1.0	19.[illegible]	14.[illegible]	*****	*****	*****	*****
A 2	21.0	0.0	16.0	12.0	*****	*****	*****	*****
A 3	6.0	0.0	10.0	3.0	*****	*****	*****	*****
A 4	15.0	2.0	5.0	11.0	*****	*****	*****	*****
A 5	8.0	0.0	14.0	13.0	*****	*****	*****	*****
A 6	0.0	0.0	6.0	12.0	*****	*****	*****	*****
A 7	3.0	0.0	10.0	14.0	*****	*****	*****	*****
A 8	4.0	0.0	9.0	9.0	*****	*****	*****	*****
A 9	2.0	1.0	1.0	3.0	*****	*****	*****	*****
A 10	8.0	1.0	6.0	12.0	*****	*****	*****	*****
A 11	4.0	1.0	3.0	5.0	*****	*****	*****	*****
A 12	1.0	0.0	2.0	1.0	*****	*****	*****	*****
			HOURLY VOLUME=		145.0	[illegible]	[illegible]	[illegible]

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	135.0	105.0	345.0	15.0	150.0	285.0	0.0	210.0
2	105.0	315.0	165.0	0.0	105.0	240.0	0.0	180.0
3	45.0	90.0	30.0	0.0	165.0	150.0	45.0	45.0
4	120.0	225.0	150.0	30.0	135.0	75.0	0.0	165.0
5	30.0	120.0	120.0	0.0	120.0	210.0	0.0	195.0
6	60.0	0.0	120.0	0.0	120.0	90.0	45.0	180.0
7	135.0	45.0	30.0	0.0	90.0	150.0	90.0	210.0
8	255.0	60.0	60.0	0.0	195.0	135.0	30.0	135.0
9	30.0	30.0	105.0	15.0	30.0	15.0	0.0	45.0
10	105.0	120.0	90.0	15.0	120.0	90.0	0.0	180.0
11	45.0	60.0	45.0	15.0	15.0	45.0	90.0	75.0
12	60.0	15.0	195.0	0.0	45.0	30.0	0.0	15.0

* REPRESENTS DATA NOT AVAILBLE
R REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BSH6JT:SH6 AND JACKSON:07/31/78:1630 -1730

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	41.0	12.0	14.0	11.0	*****	*****	*****	*****
B 2	31.0	16.0	10.0	14.0	*****	*****	*****	*****
B 3	81.0	21.0	14.0	0.0	*****	*****	*****	*****
B 4	92.0	28.0	21.0	5.0	*****	*****	*****	*****
B 5	26.0	24.0	16.0	6.0	*****	*****	*****	*****
B 6	72.0	14.0	28.0	4.0	*****	*****	*****	*****
B 7	29.0	7.0	14.0	4.0	*****	*****	*****	*****
B 8	38.0	9.0	21.0	8.0	*****	*****	*****	*****
B 9	51.0	11.0	19.0	11.0	*****	*****	*****	*****
B 10	88.0	9.0	7.0	0.0	*****	*****	*****	*****
B 11	66.0	16.0	16.0	8.0	*****	*****	*****	*****
B 12	23.0	13.0	15.0	3.0	*****	*****	*****	*****
			HOURLY	VOLUME=	645.0	460.0	125.0	20.0

ASH6JT:SH6 AND JACKSON:10/22/79 :1630-1730

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	7.0	5.0	12.0	18.0	*****	*****	*****	*****
A 2	8.0	4.0	19.0	21.0	*****	*****	*****	*****
A 3	17.0	4.0	3.0	21.0	*****	*****	*****	*****
A 4	5.0	6.0	9.0	4.0	*****	*****	*****	*****
A 5	12.0	0.0	2.0	13.0	*****	*****	*****	*****
A 6	8.0	1.0	5.0	8.0	*****	*****	*****	*****
A 7	4.0	1.0	8.0	25.0	*****	*****	*****	*****
A 8	7.0	0.0	14.0	40.0	*****	*****	*****	*****
A 9	5.0	4.0	20.0	18.0	*****	*****	*****	*****
A 10	15.0	1.0	10.0	22.0	*****	*****	*****	*****
A 11	7.0	0.0	10.0	7.0	*****	*****	*****	*****
A 12	5.0	1.0	9.0	19.0	*****	*****	*****	*****
			HOURLY	VOLUME=	110.0	35.0	565.0	625.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	615.0	105.0	180.0	75.0	210.0	180.0	165.0	270.0
2	465.0	120.0	240.0	60.0	150.0	285.0	210.0	315.0
3	1215.0	255.0	315.0	60.0	210.0	45.0	0.0	315.0
4	1380.0	75.0	420.0	90.0	315.0	135.0	75.0	60.0
5	390.0	180.0	360.0	0.0	240.0	30.0	90.0	195.0
6	1080.0	120.0	210.0	15.0	420.0	75.0	60.0	120.0
7	435.0	60.0	105.0	15.0	210.0	120.0	60.0	375.0
8	570.0	105.0	135.0	0.0	315.0	210.0	120.0	600.0
9	765.0	75.0	165.0	60.0	285.0	300.0	165.0	270.0
10	1320.0	225.0	135.0	15.0	105.0	150.0	0.0	330.0
11	990.0	105.0	240.0	0.0	240.0	150.0	120.0	105.0
12	345.0	75.0	195.0	15.0	225.0	135.0	45.0	285.0

* REPRESENTS DATA NOT AVAILBLE
B REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BSH6J7:SH6 AND JACKSON:07/31/78:1430 -1530

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	8.0	5.0	10.0	6.0	*****	*****	*****	*****
B 2	20.0	12.0	5.0	20.0	*****	*****	*****	*****
B 3	6.0	7.0	5.0	6.0	*****	*****	*****	*****
B 4	3.0	11.0	6.0	1.0	*****	*****	*****	*****
B 5	4.0	5.0	2.0	4.0	*****	*****	*****	*****
B 6	2.0	8.0	6.0	0.0	*****	*****	*****	*****
B 7	6.0	9.0	0.0	0.0	*****	*****	*****	*****
B 8	17.0	18.0	19.0	1.0	*****	*****	*****	*****
B 9	31.0	4.0	16.0	1.0	*****	*****	*****	*****
B 10	34.0	9.0	9.0	4.0	*****	*****	*****	*****
B 11	71.0	11.0	16.0	0.0	*****	*****	*****	*****
B 12	38.0	10.0	13.0	0.0	*****	*****	*****	*****
			HOURLY	VOLUME=	360.0	410.0	110.0	15.0

ASH6J7:SH6 AND JACKSON:10/22/79:1430-1530

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	7.0	1.0	11.0	20.0	*****	*****	*****	*****
A 2	12.0	1.0	15.0	26.0	*****	*****	*****	*****
A 3	5.0	0.0	0.0	5.0	*****	*****	*****	*****
A 4	9.0	0.0	8.0	10.0	*****	*****	*****	*****
A 5	6.0	0.0	4.0	9.0	*****	*****	*****	*****
A 6	4.0	2.0	4.0	7.0	*****	*****	*****	*****
A 7	6.0	6.0	5.0	7.0	*****	*****	*****	*****
A 8	6.0	13.0	11.0	16.0	*****	*****	*****	*****
A 9	7.0	4.0	14.0	18.0	*****	*****	*****	*****
A 10	12.0	14.0	12.0	16.0	*****	*****	*****	*****
A 11	4.0	0.0	6.0	18.0	*****	*****	*****	*****
A 12	9.0	1.0	3.0	20.0	*****	*****	*****	*****
			HOURLY	VOLUME=	125.0	35.0	430.0	410.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	120.0	105.0	75.0	15.0	150.0	165.0	90.0	300.0
2	300.0	180.0	180.0	15.0	75.0	225.0	300.0	390.0
3	90.0	75.0	105.0	0.0	75.0	0.0	90.0	75.0
4	45.0	135.0	165.0	0.0	90.0	120.0	15.0	150.0
5	60.0	90.0	75.0	0.0	30.0	60.0	60.0	135.0
6	30.0	60.0	120.0	30.0	90.0	60.0	0.0	105.0
7	90.0	90.0	135.0	90.0	0.0	75.0	0.0	105.0
8	255.0	90.0	270.0	195.0	285.0	165.0	15.0	240.0
9	465.0	105.0	60.0	60.0	240.0	210.0	15.0	270.0
10	510.0	180.0	135.0	210.0	135.0	180.0	60.0	240.0
11	1065.0	60.0	165.0	0.0	240.0	90.0	0.0	270.0
12	570.0	135.0	285.0	15.0	195.0	45.0	0.0	300.0

* REPRESENTS DATA NOT AVAILBLE
R REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

SH146 AND CREST LN.08/07/78-10/29/79,1545-1645

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	25.0	17.0	1.0	7.0	*****	*****	*****	*****
B 2	39.0	49.0	8.0	16.0	*****	*****	*****	*****
B 3	36.0	21.0	1.0	5.0	*****	*****	*****	*****
B 4	37.0	53.0	9.0	24.0	*****	*****	*****	*****
B 5	20.0	43.0	0.0	11.0	*****	*****	*****	*****
B 6	34.0	63.0	3.0	8.0	*****	*****	*****	*****
B 7	55.0	71.0	18.0	22.0	*****	*****	*****	*****
B 8	44.0	76.0	2.0	10.0	*****	*****	*****	*****
B 9	44.0	109.0	7.0	7.0	*****	*****	*****	*****
B 10	35.0	99.0	7.0	13.0	*****	*****	*****	*****
B 11	34.0	65.0	2.0	11.0	*****	*****	*****	*****
B 12	45.0	105.0	5.0	10.0	*****	*****	*****	*****
			HOURLY VOLUME=		830.0	935.0	55.0	130.0

ASH146S:SH146 AND CREST LN. 10/29/79

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	49.0	66.0	8.0	15.0	*****	*****	*****	*****
A 2	27.0	78.0	11.0	15.0	*****	*****	*****	*****
A 3	25.0	72.0	16.0	14.0	*****	*****	*****	*****
A 4	26.0	105.0	15.0	15.0	*****	*****	*****	*****
A 5	28.0	116.0	9.0	22.0	*****	*****	*****	*****
A 6	38.0	68.0	7.0	27.0	*****	*****	*****	*****
A 7	28.0	116.0	16.0	17.0	*****	*****	*****	*****
A 8	24.0	83.0	14.0	11.0	*****	*****	*****	*****
A 9	15.0	91.0	9.0	15.0	*****	*****	*****	*****
A 10	19.0	39.0	1.0	10.0	*****	*****	*****	*****
A 11	39.0	90.0	9.0	11.0	*****	*****	*****	*****
A 12	43.0	51.0	2.0	25.0	*****	*****	*****	*****
			HOURLY VOLUME=		780.0	1455.0	65.0	285.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	375.0	735.0	255.0	990.0	15.0	120.0	105.0	225.0
2	585.0	405.0	735.0	1170.0	120.0	165.0	240.0	225.0
3	540.0	375.0	315.0	1080.0	15.0	240.0	75.0	210.0
4	555.0	390.0	795.0	1575.0	135.0	225.0	360.0	225.0
5	300.0	420.0	645.0	1740.0	0.0	135.0	165.0	330.0
6	510.0	570.0	945.0	1020.0	45.0	105.0	120.0	405.0
7	825.0	420.0	1065.0	1740.0	270.0	240.0	330.0	255.0
8	660.0	360.0	1140.0	1245.0	30.0	210.0	150.0	165.0
9	660.0	225.0	1635.0	1365.0	105.0	135.0	105.0	225.0
10	525.0	285.0	1485.0	585.0	105.0	15.0	195.0	150.0
11	510.0	585.0	975.0	1350.0	30.0	135.0	165.0	165.0
12	675.0	645.0	1575.0	765.0	75.0	30.0	150.0	375.0

* REPRESENTS DATA NOT AVAILABLE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BSH146Y:SH146 AND CREST LN.:08/10/78:0700 - 0800

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	43.0	8.0	2.0	11.0	*****	*****	*****	*****
B 2	51.0	16.0	5.0	14.0	*****	*****	*****	*****
B 3	74.0	40.0	8.0	25.0	*****	*****	*****	*****
B 4	50.0	27.0	8.0	13.0	*****	*****	*****	*****
B 5	67.0	21.0	6.0	11.0	*****	*****	*****	*****
B 6	38.0	21.0	0.0	7.0	*****	*****	*****	*****
B 7	138.0	46.0	6.0	9.0	*****	*****	*****	*****
B 8	59.0	28.0	3.0	19.0	*****	*****	*****	*****
B 9	39.0	25.0	2.0	8.0	*****	*****	*****	*****
B 10	19.0	3.0	7.0	4.0	*****	*****	*****	*****
B 11	30.0	18.0	1.0	3.0	*****	*****	*****	*****
B 12	16.0	26.0	3.0	3.0	*****	*****	*****	*****
			HOURLY	VOLUME=	1250.0	780.0	65.0	105.0

ASH146Y:SH146 AND CREST LN.:11/01/79:0700 -0800

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	62.0	53.0	6.0	32.0	*****	*****	*****	*****
A 2	32.0	51.0	17.0	27.0	*****	*****	*****	*****
A 3	34.0	50.0	12.0	6.0	*****	*****	*****	*****
A 4	39.0	67.0	16.0	15.0	*****	*****	*****	*****
A 5	57.0	49.0	7.0	13.0	*****	*****	*****	*****
A 6	55.0	110.0	17.0	9.0	*****	*****	*****	*****
A 7	63.0	102.0	11.0	7.0	*****	*****	*****	*****
A 8	79.0	72.0	11.0	10.0	*****	*****	*****	*****
A 9	53.0	138.0	8.0	9.0	*****	*****	*****	*****
A 10	56.0	71.0	25.0	14.0	*****	*****	*****	*****
A 11	52.0	47.0	10.0	4.0	*****	*****	*****	*****
A 12	55.0	78.0	7.0	10.0	*****	*****	*****	*****
			HOURLY	VOLUME=	1020.0	555.0	100.0	160.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	645.0	930.0	120.0	795.0	30.0	90.0	165.0	480.0
2	765.0	480.0	240.0	765.0	75.0	255.0	210.0	405.0
3	1110.0	510.0	600.0	750.0	120.0	180.0	375.0	90.0
4	750.0	585.0	405.0	1005.0	120.0	240.0	195.0	225.0
5	1005.0	855.0	315.0	735.0	90.0	105.0	165.0	195.0
6	570.0	825.0	315.0	1710.0	0.0	255.0	105.0	135.0
7	2070.0	945.0	690.0	1530.0	90.0	165.0	135.0	105.0
8	885.0	1185.0	420.0	1080.0	45.0	165.0	285.0	150.0
9	585.0	795.0	375.0	2070.0	30.0	120.0	120.0	135.0
10	285.0	840.0	45.0	1065.0	135.0	375.0	60.0	210.0
11	450.0	780.0	270.0	705.0	15.0	150.0	45.0	60.0
12	240.0	825.0	390.0	1170.0	45.0	105.0	45.0	150.0

* REPRESENTS DATA NOT AVAILABLE
8 REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

BSH146Z:SH146 AND CREST LN.:08/09/78:0900 - 1000

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	21.0	26.0	4.0	10.0	*****	*****	*****	*****
B 2	18.0	15.0	0.0	1.0	*****	*****	*****	*****
B 3	17.0	9.0	0.0	8.0	*****	*****	*****	*****
B 4	14.0	18.0	0.0	8.0	*****	*****	*****	*****
B 5	22.0	14.0	7.0	4.0	*****	*****	*****	*****
B 6	5.0	5.0	6.0	12.0	*****	*****	*****	*****
B 7	23.0	15.0	3.0	1.0	*****	*****	*****	*****
B 8	19.0	25.0	9.0	4.0	*****	*****	*****	*****
B 9	15.0	14.0	9.0	5.0	*****	*****	*****	*****
B 10	17.0	15.0	6.0	0.0	*****	*****	*****	*****
B 11	11.0	13.0	0.0	5.0	*****	*****	*****	*****
B 12	33.0	13.0	6.0	8.0	*****	*****	*****	*****
			HOURLY	VOLUME=	570.0	495.0	55.0	75.0

ASH146Z:SH146 AND CREST LN.:10/31/79:0900 - 1000

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	8.0	26.0	0.0	12.0	*****	*****	*****	*****
A 2	14.0	42.0	3.0	31.0	*****	*****	*****	*****
A 3	4.0	24.0	7.0	25.0	*****	*****	*****	*****
A 4	11.0	37.0	5.0	13.0	*****	*****	*****	*****
A 5	2.0	24.0	4.0	16.0	*****	*****	*****	*****
A 6	5.0	20.0	8.0	14.0	*****	*****	*****	*****
A 7	2.0	33.0	7.0	29.0	*****	*****	*****	*****
A 8	18.0	20.0	3.0	18.0	*****	*****	*****	*****
A 9	16.0	46.0	10.0	33.0	*****	*****	*****	*****
A 10	5.0	33.0	2.0	13.0	*****	*****	*****	*****
A 11	8.0	65.0	3.0	12.0	*****	*****	*****	*****
A 12	3.0	47.0	6.0	14.0	*****	*****	*****	*****
			HOURLY	VOLUME=	560.0	645.0	70.0	160.0

TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	315.0	120.0	390.0	390.0	60.0	0.0	150.0	180.0
2	270.0	210.0	225.0	630.0	0.0	45.0	15.0	465.0
3	255.0	60.0	135.0	360.0	0.0	105.0	120.0	375.0
4	210.0	165.0	270.0	555.0	0.0	75.0	120.0	195.0
5	330.0	30.0	210.0	360.0	105.0	60.0	60.0	240.0
6	75.0	75.0	75.0	300.0	90.0	120.0	180.0	210.0
7	345.0	30.0	225.0	495.0	45.0	105.0	15.0	435.0
8	285.0	270.0	375.0	300.0	135.0	45.0	60.0	270.0
9	225.0	240.0	210.0	690.0	135.0	150.0	75.0	495.0
10	255.0	75.0	225.0	495.0	90.0	30.0	0.0	195.0
11	165.0	120.0	195.0	975.0	0.0	45.0	75.0	180.0
12	495.0	45.0	195.0	705.0	90.0	90.0	120.0	210.0

* REPRESENTS DATA NOT AVAILBLE
R REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

SH146 AND CREST LN,08/07/78-10/29/79,1545-1645

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
B 1	25.0	17.0	1.0	7.0	*****	*****	*****	*****
B 2	39.0	49.0	8.0	16.0	*****	*****	*****	*****
B 3	36.0	21.0	1.0	5.0	*****	*****	*****	*****
B 4	37.0	53.0	9.0	24.0	*****	*****	*****	*****
B 5	20.0	43.0	0.0	11.0	*****	*****	*****	*****
B 6	34.0	63.0	3.0	8.0	*****	*****	*****	*****
B 7	55.0	71.0	18.0	22.0	*****	*****	*****	*****
B 8	44.0	76.0	2.0	10.0	*****	*****	*****	*****
B 9	44.0	109.0	7.0	7.0	*****	*****	*****	*****
B 10	35.0	99.0	7.0	13.0	*****	*****	*****	*****
B 11	34.0	65.0	2.0	11.0	*****	*****	*****	*****
B 12	45.0	105.0	5.0	10.0	*****	*****	*****	*****
			HOURLY	VOLUME=	830.0	935.0	55.0	130.0

PERIOD	DELAYED VEH-NB	DELAYED VEH-SB	DELAYED VEH-EB	DELAYED VEH-WB	VOLUME NB	VOLUME SB	VOLUME EB	VOLUME WB
A 1	49.0	66.0	8.0	15.0	*****	*****	*****	*****
A 2	27.0	78.0	11.0	15.0	*****	*****	*****	*****
A 3	25.0	72.0	16.0	14.0	*****	*****	*****	*****
A 4	26.0	105.0	15.0	15.0	*****	*****	*****	*****
A 5	28.0	116.0	9.0	22.0	*****	*****	*****	*****
A 6	38.0	68.0	7.0	27.0	*****	*****	*****	*****
A 7	28.0	116.0	16.0	17.0	*****	*****	*****	*****
A 8	24.0	83.0	14.0	11.0	*****	*****	*****	*****
A 9	15.0	91.0	9.0	15.0	*****	*****	*****	*****
A 10	19.0	39.0	1.0	10.0	*****	*****	*****	*****
A 11	39.0	90.0	9.0	11.0	*****	*****	*****	*****
A 12	43.0	51.0	2.0	25.0	*****	*****	*****	*****
			HOURLY	VOLUME=	780.0	1455.0	65.0	285.0

