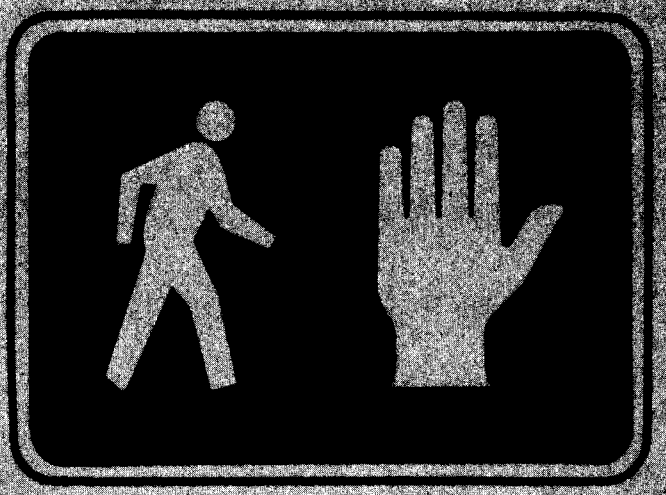
Report No. FHWA-RD-77-146

URBAN INTERSECTION IMPROVEMENTS FOR PEDESTRIAN SAFETY

Vol. V. Evaluation of Alternatives to Full Signalization at Pedestrian Crossings



December 1977
Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for

FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Washington, D.C. 20590

FOREWORD

This five-volume report describes pedestrian problems at urban intersections and timing and display improvements for pedestrian signals. This report will be of interest to traffic engineers and others responsible for pedestrian safety.

The five volumes are:

Vol. I - Executive Summary
Vol. II - Identification of Safety and Operational Problems at Intersections
Vol. III - Signal Timing for the Pedestrian
Vol. IV - Pedestrian Signal Displays and Operation
Vol. V - Evaluation of Alternatives to Full Signalization at Pedestrian Crossings

Sufficient copies of the five volumes are being distributed to provide a minimum of one copy to each FHWA Regional and Division office. Additional copies of the Executive Summary have also been provided to allow wider distribution of this report. Copies sent direct to the Division Offices should be distributed to the State highway agency, Governor's Representative for Highway Safety, and to major metropolitan areas.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-RD-77-146		

4. Title and Subtitle

URBAN INTERSECTION IMPROVEMENTS FOR PEDESTRIAN SAFETY
Volume V. Evaluation of Alternatives to Full Signalization at Pedestrian Crossings

5. Report Date: December 1977

6. Performing Organization Code:

7. Author(s)

Roger G. Petzold and Ronald Nawrocki

8. Performing Organization Code:

9. Performing Organization Name and Address

BioTechnology, Inc.
3027 Rosemary Lane
Falls Church, Va. 22042

10. Work Unit No.: FCP 31E2072

11. Contract or Grant No.: DOT-FH-11-8533

12. Sponsoring Agency Name and Address

U.S. Department of Transportation
Federal Highway Administration
Offices of Research and Development
Washington, D.C. 20590

13. Type of Report and Period Covered: Final Report
June 1974- June 1977

14. Sponsoring Agency Code:

15. Supplementary Notes

FHWA Contract Manager: Julie A. Fee, HRS-41

16. Abstract

This report summarizes the research completed in the third phase of a three-phase project. This phase was directed at identifying and evaluating alternatives to full signalization at pedestrian crossings. These pedestrian crossings are located at the intersection of a high-volume arterial street and a low-volume residential street. The selection of alternatives could not include grade-separated pedestrian structures, midblock crossings, or full signalization.

Five alternatives were selected for field evaluation with the following traffic devices on the major and minor streets, respectively: Sign and Stop Sign, Flashing Yellow Signal and Flashing Red Beacon, Flashing Green Signal and Stop Sign, (Sg-44) Signal and Stop Sign, and Crossing Guard with stop signs on the residential street.

The report compares the five school-pedestrian crossing designs with their fully signalized control sites discussing their relative advantages and disadvantages. Further comparisons were made between the various alternatives.

The Crossing Guard, (Sg -44) Signal and Stop Sign, and Flashing Green Signal and Stop Sign were determined to have operating characteristics significantly more desirable than those of a fully signalized intersection. Of these, the Crossing Guard and the Signal and Stop Sign were recommended as alternatives to full signalization at pedestrian crossings.

The report includes guidelines for the selection of the alternatives and the appropriate site criteria.

Other Volumes in this series include:

Volume I – Executive Summary
Volume II – Identification of Safety and Operational Problems at Intersections
Volume III – Signal Timing for the Pedestrian
Volume IV – Pedestrian Signal Displays and Operation

17. Key Words	18. Distribution Statement
Pedestrian Crossings, School Crossings, Pedestrian Signals, Traffic Signals, Traffic Control Devices, Pedestrians, Safety, Intersections, Traffic Operations	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	242	

Form DOT F 1700.7 (8-69)

PREFACE

This research project was conducted in three phases. Phase I dealt with the investigation and identification of both operational and safety problems encountered by pedestrians and motorists at urban-type intersections. Phase II dealt with the development, evaluation, and design criteria formulation of countermeasures that address the problems identified in Phase I. Phase III evaluated some alternatives to full signalization at intersections requiring pedestrian protection.

Volume I of the Final Report is the Executive Summary of the project. Phase I is reported in Volume II and Phase II is reported in Volumes III and IV. Specifically, Volume III addresses the subject of signal timing for the pedestrian; and Volume IV deals with pedestrian signal displays and signal operation. Phase III is reported in Volume V.

ACKNOWLEDGMENTS

The authors wish to express their gratitude for the cooperation and contributions of the following individuals and agencies:

U.S. Department of Transportation
Federal Highway Administration
Julie A. Fee
H. Milton Heywood

Traffic departments of the following participating cities and state:

Buffalo, New York
Dan W. Hoyt

State of Georgia
Archie C. Burnham, Jr.
Jerry Dubberly
Randy Doerr

Lincoln, Nebraska
Robert G. Holsinger
Richard J. Hayden
V. A. Singh
John Termaat

Memphis, Tennessee
Nathan C. Ficklin
Richard Hoffman

Seattle, Washington
Barry W. Fairfax
Ron Cameron

Sioux City, Iowa
Edward Swanson
Daniel S. Brame

Members of the Phase III Project Advisory Panel:

James L. Brown
Archie C. Burnham, Jr.
J. Mike Dawkins
Barry W. Fairfax
Nathan C. Ficklin
David G. Fielder
Harvey Friedson
Dan W. Hoyt
James M. Lee
Donald O. Robbins
P. Malcom Smith, Jr.
Edward Swanson

Appreciation is extended to those members of the NAC Signal and Sign Subcommittee who contributed many helpful ideas and comments through their participation in the design development survey.

Special appreciation and thanks goes to H. Douglas Robertson who, as Principal Investigator, helped develop the designs and evaluation techniques used in this study. Finally, we wish to thank Dr. H.W. McGee and Dr. Richard F. Pain, staff members of BioTechnology, for their contributions.

SUMMARY OF SIGNIFICANT FINDINGS

This report summarizes the research completed in the third phase of a three-phase project. This phase was directed at identifying and evaluating alternatives to full signalization at school-pedestrian crossings. These school-pedestrian crossings are located at the intersection of a high-volume arterial street and a low-volume residential street where adequate gaps do not exist to allow pedestrians to cross the arterial street safely without an unreasonable time delay. These locations would not otherwise warrant full signalization.

This study was divided into three sections:

- Identify alternative school-pedestrian crossing designs at intersections.
- Evaluate five alternative school-pedestrian crossing designs using controlled field experiments.
- Recommend the safest and most effective design for a school-pedestrian crossing based on the evaluation of the five alternatives.

The identification of alternative school-pedestrian crossings was divided into three tasks. Task one was to obtain information on school-pedestrian crossing designs currently being used. Task two was a survey of traffic engineers and safety experts to obtain information on what was currently being used for school-pedestrian crossing designs, their concerns regarding school-pedestrian crossing devices at intersections, and ideas on possible alternative school-pedestrian crossing designs to be evaluated. Task three was a meeting of the project advisory committee made up of twelve Federal, State, and local traffic engineers to develop guidelines to be used in the evaluation and to select the five school-pedestrian crossing designs to be field tested. The five school-pedestrian crossing designs selected were:*

- *Sign and Stop Sign* – Sign and beacon on the major street approach and stop sign on the local residential street.
- *Flashing Yellow Signal and Flashing Red Beacon* – Standard traffic signal dwelling in flashing yellow on the major street and a flashing red beacon on the local residential street.
- *Flashing Green Signal and Stop Sign* – Standard traffic signal dwelling in flashing green on the major street and stop signs on the local residential street.
- *(Sg-44) Signal and Stop Sign* – Standard traffic signal dwelling in solid green on the major street and stop sign on the local residential street.
- *Crossing Guard* – Crossing guard on the major street and stop signs on the local residential street.

*A detailed description of each school-pedestrian crossing design can be found on pages 8-12.

The five school-pedestrian crossing designs were evaluated in a time series, matched experimental-control site experimental design. Six measures of effectiveness were used in the evaluation: compliance, behavior, and volume, for both pedestrians and vehicles; vehicle delay; gaps in the major street vehicular traffic stream; and driver understanding. In all experiments a fully signalized intersection was used as a control site.

The data analysis consisted of two parts. Part One consisted of a detailed comparison between each school-pedestrian crossing design and its fully signalized control site. Part Two was a comparison among the five school-pedestrian crossing designs.

Based on the analysis, the following general advantages and disadvantages of the five school-pedestrian crossing designs compared to full signalization were:

Advantages:

- Increased pedestrian compliance to the pedestrian signal.
- Reduction in the stop time per vehicle on the major street approach.
- Reduction in installation costs.

Disadvantages:

- Reduction in both pedestrians' and drivers' understanding of how the traffic control devices operate.
- Increase in vehicle angle conflicts, but non-significantly.

Based on the comparison among the five school-pedestrian crossing designs, the crossing guard, (Sg-44) signal and stop sign and flashing green signal and stop sign were judged to have operating characteristics more desirable than those measured at the fully signalized control site.

TABLE OF CONTENTS

TABLE OF CONTENTS *(Continued)*

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

This report summarizes the evaluation of five school-pedestrian crossing designs developed for an intersection of a major arterial street (major street) with a low-volume residential street (minor street). The report examines each design and makes recommendations concerning its application.

Background

A request was made by the City of Seattle to the National Advisory Committee on Uniform Traffic Control Devices (NAC) for the adoption of a school-pedestrian signal design concept which uses stop signs on the minor street approach and traffic signals on the major street approach to an intersection (Figure 1) (Sg-44, change) (1)*. Recognizing that many western states were using these devices and that current information on their effect was inadequate, the NAC recommended that research be initiated to develop traffic control devices to safely accommodate pedestrians at intersections not otherwise requiring full signalization.

The situations under which this configuration of traffic control devices was used were as follows:

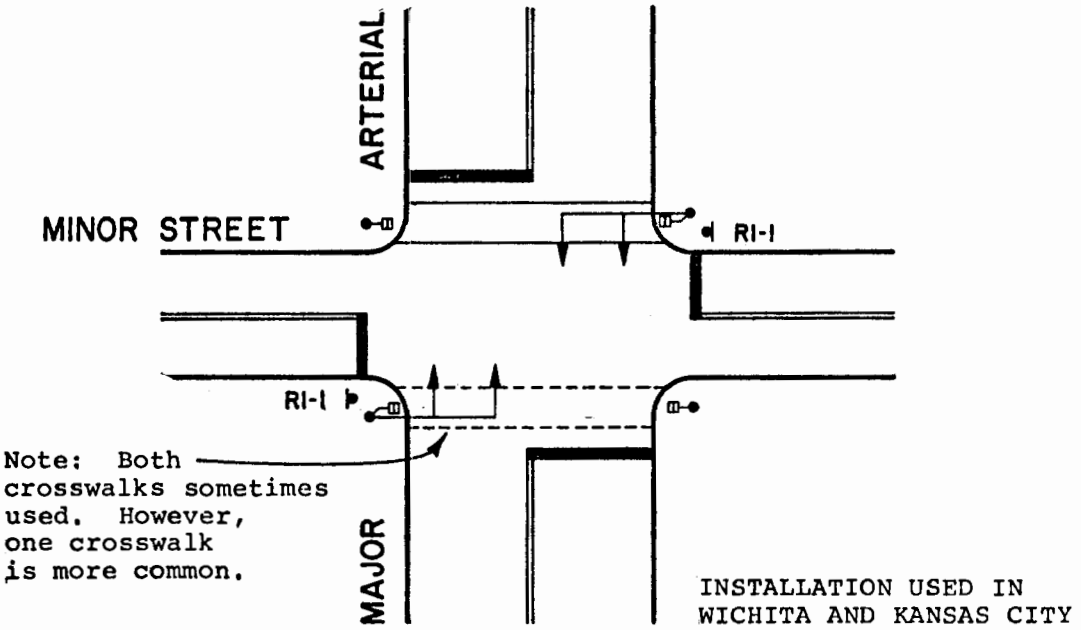
- Intersection of an arterial street (often high speed) with a low-volume residential street.
- Adequate gaps in the traffic do not exist to allow a pedestrian to cross the arterial street safely without an unreasonable time delay.
- The pedestrians are usually school children, the elderly and the handicapped.
- The pedestrians and minor street vehicle volumes do not warrant the installation of full signalization.
- The accident experience does not warrant full signalization.

Sites are seldom located at progression points within an existing signal system. In some cases where a school route crosses the major street, school crossing warrants can be used. This does not apply for non-school route crossings.

The *Manual on Uniform Traffic Control Devices (MUTCD)* (2) addresses the problem to some extent in Section 4C-6, "School Crossing Warrant," in terms of inadequate gaps. Reference is made to Section 7A-3, "School Crossing Control Criteria," which offers the following guidance when gaps are inadequate: "some form of traffic control is needed which will create (in the traffic stream) the gaps necessary to reduce the hazard." Because of the safety and operational implications of the Sg-44 configuration, this research was intended to evaluate numerous configurations of traffic control devices that could be used in this situation.

Compounding the problem is the fact that full signalization itself may be undesirable from an operational and/or cost point of view.

*Numbers underlined in parentheses correspond to the References on page 64.



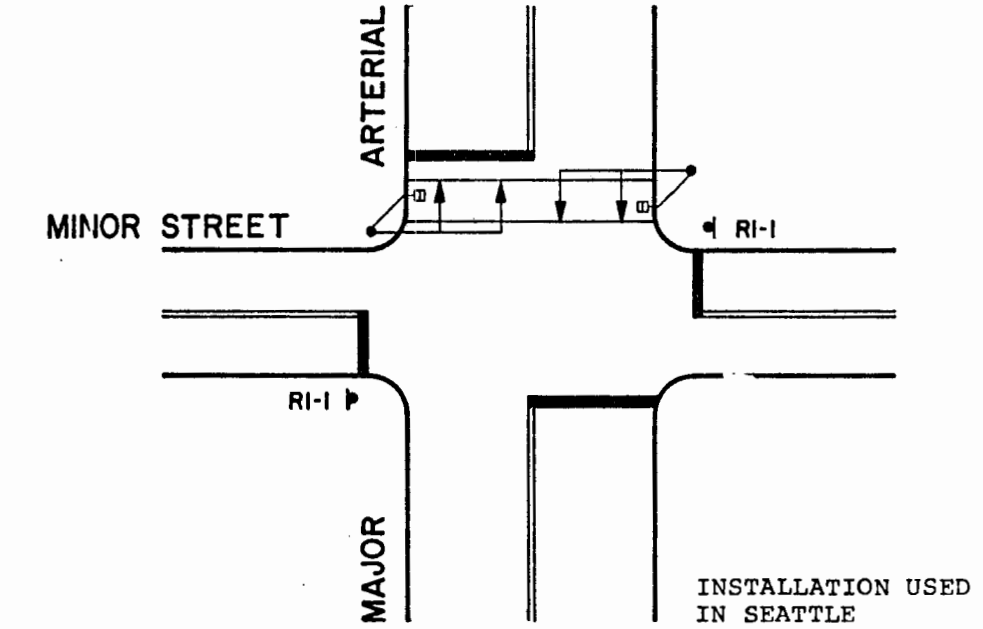


Figure 1. Sg-44 (Chng.) School-Pedestrian Signal Design Concept With Stop Signs at Signalized Intersections

Objectives and Scope of Study

The objectives of Phase III were to:

- Develop alternative school-pedestrian crossing designs at intersections other than grade-separated pedestrian overpasses or underpasses, moving the pedestrian crossing to midblock, or full signalization of the intersection. These designs should conform with the intent of the principles stated in the MUTCD (2). This includes both the modification of existing devices/applications and the development of new devices/applications.

- Evaluate the five most desirable school-pedestrian crossing designs including the (Sg-44) signal and stop sign.

- Recommend the safest and most effective treatment for a school-pedestrian crossing design.

II. SELECTION OF SCHOOL-PEDESTRIAN CROSSING DESIGNS

Introduction

The selection of school-pedestrian designs was accomplished in two steps. Initially a design development survey was distributed to a group of traffic engineers and safety experts. This was followed by a meeting of the project advisory panel to discuss the results of the survey and to make recommendations as to which school-pedestrian crossing designs should be used in further experimentation and field evaluation.

Design Development Survey

The survey was devised to elicit from traffic engineers and safety experts their concerns and design ideas on school-pedestrian crossings at intersections (Appendix A). The survey was structured to give each participant an outline of the problem and limit the scope of alternatives to *other than* the following:

- Grade-separated pedestrian over or underpasses
- Moving the pedestrian crossing midblock
- Full signalization of the intersection.

In addition each participant was asked to consider the following factors when reviewing a design and/or developing an alternative design:

- Effectiveness in protecting pedestrians
- Effectiveness in minimizing delay and stops for vehicular traffic
- Cost of the traffic control device, its installation, maintenance, and operation
- Relativity to other, existing traffic control devices
- Applicability to low cross street and low pedestrian volumes
- Impact on traffic patterns, i.e., route diversion
- Effect on type and number of accidents.

Four alternatives were then presented which showed different types of traffic control devices for the major street and the low volume residential street. Each proposed alternative contained a detailed description of its advantages and disadvantages as seen by the research team. The traffic engineers were asked to comment on each alternative based on their experience and judgment; their comments are presented in Table 1. Their major concerns were violation of drivers' expectancy, ineffectiveness in producing a safe gap for pedestrians, and confusing operation of the traffic control device.

Table 1

Design Development Survey
(Comments on Proposal Alternatives)

	DISADVANTAGES	MODIFICATIONS	ADVANTAGES	
PROPOSED ALTERNATIVE	DISADVANTAGES DISTINCTLY OUTWEIGH ADVANTAGES DO NOT INSTALL	CONCEPT ACCEPTABLE W/ MINOR MODIFICATIONS RESEARCH NEEDED TO DETERMINE IF	ADVANTAGES DISTINCTLY OUTWEIGH DISADVANTAGE CONCEPT EFFECTIVE AS IS	NO COMMENT
ALTERNATIVE 1 (Sg-44) Signal & Stop Sign	12—Violates Driver Expectancy 6—Unsafe 2—High Installation Cost 1—Confusing 2—Other	1—Cost Effective 1—Confusing	1—Safe 1—Low Installation Cost 4—Other	
TOTAL	**23**	**2**	**6**	**0**
ALTERNATIVE 2 Beacon & Stop Sign	22—Not Effective 1—Unsafe 1—Other	3—Other	2—Other	
TOTAL	**24**	**3**	**2**	**2**
ALTERNATIVE 3 Sign & Stop Sign	5—Not Effective 5—Unsafe 3—Confusing	4—Better Sign Message 2—Confusing 1—Meets Driver Expectancy 6—Other	2—Other	
TOTAL	**13**	**14**	**3**	**1**
ALTERNATIVE 4 Flashing Yellow Signal and Flashing Red Signal	14—Confusing 6—High Installation Cost 2—Violates Driver Expectancy 3—Unsafe 1—Other	1—Other	2—Maximun Safety	
TOTAL	**26**	**1**	**2**	**2**

Appendix A Contains Data that Supports this Table.

Based on the alternative design suggestions, the most frequently proposed traffic control devices on the major streets were: a two- or three-section traffic signal or a sign with beacons. On the local residential streets the most often proposed alternatives were stop signs or stop signs supplemented with red beacons.

Advisory Panel Meeting

The project advisory panel had three objectives: to develop general site criteria, to develop general measures of effectiveness (MOE) and to recommend alternative school-pedestrian crossing designs. First the discussion involved the type of intersection where a school-pedestrian signal would be applicable. Locations included:

- Intersections that do not meet the vehicle or pedestrian volume warrants of the *MUTCDs*, particularly with respect to the minor street vehicular volume
- Intersections that meet the school crossing warrant, Warrant 4, MUTCD
- Intersections that are established school crossings
- Intersections used frequently by senior citizens or handicapped persons.

The major objections to full signalization were excessive interruption of traffic flow on the major street (unacceptable delay), generation of traffic on the minor street by providing an access point to the main street, and the cost of installing or upgrading traffic control devices to full signalization.

The project advisory panel discussed factors in the survey that should be considered in the evaluation of each proposed design. They suggested including ease of understanding and acceptance by pedestrians and motorists of each school-pedestrian design as additional considerations.

Alternative designs were then presented to the panel. The panel expressed concern that the meaning of steady green would be violated by mixing stop signs and signals. After much additional discussion of the advantages and disadvantages of each design suggested, the panel formulated five recommended alternatives (including Sg-44) for consideration (Appendix A).

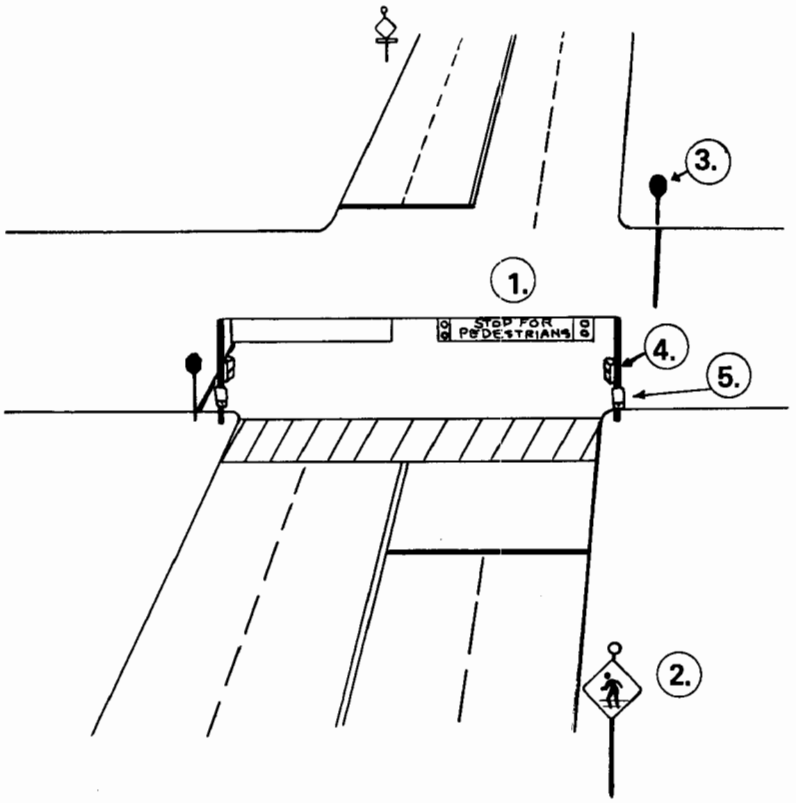
The panel made other recommendations concerning the scope of the research:

- Specific guidelines should be developed for the types of intersection at which school-pedestrian crossing devices could be located.
- More than two cities should be used as field test sites.
- Data should be collected at a fully signalized, semi-actuated intersection near the test site in each city for control purposes.

- As much existing data as possible on school-pedestrian crossing designs now in use should be gathered and synthesized as soon as possible (particularly on the Sg-44 concept).

Based on the responses to the survey and recommendations of the project advisory panel, the FHWA selected the following school-pedestrian crossing designs for further evaluation.

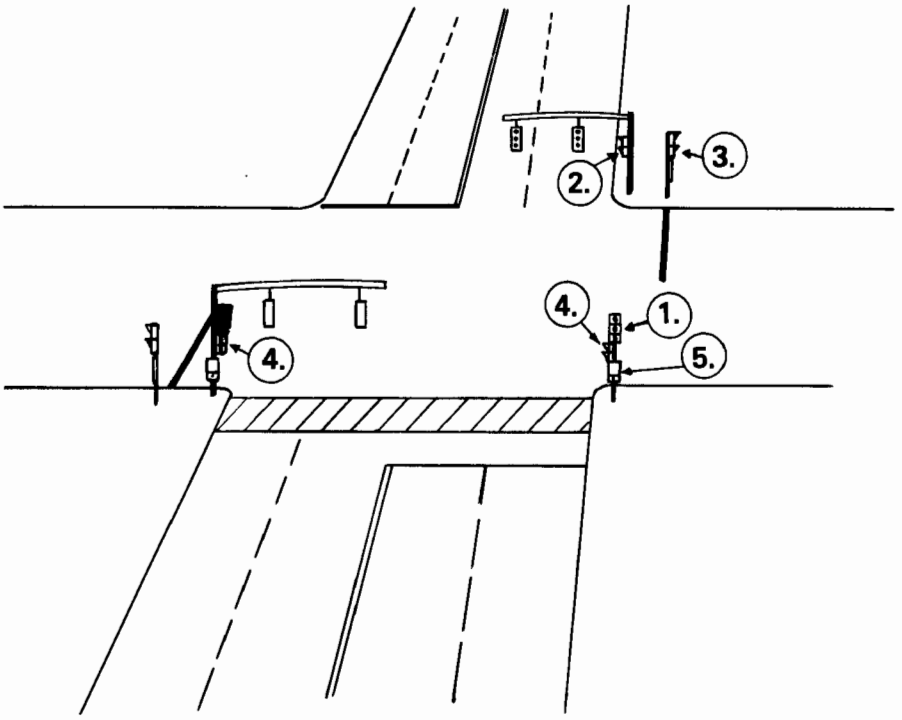
- Sign and stop sign (Figure 2)
- Flashing yellow signal and flashing red beacon (Figure 3)
- Signal and stop sign (dwelling in flashing or steady green (Figures 4 and 5)
- Crossing guard (Figure 6).