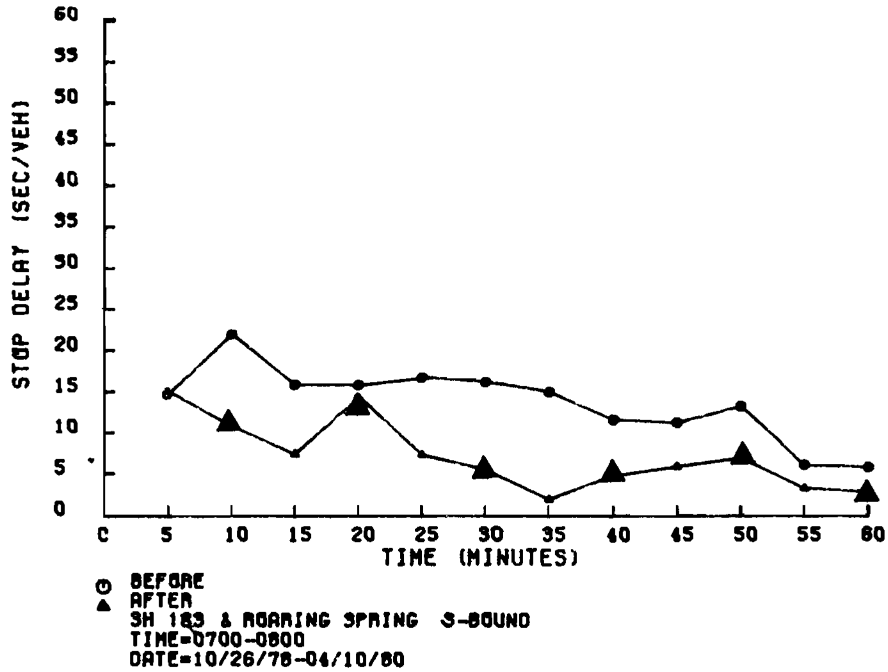
TOTAL DELAY FOR EACH APPROACH

PERIOD	TDNB	TDNA	TDSB	TDSA	TDEB	TDEA	TDB	TDA
1	375.0	735.0	255.0	990.0	15.0	120.0	105.0	225.0
2	585.0	405.0	735.0	1170.0	120.0	165.0	240.0	225.0
3	540.0	375.0	315.0	1080.0	15.0	240.0	75.0	210.0
4	555.0	390.0	795.0	1575.0	135.0	225.0	360.0	225.0
5	300.0	420.0	645.0	1740.0	0.0	135.0	165.0	330.0
6	510.0	570.0	945.0	1020.0	45.0	105.0	120.0	405.0
7	825.0	420.0	1065.0	1740.0	270.0	240.0	330.0	255.0
8	660.0	360.0	1140.0	1245.0	30.0	210.0	150.0	165.0
9	660.0	225.0	1635.0	1365.0	105.0	135.0	105.0	225.0
10	525.0	285.0	1485.0	585.0	105.0	15.0	195.0	150.0
11	510.0	585.0	975.0	1350.0	30.0	135.0	165.0	165.0
12	675.0	645.0	1575.0	765.0	75.0	30.0	150.0	375.0

* REPRESENTS DATA NOT AVAILABLE
P REPRESENTS INFINITE
TDNB=TOTAL DELAY FOR NORTH BOUND IN THE BEFORE STUDY
TDA=TOTAL DELAY FOR THE WHOLE INTERSECTION IN THE AFTER STUDY

APPENDIX F

GRAPHICAL PRESENTATION OF BEFORE AND AFTER DELAY STATISTICS (INCLUDES ONLY APPROACHES TO FIELD SITES RECEIVING MULTIPLE DETECTORS IN THE AFTER CONDITION AND SELECTED TIME PERIODS)



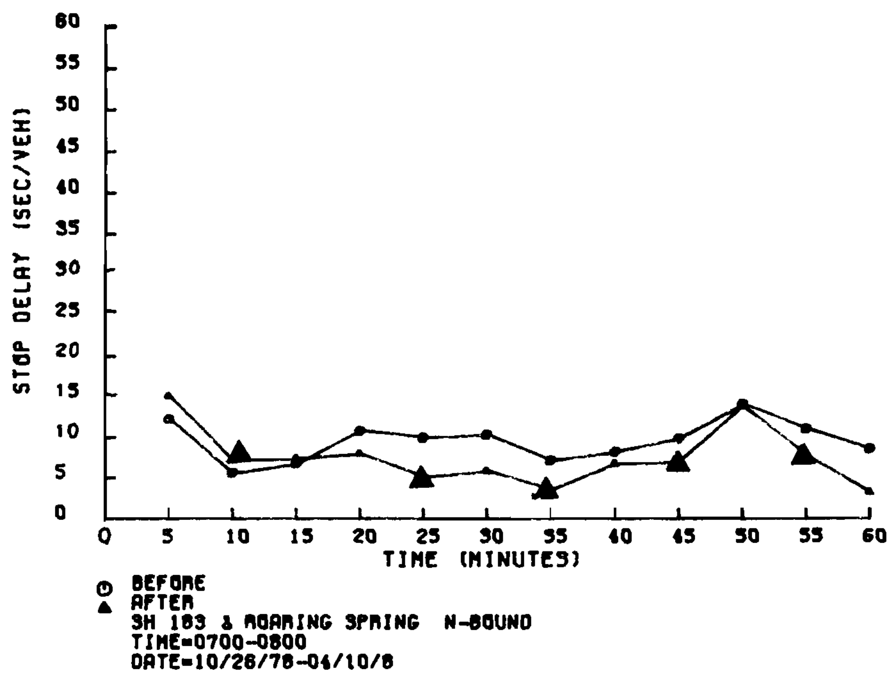
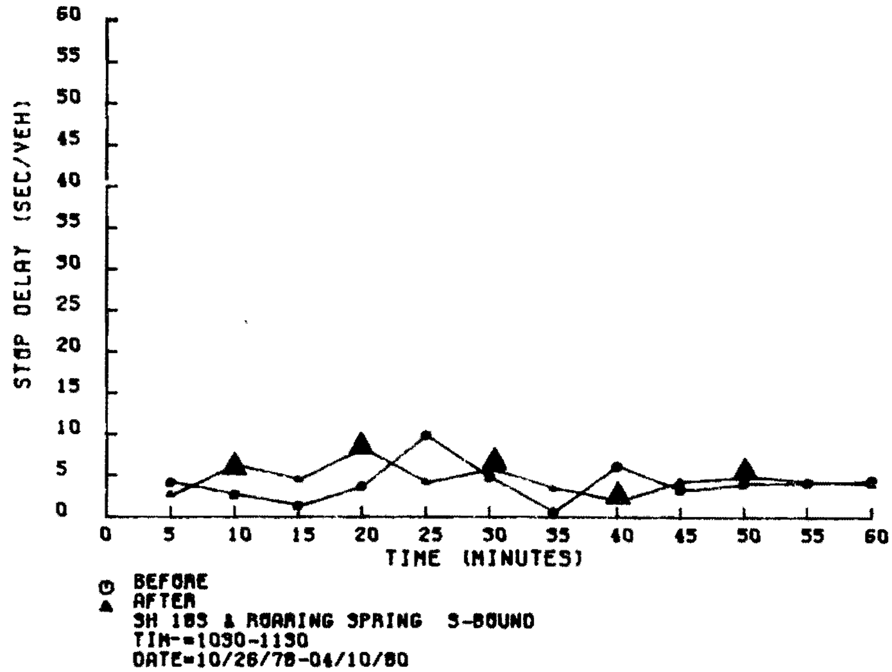


Fig F-1. Before and after delay statistics, SH 183 & Roaring Spring.



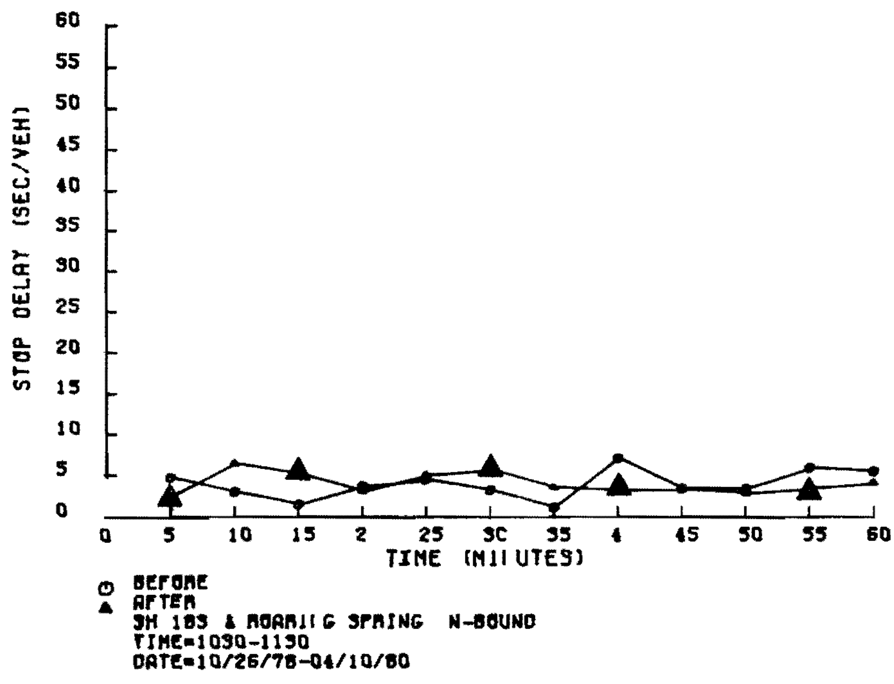
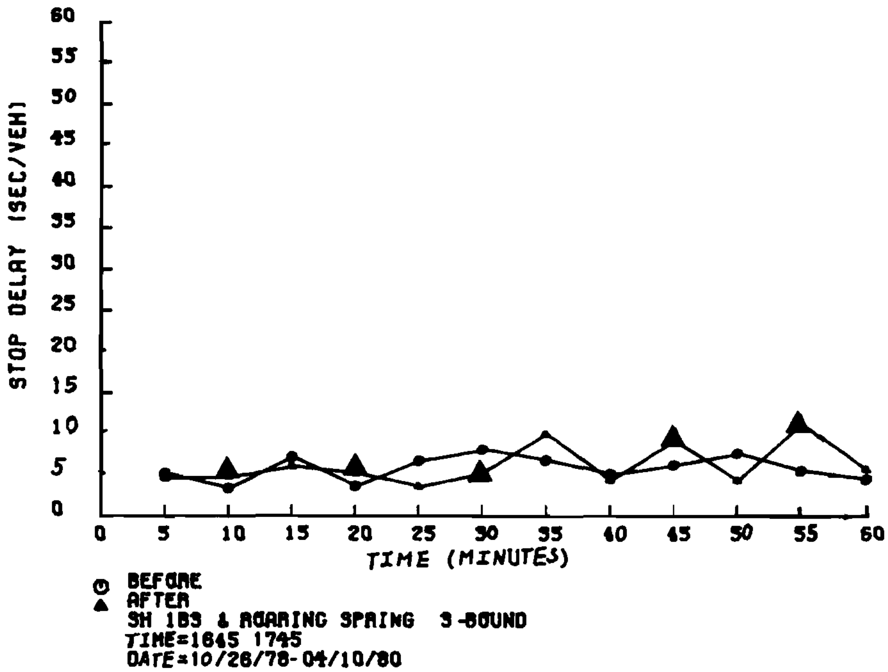


Fig F-2. Before and after delay statistics, SH 183 & Roaring Spring.



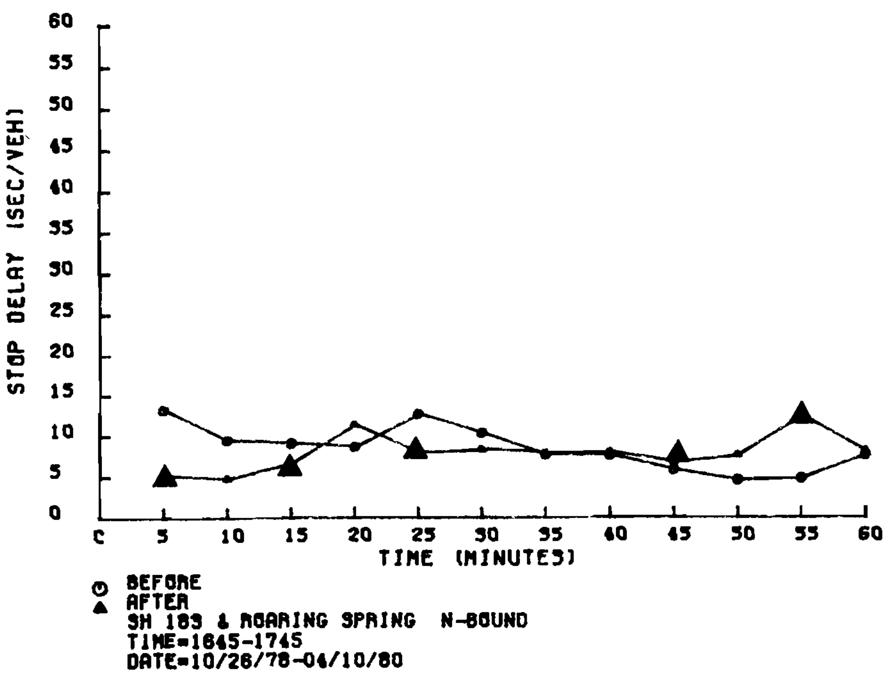
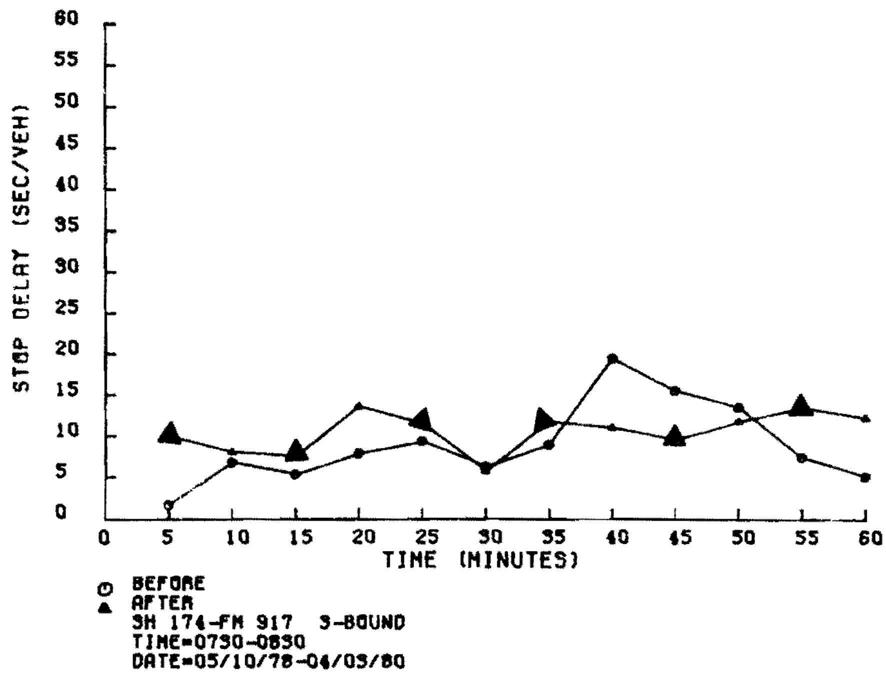


Fig F-3. Before and after delay statistics, SH 183 & Roaring Spring.



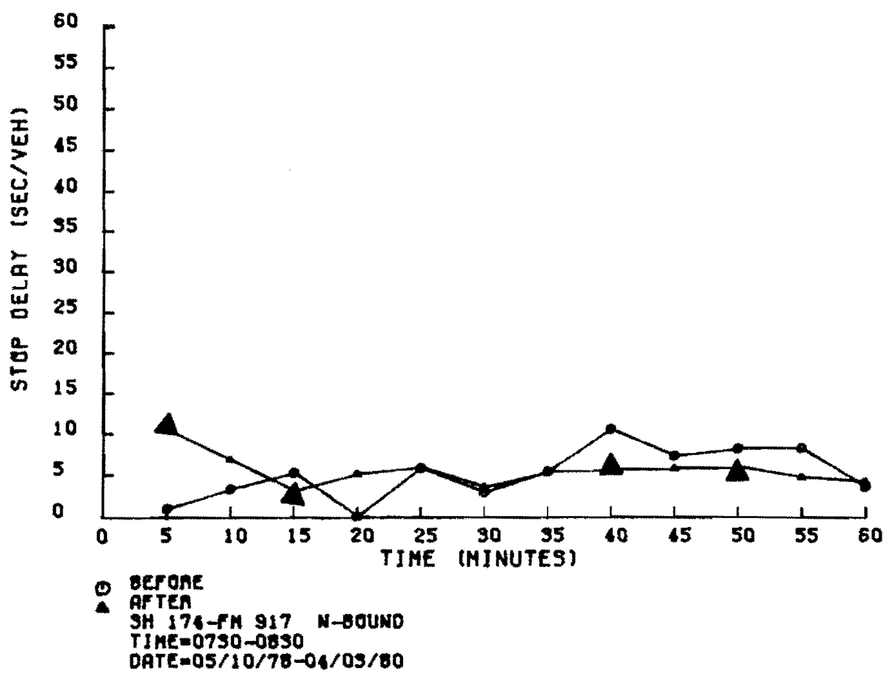
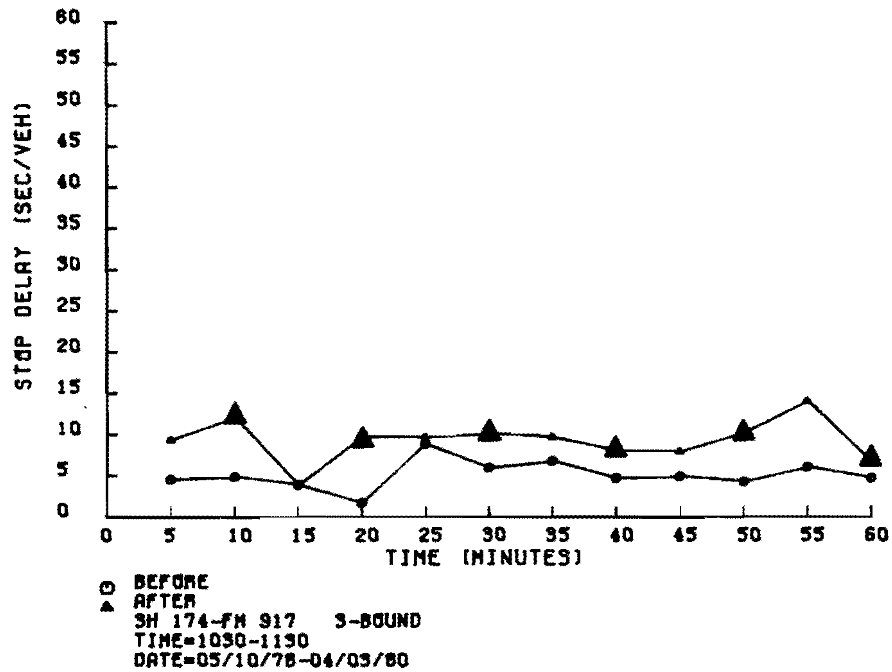


Fig F-4. Before and after delay statistics, SH 174-FM 917.