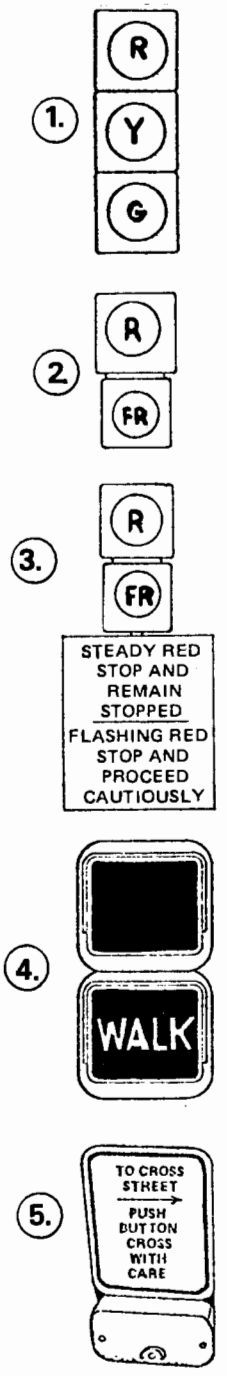


OPERATION

Approach	Dwell	Ped Act			
O.H. Sign	Dark	Y	FR	FR	FR
Advance sign	Dark	FY	FY	FY	FY
Ped Signal	DW	DW	DW	Cross with care	FDW

Figure 2. E-1, Sign and Stop Sign

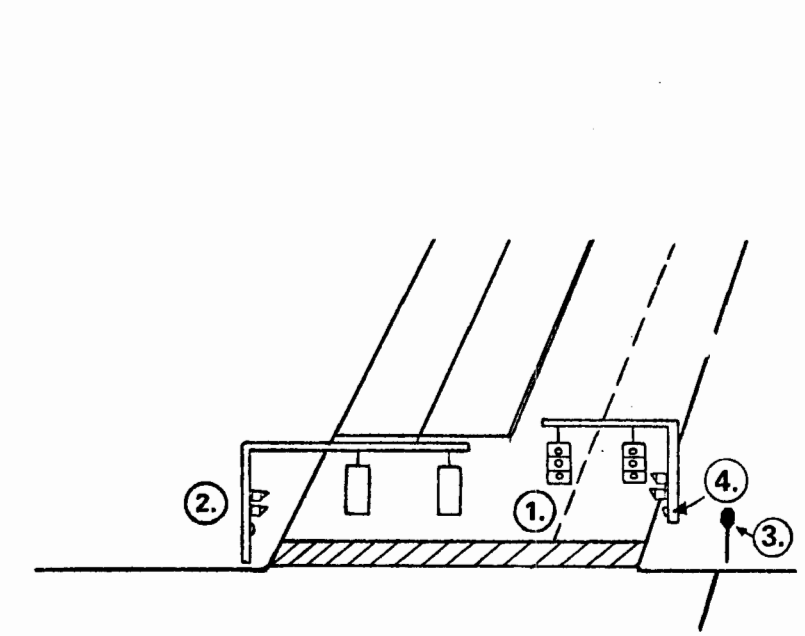


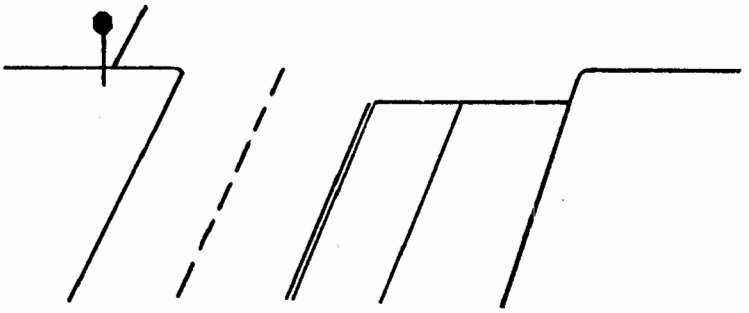


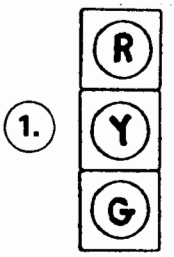
OPERATION

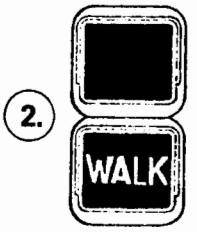
Approach	Dwell	Ped Act.			
Main	FY	G	Y	R	R
Minor	FR	R	R	R	R
Ped Signal	DW	DW	DW	W	FDW

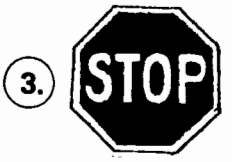
Figure 3. E-2, Flashing Yellow Signal and Flashing Red Beacon

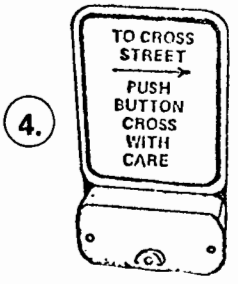








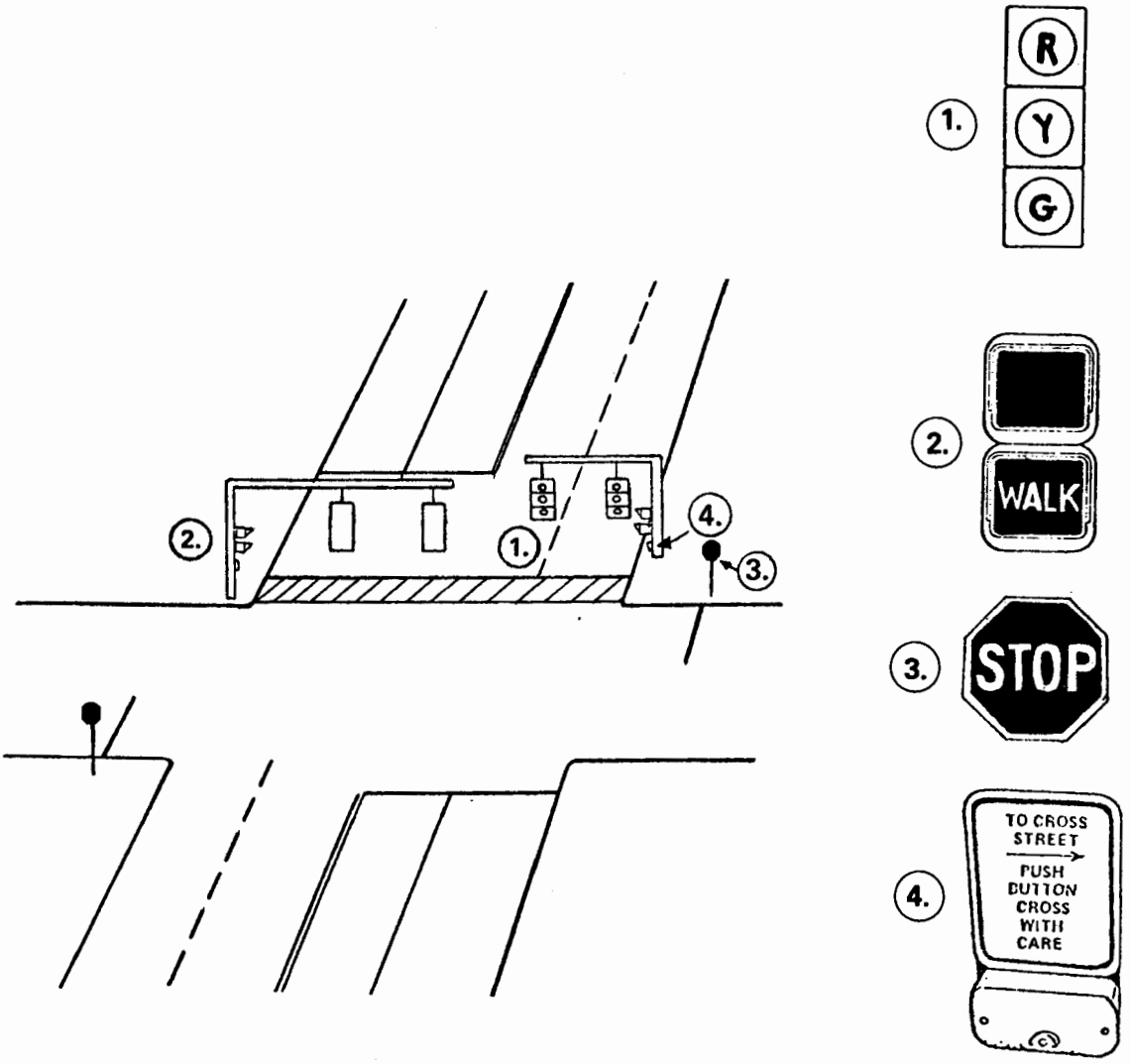




OPERATION

Approach	Dwell	Ped Act		
Major	FG	Y	R	R
Minor	Stop Sign			
Ped Signal	DW	DW	W	FDW

Figure 4. E-3, Flashing Green Signal and Stop Sign



OPERATION

Approach	Dwell	Ped Act.		
Major	G	Y	R	R
Minor	Stop Sign			
Ped. Signal	DW	DW	W	FDW

Figure 5. E-4, (Sg-44) Signal and Stop Sign

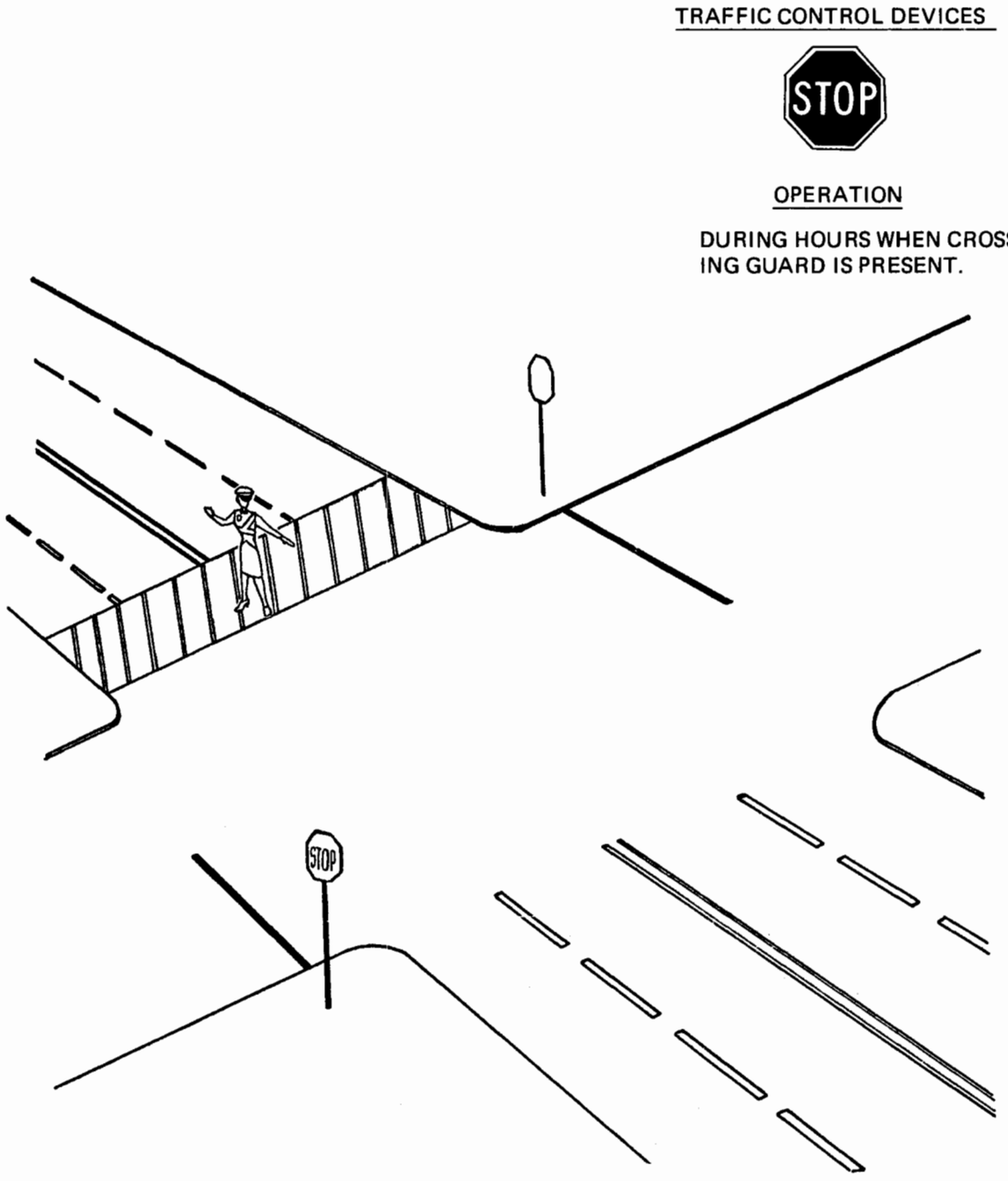


Figure 6. E-5, Crossing Guard

III. FIELD STUDY METHODOLOGY

Introduction

An experimental plan was developed based on the selection of the five school-pedestrian crossing designs for field evaluation. The evaluation of each school-pedestrian crossing design was located in two cities in different regions of the United States using existing design locations where possible in all six cities participating in the evaluation.

Experimental Plan

A time series, matched experimental-control site design was employed. A before/after experimental design was not feasible due to the difficulty in finding sites with similar "before" conditions. This was due to the cost involved in upgrading a stop sign-controlled intersection and the political problems of downgrading a fully signalized intersection to any one of the alternate designs. The control site permits changes between data collection visits to be measured and random variance reduced. Also the control site can be used as a benchmark to gauge the effect of each experimental site.

The time series consisted of three data collection visits six to eight weeks apart to each experiment and control site pair. These three data collection points revealed trends, increased the sample size, and reduced random errors. In total, ten matched pairs of experimental-control sites were observed for three data collection visits (Figure 7).

Measures of Effectiveness

Five measures of effectiveness (MOE) were used to evaluate the designs: compliance, behaviors, and volume for both pedestrians and vehicles; vehicle delay; and gaps in the major street vehicular traffic stream. A survey of driver understanding also provided valuable information (except crossing guard).

Vehicle/Pedestrian Compliance. Compliance for both vehicles and pedestrians was measured with respect to the appropriate traffic control device.

Vehicle Compliance Measures (except crossing guard) include:

- *Violation of the red signal indication.* The front wheels of the vehicle cross the stop line when the traffic signal indication is red for that approach.
- *Violation of the right-turn-on-red law.* A vehicle fails to make a locked wheel stop prior to making a right turn through a red signal indication.

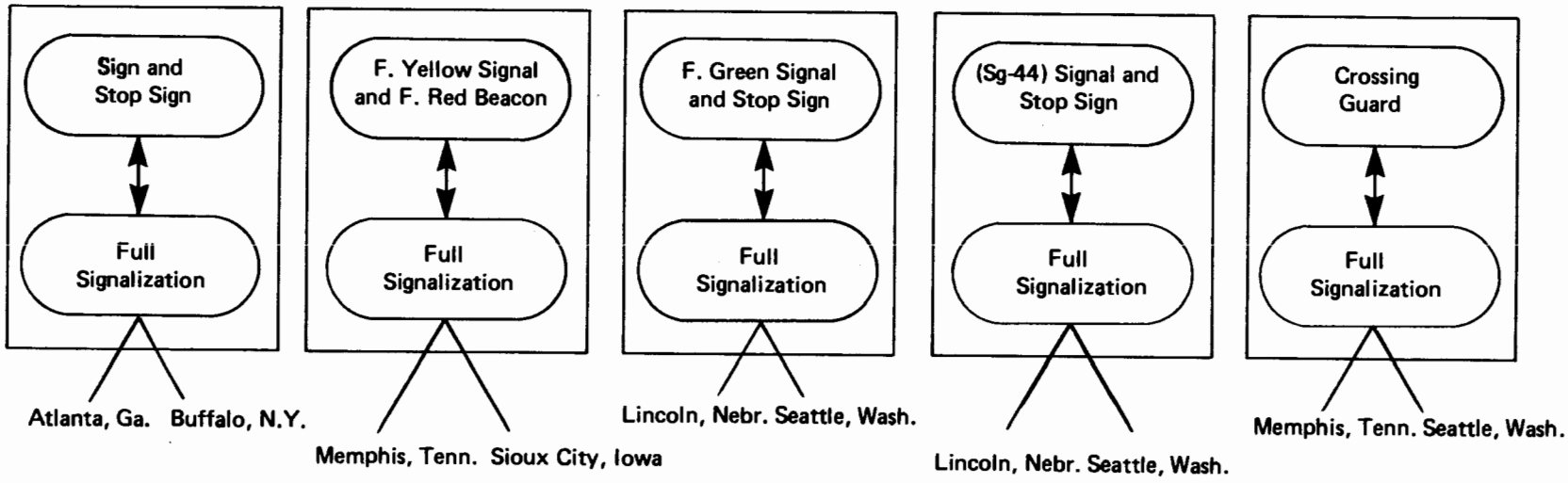


Figure 7. Experimental Plan

- *Entering the intersection on the yellow signal indication.* the front wheels of the vehicle cross the stop line when the traffic signal is amber for that approach.

Pedestrian Compliance Measures (except crossing guard) include:

- *Push-button.* The number of times the traffic control device is actuated by the push-button.
- *Enters intersection on the WALK signal.* The pedestrian enters the intersection traffic lanes when his signal shows the WALK message.
- *Enters intersection on the flashing DONT WALK signal.* The pedestrian enters the intersection traffic lanes when his signal shows the flashing DONT WALK message.
- *Enters intersection on the DONT WALK signal.* The pedestrian enters the intersection traffic lanes when his signal shows the steady DONT WALK message.
- *Unmarked crosswalk.* The pedestrian enters the intersection traffic lanes from a point where no traffic control devices are used to designate the crossing as a crosswalk.

Vehicle Compliance measures for the crossing guard design include:

- *Did not stop for crossing guard.* A vehicle disobeys an order from a crossing guard to stop.
- *Disobeys a guard order.* A vehicle disobeys an order from a crossing guard to take a particular action.

Pedestrian Compliance measures for the crossing guard design include:

- *Walked with the crossing guard.* A pedestrian crosses with the crossing guard.
- *Pedestrian crossing but not with crossing guard.* A pedestrian crosses at a crosswalk where the guard is on duty, but without the aid of the crossing guard.
- *Pedestrian crossing but guard not on duty.* A pedestrian crosses at a location where the guard is usually stationed but is not on duty at the time.
- *Unmarked crosswalk.* The pedestrian enters the intersection traffic lanes from a point where no traffic control devices are used to designate the crossing as a crosswalk.

Vehicle/Pedestrian Behavior. Previous research indicates that vehicle and pedestrian behaviors occur more frequently at high accident intersections than at similar low accident intersections (3).

The Vehicle/Vehicle Behaviors include the following:

- *Rear end.* A vehicle moving in a straight line suddenly decelerates, causing the front end to dip and the wheels to lock or squeal.
- *Angle conflict between two vehicles on the major street.* This is a conflict between two vehicles traveling on the major street, both in the intersection, one turning into the path of the other causing one or both vehicles to suddenly change their speed or path.
- *Angle conflict between two vehicles on the minor street.* Same as angle conflict between two cars on the major street except that both vehicles enter the intersection from the minor street.
- *Angle conflict between two vehicles, one entering the intersection from the major street and the other entering from the side street.* Same as angle conflict between two vehicles on the major street except one vehicle enters from the major street and the other from the minor street.

The Pedestrian/Vehicle Behavioral measures include the following:

- *Backup movement.* The pedestrian momentarily reverses his direction of travel in the traffic lane, or hesitates in response to a vehicle in the traffic lane.
- *Turning vehicle hazard.* The pedestrian is in the path of the turning vehicle with less than 20 feet (6.1 m) separating them.
- *Vehicle hazard.* The pedestrian enters a traffic lane when a through vehicle, unrestricted by a traffic control device, is approaching in that lane within half a block.

Vehicle/Pedestrian Volume. The third MOE, pedestrian and vehicle volume, was measured for all four approaches to the intersection. The vehicle volume was recorded for through, left, and right turns for each approach. Pedestrian volumes were recorded crossing each leg of the intersection.

Vehicle Delay. The fourth MOE, vehicle delay was recorded as follows:

- *Percent of vehicles stopping.* Vehicles crossing the stop line that have stopped one or more times on the intersection approach.
- *Stop time per stopped vehicle.* The average time in seconds that a stopped vehicle is delayed during the observation period.
- *Stop time per vehicle.* The total time in seconds that vehicles are stopped during the observation period divided by the number of vehicles that pass through the intersection in that observation period.

These variables were obtained for both the major and minor street approaches throughout the day.

Gaps in Major Street Traffic Stream. A gap in the major street traffic is the time interval (in seconds) between which individual vehicles are observed passing a given point for all traffic lanes and the time when no vehicles are in the traffic lanes and pedestrians may cross safely. Gaps in the major street traffic stream were obtained in 15-minute observation periods throughout the day. All gaps equal to or larger than the minimum allowable gap time* were recorded.

Appendix B contains a detailed explanation of data collection procedures, measurement of variables, and data collection observation schedule.

Driver Understanding Data. A survey of driver understanding was obtained from drivers approaching each school-pedestrian crossing design (except the crossing guard design) on the major and minor streets. The survey was structured to obtain information on the driver's perception of the traffic control devices at the intersection, how the driver thought they operated, and the driver's understanding of the purpose for the traffic control device. The driver understanding survey was conducted during only one of the three data collection periods and is described in detail in Appendix H.

Data Analysis

The variables were divided into control dependent variables and measures of effectiveness (MOEs). The control dependent variables consisted of two-way vehicle volume for both the major and minor streets and pedestrian volume crossing the major street. The MOEs consisted of pedestrian hesitation, turning vehicle hazard, vehicle hazard, rear-end conflict, angle conflict (combination of the three MOE angle conflicts measured in data collection), number of pedestrians entering the traffic lanes on the permissive indication, number of pedestrians entering the traffic lanes on the prohibited indication (steady DONT WALK) and vehicle violations of the prohibited phase.

Control dependent variables were used to determine if there were significant differences between the three data collection visits for each location, significant differences between the experimental and control sites and differences by time of day (AM, Noon, PM). The analysis was accomplished by using a three-way analysis of variance. Due to the bi-modal nature of both the vehicle and pedestrian volume data, a log transformation was performed to approximate a normal population. The F-test was used to test for significant differences. The data analysis was based on standard statistical procedures with all statistical tests evaluated at the 0.05 significance level (two tail).

The results of the analysis showed no significant difference between data collection visits for most of the experimental and control sites at the 0.05 level (see Appendix D). However, significant

*The minimum allowable gap time is defined in Appendix B.

differences between paired experimental and control sites with respect to both vehicular and pedestrian volume were revealed at the 0.01 level. Due to differing vehicular and pedestrian volumes, the evaluation of the school-pedestrian crossing design was divided into two parts. Part one consisted of a detailed comparison of variables between each of the five school-pedestrian crossing designs and their fully signalized control site. Part two was a comparison among the five school-pedestrian crossing designs.

The two-part evaluation analyzed the data using two methods to test the sensitivity of the results. It is recognized that differences in pedestrian and vehicle volume will have an effect on the MOE between paired experimental and control sites. The comparison between school-pedestrian crossing designs is affected by regional differences as well as differences in pedestrian and vehicle volumes in the evaluation. These factors that affect the MOEs cannot be quantified, therefore, differences in the MOEs may not be due to the different treatments. The uses of two analysis techniques did reveal which school-pedestrian crossing designs were less desirable.

In both evaluation sections the following criteria was used to determine the effectiveness of the school-pedestrian crossing design:

- Significant differences in one or more of the pedestrian or vehicle behaviors
- Significant differences in pedestrian compliance
- Significant differences in driver violations of the prohibited phase
- Differences in vehicle delay on both the major and minor street approaches
- Responses from the drivers concerning their understanding of how each school-pedestrian crossing design operates.

Part one of the evaluation consisted of a comparison between matched pairs of experimental and control sites for each school-pedestrian crossing design. The evaluation follows the criteria using a Z-test to reveal significant differences in the variables between each pair of experimental and control sites. A trend was then identified for each MOE by school-pedestrian crossing design. Each trend was based on results of the Z-test, differences in pedestrian and vehicle volumes, differences in location, environmental factors and presence of other school-pedestrian crossing devices (crossing guard) for each paired experimental and control site. The result is a trend for each MOE by school-pedestrian crossing design and a listing of the advantages and disadvantages of each school-pedestrian crossing design relative to a fully signalized control site. A simple ranking scheme was used to identify any pattern in the five basic categories of the measures of effectiveness across the five school-pedestrian crosssing designs.

Part two of the evaluation consisted of a comparison among the five school pedestrian crossing designs. A ranking scheme was developed in which each MOE was assigned a rank score from one to

five based on the sum of the MOEs values for each school-pedestrian crossing design, one being the most desirable and five being the least desirable. The rank scores were then analyzed by using a t-test to identify significant differences in mean rank scores between paired school-pedestrian crossing designs. The result of this analysis was a grouping of the school-pedestrian crossing designs based on their MOEs.

In addition a close examination of driver understanding data was made to reveal differences in the perceptiveness of drivers among the school-pedestrian crossing designs.

IV. DISCUSSION OF RESULTS

Introduction

The discussion of results is divided into two parts. Part one consists of an analysis between school-pedestrian crossing designs and their control sites. Part two is an analysis comparing the five school-pedestrian crossing designs.

School-Pedestrian Crossing Design Vs Full Signalization

Sign and Stop Sign

Figure 8 describes the type of traffic control devices used, their location, and method of operation that were combined to make up the sign and stop sign school-pedestrian crossing design.

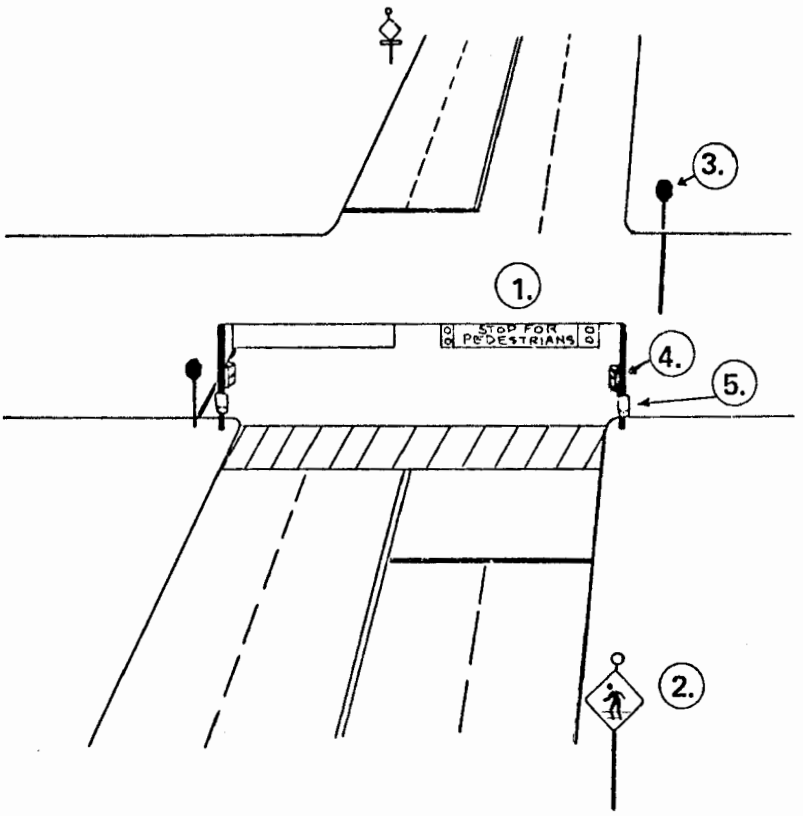
This school-pedestrian crossing design was activated whenever a pedestrian depressed the push-button, causing the device to move immediately into the pedestrian activation phase. The only time this would not happen is when the device had just completed a cycle and remained in the dwell phase for a prescribed amount of time (usually 60 to 100 seconds) before activating the traffic control device again. For the major part of the day, the school-pedestrian crossing device will dwell in the normal message phase.

Table 2 summarizes the behavioral, compliance, and driver understanding data collected in Atlanta and Buffalo. The data summaries that support this table can be found in the appendices.

Pedestrian Behavior. In Buffalo the hesitation or reversal of pedestrians at the sign and stop sign design averaged 20 percent compared to 8 percent of the control site (see Appendix G). This larger percentage of hesitation at the sign and stop sign location may be due to the pedestrians' uncertainty as to whether the vehicle would stop for the flashing red beacon and sign.

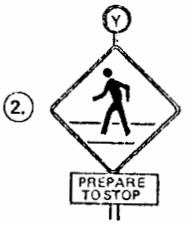
In Atlanta the low occurrence of hesitation by pedestrians at the sign and stop sign location is due to the presence of a crossing guard during times of heavy pedestrian use. However, it was noted that when the crossing guard was not present, pedestrians made sure the car had stopped before entering the traffic lane. This behavior indicated little confidence in the driver's correct response to the flashing red beacon.

The turning vehicle hazard rate in Atlanta was 16 percent at the control site and 2 percent at the sign and stop sign (see Appendix G). The large difference is due to a much higher volume of traffic on the local residential street (minor street) at the control site. This results in a higher number of turning vehicles and, consequently, a high probability for turning vehicle conflicts. In Buffalo no significant difference in turning vehicle hazards was observed between the experiment and control sites.



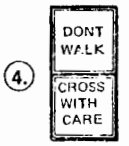
TRAFFIC CONTROL DEVICES

Sign and Beacons



Advanced Warning Sign

Stop Sign



Pedestrian Signal

Pedestrian Push-Button

Operation

Approach	Traffic Control Device	Traffic Control Device Displays				
		Normal Display Presented	Pedestrian Activation	Vehicle Clearance	Pedestrian Crossing	Pedestrian Clearance
Major Street	Overhead sign and Beacons	Beacons Dark	Yellow Beacon	Flashing Red Beacon	Flashing Red Beacon	Flashing Red Beacon
Minor Street	Stop sign	Stop sign	Stop sign	Stop sign	Stop sign	Stop sign
Pedestrian	Pedestrian signal	DONT WALK	DONT WALK	DONT WALK	CROSS WITH CARE	Flashing DONT WALK

Figure 8. Operation of E-1, Sign and Stop Sign

Table 2
Summary of Results

Sign & Stop Sign Vs Full Signalization (Semi-Actuated)

		City	Atlanta†	Buffalo	Trend
BEHAVIORAL	PEDESTRIAN	Hesitation or Reversal	ns	C**	C
		Turning Vehicle Conflict	E**	ns	ns
		Vehicle Hazard	E**	C**	ns
	VEHICLES	Rear-End Conflict	E**	ns	ns
		Angle Conflict	E**	ns	ns
COMPLIANCE	PEDESTRIAN	Leave Curb on Permissive Interval	E**	E**	E
		Leave Curb on Prohibited Interval	E**	E**	E
	VEHICLE	Violation of Major Street Prohibited Phase	C**	E**	C
COST		Cost Ratio (E/C)	1.01	0.53	0.67
UNDERSTANDING	MAJOR STREET	Question 1[A]	60%	66%	63%
		Question 2[A]	62%	61%	62%
		Question 3[A]	43%	26%	35%
		Question 4[A]	43%	46%	45%

Note: † = Crossing guard present when school children are crossing.
E = Difference in favor of experimental, school-pedestrian crossing design.
C = Difference in favor of control, full signalization.
ns = No significant difference between experimental and control condition.
* = Significant at the 0.05 level.
** = Significant at the 0.01 level.
Cost Ratio = Ratio of installation costs for experimental and control conditions.
Question 1 At the intersection you just passed, were there any traffic control devices?
Question 2 At the intersection you just passed, what is the purpose of the traffic control device?
Question 3 What causes the traffic control device to turn red?
Question 4 What controls traffic on the minor street at this intersection?
A = Percent of drivers answering question correctly.
Appendices contain the Data Summaries that support this table.

The decrease in vehicle hazards at the experimental site in Atlanta was due mostly to the presence of a crossing guard at the sign and stop sign intersection during periods of heavy pedestrian use.

Vehicle Behavior. The vehicle behaviors rear-end and angle conflicts at both the sign and stop sign and control occurred infrequently, less than 0.2 percent, of major street vehicle volume. The vehicle behaviors at the sign and stop sign occurred at or below the rate observed at the control site.

Pedestrian Compliance. A significant difference in pedestrian compliance was observed in both Atlanta and Buffalo. In Atlanta the sign and stop sign intersection had 85 percent of the pedestrians leaving the curb on the permissive indication compared to 6 percent at the control site (see Appendix F). The higher compliance rate at the sign and stop sign location most likely is due to the presence of the crossing guard and the high utilization of the crossing by elementary school students. Although semi-actuated the control site operates similar to a fixed-timed signal due to a constant flow of traffic on the minor street except that the pedestrian signal does not operate unless the pedestrian push-button is pressed. Many pedestrians crossed the major street during the green phase for the local residential street, disregarding the pedestrian signal. Therefore, the compliance rate for the sign and stop sign is higher than would be expected from the general population, and the compliance rate for the control site indicates that the pedestrian does not use the pedestrian signal.

The Buffalo site had a significantly higher compliance rate at the sign and stop sign (7 percent) compared to the control site (1 percent). However, these figures are unacceptably low. This may be attributed to the experimental site being located in the inner city where pedestrians must constantly cope with heavy traffic and have enough experience to cross the street without the aid of a traffic control device. Positioning the pedestrian push-button away from the normal pedestrian path may also have been a contributing factor to lower compliance. Overall, the pedestrian compliance rate was significantly higher at the sign and stop sign location compared to the fully signalized location but still extremely low.

Vehicle Violation of Prohibited Interval. Vehicle non-compliance with the flashing red indication in Atlanta was 2.3 percent compared to 0.2 percent of the major street vehicle volume for the steady red indication at the fully signalized control site (see Appendix F). This is disturbing because the flashing red indicators were activated only 19 times in each 7-hour observation period, and approximately 11 cars per activation did not come to a complete stop before proceeding through the intersection.

In Buffalo the non-compliance rate was 0.2 percent for the flashing red indication compared to 0.5 percent for full signalization (see Appendix F). The non-compliance rate was still high at the sign and stop sign location with one car per activation proceeding through the flashing red signal without coming to a complete stop.

Cost Ratio. In Atlanta, the cost* to erect the sign and stop sign was approximately equal to the cost to construct the fully signalized, semi-actuated intersection (see Appendix C). In Buffalo the cost to erect the sign and stop sign is approximately half the cost to erect the fully signalized intersection. There may be some installation cost savings by using the sign and stop sign design.

Vehicle Delay. The percent of vehicles stopping on the major street (Table 3) is considerably smaller for the sign and stop sign (3 and 9 percent) than for the fully signalized intersection (17 and 47 percent) both in Buffalo and Atlanta, respectively. The sign and stop sign had the highest percentage of vehicles stopping during the AM and PM #1 observation periods** compared to the fully signalized intersection which had its highest percentage during the PM #1 and PM #2 observation periods. These results indicate decreased pedestrian volume and use of the sign and stop sign when higher vehicle volumes occurred.

In both Atlanta and Buffalo the stop time per stopped vehicle for the experimental and control sites were approximately equal, with Atlanta being slightly higher than the fully signalized intersection and Buffalo slightly less. The sign and stop sign had a wider range (7.1 to 22.3 secs) in values of stop time per stopped vehicle than the control site (8.7 to 17.7 sec).

Stop time per vehicle on the major street was greater in all cases at the fully signalized location compared to the sign and stop sign location because of the larger percentage of vehicles stopped at the fully signalized location. This is expected since sign and stop sign is activated infrequently compared to the fully signalized (semi-activated) location.

The minor street stop time per stopped vehicle was shorter for the sign and stop sign than the fully signalized locations in both Atlanta and Buffalo. In Atlanta the stop times per vehicle are approximately equal during the AM and PM #2 observation period with mixed results found for the remaining observation periods. In Buffalo the stop time per vehicle is considerably less at the sign and stop sign compared to the fully signalized location.

The sign and stop sign locations for the major street had a lower percentage of vehicles stopping, approximately the same stop time per stopped vehicle and considerably less stop time per vehicle than the control site.

For the minor street the stop sign showed less stop time per stopped vehicle and equal or less stop time per vehicle than the control site.

---

*All costs used in the analysis were provided by the participating cities, and should be considered an indication of cost differences only.

**All data were collected in 15-minute intervals during four observation periods: AM – 8:00 am to 10:00 am, Noon – 11:00 am to 1:00 pm, PM #1 – 2:00 pm to 3:30 pm, and PM #2 – 3:45 pm to 5:00 pm.

Table 3

Delay Data

Sign and Stop Sign Vs Full Signalization (Semi-Actuated)

Percent of Vehicles Stopping

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Atlanta							
Sign & Stop Sign	7.8	3.1	8.5	4.4	78.1	55.0	81.4	76.6
Full Signalization	37.1	36.5	40.9	46.8	57.0	60.3	52.1	63.3
	City: Buffalo							
Sign & Stop Sign	8.9	3.6	5.1	3.9	73.6	69.6	79.8	72.4
Full Signalization	17.3	20.5	22.9	17.4	76.2	73.7	66.7	90.1

Stop Time (sec.)/Stopped Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Atlanta							
Sign & Stop Sign	17.8	22.3	15.1	17.5	15.1	10.0	21.2	15.9
Full Signalization	12.8	12.5	14.7	17.7	17.9	17.0	17.1	19.6
	City: Buffalo							
Sign & Stop Sign	8.9	9.3	7.1	7.8	11.3	19.9	13.0	18.4
Full Signalization	14.0	12.3	8.7	14.0	25.6	30.2	25.5	34.9

Stop Time (sec.)/Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Atlanta							
Sign & Stop Sign	1.4	0.7	1.3	0.8	11.8	5.5	17.2	12.2
Full Signalization	4.7	4.6	6.0	8.3	10.2	10.2	8.9	12.4
	City: Buffalo							
Sign & Stop Sign	0.3	0.3	0.4	0.3	8.3	13.8	10.4	13.3
Full Signalization	2.4	2.5	2.0	2.4	19.5	22.2	17.0	31.4

Note: Data are average value for three data collection visits. Data were collected using Point Sample, Stopped Delay Method and Percent Stopping Study using 13-minute observation periods and 13-second intervals.

Driver Understanding. The driver understanding information revealed a problem for drivers approaching the sign on the major street. Many did not notice the existence of the traffic control device and were unsure of the message presented by the sign. In Atlanta and Buffalo only 60 to 66 percent of the major street drivers noticed any traffic control devices. Of this group only 38 to 57 percent of the drivers correctly identified the message presented by the sign. The drivers also appeared unsure of the purpose (61 to 62 percent), how the traffic control device operated (26 to 43 percent), and what controlled traffic from the minor street (43 to 46 percent). The mixed response to the question, "When are you required to stop at this intersection?" revealed confusion about when a driver should stop. Answers varied from "Only when pedestrians are present" to "Only when the flashing red lights are operating" to the requirement of both factors.

In Atlanta the drivers approaching the intersection from the minor street had no problem noticing all the traffic control devices (93 percent) or understanding their purpose (100 percent).

In Buffalo the drivers approaching the intersection from the minor street did not appear to understand the purpose of the traffic control device with only 29 percent answering correctly. This could be due to the location of the sign and stop sign in the inner city where tall buildings and urban clutter obscure the driver's view of the traffic control device.

Summary. There appear to be some differences between cities, particularly with respect to vehicle and pedestrian compliance, signal costs, and driver understanding. The sign and stop sign locations appear to have the following advantages and disadvantages compared to the fully signalized (semi-actuated) control sites.

Advantages:

- Increased rate of pedestrian compliance to pedestrian signal
- Reduction of the percent of vehicles stopping on the major street approach
- Reduction of stop time per vehicle.

Disadvantages:

- Increase in the rate of violation of the prohibited phase by major street traffic
- Increase in pedestrian hesitation
- Confusion as to proper course of action by major street drivers when pedestrians are crossing and/or the device is activated.

Overall, however, the large rate of non-compliance with the flashing red signal and driver confusion as to when and what is the proper response to the sign and stop sign design outweighed the advantages. Therefore the fully signalized semi-actuated design appears more desirable than the sign and stop sign design.

Flashing Yellow Signal and Flashing Red Beacon

Figure 9 describes the type of traffic control devices used, their location, and methods of operation that were combined to make up the flashing yellow signal and flashing red beacon school-pedestrian crossing design.

This school-pedestrian crossing design was pedestrian activated exactly as stated for the previous design. The major differences between the flashing yellow signal and flashing red beacon and the previously described school-pedestrian crossing design were:

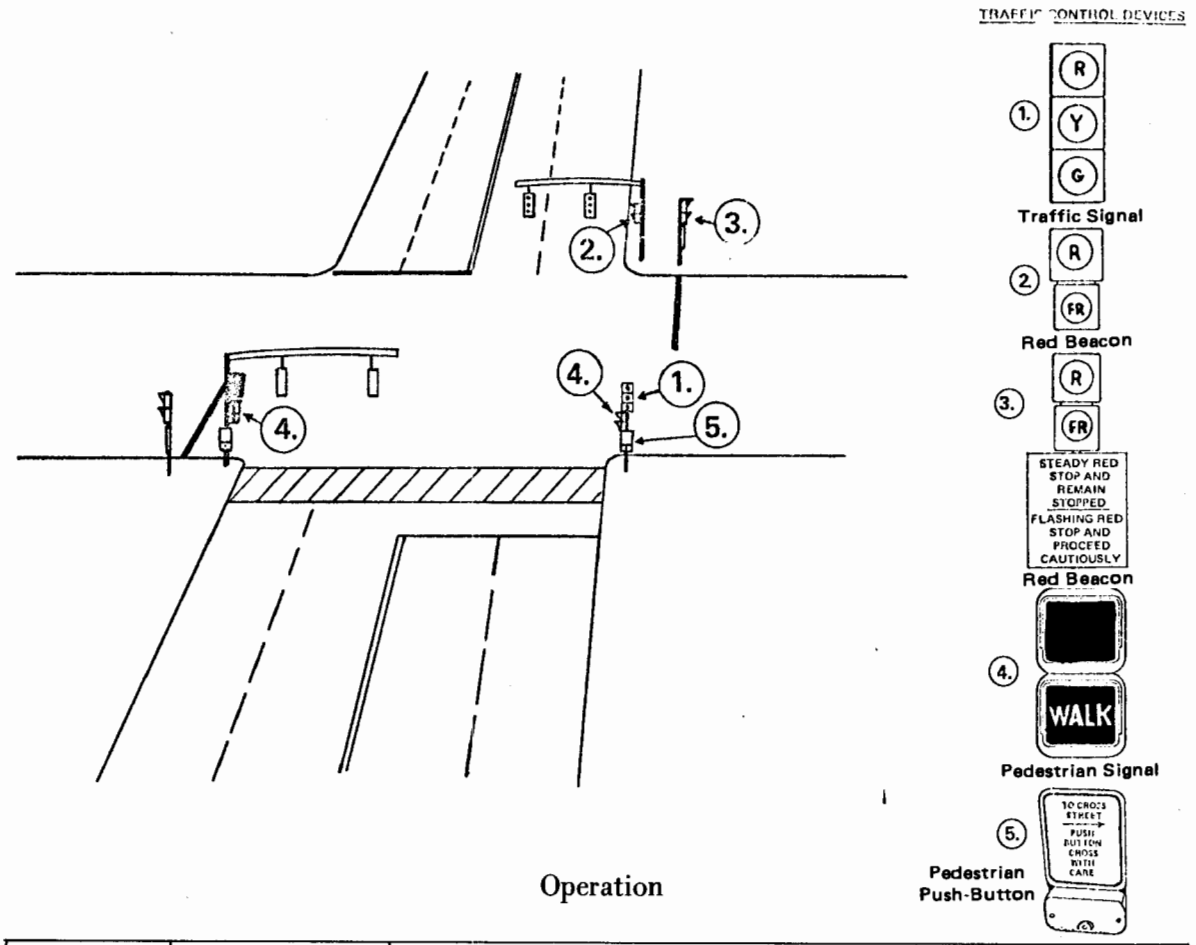
- Replacing the sign and beacon with a traffic signal which dwelled in flashing yellow
- Replacing the stop sign with red beacons
- Eliminating the advance warning sign.

Table 4 summarizes the results of the behvaioral, compliance, cost, and driver understanding data collection in Memphis and Sioux City. The data summaries that support this table may be found in the appendices.

Pedestrian Behaviors. In Sioux City the data obtained for the hesitation or reversal of pedestrians showed a significant (0.01 level) increase. The different results between Memphis and Sioux City were most likely due to the presence of a crossing guard in Memphis during the morning and afternoon when school children were present. Therefore an increase in hesitation or reversals by pedestrians could be expected at the flashing yellow signal and flashing red beacon location. This overall increase could be due to the long response time from the point when the push-button is depressed until the WALK indication appears. Many pedestrians anticipated the WALK indication and entered the street, realized that the signal had turned green for the major street and returned to the curb confused.

In both Memphis and Sioux City the occurrence of turning vehicle conflicts was reduced significantly (0.01 level). This is partially due to the solid red beacon displaying a prohibited interval to minor street traffic when the WALK indication appeared thus providing a protected WALK interval for the pedestrian. From observation, most drivers allowed pedestrians to complete their crossing before entering the intersection on the solid red indication, thereby acknowledging the pedestrians' right-of-way.

The slight decrease in the occurrence of vehicle hazards from full signalization to the flashing yellow signal and flashing red beacon in Memphis is attributable to the presence of the crossing guard instructing the school children to use the pedestrian push-button and stay on the curb until the WALK indication appears. In Sioux City the significant increase in vehicle hazards at the experimental site could be due to the longer response time once the pedestrian push-button had been depressed until a WALK indication appeared. Pedestrians used to a prompt response enter the



Approach	Traffic Control Device	Traffic Control Device Displays				
		Normal Display Presented	Pedestrian Activation	Vehicle Clearance	Pedestrian Crossing	Pedestrian Clearance
Major Street	Traffic Signal	Flashing Yellow	Steady Green	Steady Yellow	Steady Red	Steady Red
Minor Street	Red Beacons	Flashing Red	Steady Red	Steady Red	Steady Red	Steady Red
Pedestrian	Pedestrian Signal	DONT WALK	DONT WALK	DONT WALK	WALK	Flashing DONT WALK

Figure 9. Operation of E-2, Flashing Yellow Signal and Flashing Red Beacon

Table 4
Summary of Results
F. Yellow Signal & F. Red Beacon Vs Full Signalization

		City	Memphis†	Sioux City	Trend
BEHAVIORAL	PEDESTRIAN	Hesitation or Reversal	n.s.	C**	C
		Turning Vehicle Conflict	E**	E**	E
		Vehicle Hazard	n.s.	C**	C
	VEHICLES	Rear-End Conflict	n.s.	n.s.	n.s.
		Angle Conflict	n.s.	n.s.	n.s.
COMPLIANCE	PEDESTRIAN	Leave Curb on Permissive Interval	E**	E**	E
		Leave Curb on Prohibited Interval	E*	E**	E
	VEHICLE	Violation of Major Street Prohibited Phase	n.s.	E**	n.s.
COST		Cost Ratio (E/C)	0.31	0.69	0.50
UNDERSTANDING	MAJOR STREET	Question 1[A]	94%	97%	96%
		Question 2[A]	43%	24%	34%
		Question 3[A]	33%	53%	43%
		Question 4[A]	50%	21%	36%

Note: † = Crossing guard present when school children are crossing.
E = Difference in favor of experimental, school pedestrian crossing design.
C = Difference In favor of control, full signalization.
ns = No significent difference between experimental and control condition.
* = Significant at the 0.05 level.
** = Significant at the 0.01 level.
Cost Ratio = Ratio of installation costs for experimental and control conditions.
Question 1 At the intersection you just passed, were there any traffic control devices?
Question 2 At the intersection you just passed, what is the purpose of the traffic control device?
Question 3 What causes the traffic control device to turn red?
Question 4 What controls traffic on the minor street at this intersection?
A = Percent of drivers answering question correctly.
Appendices contain the Data Summaries that support this table.

street assuming cars will stop for the changing signal, not realizing that the major street signal must change from flashing yellow to solid green to solid yellow before the prohibited phase occurs. Therefore a higher incidence of vehicle hazards might be expected at the experimental site.

Vehicle Behaviors. No significant difference (0.05 level) in vehicle behaviors occurred between the two sites, both occurring very infrequently, at less than 0.07 percent of the major street vehicle volume (see Appendix G).

Pedestrian Compliance. The compliance data show a significant difference (0.01 level) which strongly favors the experimental location. These data give a somewhat conservative estimate of the pedestrian's use of the semi-actuated control site because the pedestrian signal cycles only when the button is pushed, not when the traffic signal cycles. Pedestrians tend not to use the pedestrian push-button unless the signal is placed in their normal walking path and its purpose and existence clearly identified. In addition pedestrians can cross on the green phase for the minor street ignoring the prohibited phase of the pedestrian signal. The compliance data for the control site are conservative estimates of the pedestrian uses of the traffic signal to create gaps in the traffic stream.

The compliance rate in Memphis for the flashing yellow signal and the flashing red beacon is an overestimation of the expected compliance rate, due to the presence of the crossing guard. Considering the above factors does not explain the large differences in compliance in both Memphis and Sioux City. Therefore, the experimental site should be expected to have a higher compliance rate than the control site.

Vehicle Violation of the Prohibited Interval. The rate of vehicle violation of the red indication on the major street at the experimental site was equal to or less than the violation rate for the control site in both Memphis and Sioux City. Considering that the Memphis sites are one block apart and have the same major street, the flashing yellow signal and flashing red beacon can be expected to have the same non-compliance rate or violation of the red indication as a fully signalized intersection, assuming there is similar vehicle volume.

The violation of the red signal per activation on the major street approach may be higher for the experimental site due to its infrequent activation by pedestrians. But there may be an equal or lower rate of violation of the red indication per vehicle on the major street approach compared to the fully signalized control site.

Although no quantitative conclusion can be drawn about the prohibited phase for the minor street approach to the experimental site, it was observed that vehicles confronted with a solid red beacon on this approach disregarded its meaning (as stated by a regulatory sign) and acted as if a stop sign were in its place. Therefore a high rate of violation of the solid red indication can be expected on the minor street approach to the flashing yellow signal and flashing red beacon.

Vehicle Delay. The delay data (Table 5) for the major street reveals a smaller percentage of vehicles stopping at the flashing yellow signal and flashing red beacon locations. In Memphis during the AM observation period the percentage of vehicles stopping on the major street of the experimental site approximated the percentage of vehicles stopping at the control site (20.4 percent to 26.8 percent). During all other observation periods, the percentage was at least 50 percent lower than the control site, with the greatest variation occurring during the noon and PM #1 observation periods. In Sioux City during all observations the percentage stopping was from 62 to 91 percent lower than that observed at the control site.

The stop time per stopped vehicle at the experimental sites is generally longer than for the control sites. This is due to the longer red interval (approximately 27 sec.) compared to a maximum red interval (15 to 23 sec.) for the full signalized, semi-actuated control sites (see Appendix C). In Memphis the difference in stop time per stopped vehicle was from 5.3 to 8.8 seconds longer at the flashing yellow signal location than at the control sites. The difference in stop time per stopped vehicle in Sioux City was from 11.1 seconds longer at the experimental site to 0.5 seconds longer at the control site (see Appendix E).

The stop time per vehicle was approximately the same for the major street during the AM and PM #2 observations when the school-pedestrian crossing is most heavily used. In Memphis, where the experimental and control sites are one block apart and have the same major street, the stop time per vehicle was 1.3 seconds per vehicle higher at the experimental site during the AM observation and 0.7 seconds per vehicle higher at the control site during the PM #2 observation. In Sioux City, where the school-pedestrian crossings have a lower pedestrian volume, the difference in stop time per vehicle was 3.8 and 4.2 seconds per vehicle less at the experimental site during the AM and PM #2 observations, respectively.

The minor street approach to the flashing red beacon tends to have a higher value for stop time per stopped vehicle and stop time per vehicle than the fully-signalized intersection. This is expected due to the high volume of major street traffic at these intersections. The stop time per stopped vehicle and the stop time per vehicle became much longer at the experimental site during the PM #2 observation in both Memphis and Sioux City.

Driver Understanding. From the driver understanding data, it is apparent that drivers on the major street recognize the flashing yellow signal as a traffic control signal, but have little understanding of its purpose or operation. Approximately 96 percent of drivers (n=65) on the major street recognized that there was a traffic control device at the intersection they just passed. Of this group approximately 34 percent recognized that the purpose of the device is to help pedestrians cross the street. Only 43 percent understood that this traffic control device is activated by pedestrians. When asked, "What exactly controls traffic on the minor street approach," approximately 36 percent answered correctly.

Table 5
Delay Data

F. Yellow Signal and F. Red Beacon Vs Full Signalization

Percent of Vehicles Stopping

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
F. Yellow signal	20.4	3.7	7.1	19.4	76.5	58.1	84.2	80.0
Full signalization	26.8	34.9	37.9	42.5	60.8	69.1	60.6	66.5
	City: Sioux City							
F. Yellow signal	3.3	2.3	2.9	18.9	72.7	89.7	67.9	86.1
Full signalization	37.3	23.4	30.4	49.7	52.3	55.8	62.3	67.5

Stop Time (sec.)/Stopped Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
F. Yellow signal	16.6	13.0	13.8	18.7	25.0	16.6	21.5	57.6
Full signalization	7.8	7.7	7.9	10.1	16.4	15.5	14.3	13.2
	City: Sioux City							
F. Yellow signal	23.4	15.8	14.7	12.8	11.9	14.0	14.4	25.2
Full signalization	12.3	8.4	9.9	13.3	13.7	13.6	16.1	15.7

Stop Time (sec.)/Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
F. Yellow signal	3.4	0.5	1.0	3.6	19.1	9.6	18.1	46.1
Full signalization	2.1	2.7	3.0	4.3	10.0	10.7	8.7	8.8
	City: Sioux City							
F. Yellow signal	0.8	0.4	0.4	2.4	8.7	12.6	9.8	21.7
Full signalization	4.6	2.0	3.0	6.6	7.2	7.6	10.0	10.6

Note: Data are average value for three data collection visits. Data were collected using Point Sample, Stopped Delay Method and Percent Stopping Study using 13-minute observation periods and 13-second intervals.

In interviewing drivers who approached the experimental site on the minor street, approximately 32 percent (n=15) understood that pedestrians caused the beacon to turn solid red. In Sioux City three of the nine drivers responding (33 percent) indicated they would stop and then go in response to a solid red beacon on the minor street approach, even when confronted with a regulatory sign explaining the proper response. There is some question as to whether drivers approaching the flashing red beacon from the minor street recognized the intended purpose and, when confronted with a solid red beacon, know what response is required of them.

Summary. There appears to be some difference between cities, particularly with respect to pedestrian behavior.

From the above discussion the following advantages and disadvantages of a flashing yellow signal and flashing red beacon compared to a fully signalized location were revealed:

Advantages:

- Reduction in turning vehicle conflicts
- Increase in pedestrian compliance to the permissive interval
- Reduction in the percentage of vehicles stopping on the major street approach.

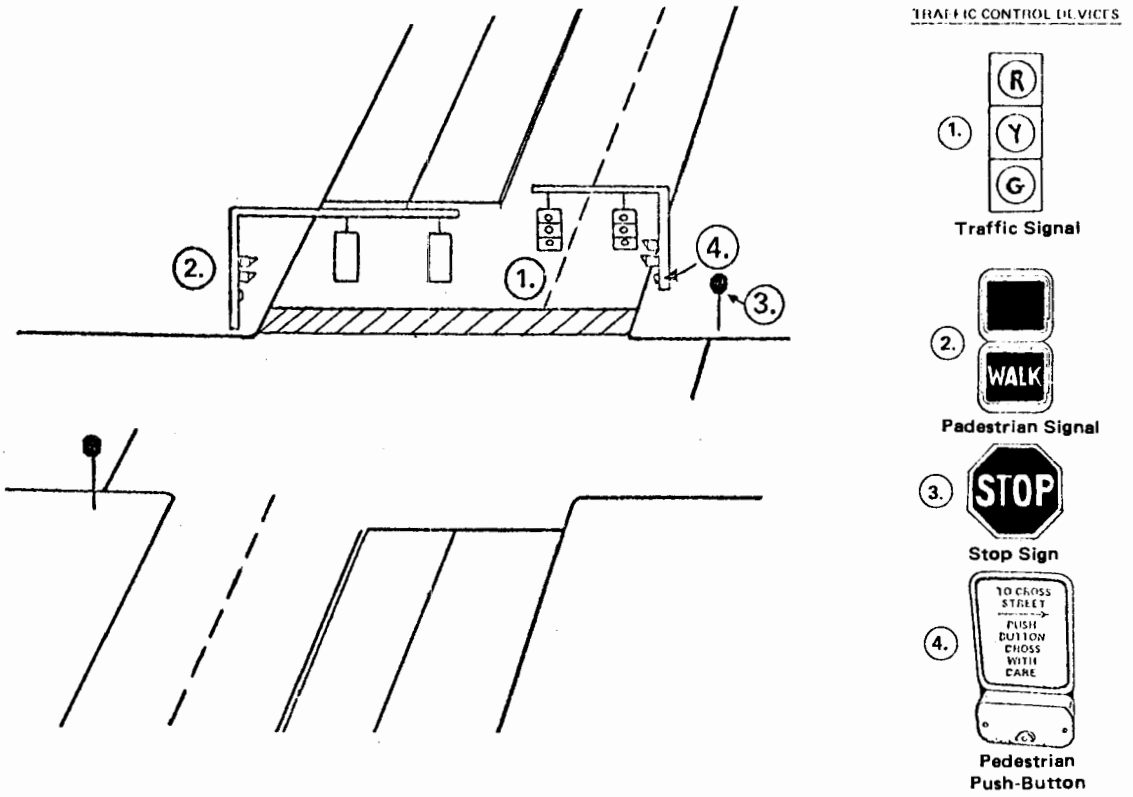
Disadvantages:

- Increase in pedestrian hesitation
- Increase in vehicle hazards
- Longer stop time per stopped vehicle on the major street approach
- Longer stop time per vehicle for the minor street approach
- Decrease in understanding of how the traffic control device is operated.

Overall, however, the advantages appear equal to the disadvantages; therefore full signalization is as desirable as the flashing yellow signal and flashing red beacon design.

Flashing Green Signal and Stop Sign

Figure 10 describes the type, configuration, and method of operation of the traffic control devices that were combined to make up the flashing green signal and stop sign school-pedestrian crossing design. This design is identical to the (Sg-44) signal and stop sign design except that the traffic signal dwells in flashing green. The flashing green indication was used as an alternative to steady green, to preserve the integrity and meaning of steady green which was non-interference from minor street traffic, thereby not violating major street drivers expectancy.



Operation

Approach	Traffic Control Device	Traffic Control Device Displays				
		Normal Display Presented	Pedestrian Activation	Vehicle Clearance	Pedestrian Crossing	Pedestrain Clearance
Major Street	Traffic Signal	Flashing Yellow	Steady Green	Steady Yellow	Steady Red	Steady Red
Minor Street	Red Beacons	Flashing Red	Steady Red	Steady Red	Steady Red	Steady Red
Pedestrian	Pedestrian Signal	DONT WALK	DONT WALK	DONT WALK	WALK	Flashing DONT WALK

Figure 10. Operation of E-3, Flashing Green Signal and Stop Sign

This school-pedestrian crossing design was pedestrian activated as previously stated for the sign and stop sign crossing design. The major differences between the flashing green signal and stop sign and the previously described school-pedestrian crossing design were:

- Replacing the red beacons with stop signs
- Changing the operating sequence of the traffic control devices.

Unlike the two previous school-pedestrian crossing designs discussed, these signals have been in operation for a long time (in Lincoln 11 years, in Seattle 5 years) with the only modification being a flashing green display rather than a steady green in the signal dwell mode. Therefore, both drivers and pedestrians have had a longer period of time to learn how these traffic control devices operate.

The control sites used for this experiment were fully signalized intersections with pre-timed controllers instead of fully or semi-activated controllers used in all other control sites. From a comparison of performance data collected at semi-actuated and pre-timed control sites in the same city, the only significant difference appears to be a higher rate of pedestrian compliance at the pre-timed location.

In Seattle the presence of the crossing guard in addition to the flashing green signal and stop sign had the effect of increasing compliance and decreasing adverse pedestrian behaviors and vehicle violations of the red signal when elementary children were present. The effect of the crossing guard is minimized by the location of the school-pedestrian crossing in a community shopping area where a larger number of pedestrian and signal activations occur.

Table 6 summarizes the results of behavior, compliance, cost, and driver understanding data collected in Lincoln and Seattle. The data summaries supporting this table are found in the appendices.

Pedestrian Behavior. Significant differences in pedestrian behavior occurred only in Seattle for the turning vehicle conflict and vehicle hazard behaviors. The turning vehicle conflict occurred more frequently at the control site due to a higher number of turning vehicles and the simultaneous occurrence of a green indication (minor street) and the WALK signal (crossing major street). This gave both the pedestrian and vehicle the assigned right-of-way at the same time. At the flashing green signal and stop sign installation, vehicles and pedestrians were not assigned the same right-of-way simultaneously. The pedestrian was assigned the right-of-way and the vehicle was allowed to proceed when its path did not conflict with that of the pedestrian. The increase in vehicle hazards at the experimental site was due partially to people parking their cars and crossing the street at the unmarked crosswalk, and people totally disregarding the pedestrian signal to catch their bus. It is felt that the increase in vehicle hazards is due to the type of location and not the school-pedestrian crossing design.

Table 6
Summary of Results

F. Green Signal and Stop Sign Vs Full Signalization (Pre-Timed)

		City	Lincoln	Seattle†	Trend
BEHAVIORAL	PEDESTRIAN	Hesitation or Reversal	n.s.	n.s.	n.s.
		Turning Vehicle Conflict	n.s.	E**	E
	VEHICLES	Vehicle Hazard	n.s.	C**	n.s.
		Rear End Conflict	n.s.	E*	n.s.
		Angle Conflict	C*	C*	n.s.
COMPLIANCE	PEDESTRIAN	Leave Curb on Permissive Interval	C**	C**	E (see discussion)
		Leave Curb on Prohibited Interval	C**	C**	E (see discussion)
	VEHICLE	Violation of Major Street Prohibited Phase	E*	C**	n.s.
COST		Cost Ratio (E/C)	0.43	0.48	0.46
UNDERSTANDING	MAJOR STREET	Question 1[A]	—	100%	100%
		Question 2[A]	62%	46%	54%
		Question 3[A]	62%	40%	51%
		Question 4[A]	38%	23%	31%

Note: † = Crossing guard present when school children are crossing.
E = Difference in favor of experimental, school-pedestrian crossing design.
C = Difference in favor of control, full signalization.
ns = No significant difference between experimental and control condition.
* = Significant at the 0.05 level.
** = Significant at the 0.01 level.
Cost Ratio = Ratio of installation costs for experimental and control conditions.
Question 1 At the intersection you just passed, were there any traffic control devices?
Question 2 At the intersection you just passed, what is the purpose of the traffic control device?
Question 3 What causes the traffic control device to turn red?
Question 4 What controls traffic on the minor street at this intersection?
A = Percent of drivers answering question correctly.
Appendices contain the Data Summaries that support this table.

Vehicle Behavior. The vehicle behavior measures occurred at both the flashing green signal and stop sign sites and the full-signalized location at very low rates (0.00 to 0.06 percent of major street volume) (see Appendix G); therefore they were not considered for further evaluation. There appeared to be a slight increase in the angle conflicts between major and minor street traffic at both experimental sites, but at a very low rate.