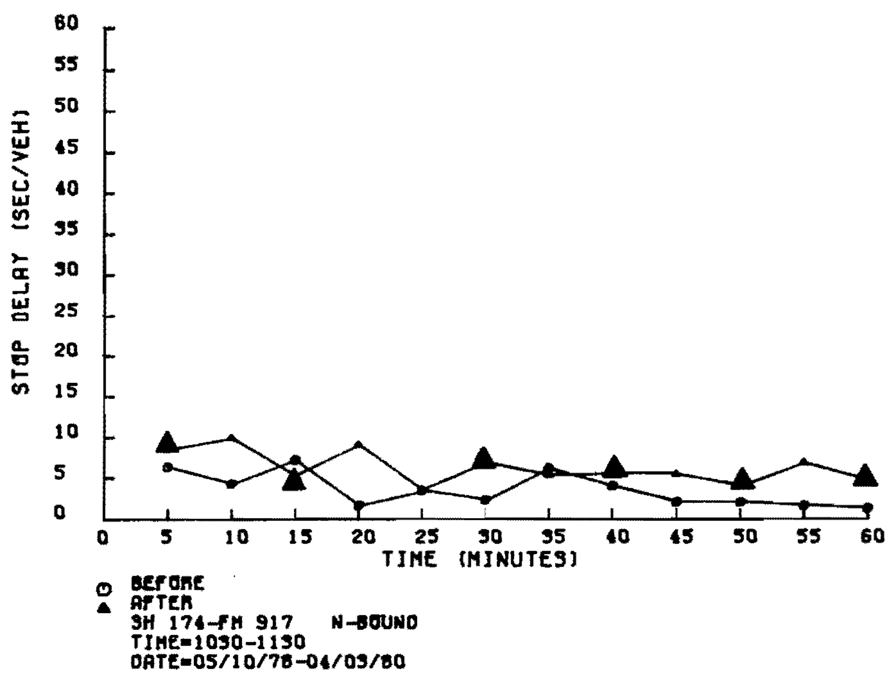
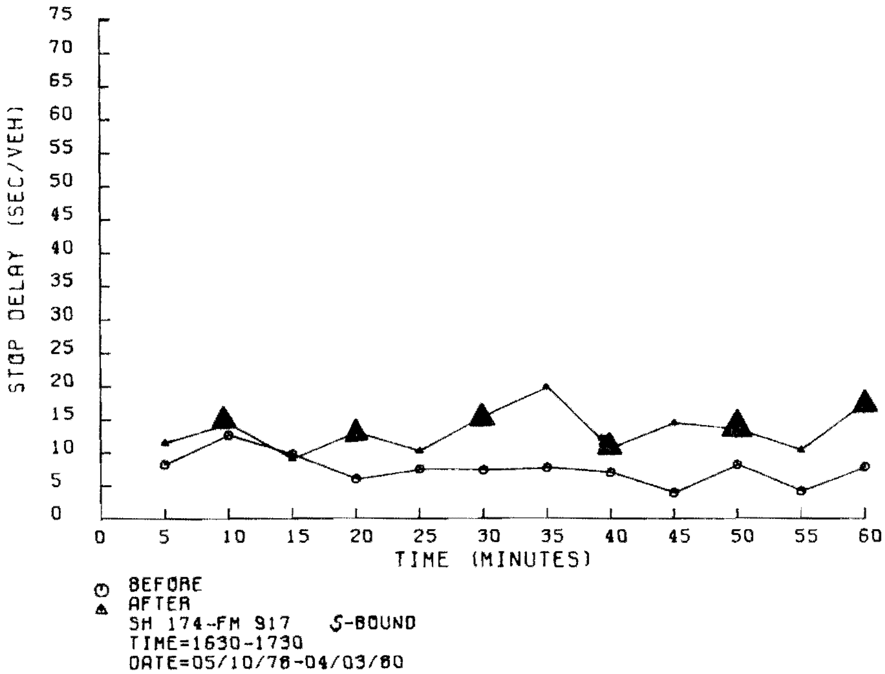


Fig F-5. Before and after delay statistics, SH 174-FM 917.



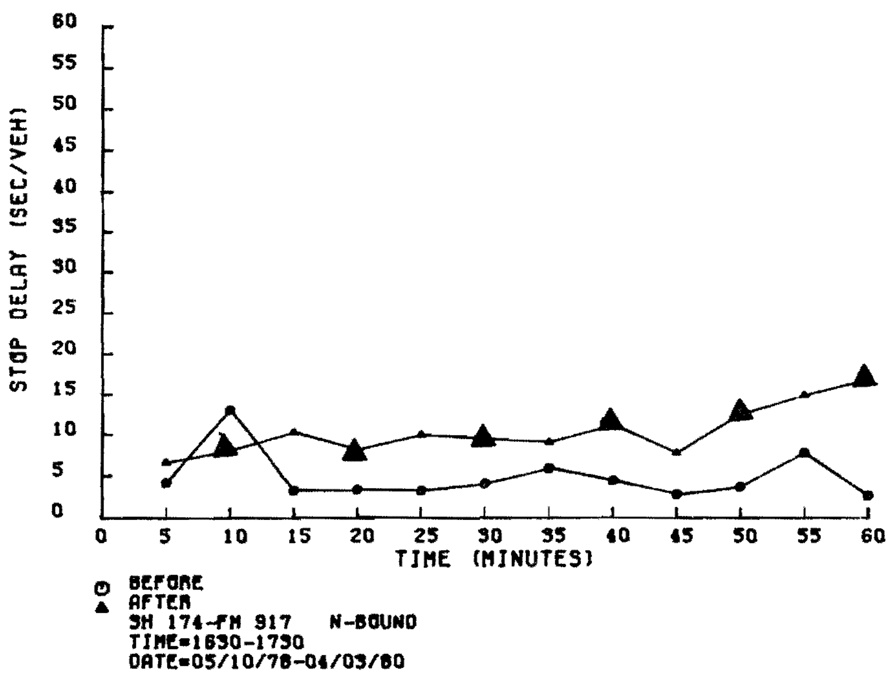
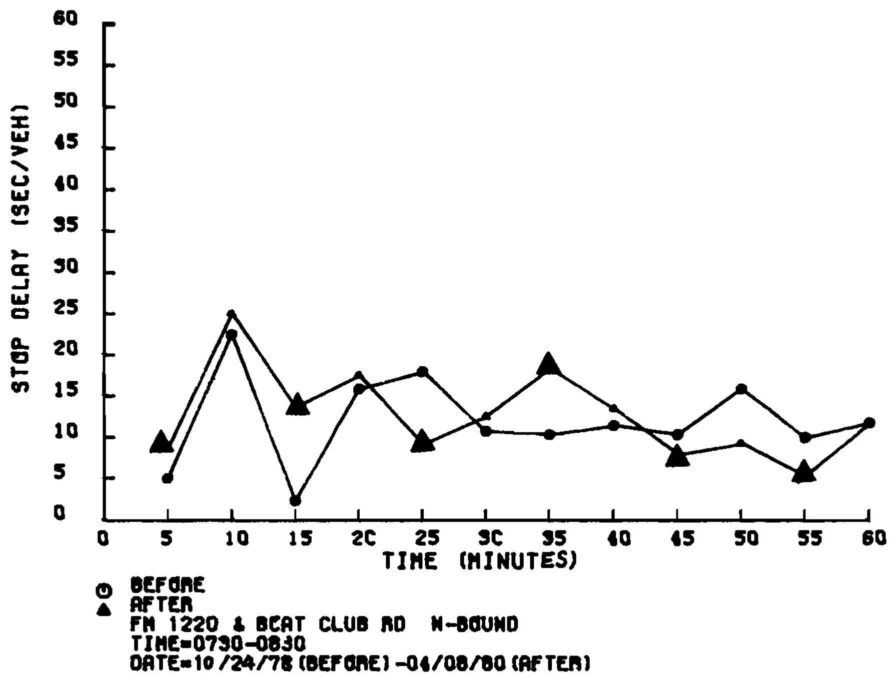


Fig F-6. Before and after delay statistics, SH 174-FM 917.



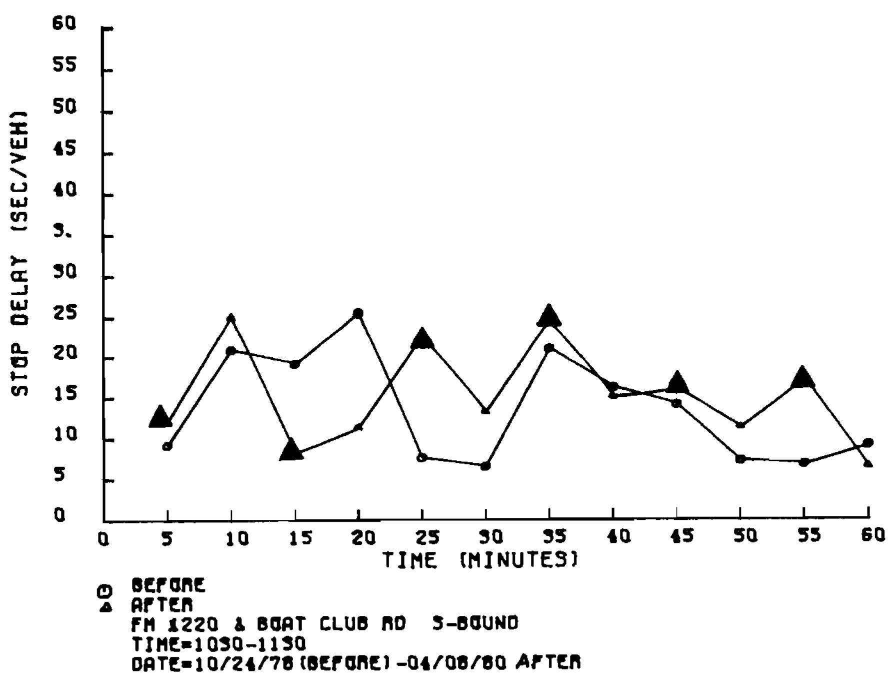
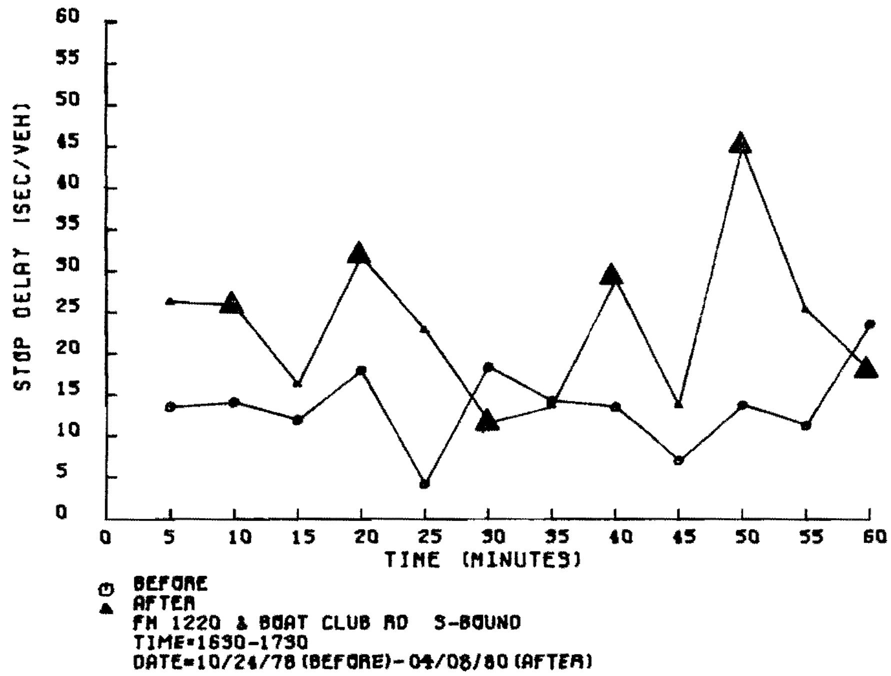


Fig F-7. Before and after delay statistics, FM 1220 & Boat Club Road.



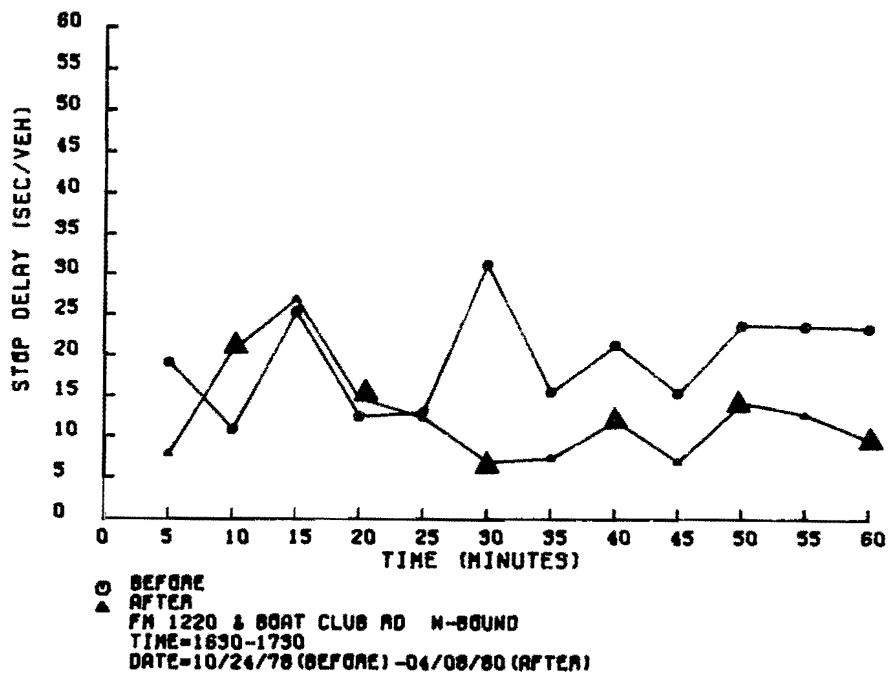
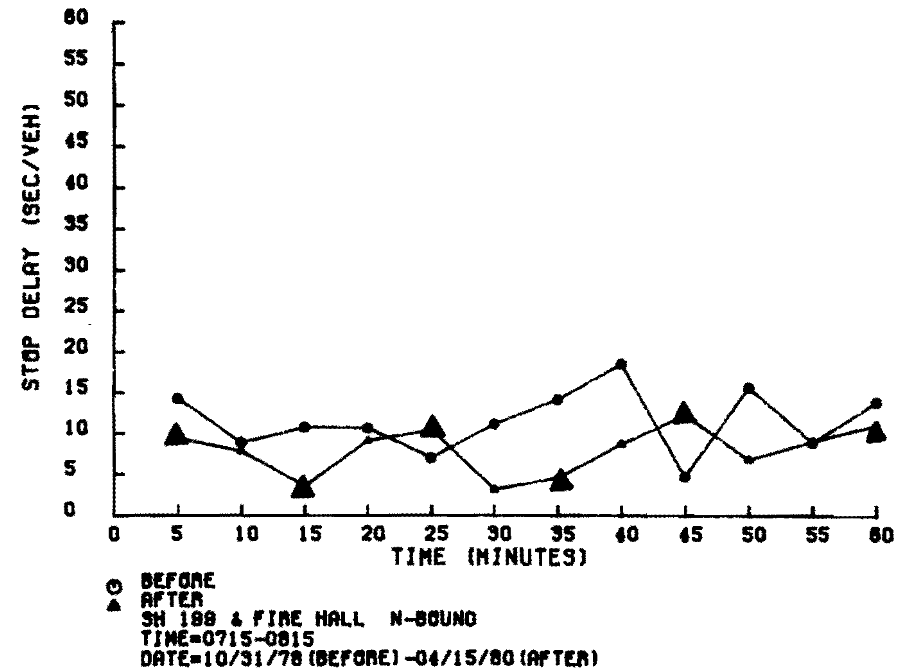


Fig F-8. Before and after delay statistics, FM 1220 & Boat Club Road.



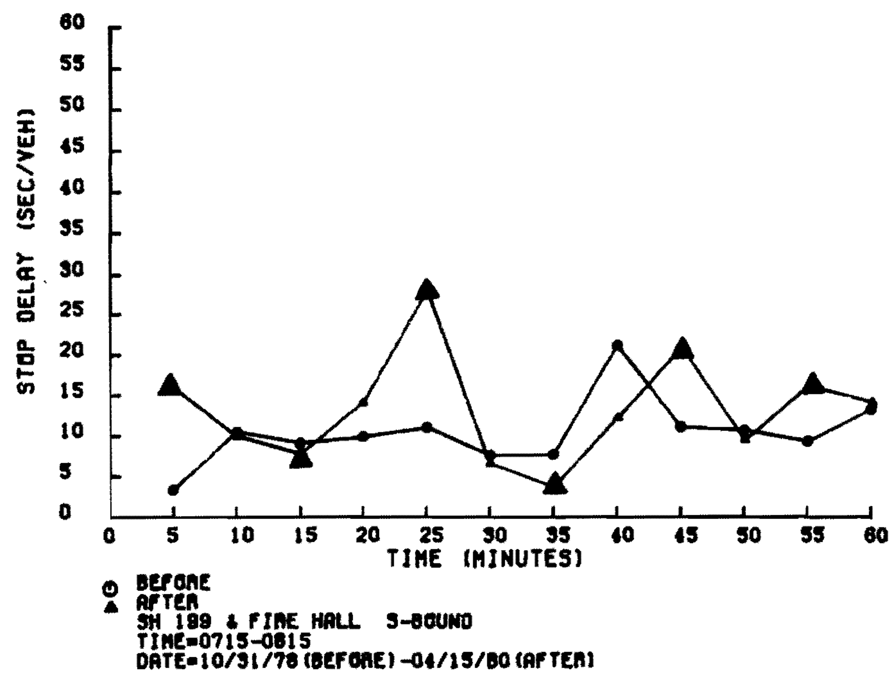
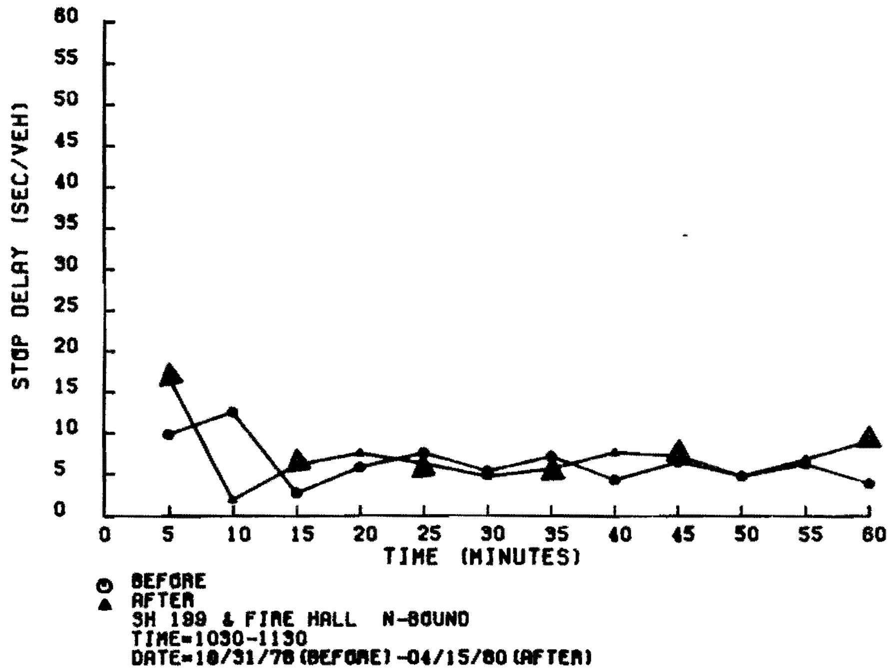


Fig F-9. Before and after delay statistics, SH 199 & Fire Hall.