Pedestrian Compliance. The pedestrian compliance rate at the fully signalized location was significantly higher (89 to 90 percent) than that observed at the flashing green signal and stop sign location (74 to 83 percent) (see Appendix F). The rate of compliance observed at the control site with a pre-timed controller was 27 to 30 percent higher than the compliance rate observed at a semi-actuated control site (60 to 62 percent) in the same cities, observed during the same weeks. Therefore it can be expected that a flashing green signal and stop sign will have a higher rate of pedestrian compliance than a similar semi-actuated fully signalized location, but a lower rate of pedestrian compliance than a similar fully signalized pre-timed signal. The pre-timed fully signalized location would be expected to have a higher compliance rate because no pedestrian push-button is needed to activate the WALK interval.

Vehicle Compliance. The violation rate per vehicle of the prohibited phase for the experimental and control sites appeared similar in both cities. In Lincoln, the violation rate of the red interval was significantly lower (0.05 level) at the flashing green signal and stop sign than at the control site. In Seattle, the violation rate of the red interval was significantly higher at the flashing green signal and stop sign location. This higher rate of violation is misleading because there was more traffic on the major street at the Seattle control site. The violation rate of the prohibited interval per actuation between the two experimental sites was approximately equal, with 0.11 in Lincoln and 0.12 in Seattle.

Cost. Based on the initial installation cost data provided by Lincoln and Seattle, the flashing green signal and stop sign is 46 percent as expensive as a fully signalized (semi-actuated) traffic signal installation in the same location.

Vehicle Delay. The delay data (Table 7) indicates that the flashing green signal for the major street approach had a decrease in the percentage of vehicles stopped, equal or larger stop time per stopped vehicle, and a wide variation in stop time per vehicle compared to the control site for the major street approach. The percentage of vehicles stopped in Lincoln was considerably less than in Seattle at the experimental sites due to a 200 percent increase in pedestrian activity in Seattle. The increased pedestrian volumes resulted in the percentage of vehicles stopped at the experimental site becoming equal to or slightly greater than those observed at the control site in Seattle. Therefore, the flashing green signal and stop sign had a lower percentage of vehicles stopped during periods of light pedestrian traffic, but during heavy pedestrian traffic the percentage of vehicles stopped was equivalent to the fully signalized (pre-timed) intersection.

Table 7
Delay Data

F. Green Signal and Stop Sign Vs Full Signalization (Pre-Timed)

Percent of Vehicles Stopping

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
F. green signal	17.8	1.7	0.0	10.6	38.5	69.2	71.4	82.8
Full signalization	30.0	27.5	22.2	38.2	45.7	43.3	36.2	54.6
	City: Seattle							
F. green signal	24.6	6.8	23.8	17.3	70.8	93.3	90.6	94.1
Full signalization	17.5	21.7	23.2	27.5	70.9	67.0	75.2	70.9

Stop Time (sec.)/Stopped Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
F. green signal	13.3	21.6	0.0	13.9	12.3	5.3	7.2	13.0
Full signalization	11.4	17.3	13.0	14.7	19.7	19.9	21.2	20.9
	City: Seattle							
F. green signal	14.3	19.0	13.3	18.7	9.9	13.0	10.3	11.8
Full signalization	13.1	8.5	9.4	12.1	24.7	20.4	19.0	28.7

Stop Time (sec.)/Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
F. green signal	2.4	0.4	0.0	1.5	4.7	3.7	5.1	10.8
Full signalization	3.4	4.8	2.9	5.6	9.0	8.6	7.7	11.4
	City: Seattle							
F. green signal	3.5	1.3	3.2	3.2	7.0	12.1	9.3	11.1
Full signalization	2.3	1.8	2.2	3.3	17.5	13.7	14.3	20.3

Note: Data are average value for three data collection visits. Data were collected using Point Sample, Stopped Delay Method and Percent Stopping Study using 13-minute observation periods and 13-second intervals.

The stop time per stopped vehicles on the major street approaching to the flashing green signal and stop sign appears to be equal to or greater than that observed at the control site. The difference in the stop time per stopped vehicle is not solely attributable to the difference in signal timing. From observation, drivers hesitated somewhat at the flashing green signal when it changed from solid red to flashing green, especially for the first two flashes. This could account for a slight increase in stop time per stopped vehicle at the experimental location.

The stop time per vehicle at the flashing green signal and stop sign location for vehicles approaching on the major street appears to be equal to or less than that observed at the pre-timed signal location. During all observation periods in Lincoln the stop time per vehicle was less than that observed at the control intersection. During the noon and PM #1 observations the extremely low values for stop time per vehicle were due to very few signal activations. In Seattle during the AM and PM #1 observations when most school children used the school-pedestrian signal, the stop time per vehicle exceeded that observed at the pre-timed signal. This is because the control site is located on a major arterial in a progression sequence within a 100-second cycle, resulting in higher vehicle volumes and longer green intervals than occur at the control site in Lincoln. Therefore, the stop time per vehicle at the experimental site would be expected to be less than or equal to that observed at a pre-timed fully signalized location and approximately equal to that observed at a semi-actuated fully signalized location.

The minor street approach to the flashing green signal and stop sign has less stop time per stopped vehicle and stop time per vehicle than the fully signalized pre-timed or semi-actuated signals observed in both cities. There was a 7.4 to 16.9 second decrease in stop time per stopped vehicle at the experimental site compared to the pre-timed control site, and a 5.2 to 13.2 second per vehicle decrease compared to the semi-actuated control site observed in the same cities. The stop time per vehicle revealed a 0.6 to 10.5 second per vehicle decrease at the experimental site compared to the pre-timed control site and a 13.4 decrease to a 2.2 second increase per vehicle at the semi-actuated control site. Only in Seattle was the stop time per vehicle lower at the semi-actuated control site compared to the stop sign on the minor approach. This is due to the low value (10 seconds) set for the minimum green interval for the major street at the control site.

Driver Understanding. The driver understanding data reveal that drivers on the major street recognize the existence of a traffic control device, but are not sure how it operates. From interviewing drivers approaching the flashing green signal on the major street, 46 percent (n=35) of the drivers in Seattle and 62 percent (n=29) of the drivers in Lincoln knew that the purpose of the traffic control device was to help pedestrians cross the street. In addition 40 percent of the drivers in Seattle and 62 percent of the drivers in Lincoln understood that the traffic signal was pedestrian-activated. Drivers were asked, "What does a flashing green light mean to you?" In Seattle 54 percent and 42 percent in Lincoln answered "caution." The second most frequent answer was

"same as a solid green signal," (23 percent in Seattle and 14 percent in Lincoln). But in Lincoln, 14 percent also thought the signals were out of order. From these responses most drivers attach the meaning "caution" or "slow down" to the flashing of the green signal. When asked if the green signal was steady or flashing, 77 percent in Seattle and 69 percent in Lincoln answered correctly. Comparing these responses indicates that drivers have some difficulty in distinguishing between steady and flashing green signals. Therefore, if a flashing green signal is to be used to identify a school-pedestrian crossing, an education program for drivers must be enacted to establish a meaning for flashing green, and the flashing green signal must become more distinguishable from a solid green signal.

Summary. The evaluation of the flashing green signal and stop sign compared to a fully signalized pre-timed intersection shows the following advantages and disadvantages of a flashing green signal and stop sign.

Advantages:

- Increase in the pedestrian compliance to the pedestrian signal
- Reduction in turning vehicle conflicts
- Reduction in the percentage of vehicles stopping on the major street approach
- Reduction in the stop time per vehicle on the minor street approach.

Disadvantages:

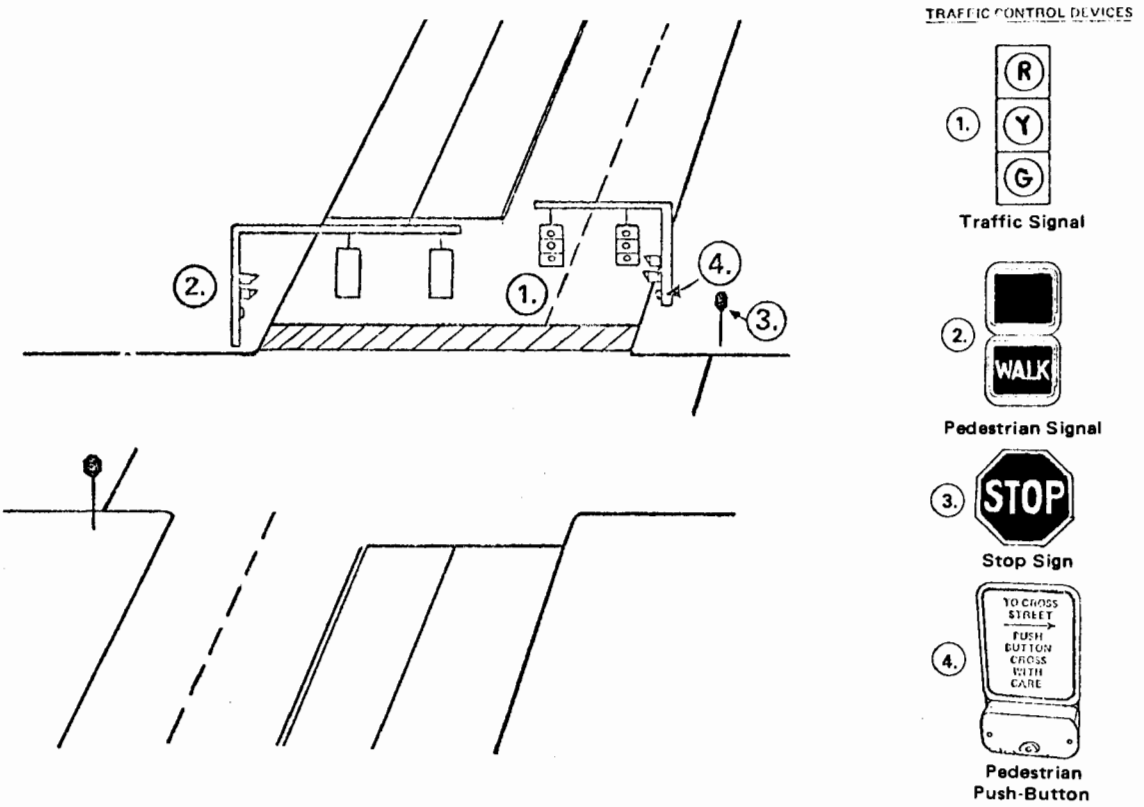
- Increase in angle conflict, but a relatively low rate
- Drivers approaching on the major street do not recognize this as a pedestrian crossing
- Drivers attach no special meaning to a flashing green signal except caution or slow down.

Overall the flashing green signal and stop sign appears to have more favorable operating characteristics than a fully signalized (pre-timed) intersection.

(Sg-44) Signal Stop Sign

Figure 11 describes the type, configuration, and method of operation of the traffic control devices that were combined to make up the (Sg-44) signal and stop sign design.

This school-pedestrian crossing design was pedestrian-activated as previously stated for the sign and stop sign crossing design. The only change made between the flashing green signal and stop sign and (Sg-44) signal and stop sign crossing design was a change in the dwell phase presented for the traffic signal from flashing green to steady green.



Operation

Approach	Traffic Control Device	Traffic Control Device Displays				
		Normal Display Presented	Pedestrian Activation	Vehicle Clearance	Pedestrian Crossing	Pedestrian Clearance
Major Street	Traffic Signal	Steady Green	Steady Yellow	Steady Yellow	Steady Red	Steady Red
Minor Street	Stop Sign	Stop Sign	Stop Sign	Stop Sign	Stop Sign	Stop Sign
Pedestrian	Pedestrian Signal	DONT WALK	DONT WALK	DONT WALK	WALK	Flashing DONT WALK

Figure 11. Operation of E-4, (Sg-44) Signal and Stop Sign

The signal and stop sign design has been in use in both cities for many years. At the site selected in Lincoln and Seattle the device has been used for 11 years and 5 years, respectively. The effect this may have had on the data collection is unclear, but both pedestrians and drivers would be expected to have a better understanding of how this traffic control device works.

Table 8 summarizes the results of the behavioral, compliance, cost and driver understanding data collected in Lincoln and Seattle. The data that support this table are found in the appendices.

Pedestrian Behavior. The pedestrian behavior measures revealed a significant decrease in pedestrian hesitation or reversals at the signal and stop sign locations. Perhaps drivers recognize that pedestrians have been given the exclusive right-of-way, and therefore do not challenge them. The other pedestrian behavior measures also appeared to decrease at the signal and stop sign location, but not significantly.

Vehicle Behavior. The vehicle behavior measures occurred at a very low rate (0.06 percent of major street vehicle volume). At the signal and stop sign location in Lincoln there was a significant increase (0.05 level) in vehicle-vehicle angle conflicts. From observation, the angle conflict occurred most often when a driver on the minor street approach was stopped at the stop sign, realized that the major traffic was stopped, and entered the intersection to turn left or proceed straight through as the signal for the major street turned green. As stated before, although there was a significant difference in angle conflicts in Lincoln favoring the control site, the rate of occurrence was extremely low (0.05 percent of major street traffic). Therefore, vehicle behaviors occurred at a very low rate at both the signal and stop sign, and the fully signalized, semi-actuated control site.

Pedestrian Compliance. The compliance data show a significant increase in the number of pedestrians leaving the curb during the permissive interval at the signal and stop sign location. At the control sites in both Lincoln and Seattle, the low volume on the minor street made it difficult for pedestrians to use the vehicle activation of the green interval for the minor street to cross the major street without using the pedestrian push-button. Therefore, the observed pedestrian compliance rate at the control site is considered to be an accurate measure of pedestrian compliance. This high compliance rate at signal and stop sign location appears to be due to the pedestrian understanding of the traffic control device and their knowledge of the fast response time in the appearance of the WALK interval.

Vehicle Violation of the Prohibited Interval. The major street violations of the prohibited signal at the signal and stop sign appear to be equal to or less than that observed at the control site. In Lincoln the red signal violation rate was significantly less (0.01 level) at the signal and stop sign. In Seattle, there was no significant difference.

Table 8

Summary of Results

(Sg-44) Signal & Stop Sign Vs Full Signalization (Semi-Actuated)

		City	Lincoln	Seattle	Trend
BEHAVIORAL	PEDESTRIAN	Hesitation or Reversal	E**	E*	E
		Turning Vehicle Conflict	n.s.	n.s.	n.s.
		Vehicle Hazard	n.s.	n.s.	n.s.
	VEHICLES	Rear-End Conflict	n.s.	n.s.	n.s.
		Angle Conflict	C*	n.s.	n.s.
COMPLIANCE	PEDESTRIAN	Leave Curb on Permissive Interval	E**	E**	E
		Leave Curb on Prohibited Interval	E**	E**	E
	VEHICLE	Violation of Major Street Prohibited Phase	E*	n.s.	n.s.
COST		Cost Ratio (E/C)	0.40	0.50	0.45
UNDERSTANDING	MAJOR STREET	Question 1[A]	—	83%	83%
		Question 2[A]	67%	94%	81%
		Question 3[A]	67%	66%	67%
		Question 4[A]	50%	49%	50%

Note: † = Crossing guard present when school children are crossing.
E = Difference in favor of experimental, school-pedestrian crossing design.
C = Difference in favor of control, full signalization.
ns = No significant difference between experimental and control condition.
* = Significant at the 0.05 level.
** = Significant at the 0.01 level.
Cost Ratio = Ratio of installation costs for experimental and control conditions.
Question 1 At the intersection you just passed, were there any traffic control devices?
Question 2 At the intersection you just passed, what is the purpose of the traffic control device?
Question 3 What causes the traffic control device to turn red?
Question 4 What controls traffic on the minor street at this intersection?
A = Percent of drivers answering question correctly.
Appendices contain the Data Summaries that support this table.

Cost. Based on the initial construction cost data provided by Lincoln and Seattle, the signal and stop sign is 45 percent as expensive as a fully signalized (semi-actuated) installation at the same location.

Vehicle Delay. The delay data presented in Table 9 reveal a decrease in the percentage of vehicles stopping at the signal and stop sign throughout the day. During the AM observation the percentage of vehicles stopping was higher at the signal and stop sign. This is due to the simultaneous occurrence of heavy pedestrian use of the signal when traffic was heavy. During periods of heavy pedestrian use, the percentage of vehicles stopped can exceed that observed at a fully signalized location.

The stop time per stopped vehicle on the major street approach was approximately equal at the signal and stop sign and the control locations. The signal and stop sign appeared to have much less variation in stop time per stopped vehicle than the control site.

There is a wide variation in the value of stop time per vehicle between the experimental and control sites. The higher stop time per vehicle at the signal and stop sign location is due to the simultaneous occurrence of heavy pedestrian (resulting in more signal activation) and vehicle volumes. During the AM observation the experimental site had a higher stop time per vehicle. But during the remaining observation periods the stop time per vehicle was much less at the experimental site.

On the minor street approach stop time per stopped vehicle appears to be less at the stop sign location compared to the fully signalized location. The higher stop time per stopped vehicle observed during the AM observation in Seattle and PM #1 observation in Lincoln were due to parents dropping off or picking up children at schools adjacent to both experimental locations. The stop time per vehicle appeared less at both experimental sites throughout the day. During the PM #1 observation in Lincoln and the AM and PM #1 observations in Seattle, the stop time per vehicle was greater at the experimental site because parents were picking up or discharging children near the school.

Driver Understanding. The driver understanding data reveal that the drivers appear to comprehend that this was a pedestrian signal location; they realized that pedestrians activate the signals, but did not understand that the side street traffic was controlled by stop signs. In response to the question, "At the intersection you just passed, what is the purpose of the traffic light?" 94 percent in Seattle and 67 percent in Lincoln answered, "to help pedestrians." In Seattle 66 percent and 67 percent in Lincoln answered correctly when asked, "What caused the traffic signal to turn red for the major street?" Only 40 percent in Lincoln and 59 percent in Seattle realized that the traffic signal did not control traffic on the minor street approach.

Table 9
Delay Data

(Sg-44) Signal and Stop Sign Vs Full Signalization (Semi-Actuated)

Percent of Vehicles Stopping

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
Signal & Stop Sign	28.3	1.0	11.3	10.4	71.2	67.6	88.4	79.2
Full signalization	19.5	21.0	30.8	36.1	69.1	68.2	61.4	59.4
	City: Seattle							
Signal & Stop Sign	27.4	5.3	17.0	4.5	67.7	70.8	77.3	62.5
Full signalization	19.0	15.1	21.9	16.2	39.3	54.4	58.6	52.4

Stop Time (sec.)/Stopped Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
Signal & Stop Sign	14.7	10.8	12.5	13.0	11.6	7.9	18.8	10.2
Full signalization	13.7	13.3	13.0	18.4	23.3	25.1	17.4	26.2
	City: Seattle							
Signal & Stop Sign	11.7	11.8	12.9	12.2	20.3	10.0	12.7	11.1
Full signalization	11.8	9.1	9.7	7.2	20.0	18.2	15.9	17.0

Stop Time (sec.)/Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Lincoln							
Signal & Stop Sign	4.2	0.1	1.4	1.4	8.3	5.4	16.6	8.1
Full signalization	2.7	2.8	4.0	6.6	16.1	17.1	10.7	15.5
	City: Seattle							
Signal & Stop Sign	3.2	0.6	2.2	0.5	13.7	7.1	9.8	6.9
Full signalization	2.2	1.4	2.1	1.2	7.9	9.9	9.3	8.9

Note: Data are average value for three data collection visits. Data were collected using Point Sample, Stopped Delay Method and Percent Stopping Study using 13-minute observation periods and 13-second intervals.

Comparing the results of the driver understanding questionnaire from the flashing green signal and stop sign and (Sg-44) signal and stop sign design indicated:

- Better recognition of the presence of a traffic control device (100% vs 83%) by major street drivers using a flashing green signal.
- Better understanding of how the traffic control devices operated with a steady green indication (83% vs 54%).
- Better understanding of the purpose of the traffic control device with a steady green indication (67% vs 51%).

Although some of these results could be due to site differences, both interviews were conducted in the same cities during the same week.

Summary. There were differences between cities but the signal and stop sign appears to have the following advantages and disadvantages compared to the fully signalized (semi-activated) control site:

Advantages

- Significant decrease in pedestrian hesitation
- Significant increase in pedestrian compliance to the permissive interval
- Decrease in installation cost by 46 percent over the cost of fully signalized (semi-actuated) installations
- For the major street approach, decrease in stop time per vehicle over an operating day
- For the minor street approach, decrease in stop time per vehicle over an operating day.

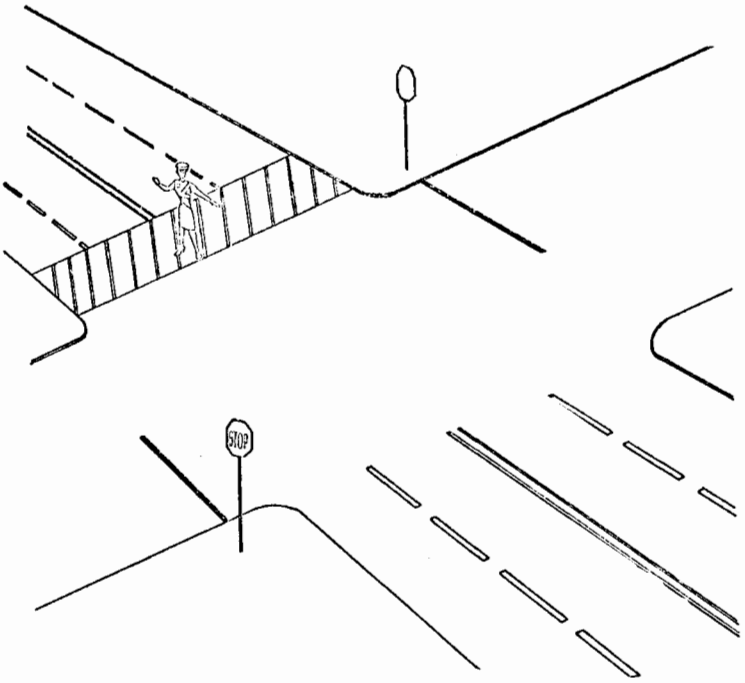
Disadvantages

- Increase in angle vehicle conflicts but non-significant
- Major street drivers are unclear on what controls minor street traffic at this location.

The signal and stop sign design has more desirable operating characteristics than a full signalization (semi-actuated) traffic signal in the same location.

Crossing Guard

The crossing guard (see Figure 12) was selected as a school-pedestrian crossing design due to its widespread use and ability to direct pedestrians across the intersections of high-volume arterial streets and low-volume residential streets without other traffic control devices. The crossing guards used in this study were on duty only when school children were present, from 0.75 to 3.5 hours per day. Crossing guards were not present during all periods of observation as were the other school-pedestrian crossing designs. In order to measure their effect as a school-pedestrian crossing design data was collected throughout the day.



TRAFFIC CONTROL DEVICES

STOP

STOP SIGN
OPERATION

DURING HOURS WHEN CROSS-ING GUARD IS PRESENT.

Operation

Approach	Traffic Control Device	Normal Display Presented	Traffic Control Device Displays			
			Pedestrian Present	Vehicle Clearance	Pedestrian Crossing	Pedestrian Clearance
Major Street	Crossing Guard (only during certain periods of time)	–	–	Crossing Guard enter street	Crossing Guard directs traffic	Crossing Guard leaves the street
Minor Street	Stop sign (at all times)	Stop sign	Stop sign	Stop sign	Stop sign	Stop sign
Pedestrian	Crossing Guard (only during certain periods of time)	–	Crossing Guard	Crossing Guard	Crossing Guard	Crossing Guard

Figure 12. Operation of E-5, Crossing Guard

Specific crossing guard locations were chosen to evaluate the effect of guards at intersections with differing pedestrian volumes. In Memphis, an average of eight school children in the morning and eleven in the afternoon crossed with the guard, compared to 184 school children in the morning and 213 in the afternoon in Seattle. Data were obtained both when the crossing guard was present and absent to gauge the effect on pedestrians throughout the day.

Table 10 summarizes the results of the behavioral, compliance, cost, and driver understanding data collected on the crossing guards in Memphis and Seattle. The data summaries that support this table are found in the appendices.

Pedestrian Behaviors. There were significant differences in all three pedestrian behaviors. In Seattle, the pedestrian hesitation significantly (0.01 level) decreased at the crossing guard location because the guard kept the children on the curb until there was a safe gap in the traffic.

In both cities the turning vehicle conflict significantly (0.01 level) decreased at the crossing guard location since the crossing guard did not let a vehicle enter the intersection when children were crossing.

The significant increase in vehicle hazard at the crossing guard location in Seattle is due mostly to pedestrians using the crossing with no guard present. This group includes children who stayed after regular school hours, children from other schools (junior or senior high), and general pedestrian traffic.

Vehicle Behaviors. There appears to be no significant change in vehicle behavior in either city.

Pedestrian Compliance. There was a significant increase in pedestrian crossing during the permissive interval* at the crossing guard location because the crossing guard lectured the children if they did not cross the street under his/her supervision.

At the test location the crossing guard made little or no attempt to help pedestrians other than elementary school children crossing the major street. Although both crossing guard locations would be classified as almost exclusively school crossings, 26 percent of the pedestrians in Memphis and 17 percent of the pedestrians in Seattle used the crosswalk when the crossing guard was not present. When the crossing guard was present the compliance rate was extremely high, but when the crossing guard was off duty, no assistance was available to the pedestrian in crossing the major street. Overall, a significant increase in compliance between the fully signalized intersection and the crossing guard location was measured.

*Permissive interval – That period of time when the crossing guard instructs the pedestrian that it is safe to cross the street.

Table 10

Summary of Results

Crossing Guard Vs. Full Signalization

		City	Memphis	Seattle	Trend
BEHAVIORAL	PEDESTRIAN	Hesitation or Reversal	n.s.	E**	E
		Turning Vehicle Conflict	E**	E**	E
	VEHICLES	Vehicle Hazard	n.s.	C*	n.s.
		Rear End Conflict	n.s.	n.s.	n.s.
		Angle Conflict	n.s.	n.s.	n.s.
COMPLIANCE	PEDESTRIAN	Leave Curb on Permissive Interval	E**	E**	E
		Leave Curb on Prohibited Interval	E**	E**	E
	VEHICLE	Violation of Major Street Prohibited Phase	n.s.	E*	n.s.
COST		Cost Ratio (E/C) †	0.75	0.69	0.72

Note: † = Ratio based on annual cost, assumed service life of 20 years and interest at 10 percent.
E = Difference in favor of experimental, school-pedestrian crossing design.
C = Difference in favor of control, full signalization.
ns = No significant difference between experimental and control condition.
* = Significant at the 0.05 level.
** = Significant at the 0.01 level.
Cost Ratio = Ratio of installation costs for experimental and control conditions.
Appendices contain the Data Summaries that support this table.

Vehicle Violation of the Prohibited Interval. There appears to be no significant increase in violations of the prohibited interval* by vehicles at the locations designated by the crossing guard, compared to a fully signalized location. Drivers appeared to respect the authority represented by the crossing guard. In Seattle a significant decrease (0.05 level) in vehicle violation of the prohibited interval was observed. This can be attributed to the narrower streets that can be controlled more effectively than a wide street by a crossing guard.

*Prohibited interval – That period of time when the crossing guard instructs all vehicles on the majro street approaches not to enter the intersection.

Cost. Based on the figures supplied by the participating cities, the cost of a crossing guard for a year is approximately 72 percent as expensive as a fully signalized semi-actuated intersection.

Vehicle Delay. Table 11 reveals the major street approach to the crossing guard location had a decrease in the percentage of vehicles stopping compared to the fully signalized location in both Seattle and Memphis. This decrease is a result of fewer interruptions in the major street flow.

The stop time per stopped vehicle was equal to or greater than that observed at the fully signalized location where the crossing guard was present. In Seattle this longer stop time per stopped vehicle was the result of the larger pedestrian volume. In Memphis the longer stop time was the result of the crossing guard's difficulty in making sure vehicles in all four traffic lanes per stopped vehicle had stopped before letting the school children enter the street.

The decrease in percentage of vehicles stopping and equivalent or slightly higher stop time per stopped vehicle results in a decrease in stop time per vehicle observed at both crossing guard locations.

The minor street approach had less stop time per stopped vehicle at the stop sign location than at the fully signalized location, but more stop time per vehicle during periods of heavy traffic on the major street.

Summary. From the above discussion the following advantages and disadvantages of the crossing guard compared to the fully signalized location were revealed:

Advantages

- Significant decrease in pedestrian hesitation
- Significant decrease in turning vehicle conflicts
- Significant increase in pedestrian compliance to permissive interval
- Decrease in the annual cost by 72 percent compared to full signalization (assume for traffic signal i = 10%, Lifetime 20 years)
- Decrease in stop time per vehicle on the major street approach
- Decrease in the percent of vehicles stopping for the major street.

Disadvantages

- Crossing guard present only part of the day
- Increase in stop time per stopped vehicle for the major street approach when crossing guard present.

Table 11

Delay Data

Crossing Guard Vs Full Signalization

Percent of Vehicles Stopping

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
Crossing guard	13.4	1.6	0.7	11.3	70.4	59.3	79.0	85.7
Full signalization	31.8	25.0	37.1	28.6	62.1	72.7	67.3	54.9
	City: Seattle							
Crossing guard	17.1	2.8	12.4	2.9	81.5	90.0	80.0	93.9
Full signalization	19.0	15.1	21.9	16.2	39.3	54.4	58.6	52.4

Stop Time (sec.)/Stopped Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
Crossing guard	12.3	3.3	8.7	13.7	14.6	8.5	8.8	19.5
Full signalization	13.9	9.0	11.9	9.6	17.7	12.5	14.7	17.1
	City: Seattle							
Crossing guard	14.0	4.9	14.8	4.9	16.7	6.7	11.2	12.4
Full signalization	11.8	9.1	9.7	7.2	20.0	18.2	15.9	17.0

Stop Time (sec.)/Vehicle

Site	Major Street				Minor Street			
	Observation Periods				Observation Periods			
	AM	Noon	PM #1	PM #2	AM	Noon	PM #1	PM #2
	City: Memphis							
Crossing guard	1.6	0.1	0.1	1.5	10.3	5.1	6.9	16.7
Full signalization	4.4	2.2	4.4	2.7	11.0	9.1	9.9	9.4
	City: Seattle							
Crossing guard	2.4	0.1	1.8	0.1	13.6	6.0	8.9	11.7
Full signalization	2.2	1.4	2.1	1.2	7.9	9.9	9.3	8.9

Note: Data are average value for three data collection visits. Data were collected using Point Sample, Stopped Delay Method and Percent Stopping Study using 13-minute observation periods and 13-second intervals.

Summary

Table 12 summarizes the results of a comparison between each school-pedestrian crossing design and its fully signalized control site. The score given to each measure of effectiveness, for each school-pedestrian crossing design, is based on the trends established for each design (Tables 2-11). Table 12 reveals three measures of effectiveness to have similar tendencies for all five school-pedestrian crossing designs with regard to driver behavior, pedestrian compliance and major street delay. Driver behavior was unaffected by the type of traffic control device used, either full signalization or any of the five school-pedestrian crossing designs. Pedestrian compliance to the pedestrian signal increased for all five school-pedestrian crossing designs. The major street delay (stop time per vehicle) decreased for all five school-pedestrian crossing designs.

Based on the total rank score, the school-pedestrian crossing designs were divided into two groups. The first group includes the school-pedestrian designs (the flashing green signal and stop sign, (Sg-44) signal and stop sign, and the crossing guard) that are more desirable, based on total rank score, than their fully signalized control sites. The second group includes those school-pedestrian crossing designs (the stop and stop sign, and flashing yellow signal and flashing red beacon) which were equally desirable based on total rank score as their fully signalized control site.

Comparison Among School-Pedestrian Crossing Designs

Introduction

The purpose of this evaluation is to examine the five experimental designs of school pedestrian crossings, and determine their relative advantages and disadvantages. The measures of effectiveness (MOEs), driver understanding data, and observed operation were the criteria used for this evaluation.

It is recognized that there are regional differences in driver and pedestrian attitudes and that all experimental locations are not identical in terms of geometrics and environmental characteristics, but this discussion notes the significant differences between the school-pedestrian crossing designs.

Table 13 summarizes the MOEs for the five experimental school-pedestrian crossing designs. The data supporting this table are found in the appendices.

Table 12

Comparision Between School-Pedestrian Crossing Design Vs Full Signalization (Numbers are Weighted Scores*)

Measure of Effectiveness	Sign & Stop Sign	F. Yellow Signal & F. Red Beacon	F. Green Signal & Stop Sign	(Sg-44) Signal & Stop Sign	Crossing Guard	Maximum Value
Pedestrian Behavior	−1	+1	+1	+1	+2	3
Driver Behavior	0	0	0	0	0	2
Pedestrian Compliance	+2	+2	+2	+2	+2	2
Vehicle Compliance	−1	0	0	0	0	1
Major Street Delay	+1	+1	+1	+1	+1	1
Minor Street Delay	+1	−1	+1	+1	+1	1
Total Rank Score	+2	+3	+5	+5	+6	10

*Weights are Based on Trends in Tables 2, 4, 6, 8, and 10 as Follows:

C = −1
ns = 0
E = +1

Weights Assigned to Delay Data are Based on Stop Time Per Vehicle for the Four Periods of Observations Per Location for the Major and Minor Street Approaches (Tables 3, 5, 7, 9, and 11) as Follows:

If Delay Time is Lower for the Control Site for Five or More Observation Periods:	−1
If Delay Time is Lower for the Control Site for Four Observation Periods (Divided Equally:	0
If Delay Time is Lower for the Experimental Site for Five or More Observation Periods:	+1

Table 13

Operational Data Summary

Measures of Effectiveness				Sign & Stop Sign		F. Yellow Signal & F. Red Beacon		F. Green Signal & Stop Sign		(Sg-44) Signal & Stop Sign		Crossing Guard	
				ATL*	BUF	MEM*	S.C.	LIN	SEA*	LIN	SEA	MEM	SEA
BEHAVIORS	PEDESTRIANS	Hesitation or Reversal	Percent [a]	1.6	20.19	3.61	7.80	3.31	0.86	2.08	1.38	13.23	1.38
			Rank [e]	5		3		2		1		4	
		Turning Vehicle Conflict	Percent [a]	1.60	2.40	1.11	0.71	1.55	1.93	3.01	0.69	0.00	0.15
			Rank [e]	5		2		3		4		1	
		Vehicle Hazard	Percent [a]	0.00	25.00	4.44	9.22	2.43	4.39	3.22	1.38	20.59	4.23
			Rank [e]	5		3		2		1		4	
	VEHICLES	Rear End	Percent [b]	0.00	0.00	0.01	0.01	0.00	0.00	0.02	0.01	0.00	0.00
			Rank [e]	2		4		2		5		2	
		Angle	Percent [b]	0.03	0.14	0.06	0.00	0.05	0.03	0.04	0.00	0.02	0.00
			Rank [e]	5		3		4		2		1	
COMPLIANCE	Pedestrians	Permissive Interval	Percent [c]	85.4	7.1	89.4	65.3	74.5	83.5	80.8	91.4	74.1	94.1
			Rank [e]	5		4		3		1		2	
	Vehicle	Violations per Actuation	Frequency	10.66	1.19	0.26	0.13	0.11	0.12	0.02	0.03	0.00	0.00
			Rank [e]	5		4		3		2		1	
DELAY	MAJOR	Stop Time Per Vehicle [d]	AM	1.4	0.3	3.4	0.8	2.4	3.5	4.2	3.2	1.6	2.4
			Noon	0.7	0.3	0.5	0.4	0.4	1.3	0.1	0.6	0.1	0.1
			PM #1	1.3	0.4	1.0	0.4	0.0	3.2	1.4	2.2	0.1	1.8
			PM #2	0.8	0.3	3.6	2.4	1.5	3.2	1.4	0.5	1.5	0.1
			Rank [e]	1		3		5		4		2	
	MINOR	Stop Time Per Vehicle [d]	AM	11.8	8.3	19.1	8.7	4.7	7.0	8.3	13.7	10.3	13.6
			Noon	5.5	13.8	9.6	12.6	3.7	12.1	5.4	7.1	5.1	6.0
			PM #1	17.2	10.4	18.1	9.8	5.1	9.3	16.6	9.8	6.9	8.9
			PM #2	12.2	13.3	46.1	21.7	10.8	11.1	8.1	6.9	16.7	11.7
			Rank [e]	4		5		1		2		3	
Total Rank Score				37		31		25		22		20	

NOTE: * = Crossing guard present when school children are corssing.
a = Percent of pedestrians crossing major street.
b = Percent of vehicles on major street.
c = Percent of pedestrians using marked crosswalk.
d = Seconds per vehicle
e = Rank based on sum of operational measure by school-pedestrian crossing design, 1-Best, 5-Worst.

Pedestrian Behavior

Of the three pedestrian behaviors measured, pedestrian hesitation and vehicle hazard have the widest variation in occurrence among school-pedestrian crossing designs. Pedestrian hesitation has the highest rate of occurrence at the sign and stop sign, flashing yellow signal and flashing red beacon, and crossing guard designs. The reason for this higher rate is due to characteristics of each design:

- *Sign and stop sign.* The pedestrian is unsure whether the driver will yield the right-of-way.
- *Flashing yellow signal and flashing red beacon.* There is a long response time from activating the pedestrian push-button until the WALK indication appears.
- *Crossing guard.* The guard is present for only a short period of time.

At all locations the turning vehicle hazards occurred at a much lower rate than any of the pedestrian behavior measures due to the small volume of traffic on the minor street approaches. Of the school-pedestrian crossing designs, the crossing guard has the lowest rate of turning vehicle conflicts due to the crossing guard's control of traffic on all approaches to the intersection.

The frequency of vehicle hazards is highest for the sign and stop sign, crossing guard, and flashing yellow signal and flashing red beacon designs. The higher frequency of vehicle hazards at these designs is due to pedestrians entering the roadway when vehicles are present during the prohibited phase of the pedestrian signal, or when the crossing guard is not present. There appears to be some relationship between the low compliance rate for pedestrians and high rate of vehicle hazards. The following difficulties using these school crossing designs could exist:

- *Sign and stop sign.* Lack of confidence that the traffic control device will provide a gap safe enough for the pedestrian to cross
- *Flashing yellow signal and flashing red beacon.* Unacceptable pedestrian delay in using the crossing device
- *Crossing guard.* School-pedestrian crossing design not in operation when pedestrian wants to cross the street.

Vehicle Behavior

The vehicle behaviors of rear-end and angle conflicts do not distinguish many differences among the school-pedestrian crossing designs. The rear-end conflict occurred very infrequently and was not observed at all for sign and stop sign, flashing green signal and stop sign, and crossing guard designs. The angle conflicts occurred most frequently at the sign and stop sign, flashing green signal and stop sign, and flashing yellow signal and flashing red beacon design. Two major reasons for the increase in angle conflicts were higher minor street traffic volumes and a higher percentage of left-turning vehicles. From observations, the angle conflict occurred most often when a car approaching the intersection on the minor street saw a stop sign or solid red beacon and the traffic on the major

street stopped and entered the intersection to turn left just as the signal changed to the permissive phase for the major street. The left-turning driver thus had traffic coming at him in two directions. The driver became confused and often stopped in the intersection. Although this is a potential problem, it occurred at a very low rate.

Pedestrian Compliance

For most school-pedestrian crossing designs, the pedestrian compliance rate to the permissive interval was higher than for the fully signalized control sites. The sign and stop sign, and flashing yellow signal and flashing red beacon had the lowest compliance rate of the five school-pedestrian crossing designs. The major reasons for the low compliance rate at the sign and stop sign location was a lack of confidence in vehicle compliance to the traffic control device and the location of the pedestrian push-button away from the pedestrian's normal path.

The flashing yellow signal and flashing red beacon had a lower pedestrian compliance rate due to the long wait after the pedestrian had pushed the button (to allow proper sequencing of the traffic signal) until the WALK indication appeared. During this response period, many pedestrians (particularly junior high and high school students) entered the street assuming that the traffic signal had turned yellow or red when, in fact, the traffic signal had turned green; or seeing the traffic signal change from flashing yellow to solid green, assumed the traffic signal was not working. It should be remembered that traffic signals for the major streets are difficult for the pedestrian to see in most of the school-pedestrian designs. This design, to some degree, violates pedestrian expectancy of how the school pedestrian design should operate (short response time and expected sequence of traffic signal indications) resulting in a lower compliance rate at this design.

Vehicle Compliance

Vehicle violation of the prohibited interval on the major street is directly related to the complexity of the presentation of prohibited interval. The crossing guard design had the lowest vehicle violation of the prohibited phase for the major street approach, and the sign and stop sign had the highest. When the crossing guard was present, drivers knew the appropriate response; but when they saw a flashing red signal and a stop sign saying "STOP FOR PEDESTRIANS," their perceived response was unclear, especially if they did not see a pedestrian. The sign and stop sign design had an unacceptably high violation rate of the prohibited interval, which is a hazard to pedestrians using the crossing. The flashing yellow signal and flashing red beacon had a violation of prohibited interval per activation similar to a fully signalized control site. The crossing guard design was the most effective in reducing violations of the prohibited interval for the major street traffic. The flashing green signal and stop sign and (Sg-44) signal and stop sign had violation of the prohibited interval similar to their fully signalized control sites.

Delay, Major Street

Stop time per vehicle reveals that the sign and stop sign, and crossing guard designs had the least stop time per vehicle for the combined observation periods. During periods of light pedestrian volume, all five school-pedestrian crossings had low values for stop time per vehicle. During periods of heavy pedestrian volume, the flashing yellow signal and flashing red beacon, flashing green signal and stop sign, and (Sg-44) signal and stop sign stop time per vehicle approached or equalled that observed at the fully signalized control site.

Delay, Minor Street

The minor street stop time per vehicle for the four observation periods was higher at the flashing yellow signal and flashing red beacon than the other school-pedestrian crossing designs. This shows that the red beacon on the minor street approach had the effect of holding traffic for a longer period of time, although part of this increase may be due to gap size in major street traffic and sight distance. There appears to be very little difference in stop time per vehicle for the minor street approach among the remaining school-pedestrian crossings which were all controlled by stop signs.

Rank Score

Each operational measure was then ranked one through five in Table 13 based on the sum of the measures for the two locations of each school-pedestrian crossing design, one being the most desirable rank and five the least desirable rank. Then a total rank score was developed for each school-pedestrian design by adding together the ranks for each measure for that design. The mean and standard deviations were then calculated for each school-pedestrian crossing design based on total rank scores and a t-test was calculated between paired school-pedestrian crossing designs (Appendix I). The null hypothesis for the t-test (variance not equal) was that the mean rank score for the two school-pedestrian crossing designs are the same. Figure 13 shows the results of the t-test with the solid line indicating a significant difference in mean rank scores.

Based on the total rank score for each design and the significant difference in mean rank score between the school-pedestrian crossing designs, there appear to be two distinct groupings. The best total rank score was for the crossing guard with no significant (0.05 level) difference in mean rank score between crossing guard, (Sg-44) signal and stop sign, and flashing green signal and stop sign. The least desirable total rank score was for the sign and stop sign, with no significant difference (0.05 level) in mean rank score between the sign and stop sign, and flashing yellow signal and flashing red beacon. Based on the foregoing nine measures, it appears that the crossing guard is the most desirable school-pedestrian crossing, with no significant difference between it and the (Sg-44) signal and stop sign, and the flashing green signal and stop sign.

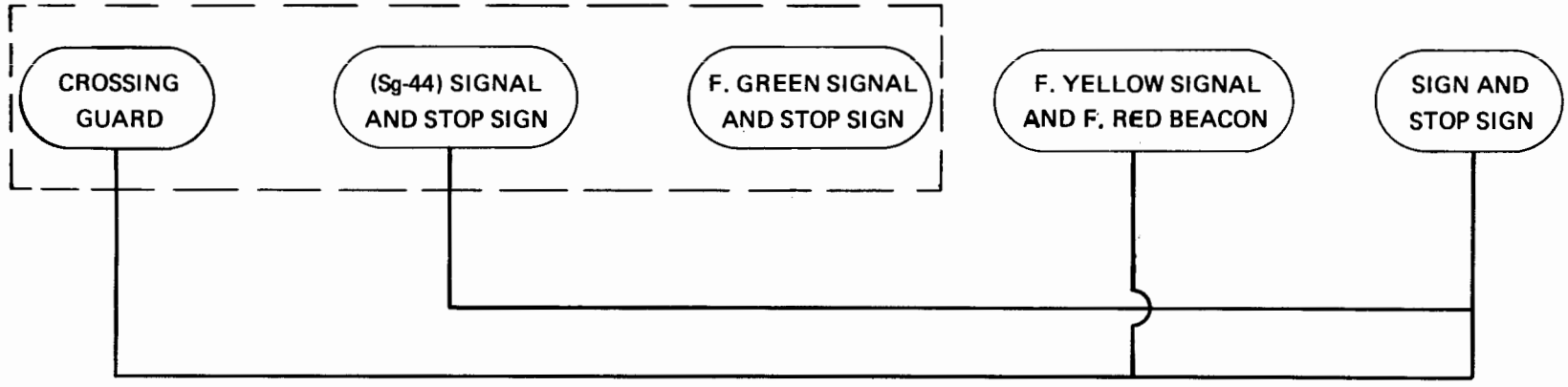


Figure 13. Significant Differences Between School-Pedestrian Crossing Design Mean Rank Scores

Cost

From the installation costs provided by the participating cities for each school-pedestrian crossing design and a fully signalized semi-actuated intersection design, a cost ratio was developed. It reveals that all but one (sign and stop sign) of the school-pedestrian crossing design installations have a lower installation cost than a fully signalized design (Table 14).

Table 14

Cost Ratio
Experimental Design Cost Vs Full Signalization Cost

Cost Ratio*	Sign and Stop Sign	F. Yellow Signal and F. Red Beacon	F. Green Signal and Stop Sign	(Sg-44) Signal and Stop Sign	Crossing Guard**
	1.0, 0.53	0.31, 0.69	0.43, 0.48	0.40, 0.50	0.59, 0.69

* Cost ratio = Installation cost for school-pedestrian crossing design ÷ installation cost for full signalization.
** Ratio based on annual cost, assume service life of 20 years and interest at 10 percent.

Driver Understanding

Table 15 presents the results of the driver understanding survey for the school-pedestrian crossing designs except for the crossing guard location where no survey was conducted due to the brief period the crossing guard was present. Question One for the major street approach revealed that drivers did not recognize the sign and stop sign design as a traffic control device as easily as the other school-pedestrian crossing designs. Approximately 50 percent of the drivers correctly identified the message presented by the sign.

Questions Two and Three show that many drivers on the major streets do not recognize that the purpose of school-pedestrian crossing design is to help pedestrians cross the street, nor do they understand that the prohibited interval for the major street results from pedestrian activation of the signal. Question Four for the major street driver shows that less than 50 percent realized that the side street was controlled by a stop sign or flashing red beacon. Question Seven reveals that 60 percent of the drivers think a flashing green signal means "caution," while the remaining feel it means the same as a solid green signal.

The majority of drivers approaching the school-pedestrian design from the minor street appear to recognize the existence of a traffic control device for the major street approaches. Minor street drivers appear to understand the purpose and operation of the school-pedestrian signal better than major street drivers because they use the intersection more frequently and were often area residents. The differences in response to the minor street driver questionnaire appear to be a function of exposure rather than the specific school-pedestrian design.

Table 15

Driver Understanding Data
(Numbers indicate percentage answering question correctly)

School-Pedestrian Crossing Device	City	Major Street							Minor Street			
		Question 1	Question 2*	Question 3*	Question 4	Question 5	Question 6	Question 7	Question 1	Question 2†	Question 3†	Question 4
Sign and Stop Sign	Atlanta	60	62	43	43	38	–	–	93	100	39	54
	Buffalo	66	61	26	46	57	–	–	47	29	29	29
F. Yellow Signal and F. Red Beacon	Memphis	94	43	33	50	–	100	–	89	78	45	–
	Sioux City	97	24	53	21	–	100	–	86	50	17	–
F. Green Signal and Stop Sign	Lincoln	–	62	62	38	–	–	52	–	75	85	–
	Seattle	100	46	40	23	–	–	66	63	40	40	60
(Sg-44) Signal and Stop Sign	Lincoln	–	67	67	50	–	–	–	62	76	92	61
	Seattle	83	94	66	49	–	–	–	100	100	85	77

Major Street Questions:

Question 1 – At the intersection you just passed, were there any traffic control devices?
Question 2 – At the intersection you just passed, what is the purpose of the traffic control devices?
Question 3 – What causes the traffic control device to turn red for the major street?
Question 4 – What controls traffic on the minor street at this intersection?
Question 5 – (E-1 only) What message was on the sign?
Question 6 – (E-2 only) What does a flashing yellow signal mean to you?
Question 7 – (E-3 only) What does a flashing green signal mean to you?
* – Sample size based on the number who answered Q1 correctly, except in Lincoln.

Minor Street Questions:

Question Q1 – Was there a traffic control device other than a stop sign at the intersection?
Question Q2 – At the intersection you just passed, what is the purpose of that traffic control device?
Question Q3 – What causes the traffic control device to turn red for the major street?
Question Q4 – Does the traffic signal control traffic on the minor street?
† – Sample size based on the number who answered Q1 correctly, except in Memphis.

Summary

Based on the comparison among the five school-pedestrian crossing designs, the following conclusions can be drawn:

- Based on the total rank score the crossing guard, (Sg-44) signal and stop sign, and flashing green signal and stop sign have significantly better operating characteristics than the other designs analyzed.
- Sign and stop sign, and flashing yellow signal and flashing red beacon are significantly less desirable than the crossing guard.
- The sign and stop sign design does not significantly reduce hazards to the pedestrian using this device.
- Major street vehicle delay varies greatly depending upon the number of signal activations at the school-pedestrian crossing designs.
- The flashing green signal vs the steady green signal had no significant effect on vehicle operational measures.
- Drivers attach the meaning "caution" to a flashing green signal.

V. CONCLUSIONS AND RECOMMENDATIONS

Introduction

It should be noted that the following statements refer to a specific type of intersection. The intersection has a major arterial street crossing a local residential street where an established pedestrian crossing exists. At this type of intersection, the pedestrian encounters excessive delay in trying to cross the major arterial street and no increase in through traffic on the local residential street is desirable.

Conclusion

Based on the data analysis and observations at each school-pedestrian crossing design, the following are advantages and disadvantages of the school-pedestrian designs as compared to full signalization:

Advantages:

- Increased pedestrian compliance to the pedestrian signal
- Reduction in the percentage of vehicles stopping on the major street approach
- Reduction in the stop time per vehicle on the major street approach
- Reduction in installation costs.

Disadvantages

- Reduction in both pedestrians' and drivers' understanding of how the traffic control device operates
- Increase in vehicle angle conflicts, but non-significantly.

School-Pedestrian Crossing Designs Vs Full Signalization

Based on the comparison between each school-pedestrian crossing design and its fully signalized control site, the following conclusions were developed:

- The *sign and stop sign* school-pedestrian crossing design revealed many undesirable characteristics especially concerning vehicle compliance to the flashing red beacon. Therefore it was concluded that full signalization is more desirable than the sign and stop sign design.
- The *flashing yellow signal and flashing red beacon* show characteristics similar to those obtained at the fully signalized control site. Therefore, the flashing yellow signal and flashing red beacon is judged equivalent to full signalization, except that full signalization could generate through traffic on the minor street approach.

- The remaining three school-pedestrian crossing designs (*crossing guard, (Sg-44) signal and stop sign* and *flashing green signal and stop sign*) were judged to have operating characteristics more desirable than those measured at the fully signalized control site.

Comparison Among School-Pedestrian Crossing Designs

Based on the comparison of mean rank scores among the five school-pedestrian crossing designs, it was determined that the crossing guard had significantly better operating characteristics than the sign and stop sign, and the flashing yellow signal and flashing red beacon designs. The crossing guard operating characteristics were not significantly different from the operating characteristics observed at the (Sg-44) signal and stop sign and flashing green signal and stop sign designs.

Recommendations

The recommendations are divided into two sections. The first section recommends two alternatives to full signalization at pedestrian crossings. The second recommends guidelines for selecting the intersection where the school pedestrian crossings devices are appropriate.

Alternative to Full Signalization of Pedestrian Crossings

The crossing guard and (Sg-44) signal and stop sign are the more desirable school-pedestrian crossing design evaluated.

Guidelines for the Selection of Intersections and Locations of School-Pedestrian Crossing Designs

1. Major Street (assume two lanes in each direction)
   - Number of adequate gaps in the traffic stream during periods of pedestrian activity is less than the number of minutes in that same time period.
   - Minimum AADT 7,000 – 10,000 vehicles, both directions
   - Minimum peak hour volume of 1,100 – 1,400 vehicles, both directions.
2. Minor Street (assume one lane in each direction)
   - Local residential street
   - Maximum AADT 900 – 1,200 vehicles, both approaches
   - Maximum peak hour 100 – 150 vehicles, both approaches.
3. One criterion in selecting the type of school-pedestrian crossing design should be the arrival and distribution pattern of pedestrians throughout the day at each location due to differences in the times of operation between the two recommended designs. The time of operation for the crossing guard usually consists of only several hours a day where the (Sg-44) signal and stop sign operates on demand.

4. The pedestrian crosswalk should be located with consideration to turning vehicle volume through the crosswalk from the minor street and the pedestrian volume of each crosswalk.

5. Response time from the point at which the push-button is depressed until the WALK interval appears should be minimized to ensure maximum pedestrian compliance to the pedestrian signal.

References

1. U.S. Department of Transportation. *Manual on Uniform Traffic Control Devices for Streets and Highways, Vol. VI: Official Rulings on Requests for Interpretations, Changes and Experimentation*. Washington, D.C., June 1975.

2. U.S. Department of Transportation. *Manual on Uniform Traffic Control Devices for Streets and Highways*. Washington, D.C., 1971.

3. Robertson, H.D. *Urban Intersection Improvements for Pedestrian Safety, Vol. IV: Pedestrian Signal Display and Operation*. BioTechnology, Inc., Falls Church, Va., January 1977.

4. Edwards, A.L. *Experimental Design in Psychological Research*. New York: Holt, Rinehart & Winston, 1962.

5. Reilly, W.R.; Gardner, C.C., & Kell, J.H. *A Technique for Measurement of Delay at Intersections*. Federal Highway Administration, Washington, D.C., July 1975.

APPENDIX A

TRAFFIC ENGINEER DESIGN SURVEY

URBAN INTERSECTION IMPROVEMENTS FOR PEDESTRIAN SAFETY

Pedestrian Crossings at Intersections - Special Problem

Design Development

Problem

The problem, which has both safety and operational implications, is exhibited at the intersection of a high-volume (and often high speed) arterial street with a low-volume residential street. Adequate gaps do not exist to allow a pedestrian to cross the arterial safely without an unreasonable time delay. The pedestrians desiring to cross usually include school children and the elderly or handicapped. The pedestrian and minor street vehicle volumes do not warrant the installation of signals. Neither can the accident experience warrant be applied. These locations seldom exist at progression points within an existing signal system. In some cases, where a school route crosses the arterial, the school crossing warrant can be used, but there is no provision made for non-school route crossings. Compounding the problem of not being able to warrant the use of full signalization is the fact that full signalization itself may be undersirable from an operational and/or a cost point of view.

Purpose of the Research

The MUTCD addresses the problem to some extent in section 4C-6, School Crossing Warrant, in terms of inadequate gaps. Reference is made to section 7A-3, School Crossing Control Criteria, which offers the following guidance: when gaps are inadequate "some form of traffic control is needed which will create (in the traffic stream) the gaps necessary to reduce the hazard." The objective of this research is to determine the appropriate form of traffic control for the type of intersection described above.

Scope

The object of the research will be to conform with the intent of the principles stated in the MUTCD. Solutions may include both the modification of existing devices/applications and the development of new devices/applications. Solutions other than the following are sought:

- Grade separated pedestrian over or under pass.
- Moving the pedestrian crossing to mid-block.
- Full signalization of the intersection.

Considerations

Considerations for a desirable type of control to allow young, handicapped, and older pedestrians to cross the roadway safely include:

- Effectiveness in protecting pedestrians.
- Efficiency in minimizing delay and stops for vehicular traffic.
- Cost of the installation, its maintenance and operation.
- Relatability to other, existing traffic control devices.
- Applicability to low cross street and low pedestrian volumes.
- Impact on traffic patterns, i.e., route diversion.
- Effect on type and number of accidents.

Procedure

You are being asked to help us identify appropriate designs that may remedy the above problem and that will fit within the constraints listed above. We are presenting four alternatives to help stimulate your thinking. They do not necessarily represent the solution. We would first like for you to comment on each of the four in terms of advantages, disadvantages and improvements based on your experience and judgement. Then on the sheets provided present your ideas on how best to treat the problem.

The comments and ideas generated by this exercise will be reviewed by the Project Advisory Panel, and three of the designs will be selected in addition to the Sg-44 proposal for field evaluation. Your input is important. In order to maintain the project schedule, we ask that you return your comments to us in the envelope provided no later than 26 April 1976.

ALTERNATIVE 1 (Sg-44 Concept)

Description

The school-pedestrian signals in use in Seattle consist of dual vehicular signal heads (red, amber, green lenses) facing both directions of travel on the major (arterial) street, and "DONT WALK-WALK" pedestrian signal heads controlling the crosswalk across the major street. The second crosswalk across the arterial is closed to pedestrian travel by means of signs erected at each side of the street facing the sidewalk. These signs state "DO NOT CROSS HERE, USE SIGNAL". The minor street approaches are controlled by stop signs. Refer to Figure 1(a) for typical design. The majority of the vehicular signal heads are supported by steel mast arms and poles. Certain intersections considered temporary have been equipped with span wire signal suspension in lieu of the steel mast arm poles. In addition, high pressure sodium vapor luminaires are mounted on each end of the crosswalk to provide added night visibility and safety.

Each signal is in operation 24 hours per day every day. The signal dwells in (displays) a solid green indication to the major street vehicular traffic and a "DONT WALK" indication for the pedestrian. The controller either runs continuously or is released by a system syncronization pulse in order to provide the best feasible progression. Upon actuation and at the appropriate point in the system cycle, the signal displays a main street amber indication and then a two-to-three second red indication prior to display of the "WALK" indication. The "WALK" is followed by a flashing "DONT WALK" pedestrian clearance interval after which the green is returned to the main street and the steady "DONT WALK" to the pedestrian.

The typical layout used in Wichita and Kansas City is shown in Figure 1(b).

Advantages

- Improved pedestrian safety without increased vehicular hazard.
- Reduced installation, maintenance and operation cost.*
- Reduced potential for rear-end vehicular collisions on main street.*
- Reduced vehicular emissions due to minimum stopping and starting of vehicles.*
- Reduced pedestrian and vehicular delay.*
- Does not impede minor street vehicular egress.*
- Reduces conflict between minor street turning vehicles and pedestrians where only one crosswalk is used.
- Does not make the minor street any easier an access point to the major street than its adjacent intersecting streets.*

* Compared to full signalization of the intersection.

Disadvantages

- Violates typical driver expectancy since a driver facing a green (on main street) assumes that a red indication is in effect on the minor street.
- Minor street drivers may become confused when they see main street traffic stopped, but cannot tell when the signal will return right-of-way to the main street.
- Drivers turning from the minor street while pedestrians are crossing may be distracted by the main street traffic and, therefore, not see the pedestrian.
- Does not conform to the intent of Sections 2B-5 and 4B-26 of the MUTCD.

Comments

ALTERNATIVE 2 (See Figure 2)

Description

A beacon flashes continuously at the intersection (amber on the arterial, red on the minor street). Stop signs are also located on the minor street. Crosswalks are marked on the arterial and pedestrian crosswalk signs are located on the arterial approaches.