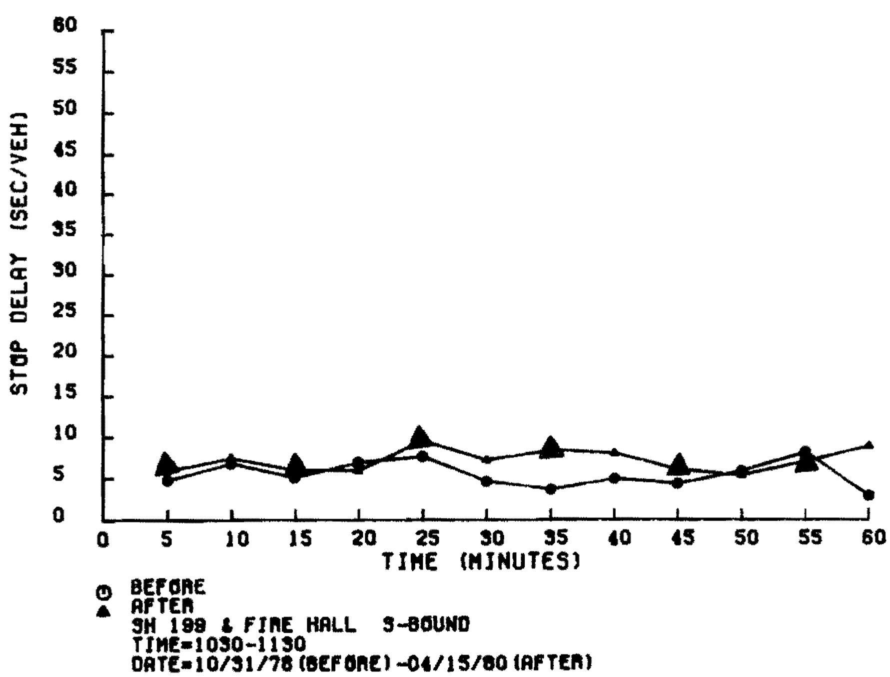
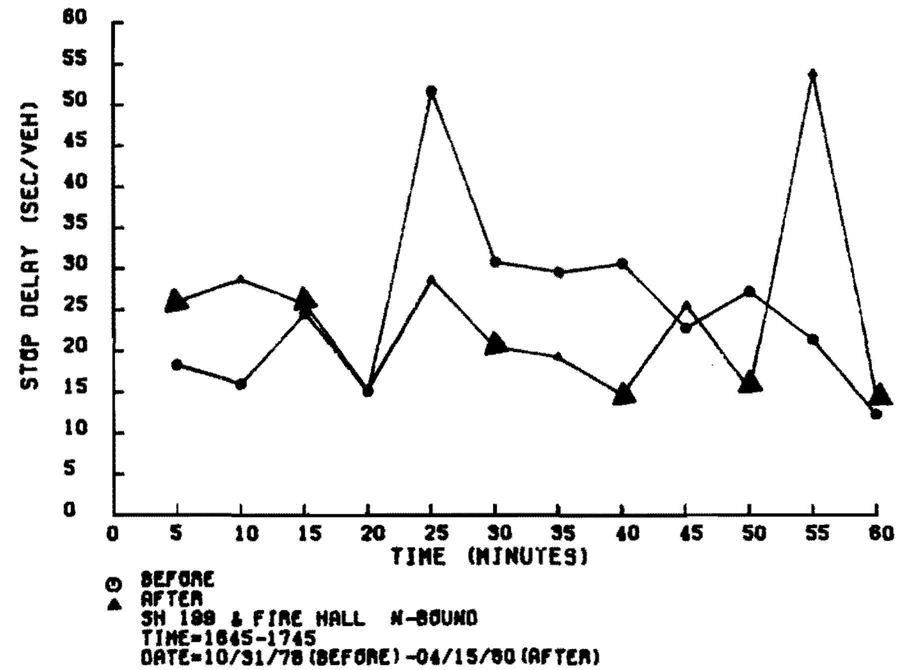


Fig F-10. Before and after delay statistics, SH 199 & Fire Hall.



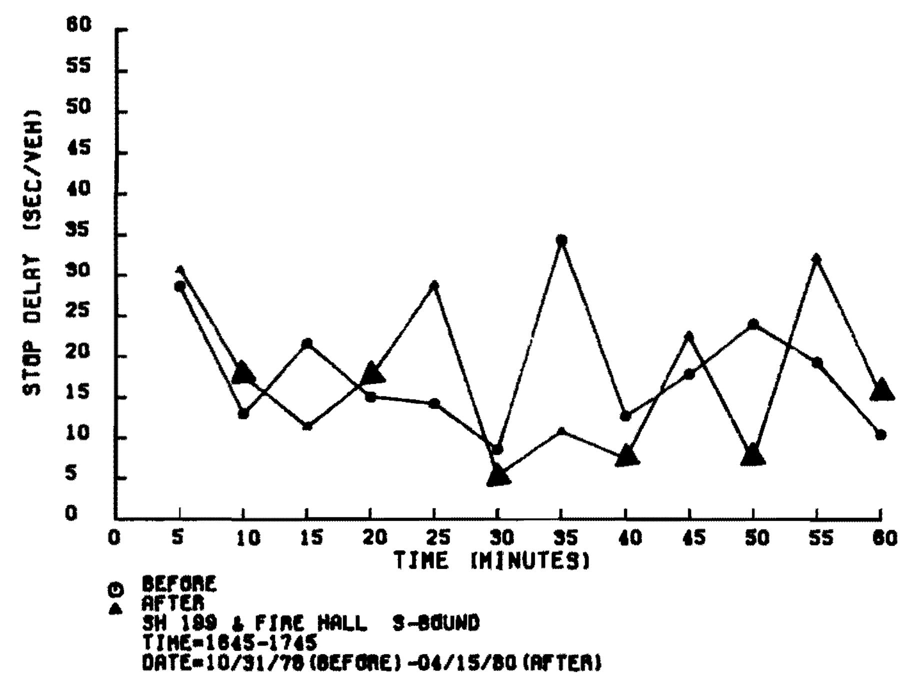
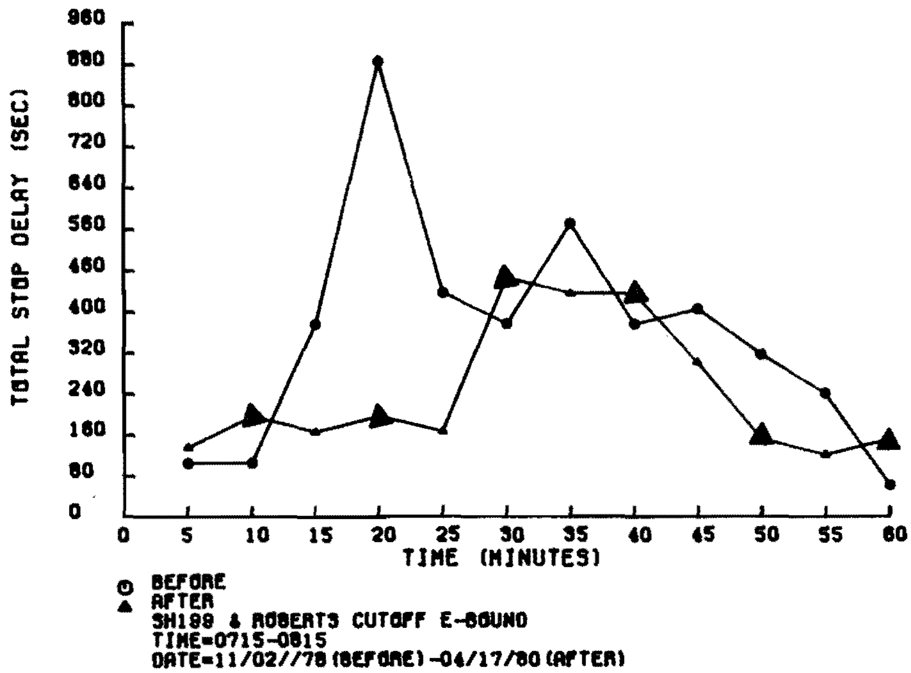


Fig F-11. Before and after delay statistics, SH 199 & Fire Hall.



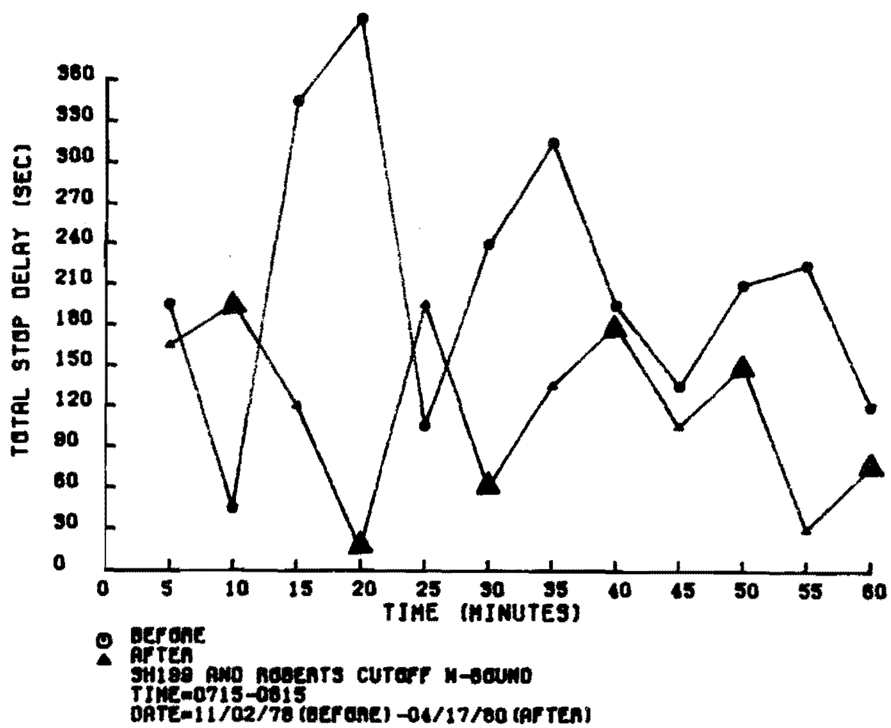
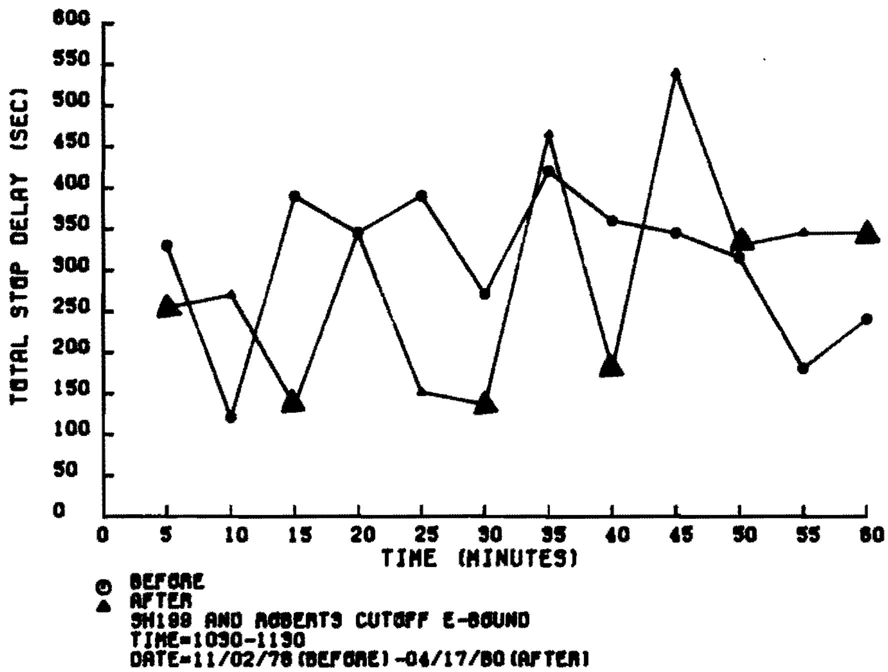


Fig F-12. Before and after delay statistics, SH 199 & Roberts Cutoff.



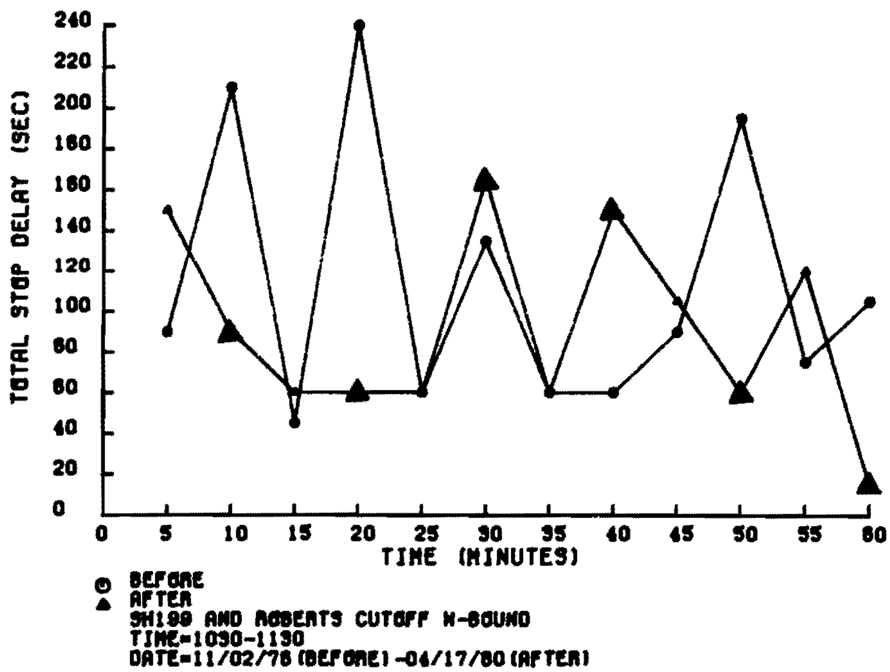
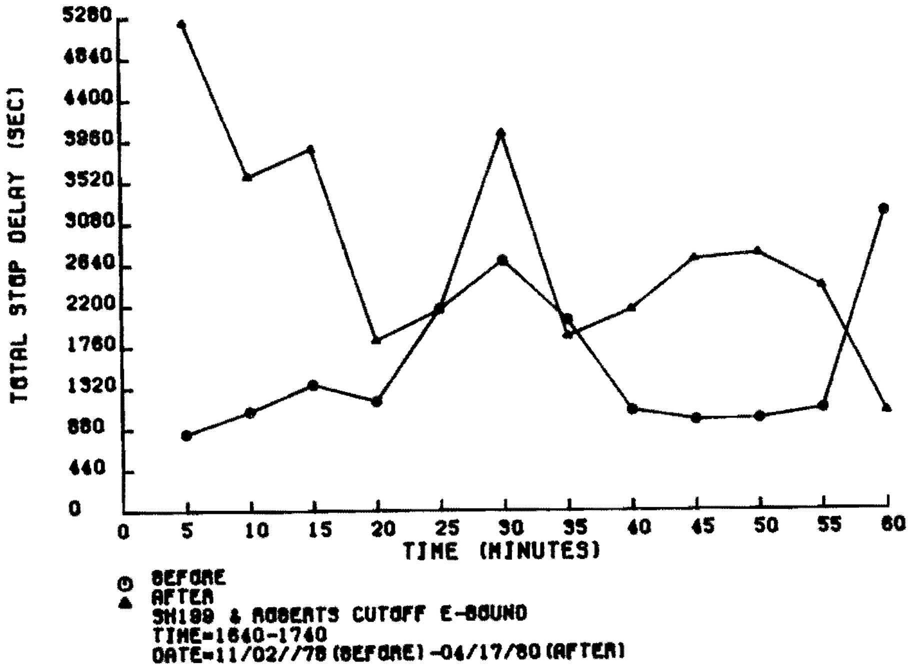


Fig F-13. Before and after delay statistics, SH 199 & Roberts Cutoff.



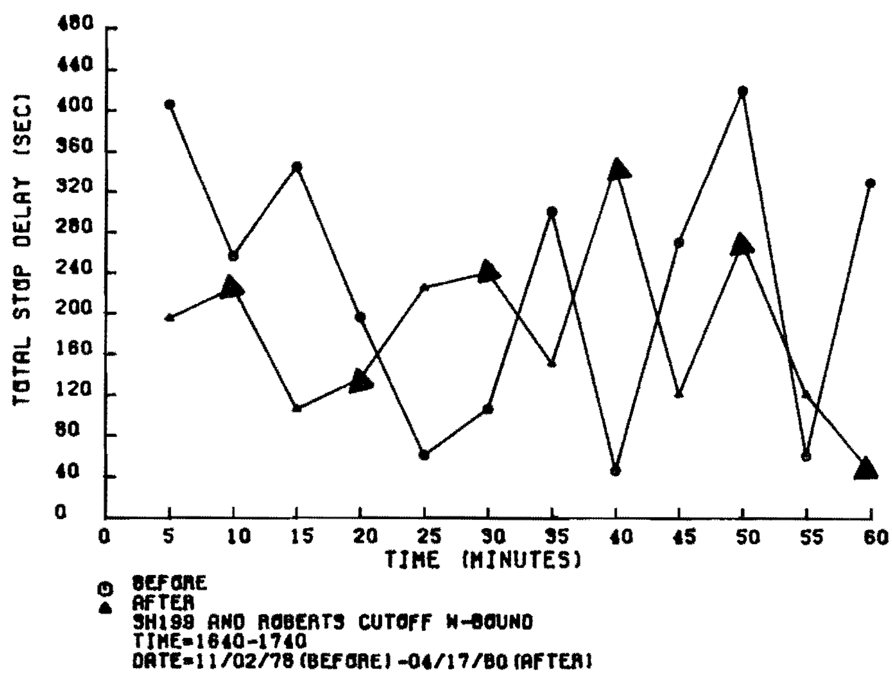
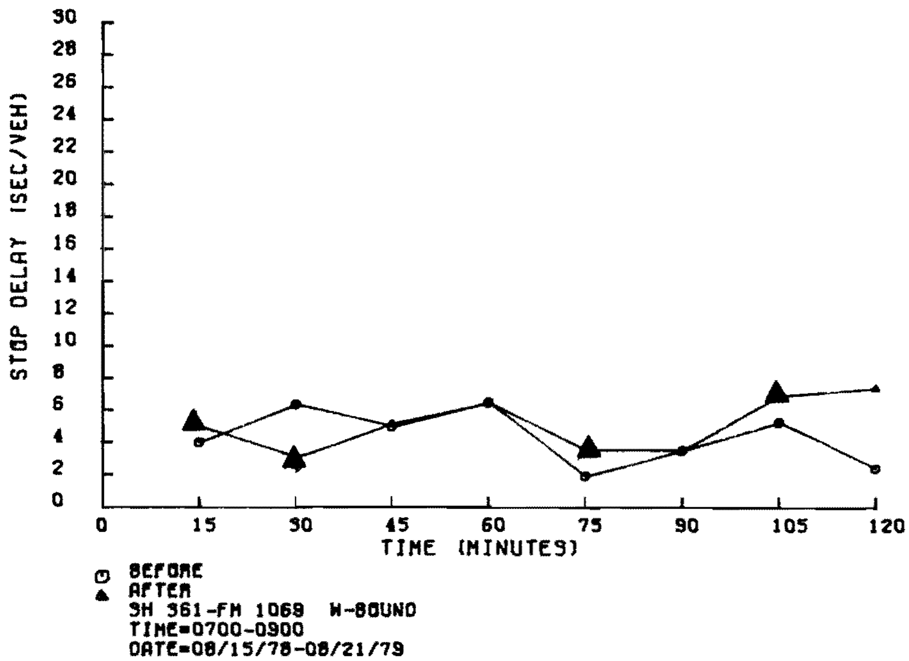


Fig F-14. Before and after delay statistics, SH 199 & Roberts Cutoff.