Advantages

- All of the traffic control devices are standard MUTCD devices.
- Installation, operation and maintenance costs are minimal.
- Vehicle delay is minimal.
- Does not provide a good access point for through traffic on the minor street.
- Does not impede minor street egress.

Disadvantages

- The control only warns drivers to watch for pedestrians, it does not regulate them as does a traffic signal.
- Because of its continuous operation, the beacon may lose its effect as a warning device to familiar drivers.

Comments

ALTERNATIVE 3 (See Figure 3)

Description

One crosswalk is marked on the arterial and a sign, YIELD TO PED WHEN FLASHING, with pedestrian actuated amber beacons is hung over the crosswalk. Advance warning signs, PED CROSSING WHEN FLASHING, with ped actuated amber beacons are located on the arterial approaches. Stop signs with ped actuated red beacons control the minor street. A sign with the message TO CROSS STREET, PUSH BUTTON, CROSS WITH CARE is located over each pushbutton. When a pedestrian pushes the button, all beacons are activated and continue to operate long enough for the pedestrian to complete his crossing.

Advantages

- Presents a conspicuous and credible warning to drivers.
- Lower installation, operation and maintenance costs compared to full signalization.
- Minimum delay to traffic and pedestrians.
- Does not impede minor street egress.
- Does not violate driver expectancies.
- Does not make the minor street an easier access point to the arterial street.

Disadvantages

- Does not provide a positive control of traffic on the arterial.
- Actuation of the beacons may confuse unfamiliar drivers.
- May convey a false sense of security to the pedestrian.

Comments

ALTERNATIVE 4 (See Figure 4)

Description

Two three-section traffic signals are displayed to each intersection approach. Pedestrian DONT WALK-WALK signals are located on the one marked crosswalk on the arterial. Advance warning signs, PED CROSSING WHEN FLASHING, with ped actuated beacons are located on the arterial approaches. Barriers and signs, USE MARKED CROSSWALK, are located at the other arterial crossing. All beacons and signals are ped actuated. Signs with the message TO CROSS STREET, PUSH BUTTON, WAIT FOR WALK SIGNAL (Note. Drawing is in error) are located above each pushbutton. Under normal operation the signal on the arterial flashes amber (bottom lens) and the signal on the minor street flashes red (bottom lens). The pedestrian signal displays DONT WALK. Upon actuation by a pedestrian, the beacons on the advance warning signs begin to flash, all of the traffic signals go to steady amber (center lens) for 3-5 seconds. Then all signals go to steady red (top lens). After 2-3 seconds, the pedestrian signal displays WALK followed by a flashing DONT WALK clearance and a steady DONT WALK as the traffic signals return to normal operation and the beacons turn off. A minimum time must expire before a pedestrian can actuate the beacons and signals again.

Advantages

- Affords maximum protection to the pedestrian.
- Minimizes pedestrian delay.
- Eliminates pedestrian/vehicle turning conflicts.
- Causes less vehicle delay than would full signalization with either fixed-time or semi-actuated control.
- Does not impede minor street egress under normal operation.
- Does not make the minor street an easier access point to the arterial.

Disadvantages

- Drivers may not perceive the change from flashing amber to steady amber on the arterial.
- Actuation of the advance sign beacons may startle drivers.
- Minor street drivers may be confused by the flashing red, steady amber, steady red sequence.
- Cost of installation, operation and maintenance may approach that of full signalization.

Comments

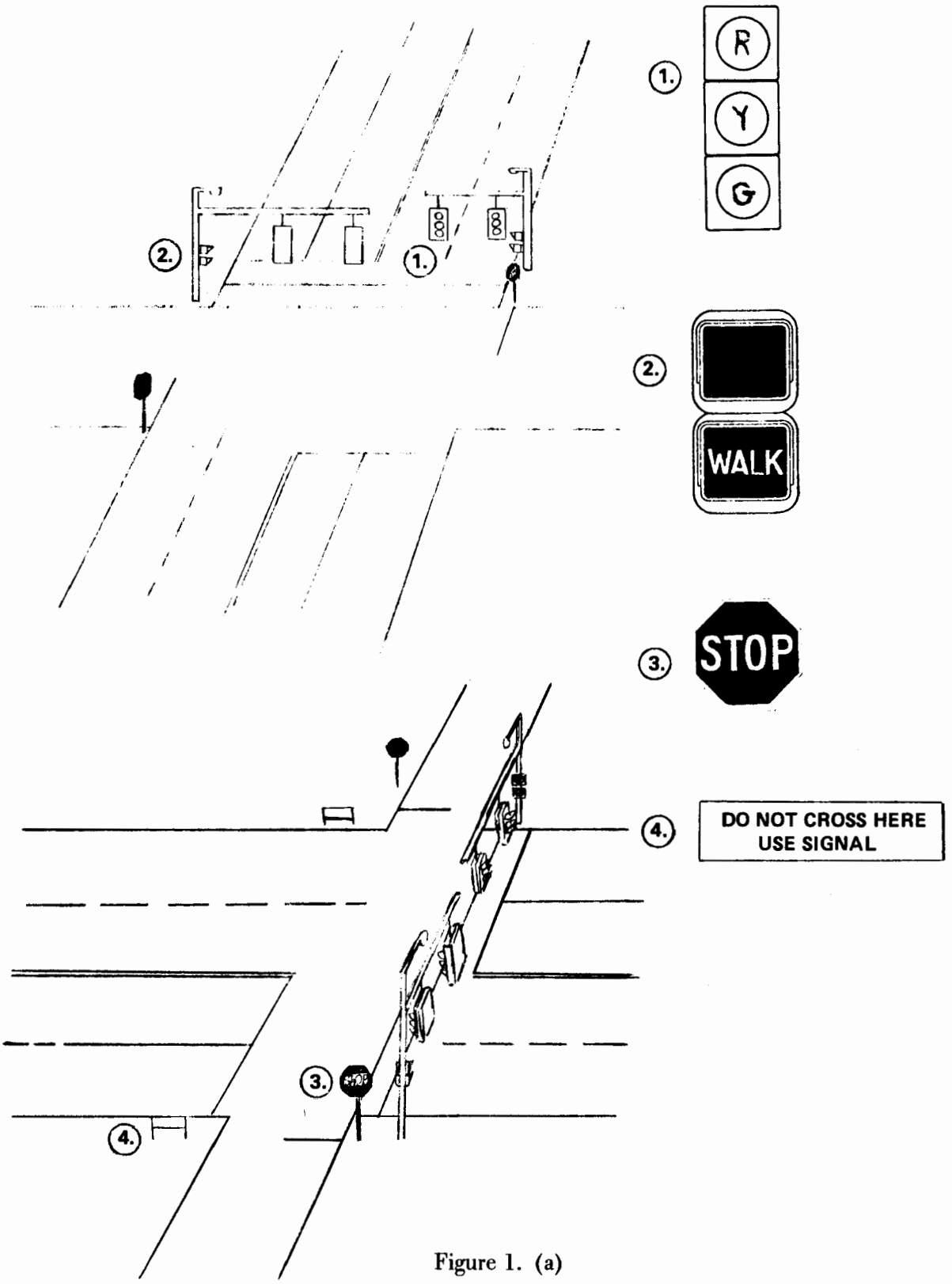


Figure 1. (a)

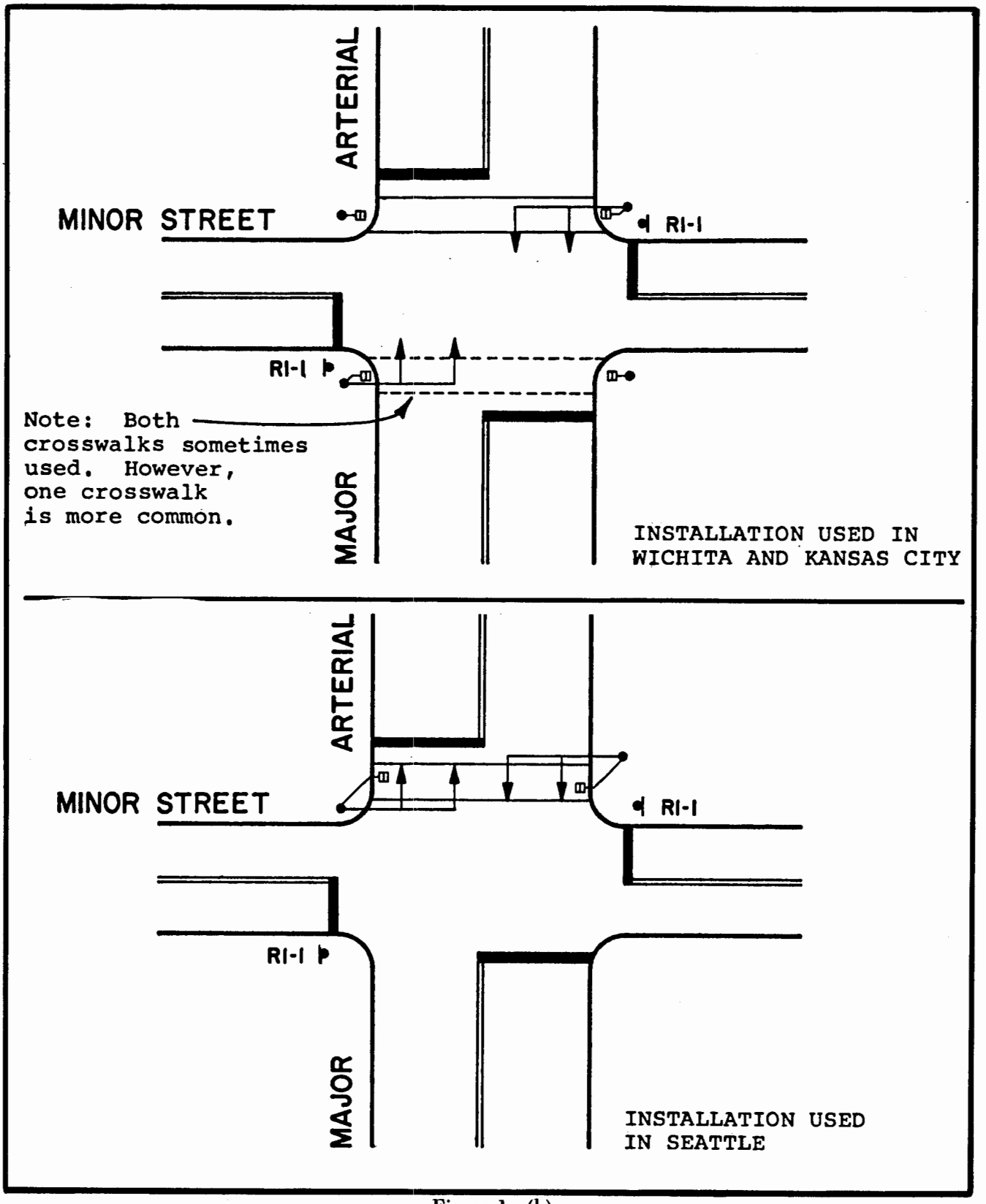

ARTERIAL
MINOR STREET
RI-I
RI-I
Note: Both crosswalks sometimes used. However, one crosswalk is more common.
MAJOR
INSTALLATION USED IN WICHITA AND KANSAS CITY
ARTERIAL
MINOR STREET
RI-I
RI-I
MAJOR
INSTALLATION USED IN SEATTLE

Figure 1. (b)

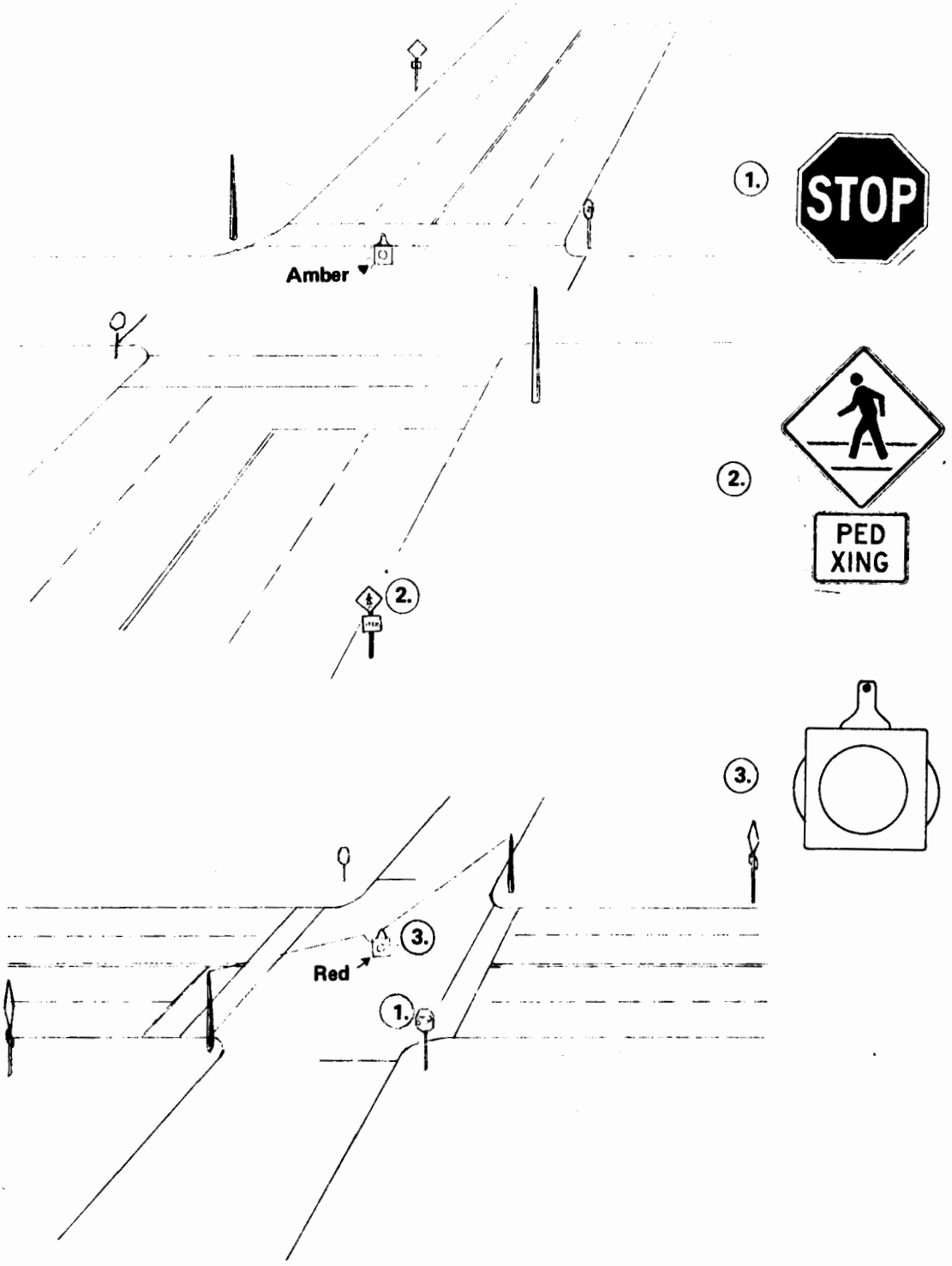


Figure 2.

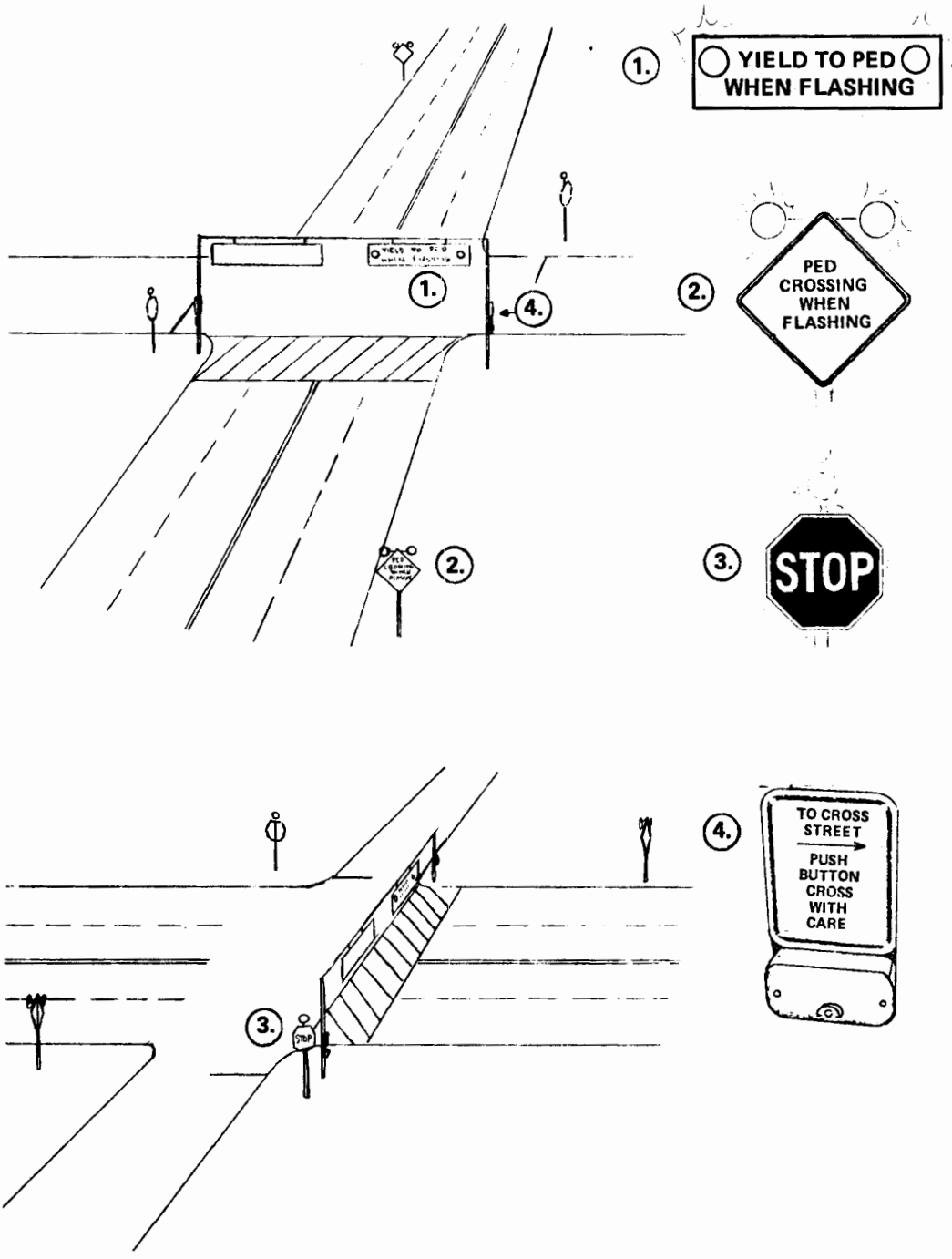

1.
YIELD TO PED
WHEN FLASHING
2.
PED
CROSSING
WHEN
FLASHING
3.
STOP
4.
TO CROSS
STREET
PUSH
BUTTON
CROSS
WITH
CARE

Figure 3.

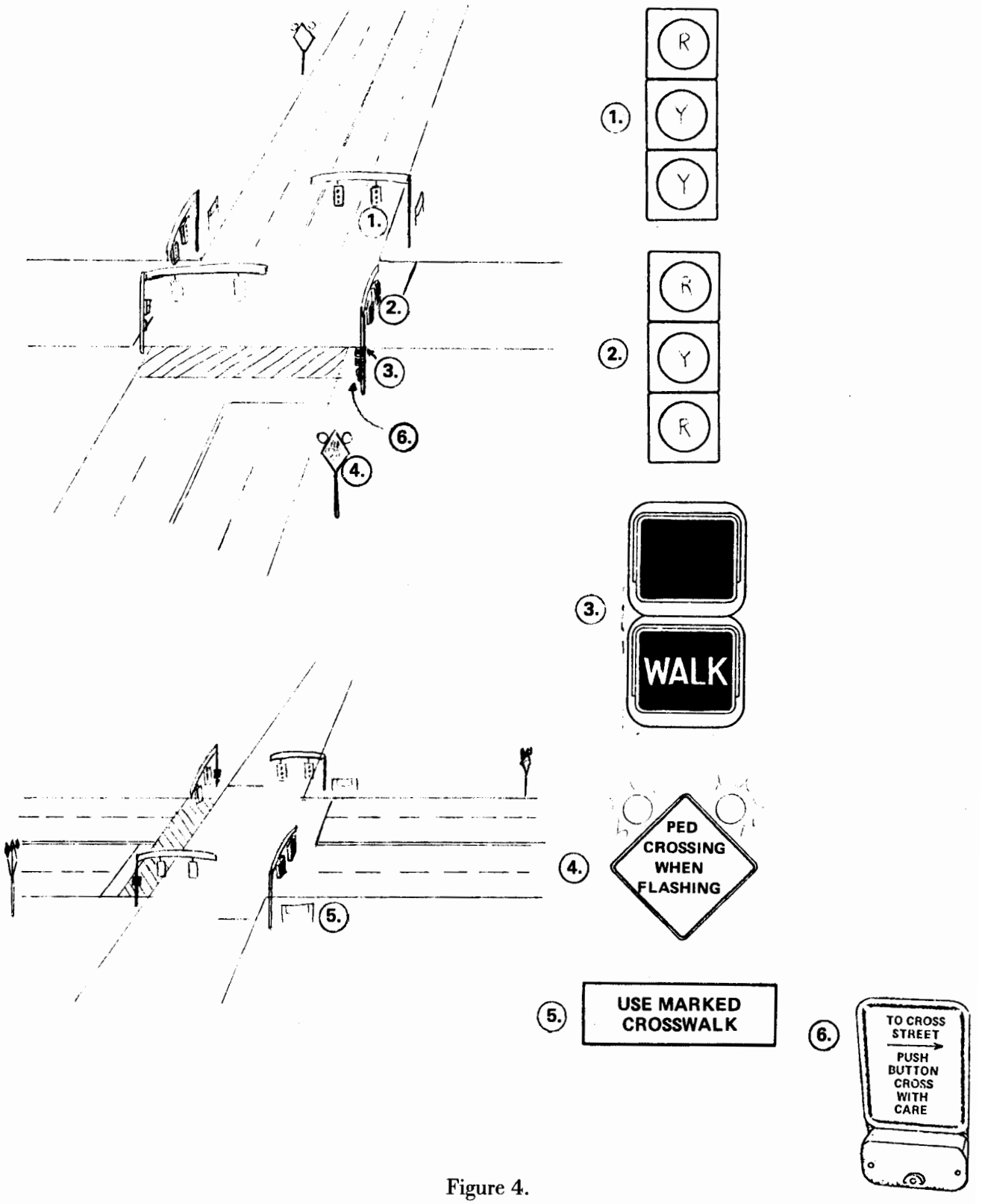

1.
2.
3.
6.
4.
5.
R
Y
Y
R
Y
R
WALK
PED
CROSSING
WHEN
FLASHING
USE MARKED
CROSSWALK
TO CROSS
STREET
PUSH
BUTTON
CROSS
WITH
CARE

Figure 4.

SELECTED COMMENTS

Alt. #1, (Sg-44) Signal and Stop Sign

- "We have made numerous observations...and have found no apparent confusion on the part of drivers moving on the main street with the green light when a vehicle enters or crosses the street from the side street. Side street drivers with the stop sign must of course yield to main street flow in the same manner as they would if there were no signal indications at all on the main street. The green signal in effect is the same as no lights at all as far as the side street driver is concerned."
- "...a flagrant safety problem..."
- "We are booby-trapping the arterial motorist who is approaching a green signal and because of habit assumes he has the right of way."
- "...A flashing green display...overcomes the solid green definition problem and is consistent with the flashing meaning being less strict than the solid meaning of each color."

Alt. #2, Yellow and Red Beacon

- "I question their value as a pedestrian warning device but certainly encourage experimentation."
- "This provides no significant aid to the pedestrian."
- "OK"
- "Should be reserved for especially hazardous locations and used sparingly."

Alt. #3, Sign and Stop Sign

- "Alternative #3 comes closest to providing safe crossing time while still not violating driver expectancy or installing non-standard devices."
- "This is very unconventional...and it is not cheap."
- "Alternative #3 seems to be a confusing application of traffic control devices and traffic law."
- "The message might better read 'Yield To Pedestrians,' omitting the 'When Flashing.'

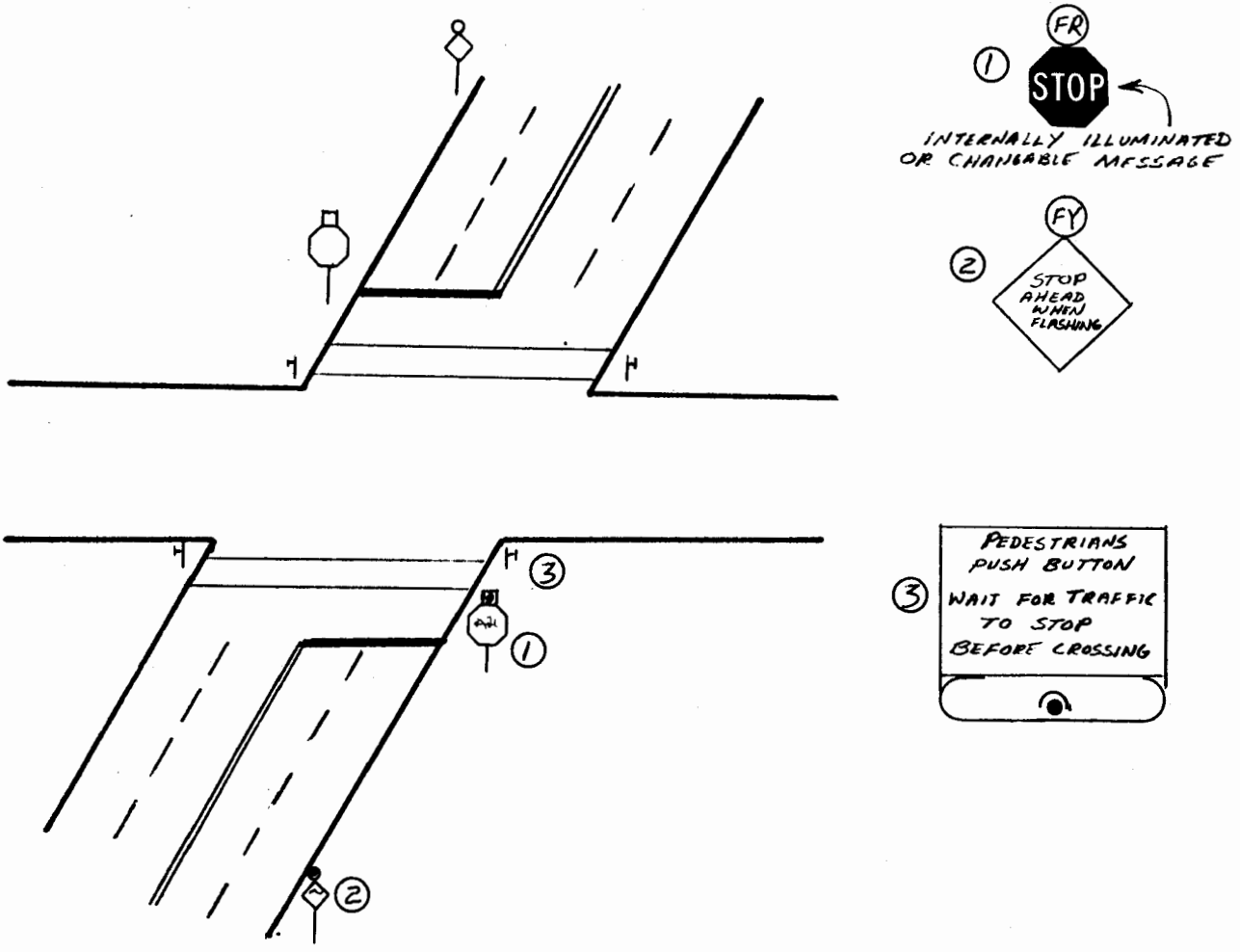
Alt. #4, Signals On All Approaches

- "The cost of this installation is equal to that of a standard pretimed or semi-actuated intersection."
- "Probably best for pedestrians of any of these four alternatives."
- "Alt. #4, by providing a conflicting amber display, creates a unique and unusual hazard."
- "Approaches a workable solution."