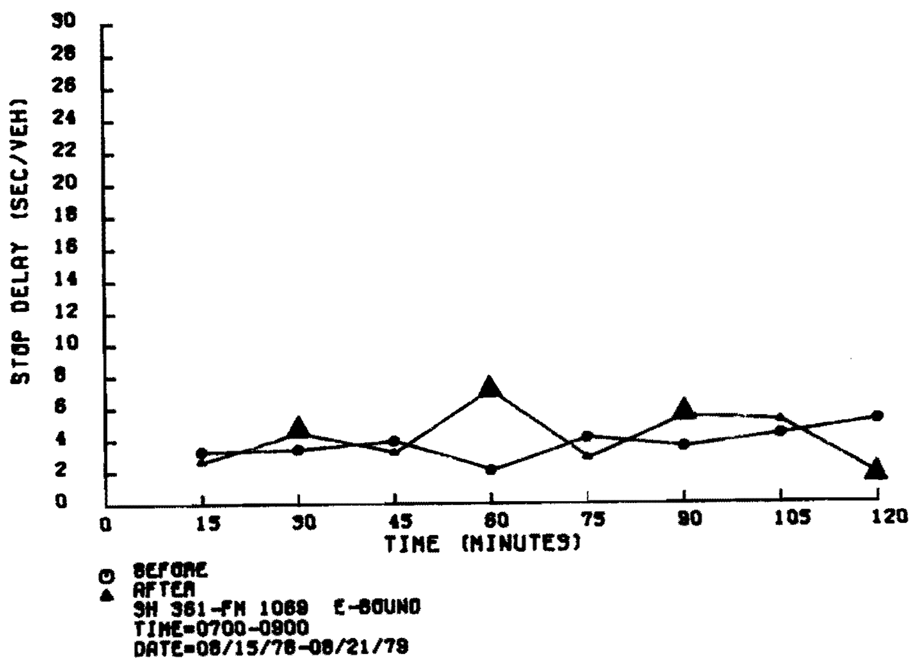
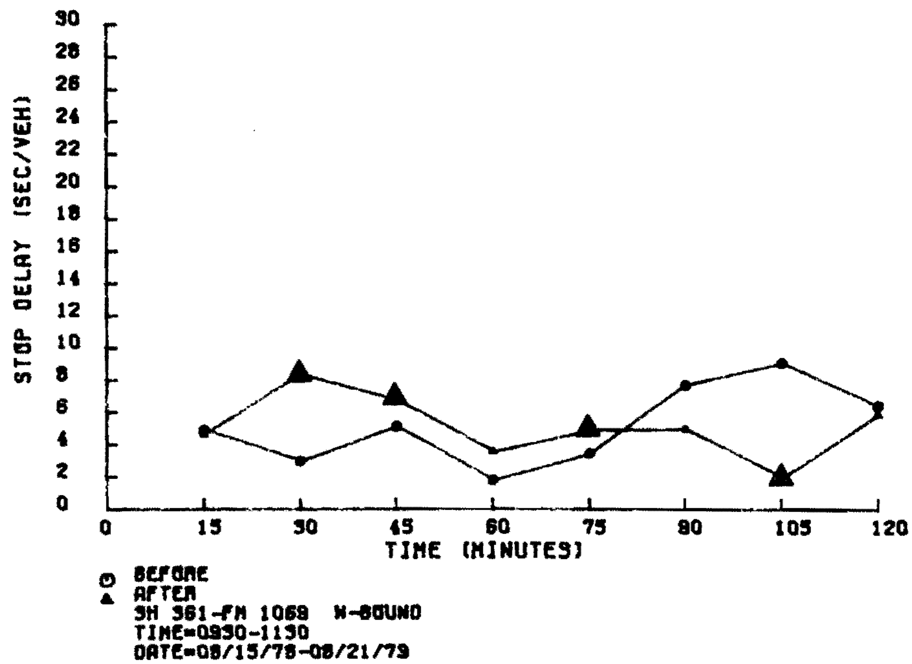


Fig F-15. Before and after delay statistics, SH 361-FM 1069.



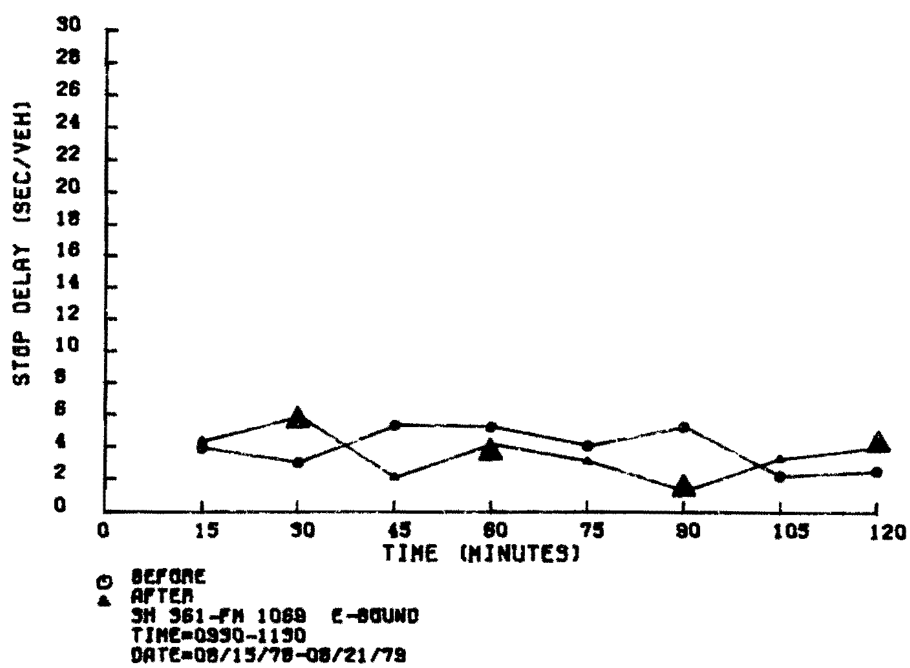
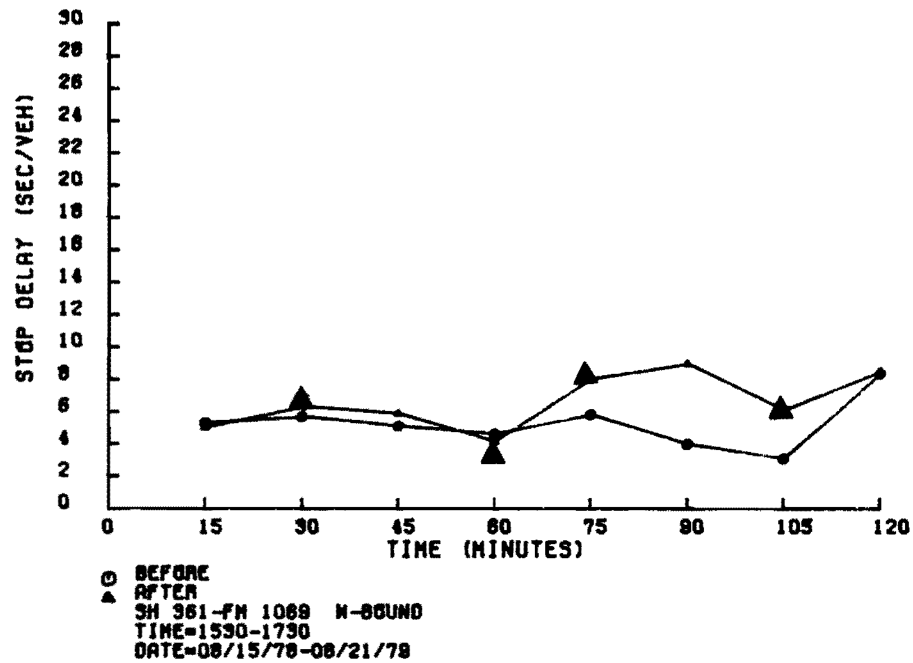


Fig F-16. Before and after delay statistics, SH 361-FM 1069.



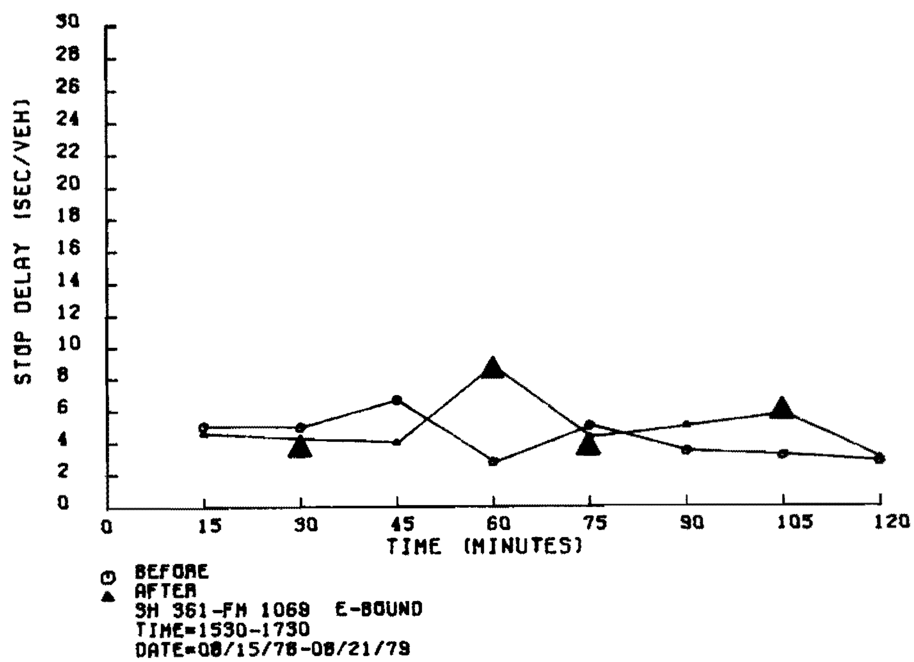


Fig F-17. Before and after delay statistics, SH 361-FM 1069.

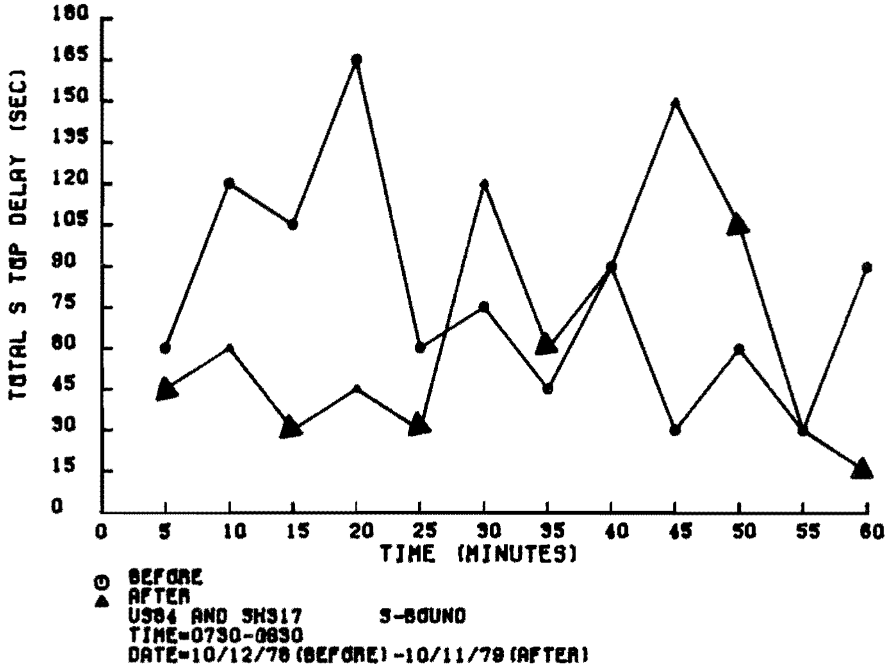
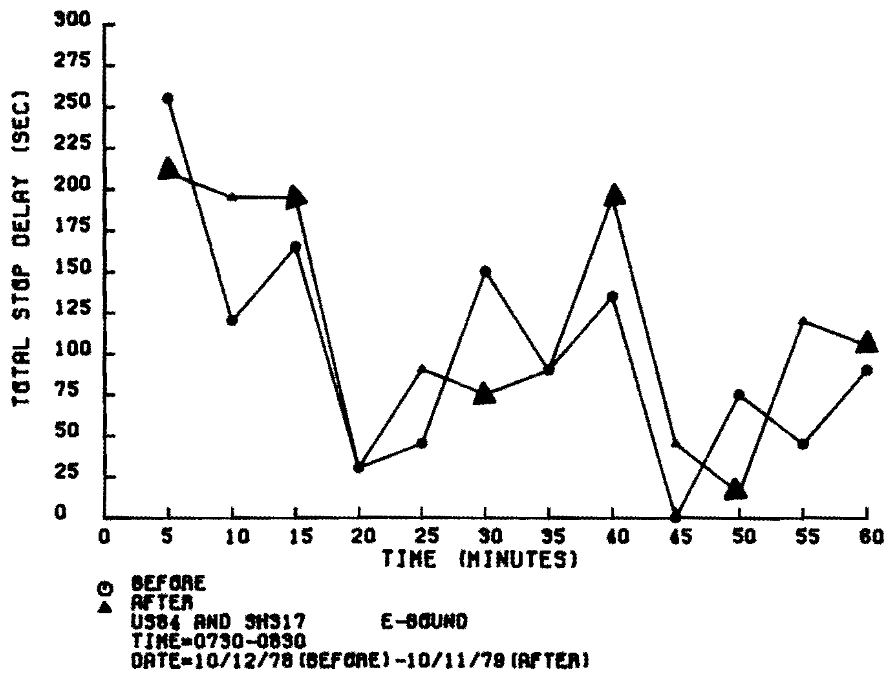


Fig F-18. Before and after delay statistics, US 84 and SH 317.



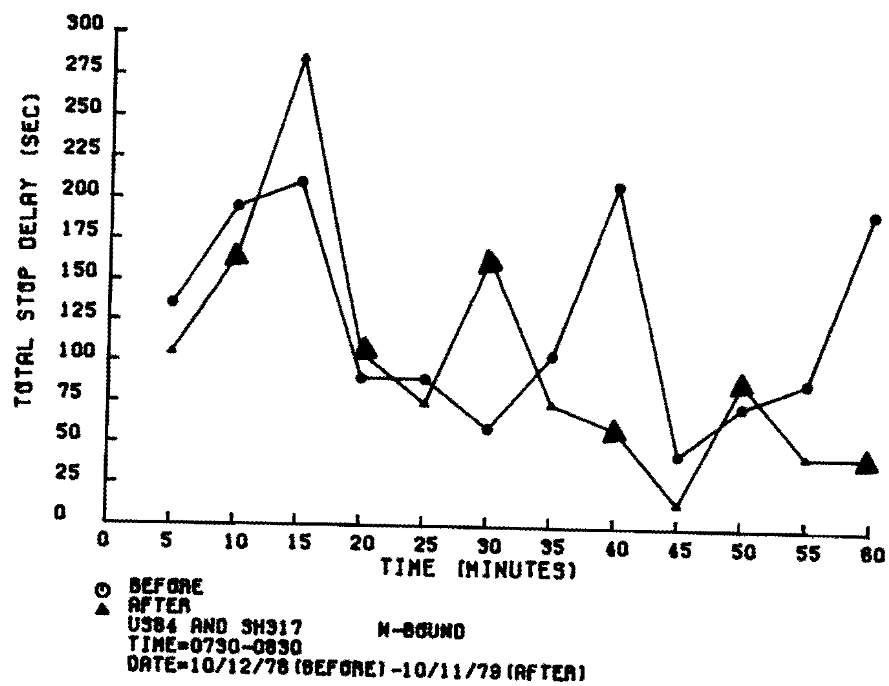


Fig F-19. Before and after delay statistics, US 84 and SH 317.

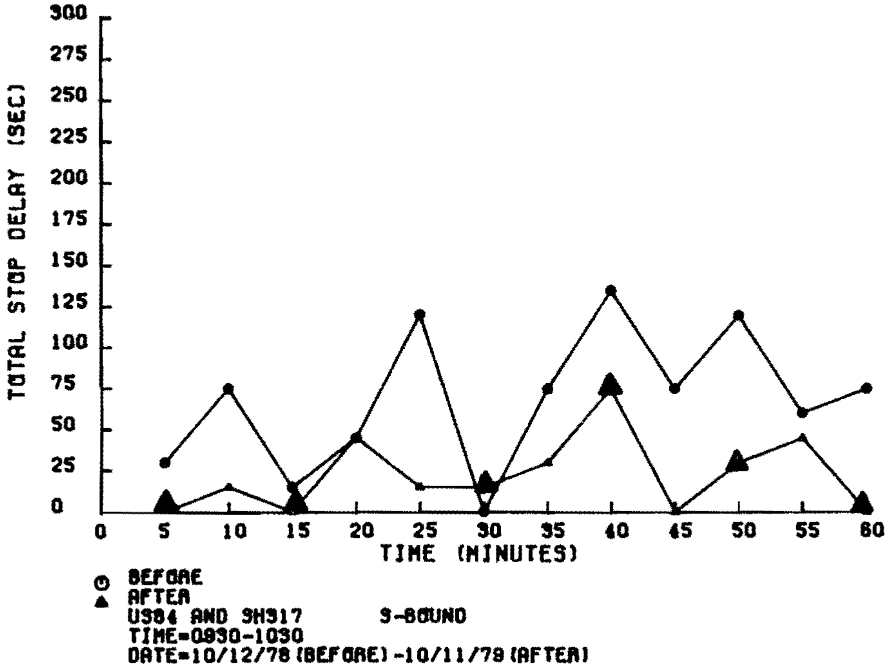
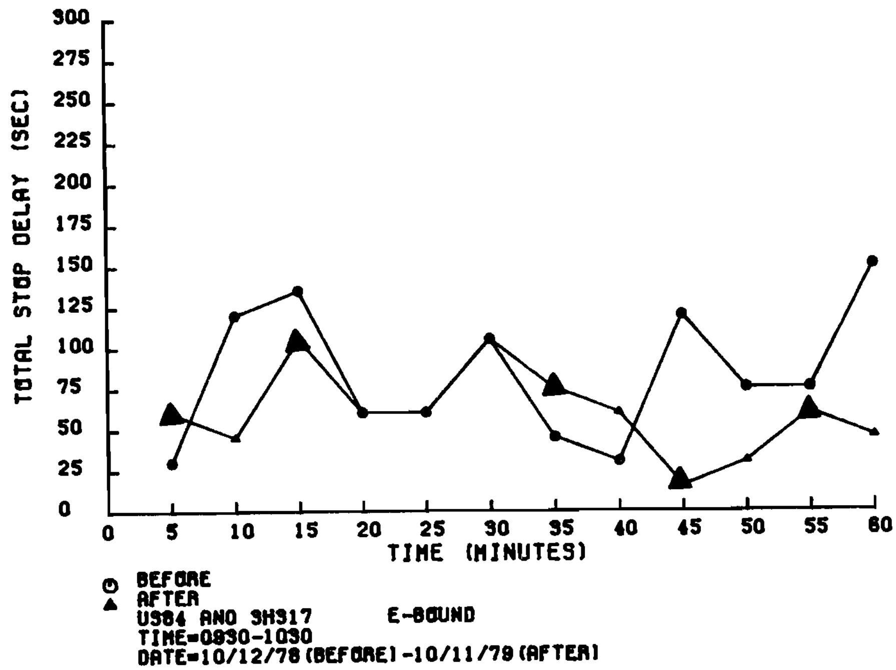


Fig F-20. Before and after delay statistics, US 84 and SH 317.



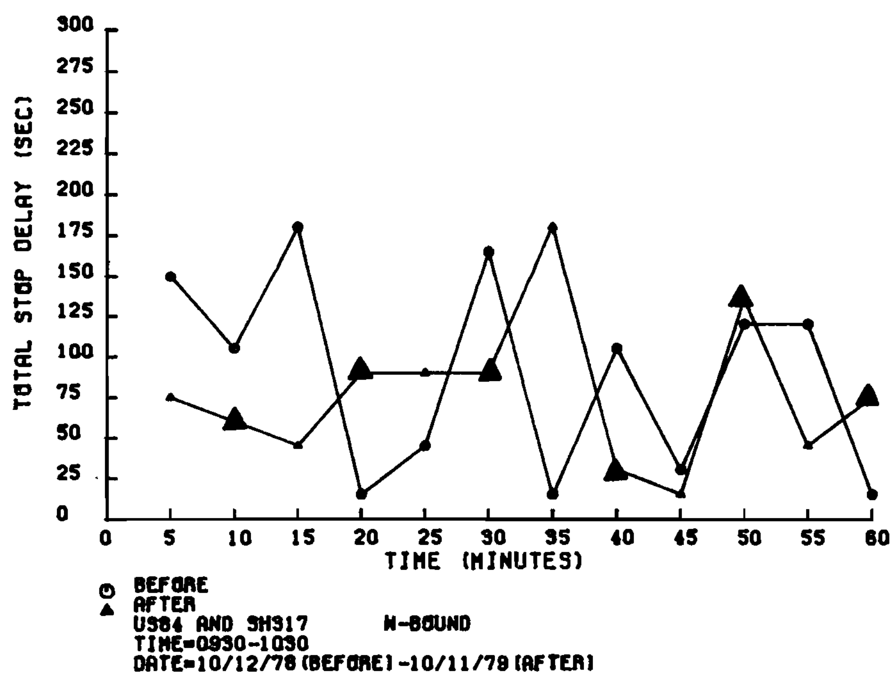


Fig F-21. Before and after delay statistics, US 84 and SH 317.