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices

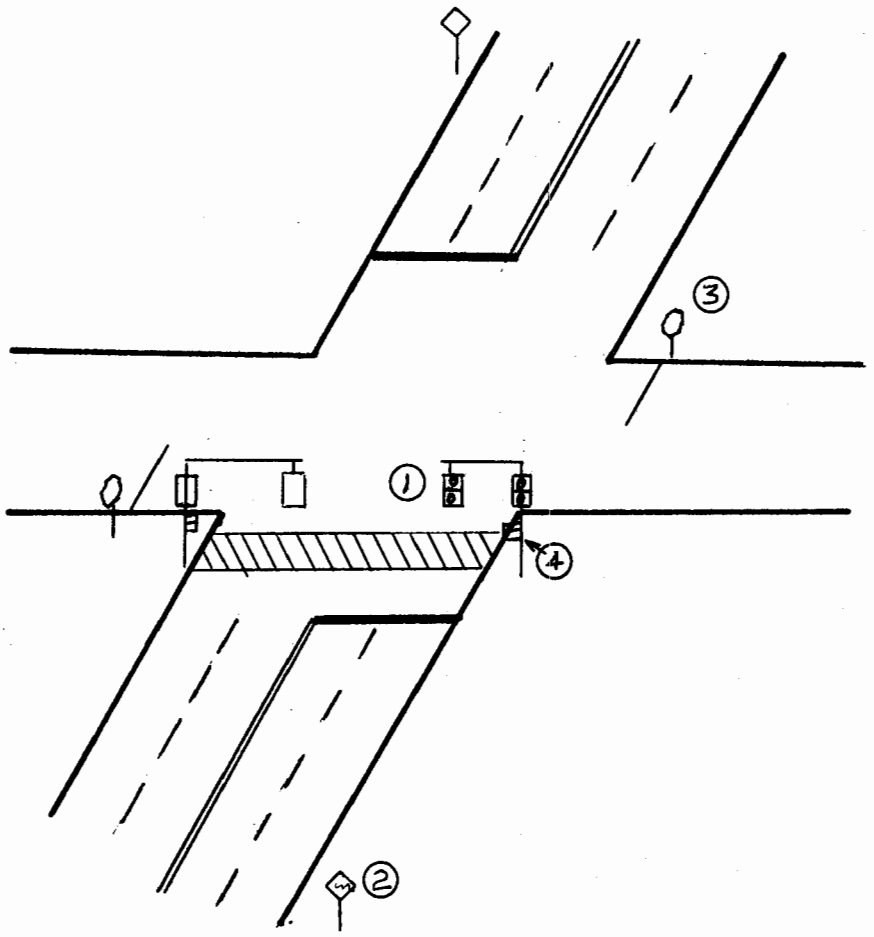


OPERATION

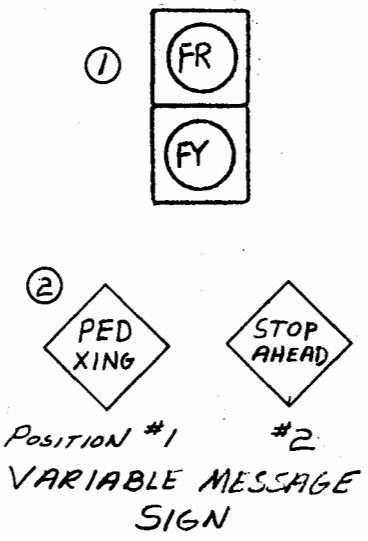
APPROACH	DWELL	PED. ACT.	
ADVANCE	DARK	FY	FY
STOP	DARK	DARK	Stop/FR

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design



Traffic Control Devices



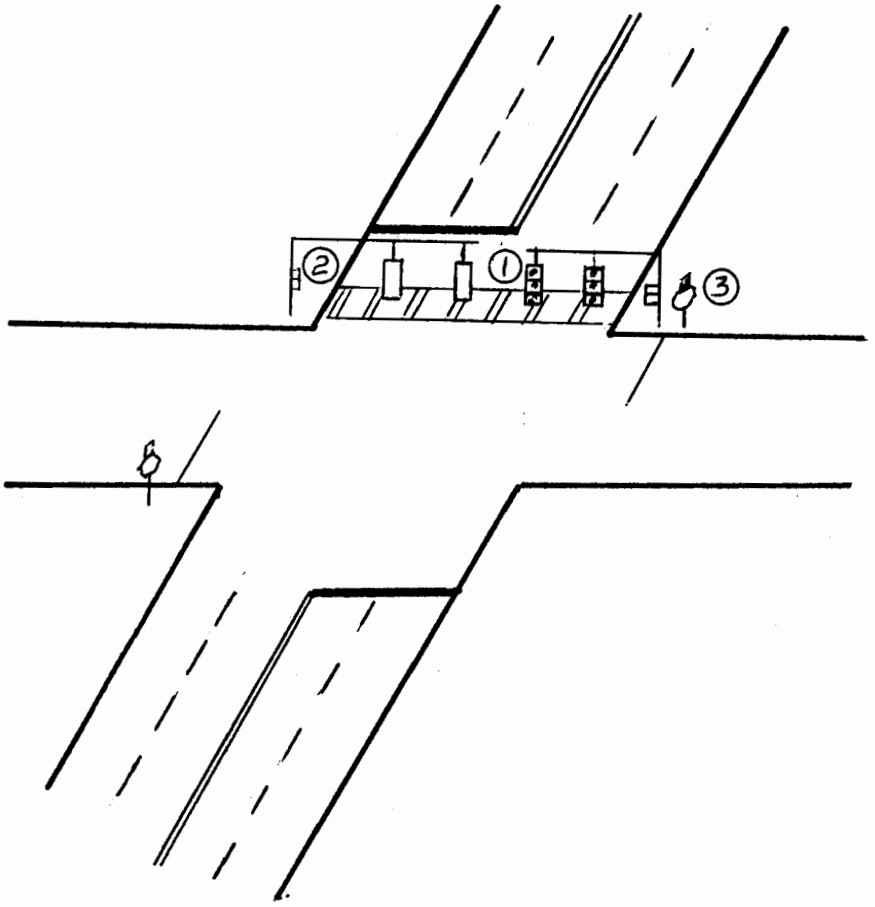
OPERATION

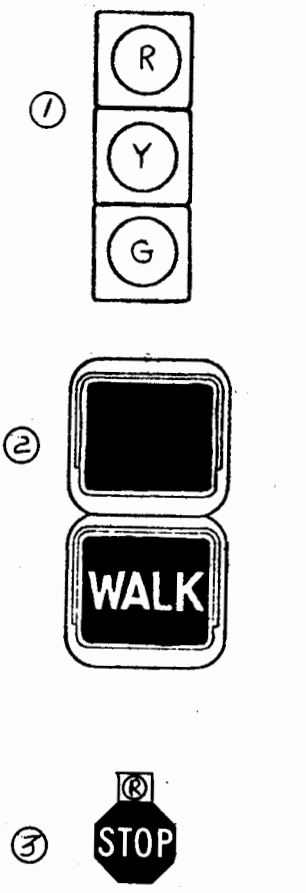
APPROACH	DWELL	PED. ACT.	
Advance Sign	Ped-Xing	Stop Ahead	Stop Ahead
Major St. Signal	DARK	FY	FR
Pedestrain Signal	DARK	DARK	Cross W/Care

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices





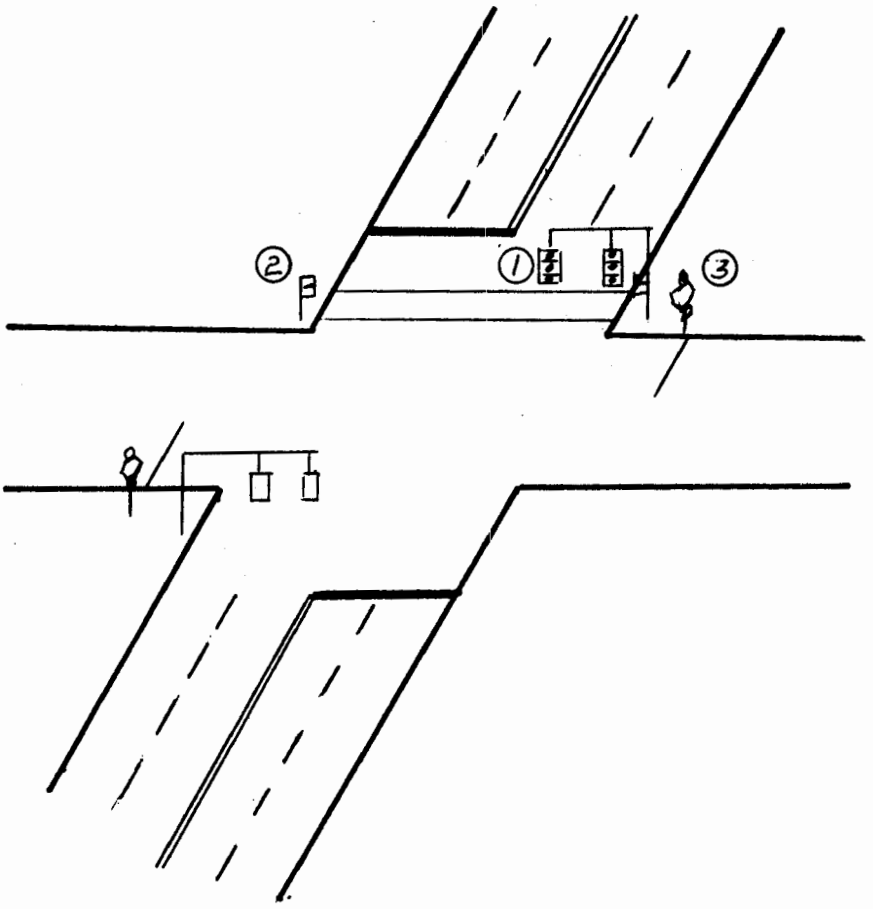
OPERATION

APPROACH	DWELL	PED. ACT.			
MAJOR	FY	Y	R	R	R
MINOR	FR	R	R	R	R
Pedestrian Signal	DW	DW	DW	W	FDW

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices



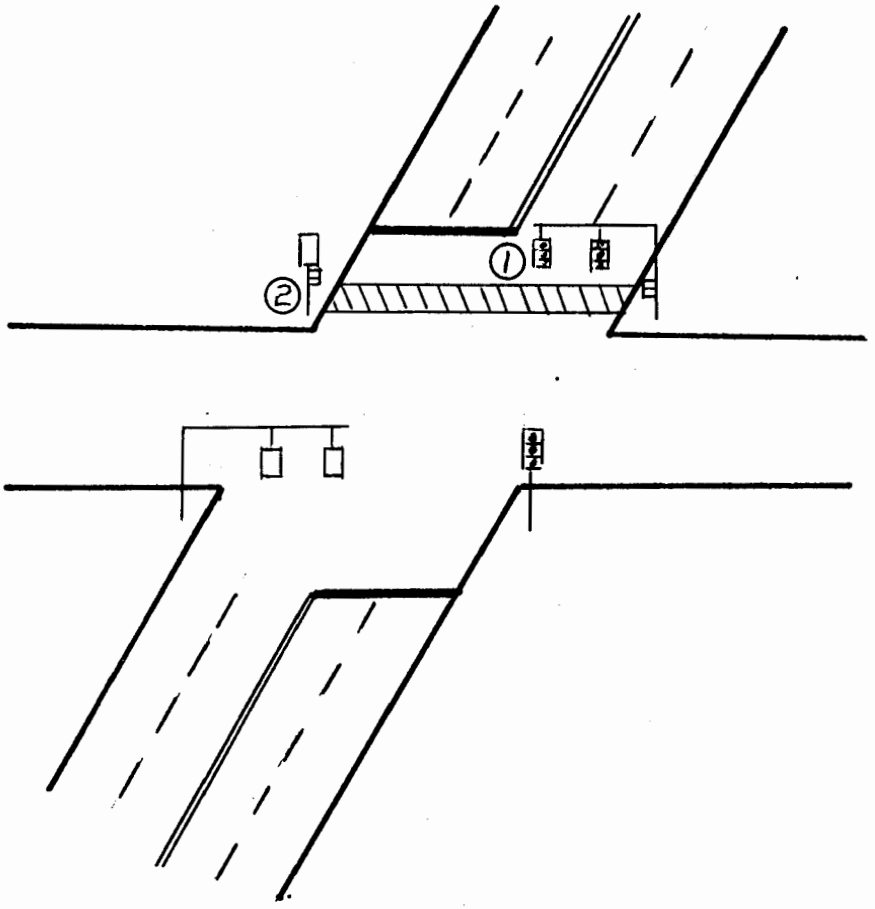
OPERATION

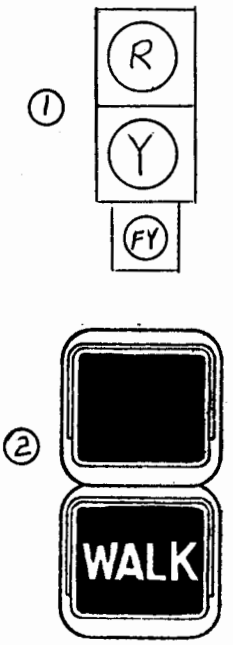
APPROACH	DWELL	PED. ACT.		
MAJOR	G	Y	R	R
MINOR	DARK	DARK	FR	FR
Pedestrian Signal	DW	DW	W	FDW

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices





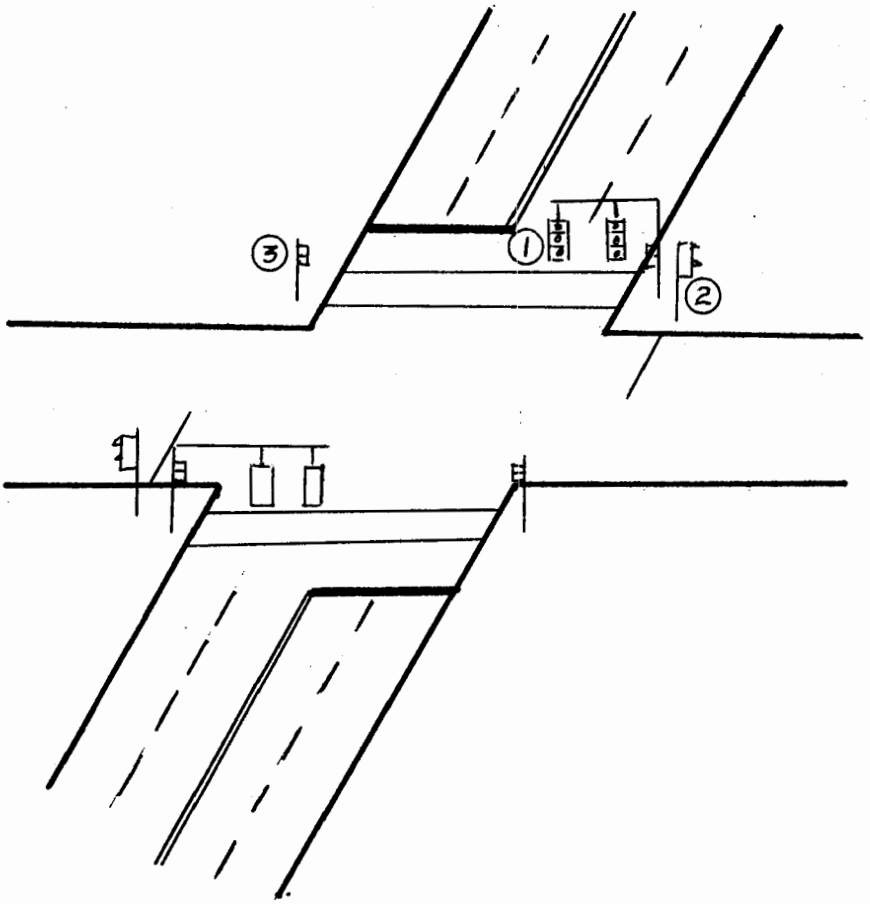
OPERATION

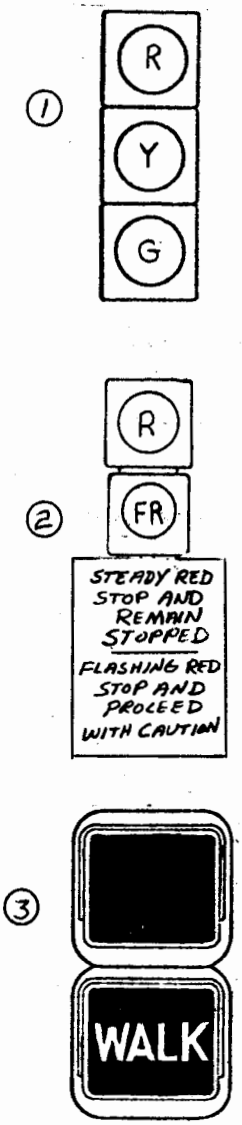
APPROACH	DWELL	PED. ACT.		
MAJOR	FY	Y	R	R
Pedestrian Signal	DW	DW	W	FDW

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices





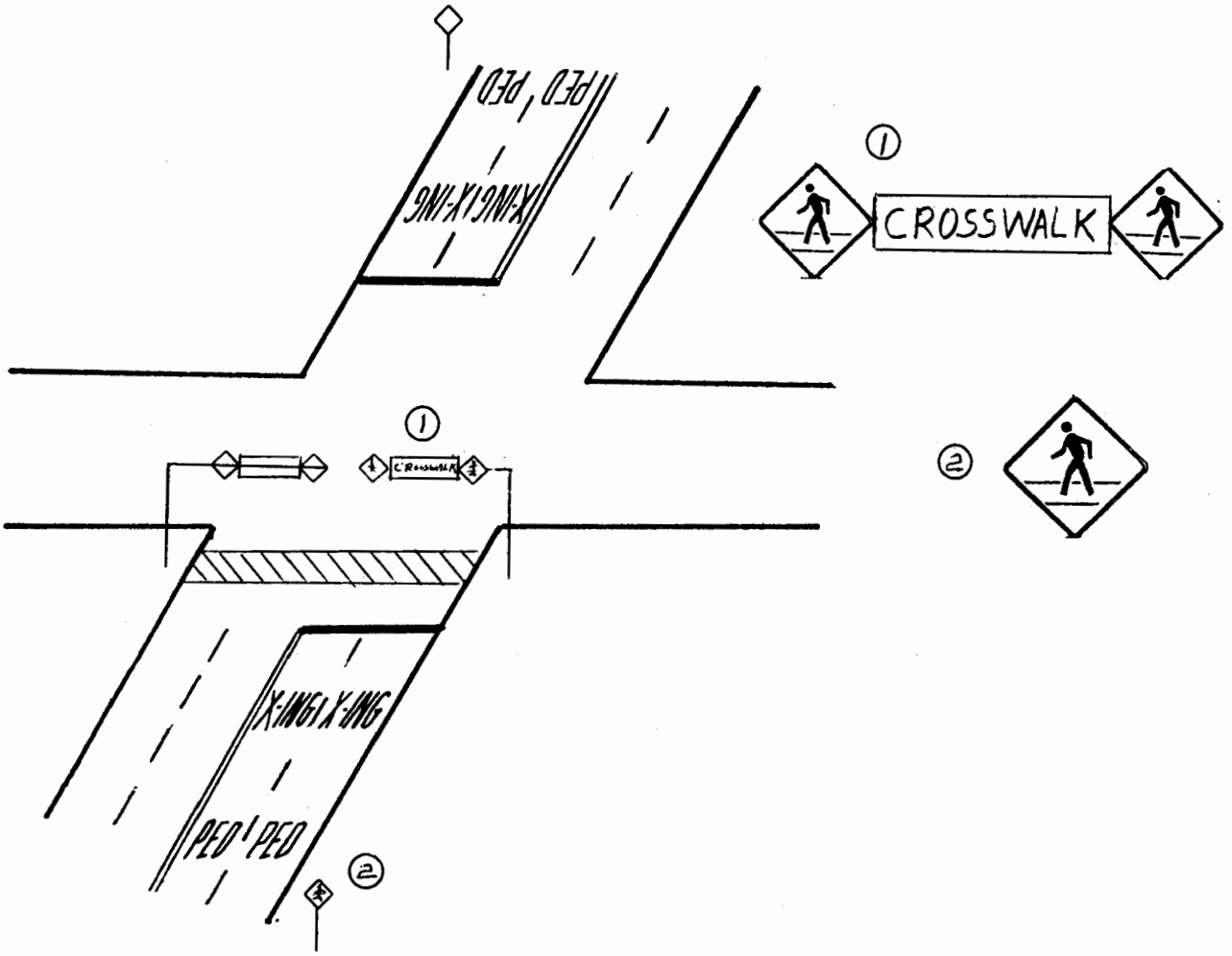
OPERATION

APPROACH	DWELL	PED. ACT.					
MAJOR	FY	FY	G	Y	R	R	R
MINOR	FR	R	R	R	R	FR	R
Pedestrian Signal	DARK	DW	DW	DW	W	FDW	DARK

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

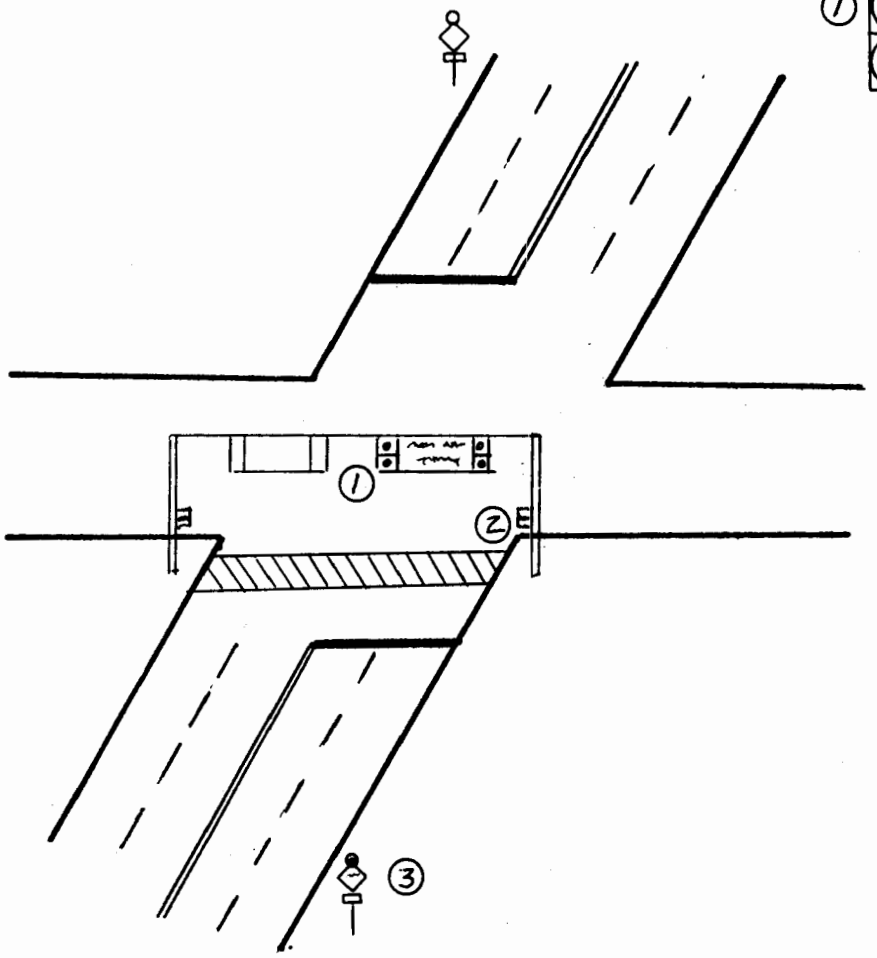
Traffic Control Devices

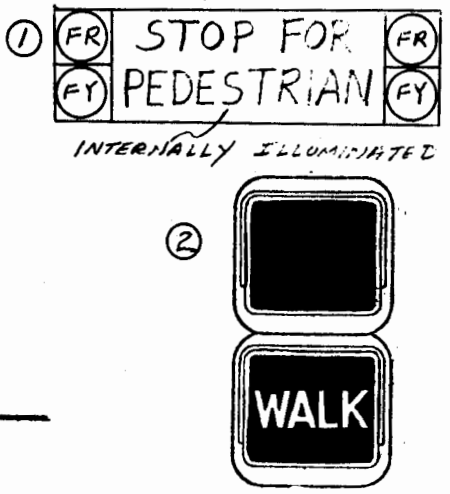


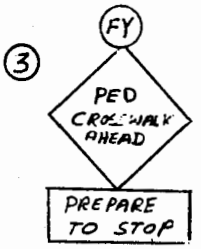
SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design

Traffic Control Devices







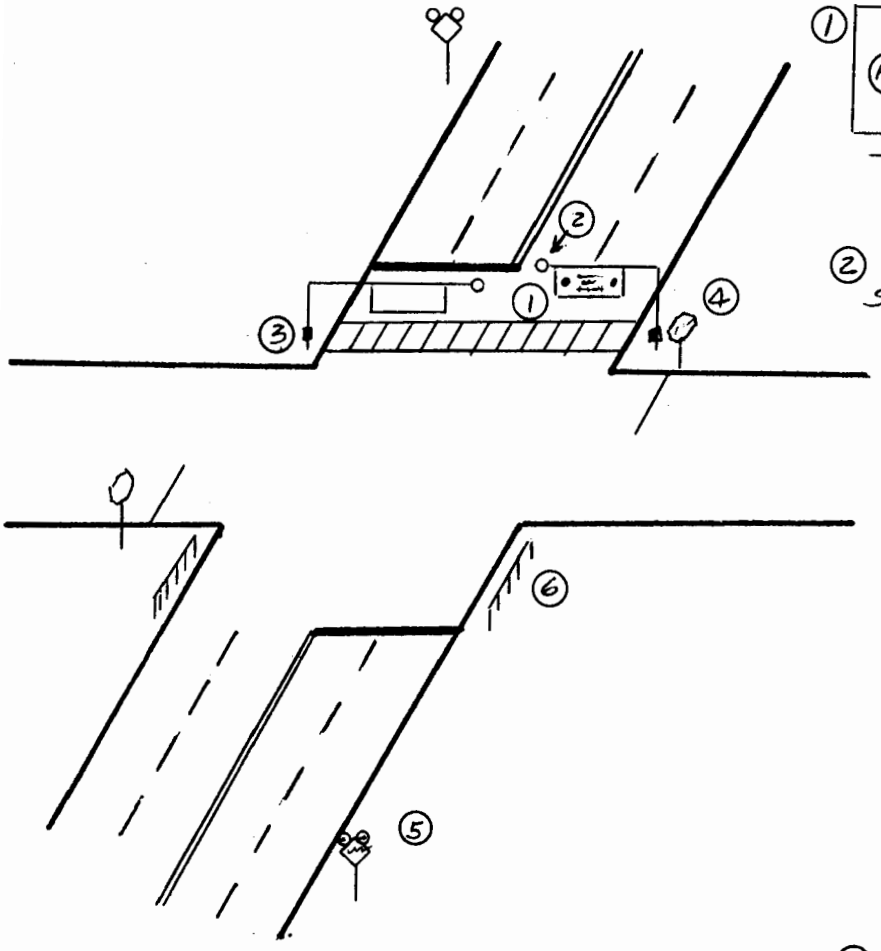
OPERATION

APPROACH DWELL PED. ACT.