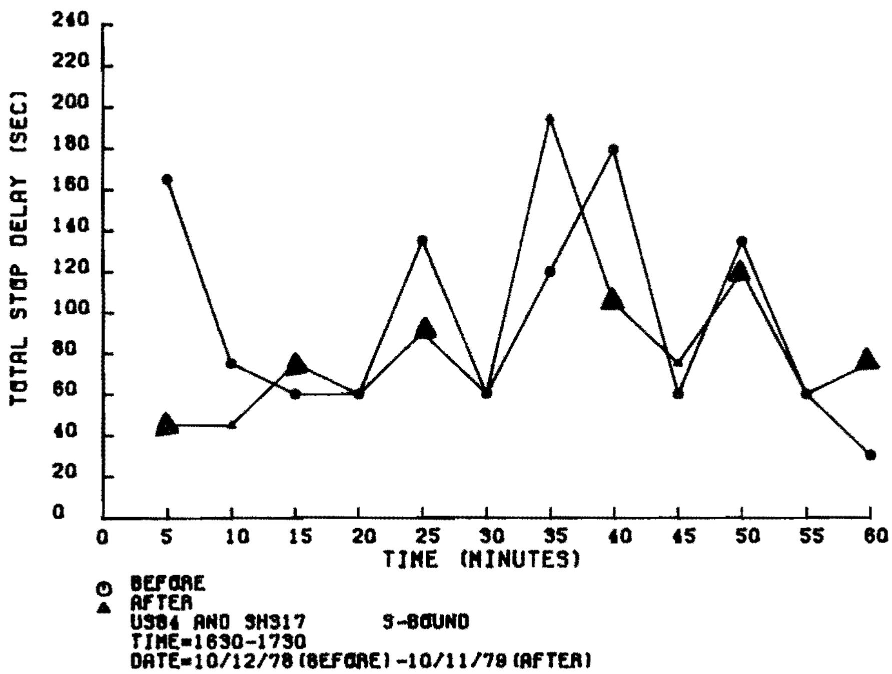
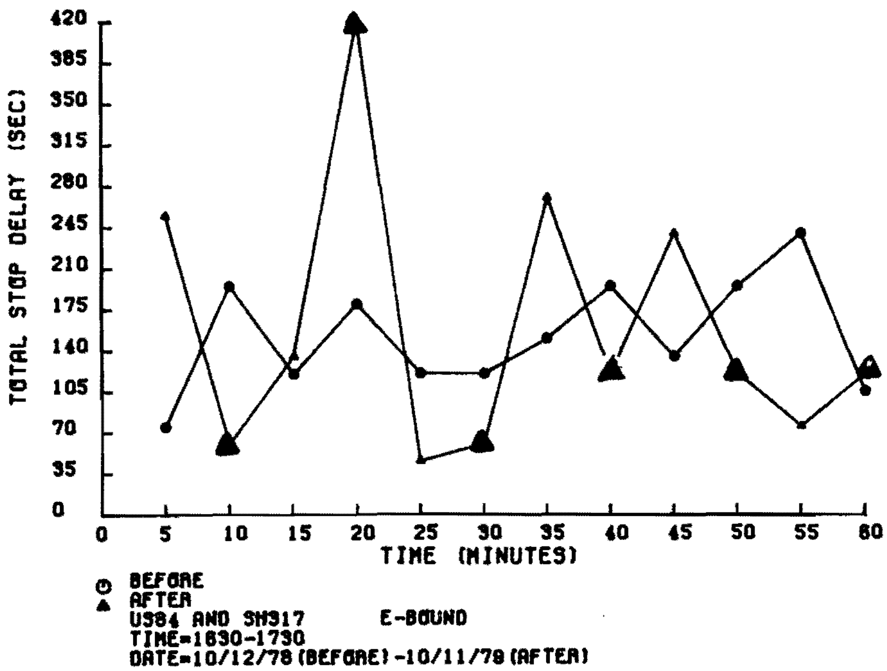


Fig F-22. Before and after delay statistics, US 84 and SH 317.



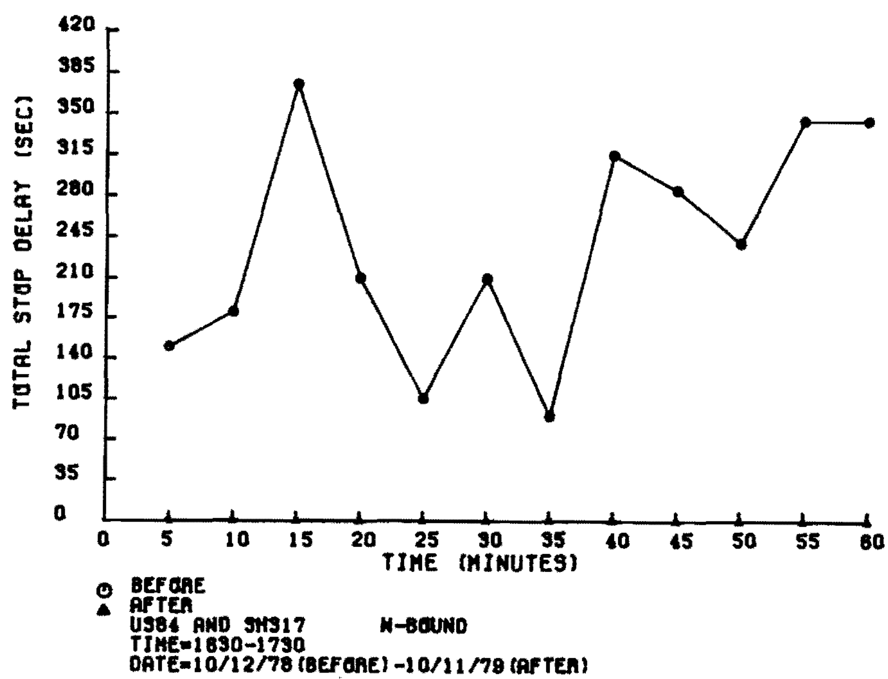
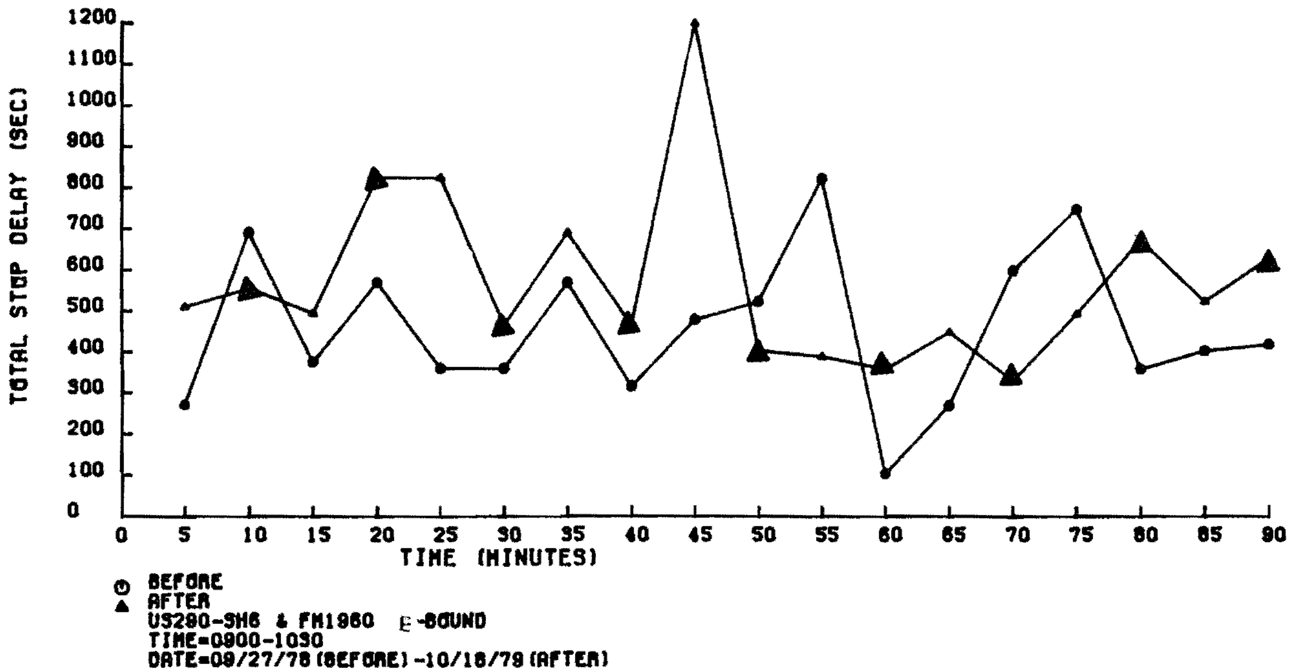


Fig F-23. Before and after delay statistics, US 84 and SH 317.



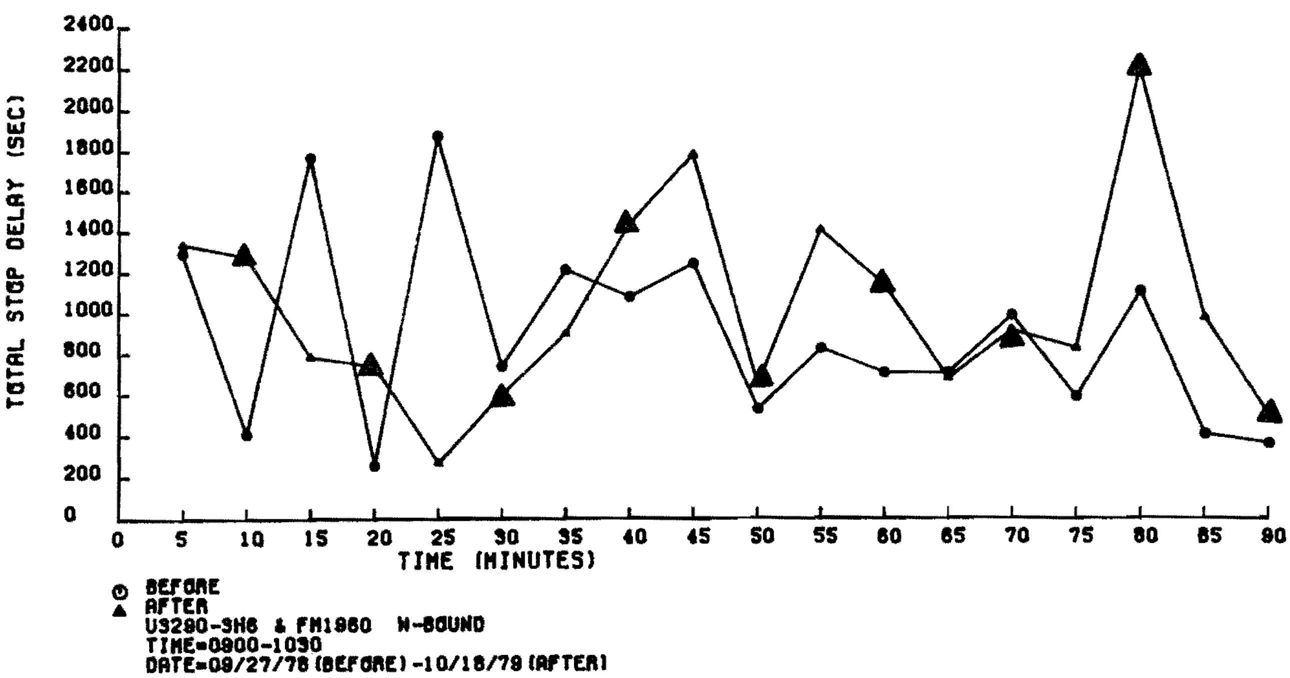
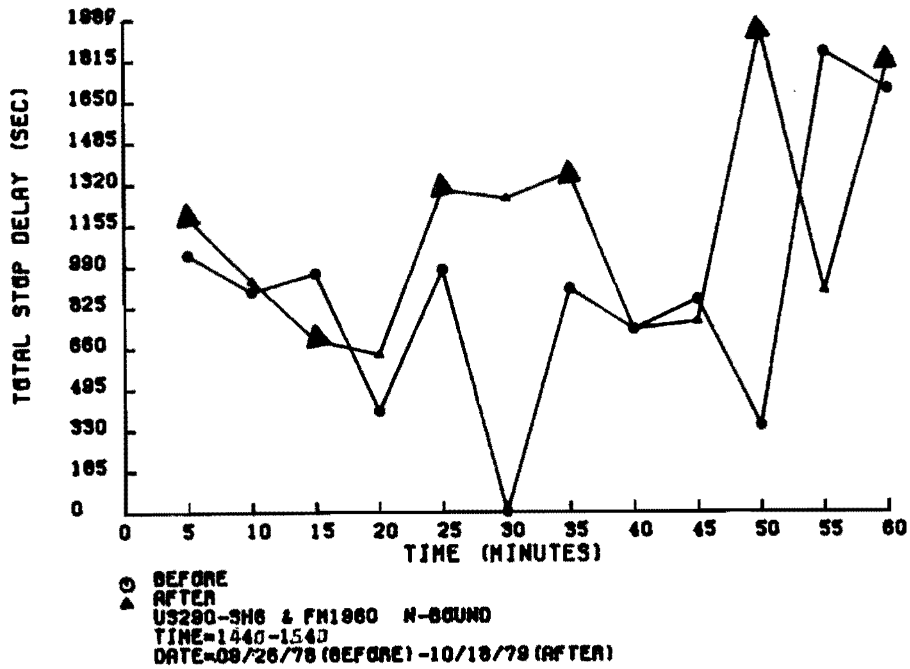


Fig F-24. Before and after delay statistics, US 290-SH 6 & FM 1960.



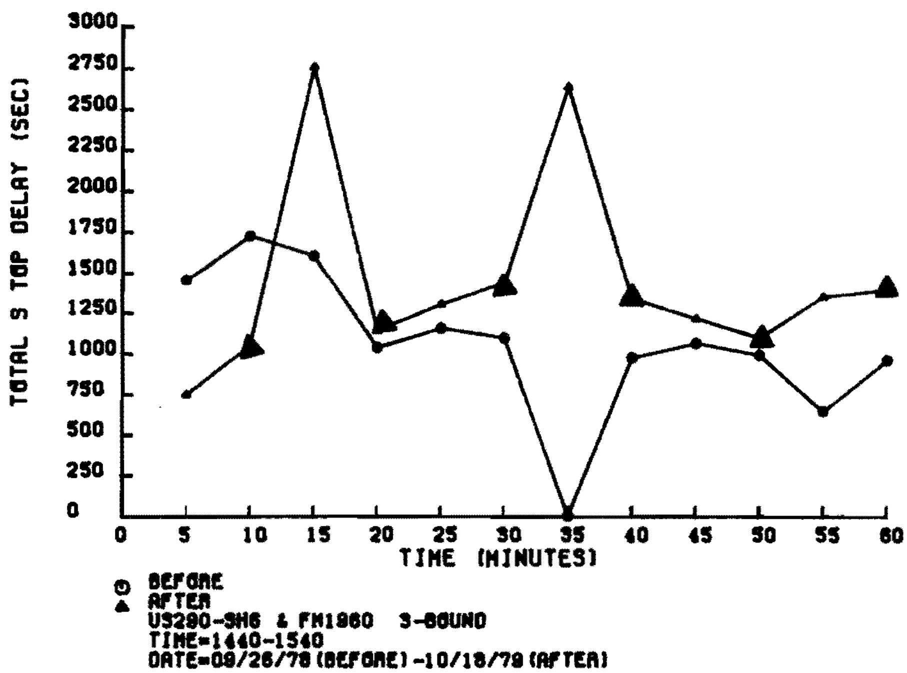
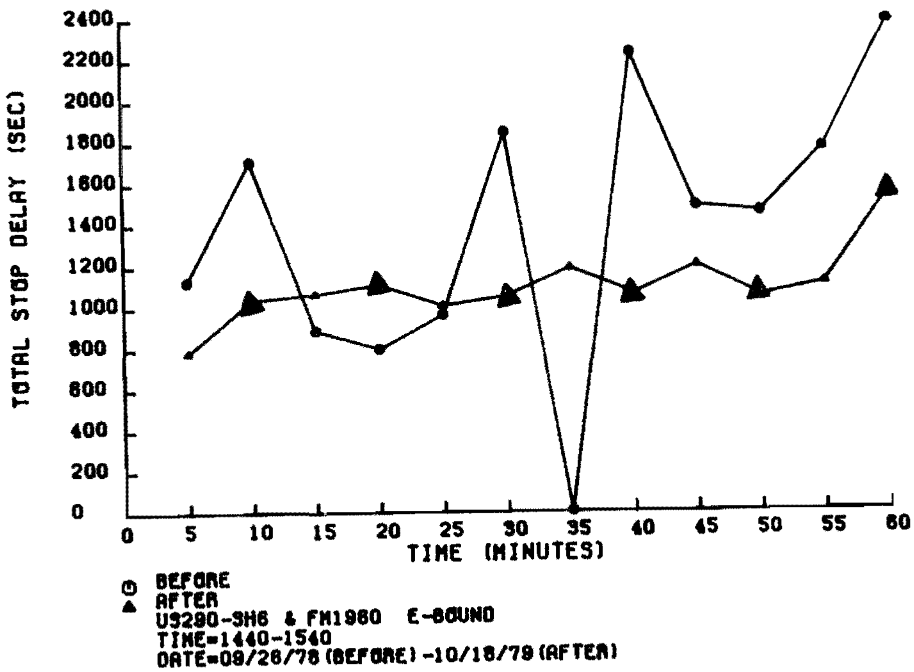


Fig F-25. Before and after delay statistics, US 290-SH 6 & FM 1960.



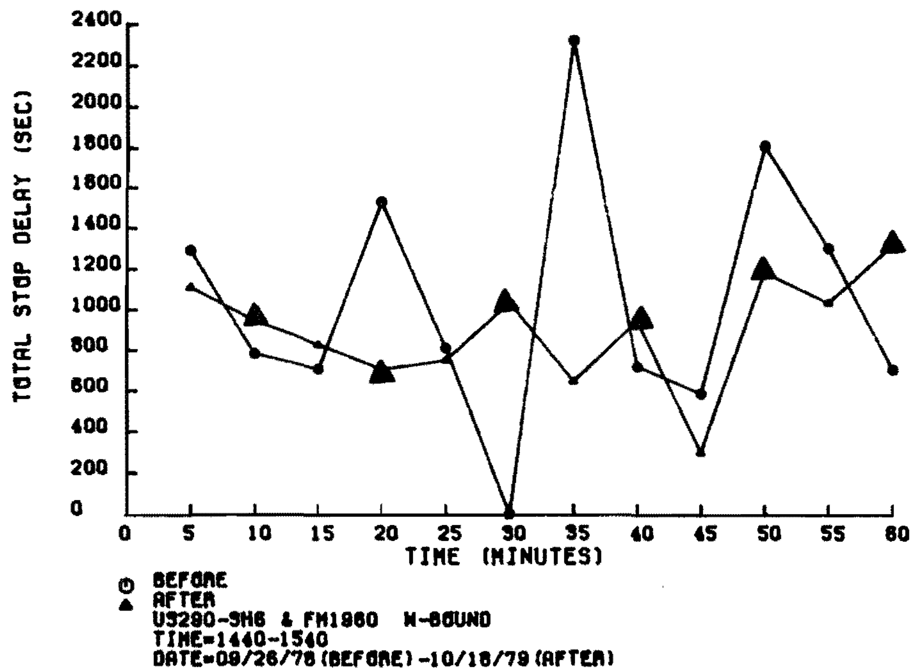
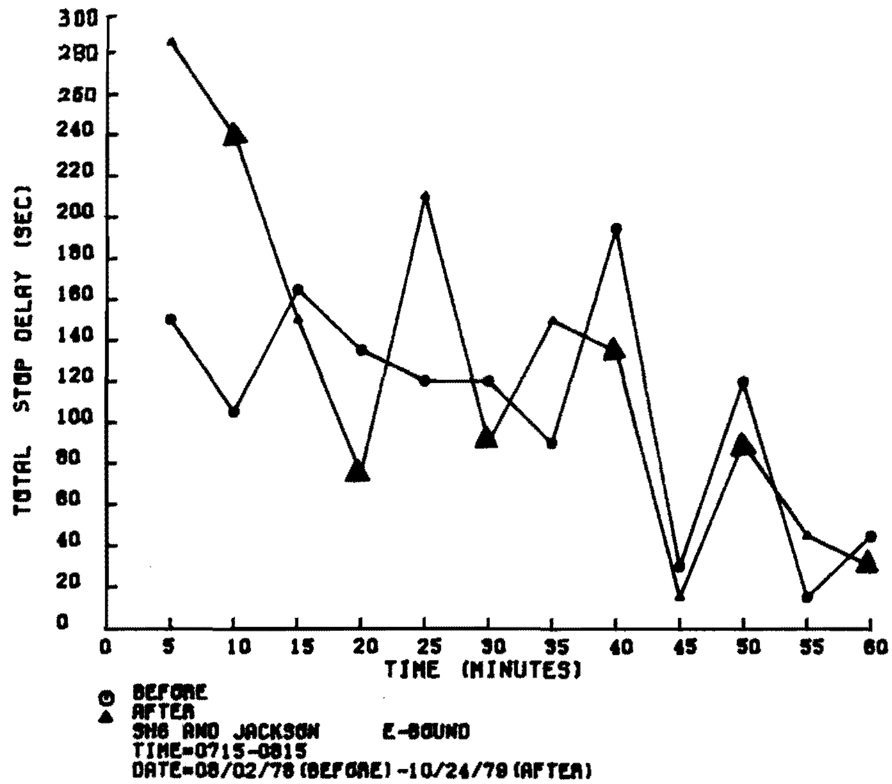


Fig F-26. Before and after delay statistics, US 290-US 6 & FM 1960.



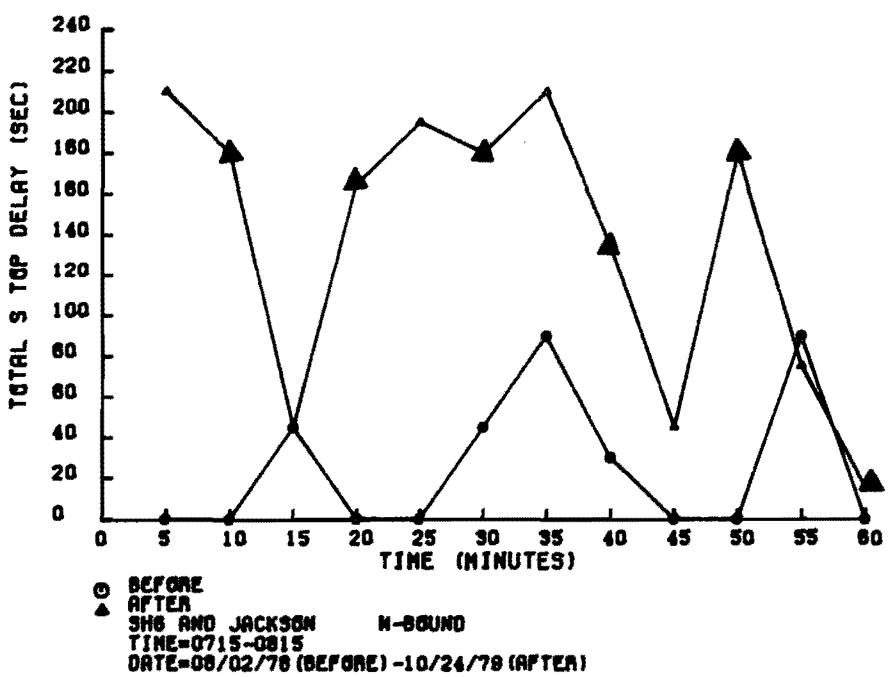
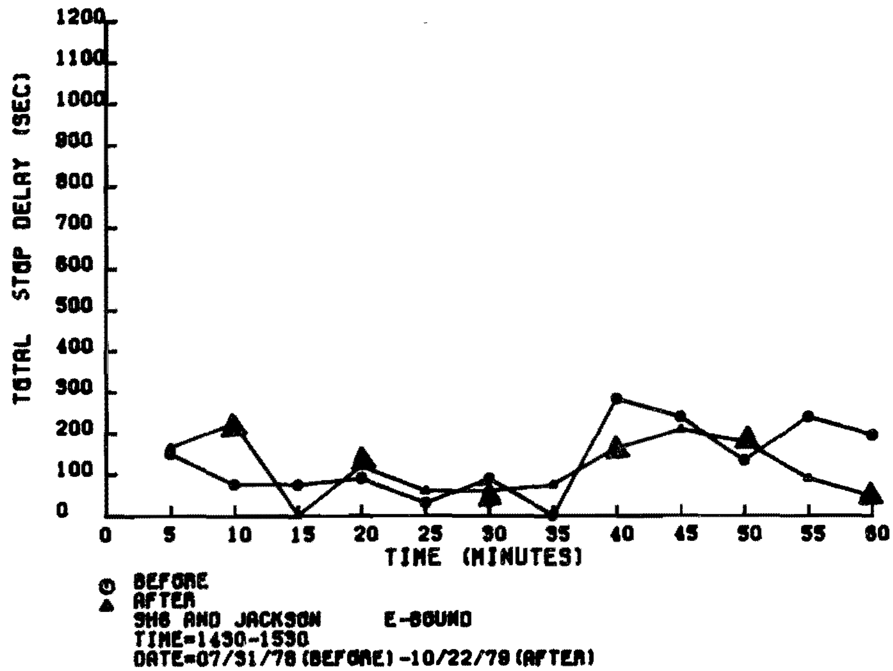


Fig F-27. Before and after delay statistics, SH 6 and Jackson.



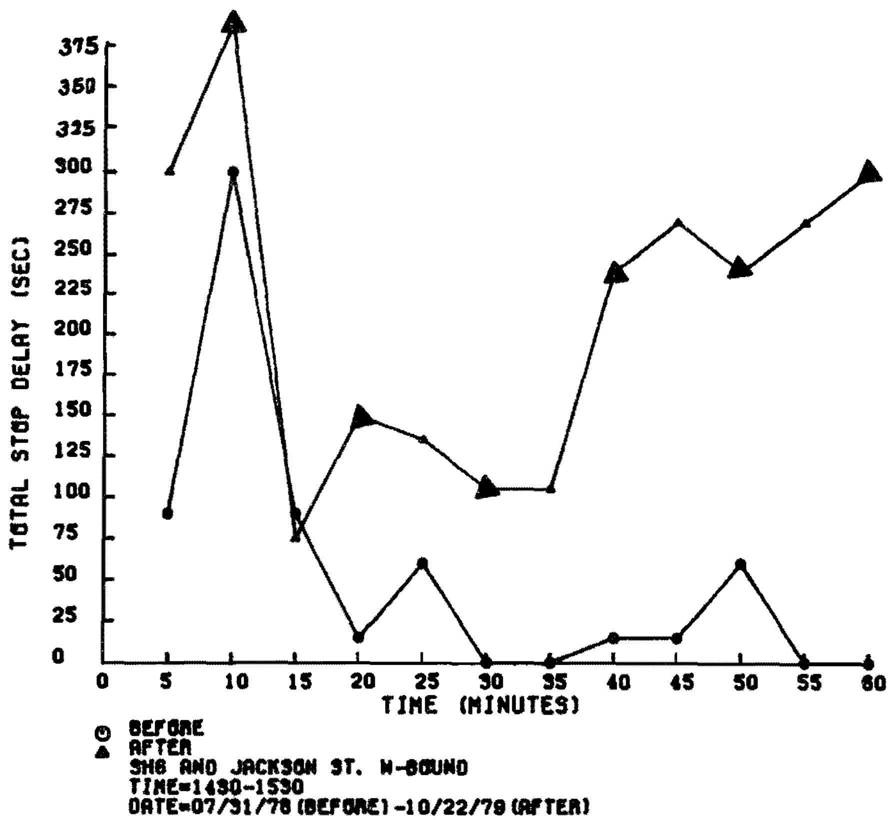
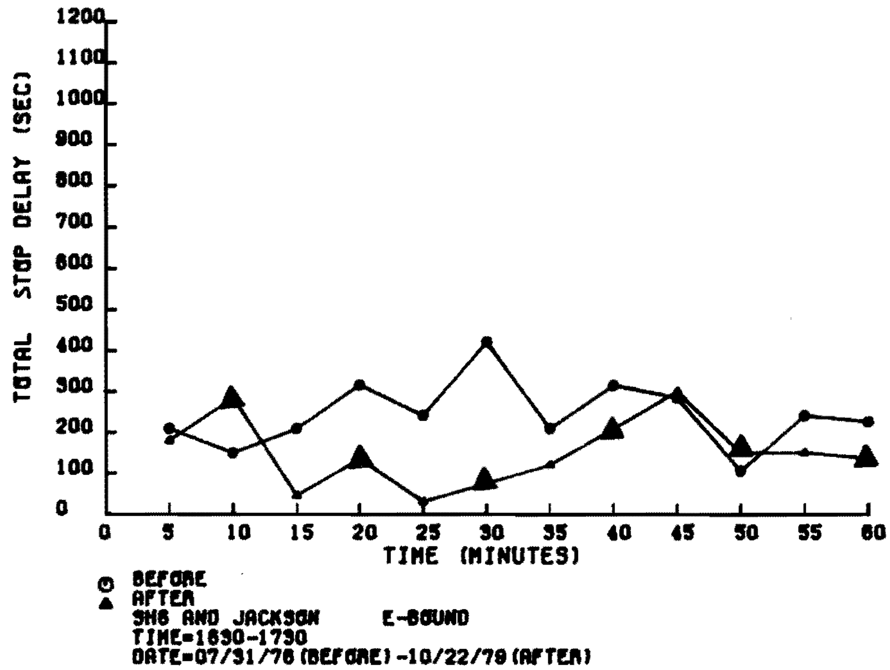


Fig F-28. Before and after delay statistics, SH 6 and Jackson.



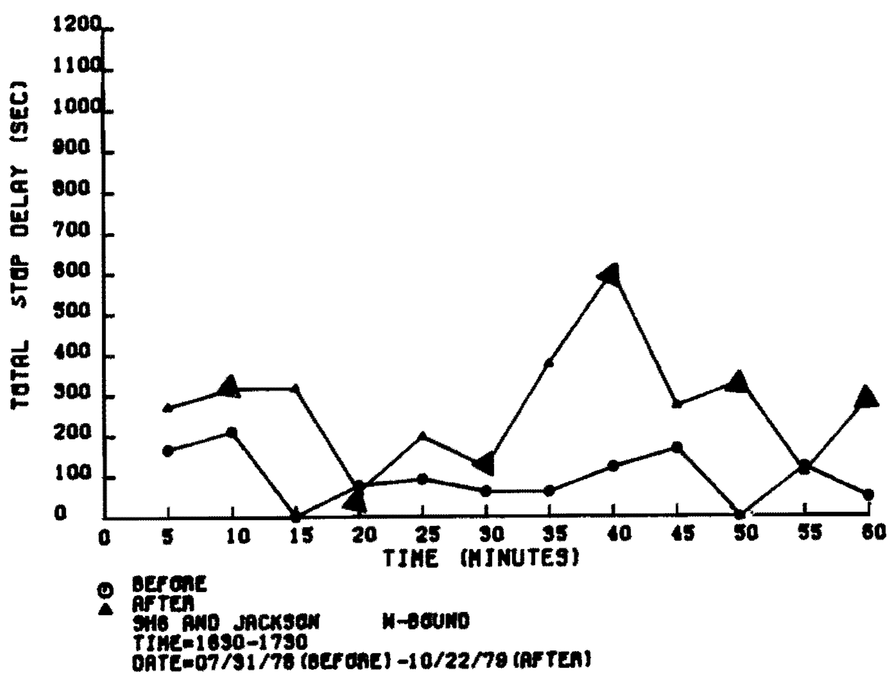
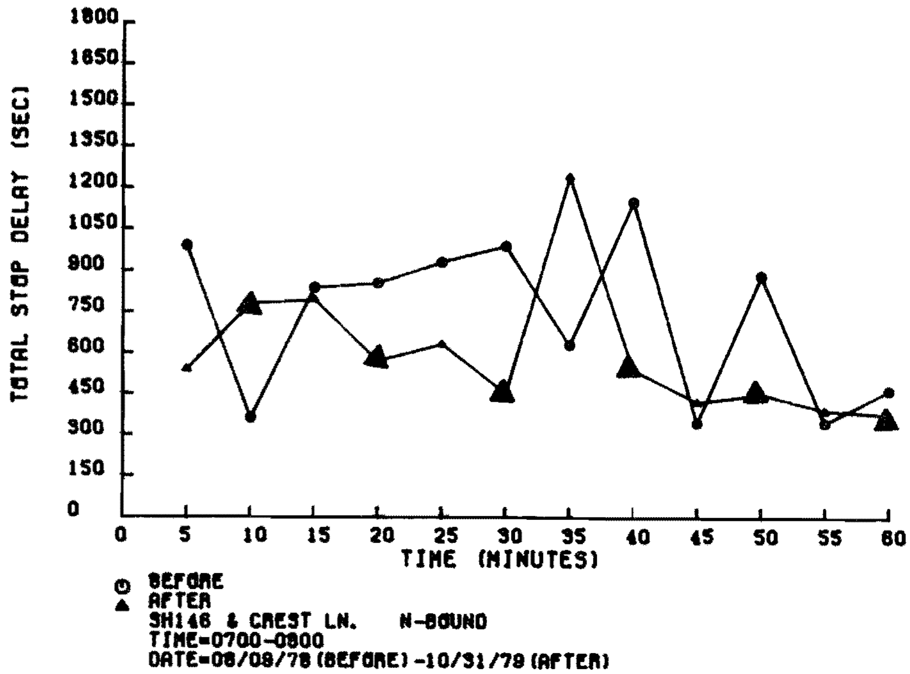


Fig F-29. Before and after delay statistics, SH 6 and Jackson.



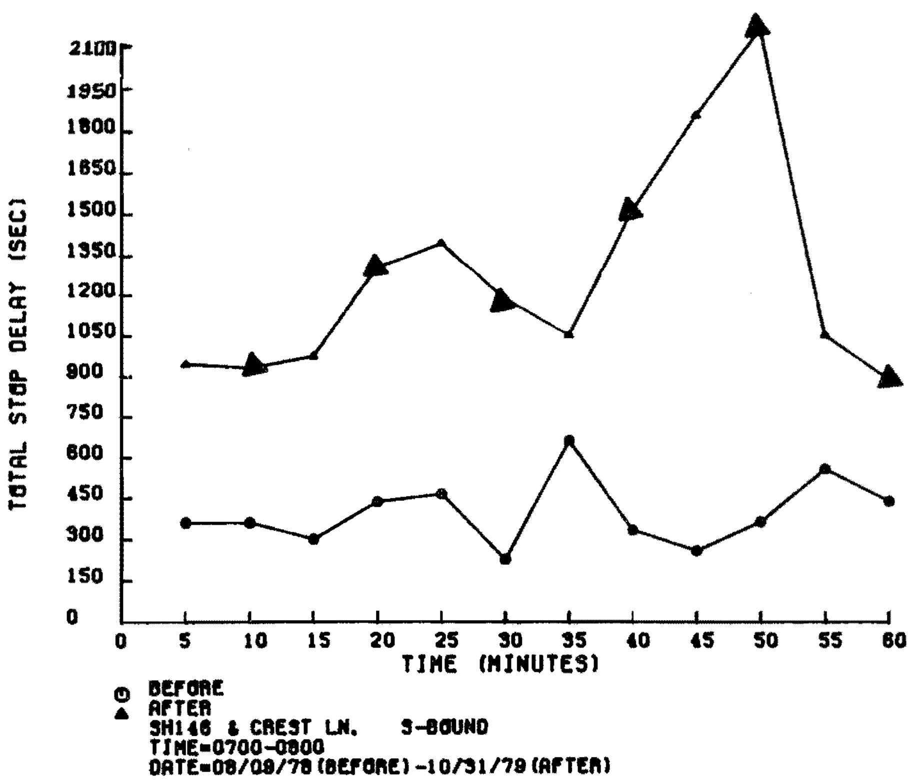
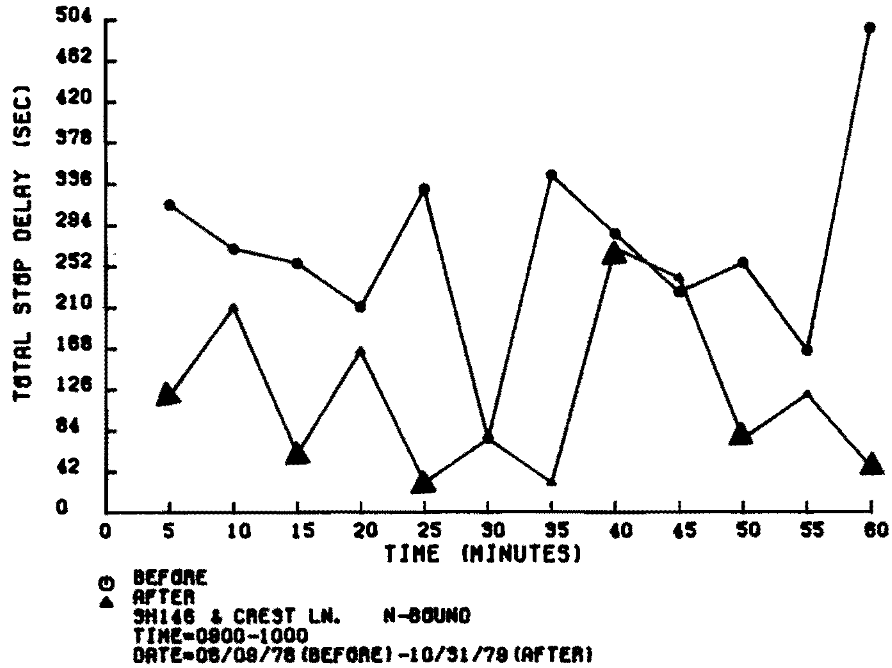


Fig F-30. Before and after delay statistics, SH 146 & Crest Lane.



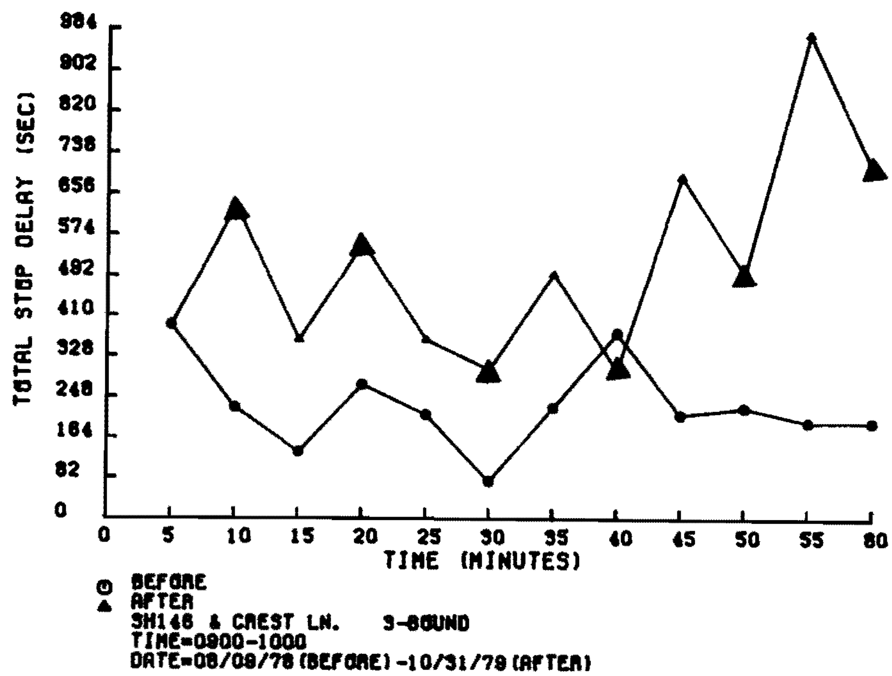
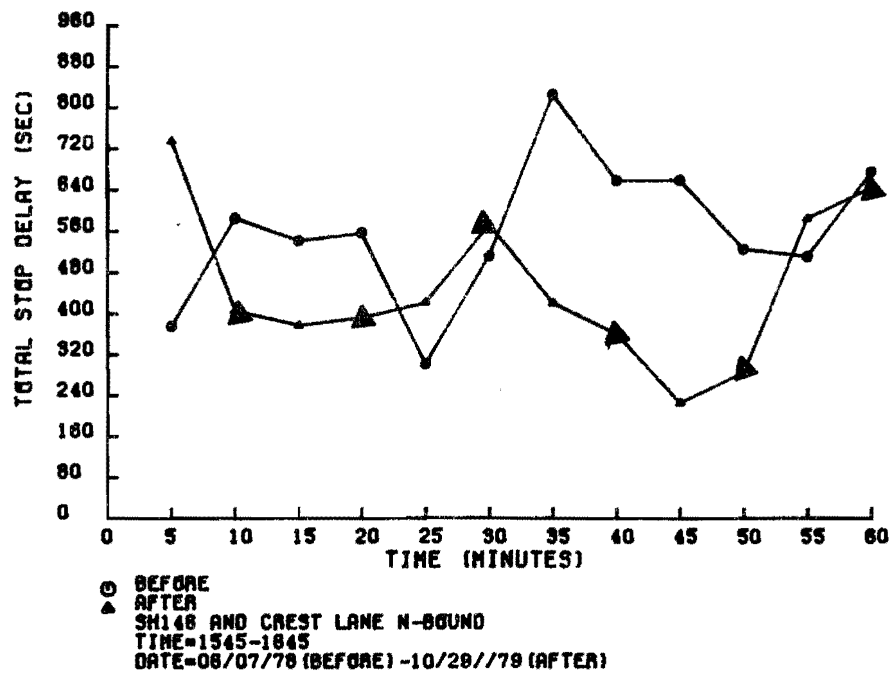


Fig F-31. Before and after delay statistics, SH 146 & Crest Lane.



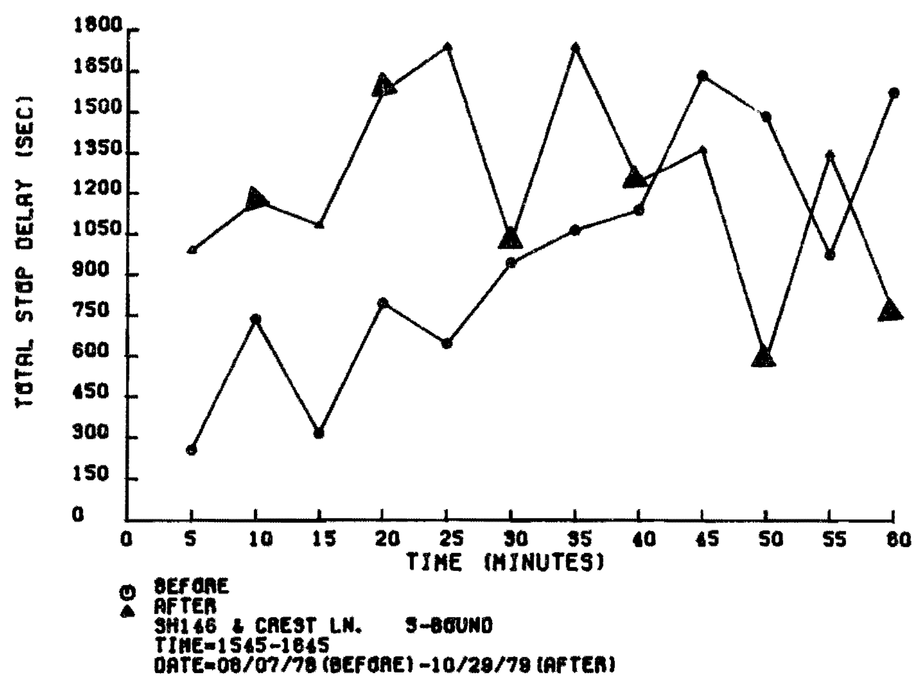


Fig F-32. Before and after delay statistics, SH 146 & Crest Lane.

APPENDIX G

TRAFFIC VOLUME FOR THE ACCIDENT STUDY

TABLE G-1. TRAFFIC VOLUME INFORMATION FROM AUTOMATIC TRAFFIC RECORDED FOR TEN TEST INTERSECTION

Test Site \ Approach \ Time	Before												After			
	1977				1978				1979				1980			
	*NL	SL	EL	WL	NL	SL	EL	WL	NL	SL	EL	WL	NL	SL	EL	WL
S.H. 199 and Fire Hall	23440	26340	200	200	26420	29210	200	200	26510	28650	250	250	26600	29000	250	250
F.M. 1220 and Boat Club Rd.	7410	2680	9940	1000	7730	2770	10070	1000	8050	2860	10540	1100	8370	3000	11000	1100
S.H. 199 and Roberts Cut-off	3000	11520	19510	22930	3100	12790	21650	25430	3100	12600	20900	24280	3100	12700	21100	25050
S.H. 183 and Roaring Springs Road	23500	25190	10630	5000	24000	25680	10830	3700	23820	25460	10760	5000	23820	25460	10760	5100
S.H. 174 and F.M. 917	12770	17900	2500	24200	13710	14600	2460	2300	15390	15320	2590	2550	16690	16720	2720	2750
U.S. 290 and S.H. 6 and F.M. 1960	8410	11060	20710	26810	10020	12010	26870	29970	11190	13950	23380	30280	20410	13920	24360	29630
S.H. 6 and Jackson	700	710	13220	12440	700	710	13140	12360	630	640	11930	11230	640	650	12000	11290
S.H. 146 and Crest Lane	20170	20170	5000	1025	22770	22770	5650	1160	23220	23220	5960	1180	27550	27550	6935	1400
S.H. 361 and F.M. 1069	2700	3970	3650	5850	3410	5380	4440	7310	3730	6090	4580	8190	4060	6480	4740	9070
U.S. 84 and S.H. 317	1770	2990	6340	3600	1750	3020	6640	3630	1730	3050	6940	3670	–	–	–	–

* Two way volume (i.e., NL = north leg of intersection both directions)

TABLE G-2. ESTIMATED DAILY TRAFFIC VOLUME FOR TEN TEST INTERSECTIONS

Test Site \ Time / Approach	Before												After			
	1977				1978				1979				1980			
	*NL	SL	EL	WL	NL	SL	EL	WL	NL	SL	EL	WL	NL	SL	EL	WL
S.H. 199 and Fire Hall	11720	13170	100	100	13210	14605	100	100	13255	14325	125	125	13300	14500	125	125
F.M. 1220 and Boat Club Rd.	3705	1340	4970	500	3865	1385	5035	5600	4025	1430	5270	550	4185	1500	5500	550
S.H. 199 and Roberts Cut-off	1500	5760	9755	11465	1550	6395	10825	12715	1550	6300	10450	12140	1550	6350	10550	12525
S.H. 183 and Roaring Springs Road	11750	12595	5315	2500	12000	12840	5415	2550	11910	12730	5380	2500	11910	12730	5380	2550
S.H. 174 and F.M. 917	6385	8950	1250	12100	6855	7300	1230	1150	7695	7660	1295	1275	8345	8360	1360	1375
U.S. 220 and S.H. 6 and F.M. 1960	4205	5530	10355	12405	5010	6005	13435	14985	5595	6975	11690	15140	10205	6960	12180	14815
S.H. 6 and Jackson	350	350	6610	6220	350	355	6570	6180	315	320	5965	5615	320	325	6000	5645
S.H. 146 and Crest Lane	10085	10085	2500	512	11385	11385	2825	580	11610	11610	2880	590	13775	13775	3467	700
S.H. 361 and F.M. 1069	1350	1985	1810	2925	1705	2690	2220	3655	1865	3045	2290	4095	2030	3240	2370	4535
U.S. 84 and S.H. 317	885	1495	3170	1800	875	1510	3320	1815	865	1525	3470	1835	-	-	-	-

* Two way volume (i.e., NL = north leg of intersection both directions)

APPENDIX H

VEHICULAR DELAY PARAMETERS UNDER VARIOUS COMBINATION OF LOOP LENGTH, LANE VOLUME SPEED, AND APPROACH

TABLE H-1. DELAY STATISTICS FOR SPEED 25 MPH

L.V.	L.L.	ATDV 1	ATDV 2	ATDV 3	ATDV 4	AQDV 1	AQDV 2	AQDV 3	AQDV 4	ASDV 1	ASDV 2	ASDV 3	ASDV 4
200	6	7.3	11.5	6.5	13.0	3.5	6.2	3.0	7.1	3.0	4.9	2.7	5.9
200	37	6.7	12.9	7.3	11.6	2.9	6.8	3.2	5.7	2.6	5.4	2.9	4.8
200	55	7.1	11.8	6.8	11.1	3.0	5.6	2.7	5.1	2.6	4.6	2.4	4.4
200	74	7.0	12.5	6.7	11.3	2.5	6.1	2.5	5.2	2.3	4.7	2.3	4.4
200	92	6.5	9.3	5.9	9.5	3.3	4.8	2.9	4.9	3.0	4.1	2.6	4.2
300	6	13.0	42.0	13.4	36.6	7.5	33.9	7.8	29.0	6.0	24.5	6.2	21.7
300	37	11.6	34.2	14.1	36.3	6.2	26.0	7.8	28.1	5.2	18.5	6.2	20.2
300	55	11.7	34.9	12.5	31.4	6.0	27.1	6.6	22.2	4.9	20.0	5.3	15.8
300	74	12.0	39.7	13.3	41.5	5.7	30.9	6.9	31.8	4.6	22.8	5.5	23.2
300	92	9.5	15.3	10.5	16.4	5.6	9.4	6.5	10.8	4.7	7.2	5.5	8.4
400	37	18.6	29.9	18.6	24.9	13.3	22.7	13.0	18.8	10.7	16.3	10.1	14.5
400	55	27.8	32.5	18.8	22.1	22.4	25.7	13.8	17.0	18.5	18.2	11.1	13.1
400	74	23.2	29.5	19.6	28.0	18.6	23.2	14.9	21.8	15.1	17.4	11.6	16.7
400	92	21.8	26.9	17.0	24.4	16.1	20.4	12.3	17.7	12.8	15.9	9.9	13.9
500	37	95.5	115.6	75.2	76.7	89.9	115.9	68.6	72.0	72.4	66.7	49.9	44.2
500	55	105.2	118.7	78.2	81.0	103.0	121.2	70.5	76.8	80.1	67.8	52.3	46.5
500	74	82.3	121.2	82.9	100.3	76.5	119.6	74.9	98.3	59.9	72.1	57.6	56.8
500	92	80.0	96.5	117.7	52.3	73.8	93.2	114.8	44.9	56.5	57.9	88.1	31.9

LEGEND:

ATDV = AVERAGE TOTAL DELAY PER APPROACH VEHICLE, SEC/VEH
AQDV = AVERAGE QUEUE DELAY PER APPROACH VEHICLE, SEC/VEH
ASDV = AVERAGE STOP DELAY PER APPROACH VEHICLE, SEC/VEH
D = TYPE OF DELAY STATISTICS
A = APPROACH NUMBER
L.L = INDUCTIVE LOOP LENGTH, FEET
L.V. = LANE VOLUME, VEHICLES PER LANE PER HOUR (VPLPH)

TABLE H-2. DELAY STATISTICS FOR SPEED 30 MPH

D		ATDV				AQDV				ASDV			
L.V.	L.L. \ A	1	2	3	4	1	2	3	4	1	2	3	4
200	6	6.4	9.7	6.7	9.4	3.3	5.3	3.5	5.1	2.9	4.5	3.1	4.2
200	44	6.2	9.5	6.0	9.2	3.3	5.2	3.2	5.0	2.9	4.5	2.9	4.3
200	66	6.1	9.4	5.8	8.8	3.3	5.5	3.0	4.9	2.9	4.7	2.7	4.3
200	88	6.5	9.2	6.4	9.9	3.0	4.2	3.0	4.8	2.7	3.7	2.7	4.2
200	110	6.4	9.3	6.4	9.7	3.1	4.5	3.0	4.9	2.7	4.1	2.7	4.2
300	6	9.9	17.2	10.9	15.8	6.2	11.8	6.9	10.4	5.2	9.2	5.9	8.6
300	44	10.0	17.8	11.4	15.3	6.4	12.2	7.5	10.5	5.4	10.1	6.3	8.5
300	66	10.0	17.3	10.4	15.5	6.6	12.0	6.7	10.5	5.4	9.8	5.7	8.6
300	88	10.5	16.6	10.4	16.7	5.9	10.4	6.1	10.8	4.9	8.5	5.1	8.6
300	110	10.0	17.4	10.8	15.2	6.0	11.4	6.4	9.3	5.1	9.0	5.4	7.6
400	44	27.2	33.7	20.4	28.0	21.5	27.0	14.6	21.6	17.6	19.3	11.8	16.1
400	66	22.6	29.7	18.3	28.2	17.0	22.1	13.2	21.7	13.2	17.0	10.3	16.3
400	88	20.4	28.0	19.1	24.4	14.5	20.8	13.5	17.6	11.5	15.9	11.0	13.5
400	110	22.0	30.5	21.4	28.1	16.1	23.7	15.6	21.4	13.0	17.9	12.6	16.3
500	44	83.6	127.4	103.0	110.3	75.8	124.5	94.5	107.9	59.6	84.3	69.5	63.1
500	66	79.4	128.0	89.6	84.1	70.4	127.9	78.2	80.2	58.9	84.8	57.9	48.7
500	88	82.9	77.3	111.5	113.0	77.0	72.8	106.0	114.3	59.8	43.3	80.9	64.7
500	110	113.9	86.2	80.4	116.4	108.5	81.4	71.0	117.5	85.9	46.7	53.5	65.8

LEGEND:

ATDV = AVERAGE TOTAL DELAY PER APPROACH VEHICLE, SEC/VEH
AQDV = AVERAGE QUEUE DELAY PER APPROACH VEHICLE, SEC/VEH
ASDV = AVERAGE STOP DELAY PER APPROACH VEHICLE, SEC/VEH
D = TYPE OF DELAY STATISTICS
A = APPROACH NUMBER
L.L. = INDUCTIVE LOOP LENGTH, FEET
L.V. = LANE VOLUME, VEHICLES PER LANE PER HOUR (VPLPH)

TABLE H-3. DELAY STATISTICS FOR SPEED 35 MPH

D / A: L.V.	L.L.	ATDV 1	ATDV 2	ATDV 3	ATDV 4	AQDV 1	AQDV 2	AQDV 3	AQDV 4	ASDV 1	ASDV 2	ASDV 3	ASDV 4
200	6	6.8	9.6	6.5	9.4	3.4	4.7	3.3	4.8	3.0	4.2	2.9	4.2
200	51	6.5	9.6	6.0	9.5	3.5	5.2	3.0	5.1	3.1	4.5	2.7	4.4
200	77	6.4	9.4	6.2	9.7	2.6	4.2	2.5	4.4	2.4	3.7	2.3	3.8
200	103	6.4	8.7	6.2	9.7	2.8	3.8	2.7	4.7	2.5	3.4	2.5	4.0
200	129	6.3	9.3	6.1	9.6	2.9	4.6	2.7	4.7	2.7	4.0	2.4	4.1
300	6	9.9	16.6	10.7	15.7	5.8	11.0	6.7	10.2	5.0	9.0	5.6	8.4
300	51	10.8	16.1	12.2	16.4	6.8	11.2	8.0	11.0	5.7	9.1	6.7	8.8
300	77	10.6	16.0	11.1	16.4	5.9	9.6	6.3	10.1	5.0	7.6	5.3	8.1
300	103	10.9	16.9	11.1	17.3	6.5	11.0	6.5	11.0	5.5	8.7	5.6	8.8
300	129	11.3	16.7	11.2	17.3	6.8	10.6	6.8	11.3	5.8	8.4	5.8	8.8
400	51	22.4	24.4	22.0	22.5	16.9	17.5	16.0	16.3	13.8	13.9	12.8	12.8
400	77	26.9	26.9	19.5	23.8	20.7	19.0	14.0	17.8	16.9	14.1	11.3	13.7
400	103	22.4	32.2	20.0	27.5	16.2	24.0	14.5	21.0	13.1	18.0	11.4	16.0
400	129	29.1	28.9	20.1	24.5	23.0	21.3	14.5	17.8	19.1	15.6	11.7	13.1
500	51	68.6	139.2	80.5	127.4	59.0	132.8	71.1	121.0	46.1	90.9	55.2	70.8
500	77	102.7	166.6	116.2	87.1	92.3	164.8	106.4	78.5	75.1	112.4	83.1	48.0
500	103	73.8	173.7	105.3	97.7	65.8	172.8	92.8	91.1	58.4	125.8	70.2	55.5
500	129	102.3	127.5	119.4	84.2	95.0	124.1	109.8	75.4	76.0	83.6	82.3	47.9

LEGEND:

ATDV= AVERAGE TOTAL DELAY PER APPROACH VEHICLE, SEC/VEH
AQDV= AVERAGE QUEUE DELAY PER APPROACH VEHICLE, SEC/VEH
ASDV= AVERAGE STOP DELAY PER APPROACH VEHICLE, SEC/VEH
D = TYPE OF DELAY STATISTICS
A = APPROACH NUMBER
L.L.= INDUCTIVE LOOP LENGTH, FEET
L.V.= LANE VOLUME, VEHICLES PER LANE PER HOUR (VPLPH)

TABLE H-4. DELAY STATISTICS FOR SPEED 40 MPH

L.V.	L.L. \ D / A	ATDV 1	ATDV 2	ATDV 3	ATDV 4	AQDV 1	AQDV 2	AQDV 3	AQDV 4	ASDV 1	ASDV 2	ASDV 3	ASDV 4
200	6	6.9	9.8	6.4	9.9	3.4	5.0	3.1	4.9	3.1	4.4	2.7	4.3
200	59	6.8	9.5	6.3	9.3	2.7	4.0	2.6	4.1	2.4	3.4	2.3	3.5
200	88	6.6	9.8	6.7	9.4	2.7	4.2	2.9	4.2	2.4	3.6	2.6	3.6
200	118	6.8	9.5	6.7	9.8	2.8	4.1	2.9	4.4	2.6	3.6	2.5	3.9
200	147	6.8	10.5	6.6	10.5	3.0	5.0	2.8	4.9	2.6	4.4	2.5	4.3
300	6	10.8	18.2	11.5	17.8	6.5	12.6	7.1	12.1	5.4	10.2	6.0	9.9
300	59	10.1	15.1	11.0	14.6	5.1	8.9	5.7	7.9	4.4	7.2	4.8	6.3
300	88	10.1	18.2	11.2	16.7	5.1	11.8	6.3	10.0	4.4	9.1	5.4	8.0
300	118	10.8	16.3	10.4	17.3	6.0	10.5	5.7	11.3	5.1	8.6	4.8	9.2
300	147	10.5	18.8	10.9	16.5	5.8	12.4	6.2	10.3	4.9	10.2	5.3	8.6
400	59	20.6	24.2	17.1	22.6	14.6	15.9	11.0	16.1	12.0	12.8	8.8	12.8
400	88	22.0	25.0	16.8	24.1	15.8	17.8	10.9	17.3	13.2	12.9	8.8	13.7
400	118	21.7	24.3	18.0	21.3	15.2	16.2	12.1	14.6	12.6	12.6	9.9	11.4
400	147	21.3	25.8	19.0	24.6	14.6	18.0	13.4	17.6	12.1	14.2	10.7	13.4
500	59	113.7	142.9	111.6	126.8	101.6	135.8	100.0	121.8	82.5	93.8	74.9	70.0
500	88	104.2	161.4	98.3	91.6	94.4	157.0	88.5	81.5	77.7	105.5	68.3	49.5
500	118	97.6	134.7	97.9	131.5	87.1	127.7	87.5	126.0	69.2	88.2	68.2	74.8
500	147	111.9	132.0	102.1	121.3	102.7	126.0	91.9	115.8	82.6	83.2	69.4	67.1

LEGEND:

ATDV= AVERAGE TOTAL DELAY PER APPROACH VEHICLE, SEC/VEH
AQDV= AVERAGE QUEUE DELAY PER APPROACH VEHICLE, SEC/VEH
ASDV= AVERAGE STOP DELAY PER APPROACH VEHICLE, SEC/VEH
D = TYPE OF DELAY STATISTICS
A = APPROACH NUMBER
L.L = INDUCTIVE LOOP LENGTH, FEET
L.V.= LANE VOLUME, VEHICLES PER LANE PER HOUR (VPLPH)