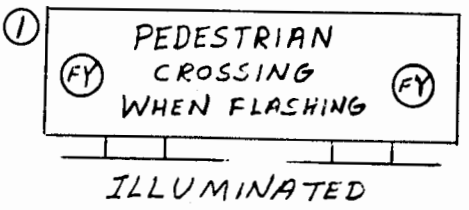
O.H. SIGN	DARK	FY	FR/Stop for Ped	FR/Stop for Ped	FR/Stop for Ped
Advance Sign	FY	FY	FY	FY	FY
Pedestrian Signal	DW	DW	DW	W	FDW

SURVEY OF TRAFFIC ENGINEERS

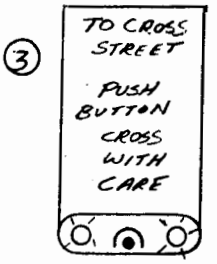
Suggested Alternative Design

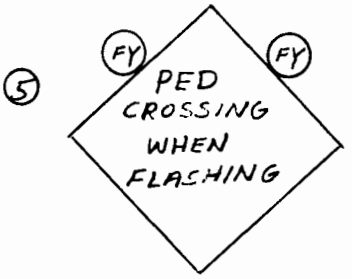


Traffic Control Devices



2 HIGH PRESSURE SODIUM VAPOR STREET LIGHT





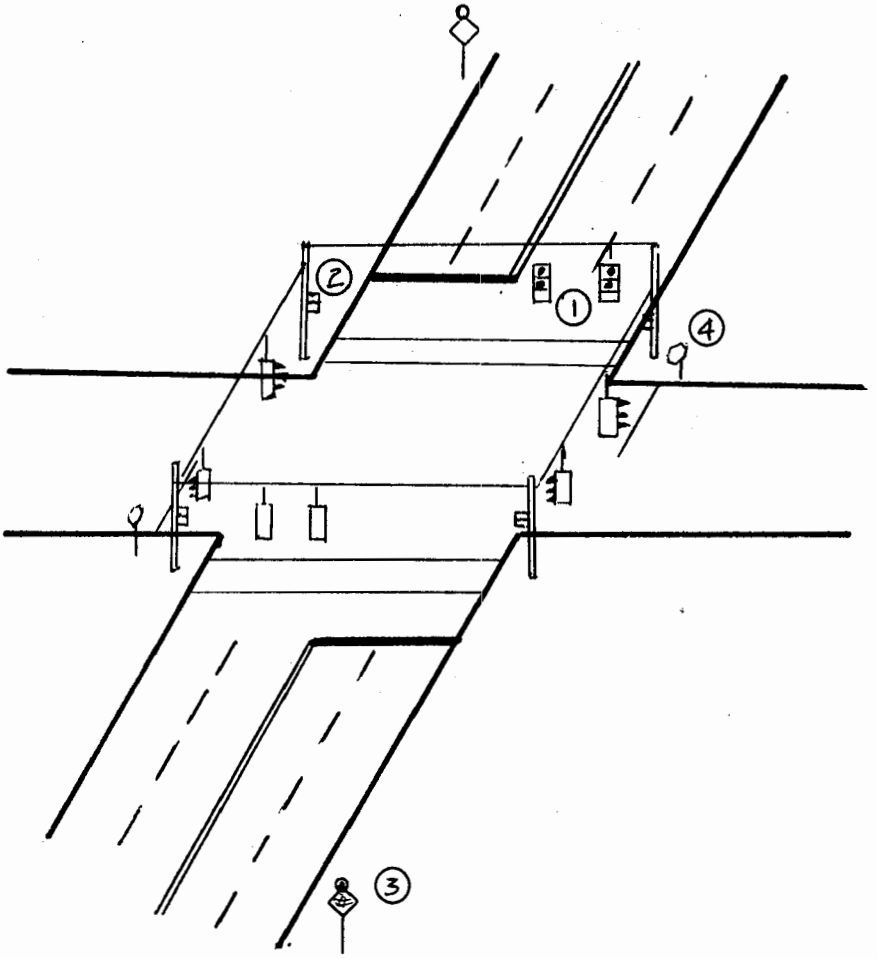
6 PEDESTRIAN BARRIER

OPERATION

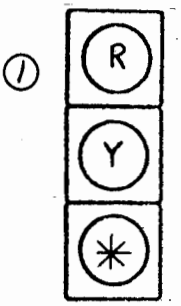
APPROACH	DWELL	PED. ACT.
O.H. SIGN	DARK	FY
Advance Sign	DARK	FY

SURVEY OF TRAFFIC ENGINEERS

Suggested Alternative Design



Traffic Control Devices

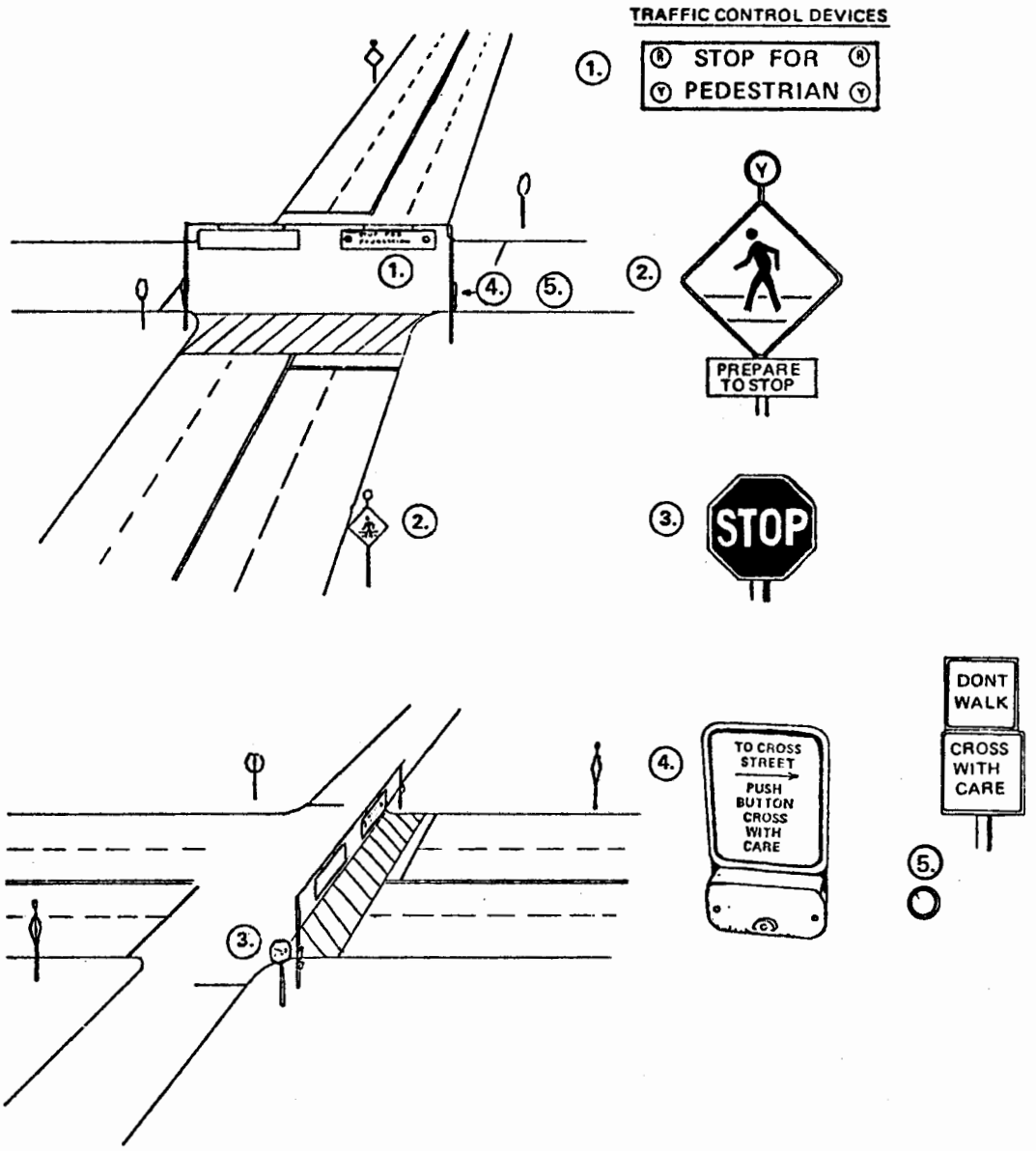


*GREEN OMITTED

OPERATION

APPROACH	DWELL	PED. ACT.		
MAJOR	FY	Y	R	R
Advance Sign	DARK	FY	FY	FY
MINOR	FR	R	R	R
Pedestrian Signal	DW	DW	W	FDW

ALTERNATIVE 1



INTERESTED CITIES

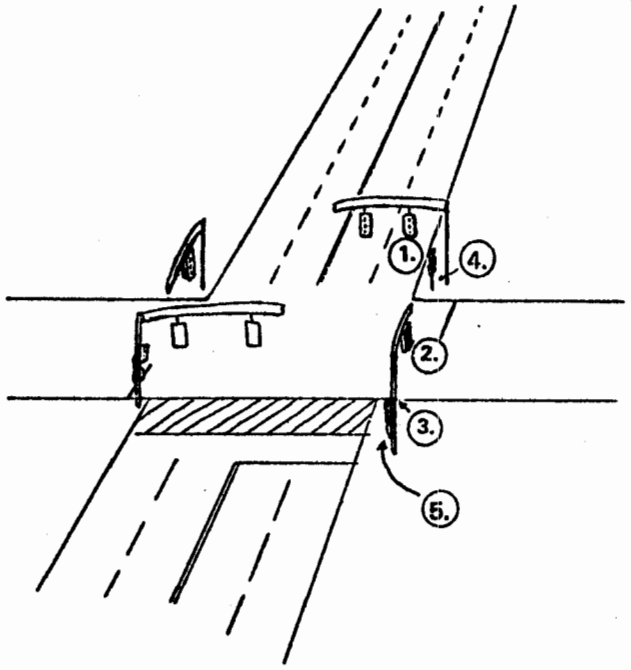
1.) SAN DIEGO, CALIFORNIA
2.) BUFFALO, NEW YORK
3.) MEMPHIS, TENNESSEE
4.) STATE OF GEORGIA

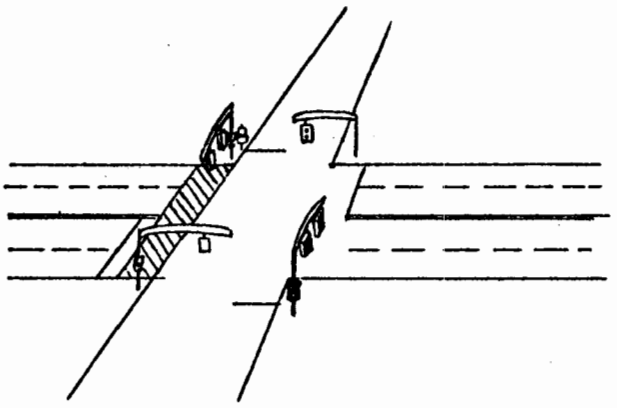
OPERATION

Approach	Dwell	Ped Act			
O.H. Sign	Dark	Y	FR	FR	FR
Advance sign	Dark	FY	FY	FY	FY
Ped Signal	DW	DW	DW	Cross with care	FDW

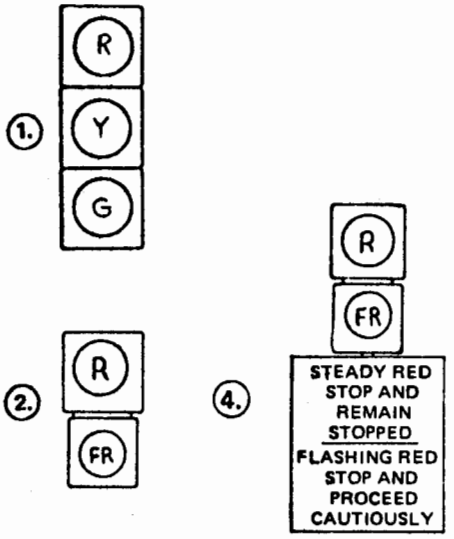
Figure 1

ALTERNATIVE 2





TRAFFIC CONTROL DEVICES



INTERESTED CITIES

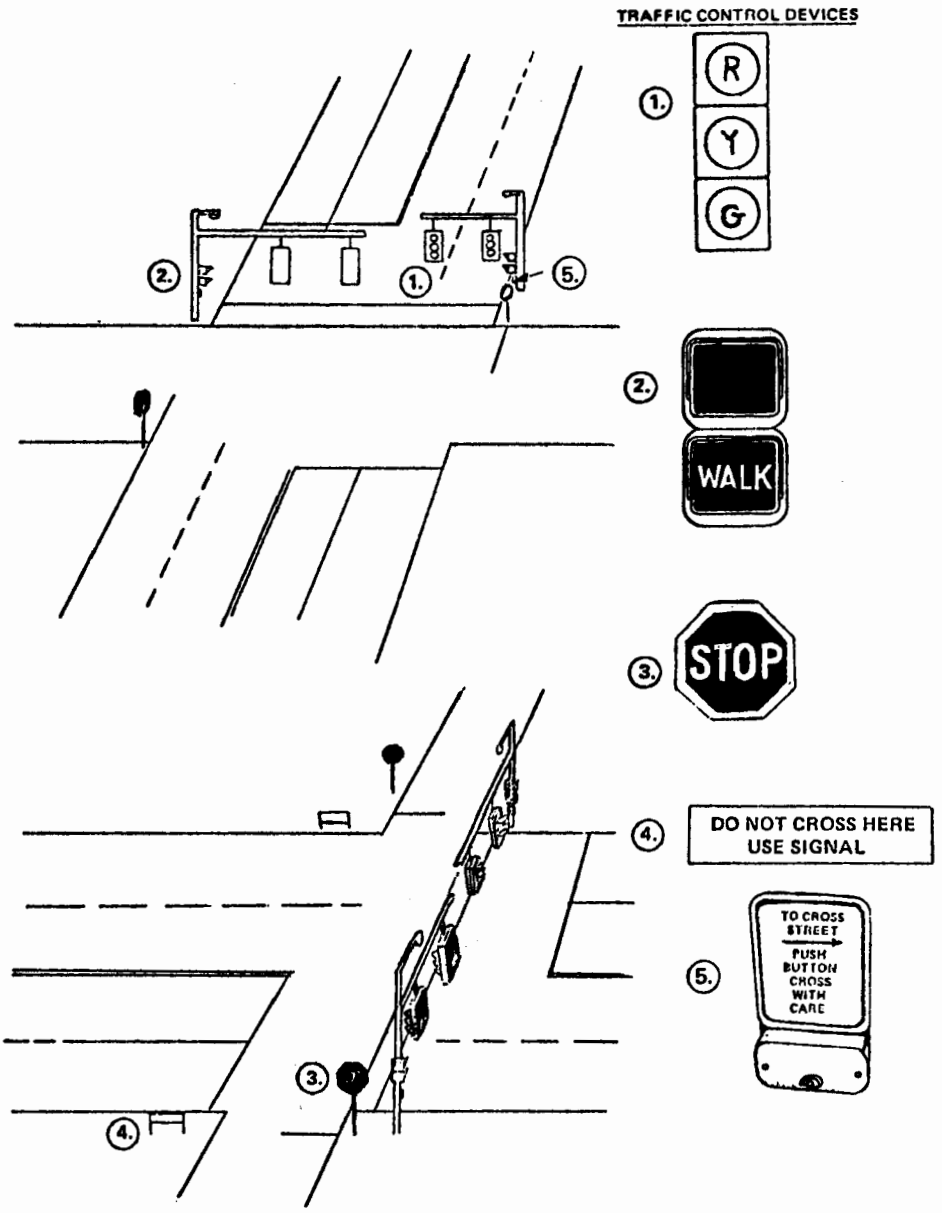
1.) MEMPHIS, TENNESSEE
2.) BUFFALO, NEW YORK

OPERATION

Approach	Dwell	Ped Act.			
Main	FY	G	Y	R	R
Minor	FR	R	R	R	R
Ped Signal	DW	DW	DW	W	FDW

Figure 2

ALTERNATIVE 3



INTERESTED CITIES

1.) KANSAS CITY, KANSAS
2.) SEATTLE , WASHINGTON
3.) SIOUX CITY, IOWA
4.) DELAND COUNTY, FLORIDA

OPERATION

Approach	Dwell	Ped Act		
Major	FG	Y	R	R
Minor	Stop Sign			
Ped Signal	DW	DW	W	FDW

Figure 3

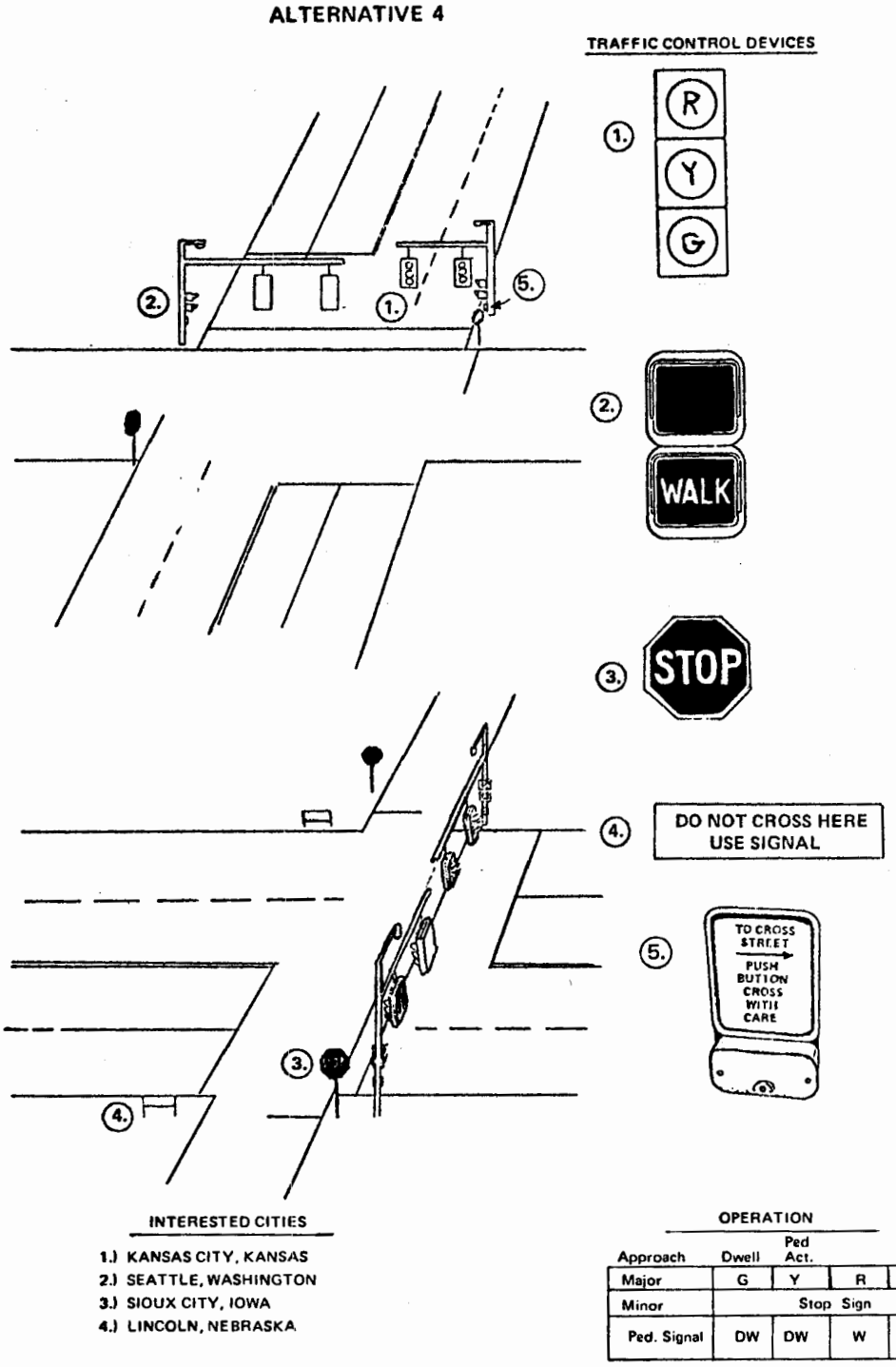
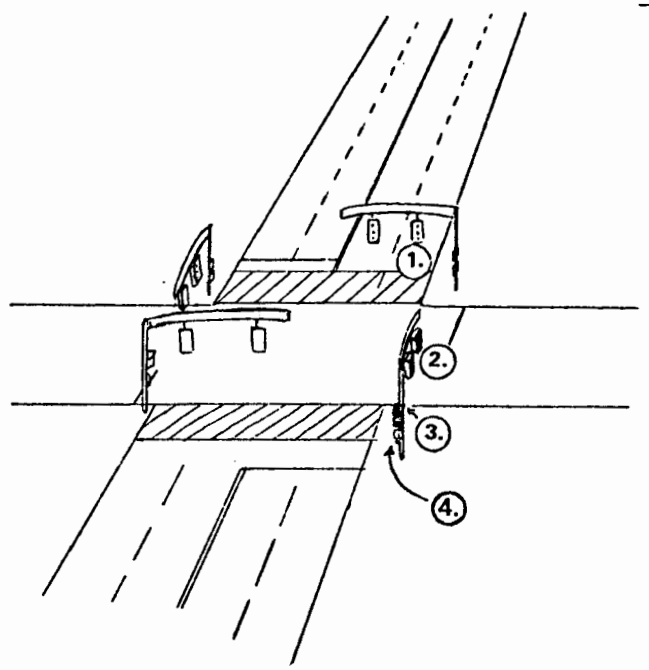
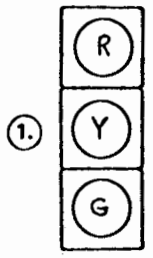

ALTERNATIVE 4
TRAFFIC CONTROL DEVICES
1.
R
Y
G
2.
WALK
3.
STOP
4.
DO NOT CROSS HERE
USE SIGNAL
5.
TO CROSS STREET
PUSH BUTTON
CROSS WITH CARE
INTERESTED CITIES
1.) KANSAS CITY, KANSAS
2.) SEATTLE, WASHINGTON
3.) SIOUX CITY, IOWA
4.) LINCOLN, NEBRASKA
OPERATION
Approach
Dwell
Ped Act.
Major
G
Y
R
R
Minor
Stop Sign
Ped. Signal
DW
DW
W
FDW

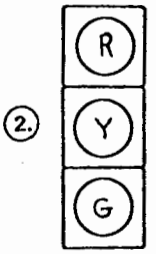
Figure 4

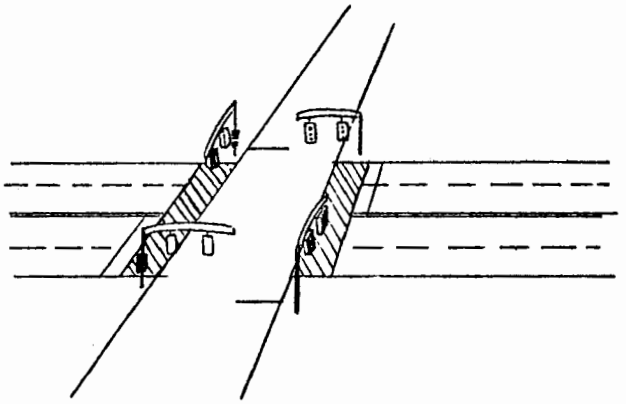
ALTERNATIVE 5



TRAFFIC CONTROL DEVICES







INTERESTED CITIES

1.) MEMPHIS, TENNESSEE
2.) BUFFALO, NEW YORK

OPERATION

Approach	Dwell	Ped. Act.				
Major	FY	G	Y	R	R	R
Minor	FR	R	R	G	G	Y
Ped. Signal	DW	DW	DW	W	FW	DW

Figure 5

APPENDIX B

DATA COLLECTION PROCEDURE

DATA COLLECTION PROCEDURES

Introduction

A time series, matched experiment – control site, experimental design was used to examine the safety and operational implications of different pedestrian crossing techniques at intersections of high volume major streets with low volume minor residential streets. In all cases the control site was a fully signalized; fully-actuated, semi-actuated, or pretimed controlled intersection with pedestrian signals. The experimental site was matched (paired) with the control site using the desired site criteria shown in Table B-1 as a guide.

Table B-1

Site Criteria

Alt.The following are the *desired* criteria for matching the experimental site to the control site.

- Two way-two way direction of flow
- Four leg, 90 degrees with no median islands or service roads
- Minimum of 4 lanes on the major arterial with 2 lanes on the minor residential
- Major street should be common to both the experimental and the control site
- An established school route must cross the major street
- Sidewalks on all approaches
- Must meet warrant 4, School Crossing (Section 4C-6, MUTCD-gap warrant) and *not* meet other warrants
- Major street speed limit should be between 30 and 50 mph
- Control site must be fully signalized with semi-actuated control and pedestrian signals
- The following are guidelines for desired traffic and pedestrian volumes.

	Major Street	Minor Street
Traffic: (one drirection)		
ADT	4,500–10,000	250–600
AM Peak Hour	6–10% of ADT	8–13% of ADT
PM Peak Hour	9–12% of ADT	8–14% of ADT
Pedestrians:		
Peak	15–50 peds/hr	
Off Peak	0–10 peds/hr	

Variables to be Measured

Five types of variables were measured: compliance, behaviors and volumes for both pedestrians and vehicles; vehicular delay; and gaps in the major street vehicular traffic stream. In addition, a survey of driver understanding was taken during one of the three data collection periods and is described in Appendix H.

The following measures of effectiveness were observed during each data collection visit:

Vehicle Compliance (All Alternatives Except Crossing Guard)

(R) – Violation of the Red Signal Indication – the front wheels of the vehicle cross the stop lines when the traffic signal indication is red for the approach.

(RTR) – Violation of the Right Turn on Red Law – a vehicle fails to make a locked wheel stop prior to making a right turn through a red signal indication.

(Y) – Entering the Intersection on the Yellow Signal Indication – the front wheels of the vehicle cross the stop line when the traffic signal is amber for the approach.

Pedestrian Compliance (All Alternatives Except Crossing Guard)

(PB) – Push-Button – the number of times the traffic control device is actuated by the push-button. Also note the number of pedestrians crossing with each actuation.

(W) – Enters Intersection on the WALK signal – the pedestrian enters into the traffic lanes of the intersection when the pedestrian signal is displaying the WALK message.

(FDW) – Enters Intersection on the Flashing DONT WALK Signal – the pedestrian enters the traffic lanes of the intersection when the pedestrian signal is displaying the flashing DONT WALK message.

(DW) – Enters Intersection on the DONT WALK Signal – the pedestrian enters the traffic lanes of the intersection when the pedestrian signal is displaying the steady DONT WALK message.

(UM) – Unmarked Crosswalk – the pedestrian enters the traffic lanes of the intersection from a point where no traffic control devices are used to designate the crossing as a crosswalk.

Vehicle Compliance (Crossing Guard Alternative)

(DSFG) – Did Not Stop for Crossing Guard – a vehicle that disobeys a crossing guard's order to stop.

(DGO) – Disobeys a Guard Order – a vehicle that disobeys an order from a crossing guard to take a particular action.

Pedestrian Compliance (Crossing Guard Alternative)

(WWG) – Walked With the Crossing Guard – a pedestrian who crosses with the crossing guard.

(NWG) – Pedestrian Crossing but Not With Crossing Guard – a pedestrian who crosses the street at a location where the crossing guard is stationed, when on duty, but not with the crossing guard.

(GNT) – Pedestrian Crossing but Guard Not On Duty – a pedestrian who crosses the street at the location where the crossing guard is located but is not on duty at that time.

(UM) – Unmarked Crosswalk – the pedestrian enters the traffic lanes of the intersection from a point where no traffic control devices are used to designate the crossing as a crosswalk.

Vehicle Behaviors

(RE) – Rear End – a vehicle moving in a straight line suddenly decelerates causing the front end to dip and wheels to lock resulting in a squealing sound.

(AM) – Angle Conflict Between Two Cars on the Major Street – a conflict between two cars both traveling initially on the major street, both in the intersection, one in the path of the other causing one or both vehicles to change their speed or path suddenly.

(AS) – Angle Conflict Between Two Cars on the Minor Street – same as AM except both cars entered the intersection from the minor street.

(A) – Angle Conflict Between Two Cars, One Entering the Intersection from the Major Street and the Other Entering from the Side Street – same as AM except one car enters from the major street and the other from the minor street.

Pedestrian Behaviors

(B) – Backup Movement – momentary reversal in pedestrian direction of travel in the traffic lane or hesitation, in response to a vehicle in the traffic lane.

(TV) – Turning Vehicle – pedestrian in the path of the turning vehicle and 20 feet or less between the vehicle and the pedestrian.

(VH) – Pedestrian entering a traffic lane when a thru vehicle, unrestricted by a traffic control device, is approaching in that lane within half a block.

Method of Data Collection

Data was collected simultaneously for a two day period at the control and experimental sites. Data was collected at each site pair on three occasions approximately six to eight weeks apart. The field evaluation schedule is given in Figure B-2.

The two man data collection team was employed at each of the two sites. The following is a description of the duties of each team member:

- Team Leader – responsible for the conduct of all the data collection to include adherence to the schedule and the quality, accuracy, and completeness of the data. Collects one day of compliance and behavior data for pedestrians and vehicles and one day of delay and gap data.

Table B-2

Field Evaluation Schedule

City	Alternatives	Data Collection Periods #1	#2	#3
Lincoln	Sg-44 Flashing Green	9/27 - 10/1	11/15 - 11/19	1/17 - 1/21
Seattle	Sg-44 Flashing Green Crossing Guard	10/4 - 10/8	11/29 - 12/3	1/31 - 2/4
Buffalo	Special Sign	10/26 - 10/27	12/14 - 12/15	3/15 - 3/16
Atlanta	Special Sign	10/28 - 10/29	12/8 - 12/9	2/7 - 2/8
Sioux City	Flashing Yellow	11/3 - 11/5	1/5 - 1/7	2/9 - 2/10
Memphis	Crossing Guard Flashing Yellow	11/9 - 11/12	1/11 - 1/12 1/25 - 1/26	2/22 - 2/25

- Assistant Observer – collects vehicular and pedestrian volumes by 15-minute periods on one day. Assists the team leader with gap and delay studies on the second day.

The data collection schedule for one study site (control *or* experiment) in one city is shown in Table B-3.

Table B-3

Sample Data Collection Schedule

Day	Data	Time Period
1	a) Volume (traffic and pedestrian)	8:00 AM to 10:00 AM
	Compliance (traffic and pedestrian), and	11:00 AM to 1:00 PM
	Behavior (traffic and pedestrian)	2:00 PM to 5:00 PM
2	a) Vehicle Delay Study	8:00 AM to 9:00 AM
		11:00 AM to 12:00 PM
		2:00 PM to 3:00 PM
		3:30 PM to 4:30 PM
	b) Vehicle Gap Study	9:00 AM to 9:30 AM
		12:00 PM to 12:30 PM
		3:00 PM to 3:30 PM

Definitions

1. Pedestrian – an individual whose feet are in contact with the roadway during his entire crossing and who leaves the curb within 20 feet of the crosswalk being observed. Does not include bicyclists unless they dismount and walk their bicycles from curb to curb.
2. Traffic Lanes – the portion of the roadway for movement of vehicles, exclusive of parking lanes.
3. Vehicle – any motorized vehicle using the intersection approach. This category does not include bicycles.
4. Stopped Vehicle – a vehicle which comes to a locked wheel stop (no motion) one or more times on the intersection approach.

Instructions

1. Volume Study –
   a. Use "Traffic - Ped. Volumes" form.
   b. Record the city, date, day alternative street names, and legs (north, south, east, or west).
   c. Conduct study at 15-minute intervals recording on a single row of the form the number of observations of each of the variables.

d. For each leg record the number of vehicles on that leg by counting the movement (right turn, straight through, or left turn) of all vehicles at the intersection.

e. For each leg record the number of pedestrians crossing that leg.

f. Use one data form for each observation period (8-10 AM, 11-1 PM, 2-5 PM).

2. Behavior Study

a. Use "Ped, Vehicle Behaviors" form.

b. Record City, date, day, alternative, major street and legs.

c. Conduct study at 15-minute intervals.

d. For each leg record the pedestrian behaviors under 'Ped" and vehicle behaviors under "Veh" in the appropriate box.

e. Use one data form for each observation period.

3. Compliance Study

a. Use "Ped, Vehicle Compliance" form. For the crossing guard alternate use the modified form.

b. Record the city, date, day, alternative, major street, and minor street.

c. Conduct study at 15-minute intervals.

d. Record pedestrian and vehicle compliance by leg for the major street. For the minor street vehicle compliance is recordas as the sum for both legs.

e. Use one data form for each observation period.

4. Delay Study

The intersection delay study was conducted simultaneously with a percent stopping study as recommended in "A Technique for Measurement of Delay at Intersections," (W.R. Reilly, et al., A report by JHK & Associates, for FHWA, 1976). The point sample, stopped delay method was used with an interval between samples of 13 seconds and a 13 minute observation period.

The "Intersection Delay Study" data form is used to record the vehicle delay that occurs on a street (major or minor) for one leg during a 13 minute study period. Space is also provided to record the number of vehicles that do not stop ("not stopped") and do stop ("stopped") the sum being equal to the total approach volume during the 13 minute study period. The delay study was performed for each of the four legs, usually in the following sequence:

a. Major Street – north/south or east/west, then

b. Minor Street – east/west or north/south. Adjustments were made to the sequence at some sites to conduct the major street delay study during periods of maximum pedestrian activity. This was done to determine "maximum" major street vehicle delay under observed pedestrian usage of the alternative being tested.

5. Gap Study

The gap study is conducted to record all major street vehicle gaps at the pedestrian crossing that are equal to or larger than the minimum allowable gap time, G, where:

$$G = \frac{W}{3.5} + (N-1)\,2$$

G = adequate gap time in seconds

W = width in feet of the pavement to be crossed

N = numbers of rows of five children that cross when the children are allowed to cross the street.

Ref: Institute of Traffic Engineers, *Transportation and Traffic Engineering Handbook*, 1976, pp. 440-441.

The gap study using the "Gap Study" data form was conducted for a survey time period of 15 minutes *or* 15 minutes of major street green time at the fully signalized intersections. To minimize the effect on the traffic pattern, the study was normally conducted during the periods immediately before or after the crosswalk was in maximum use by the school children.

TRAFFIC – PED. VOLUMES

City_____

Date_____ Day _____

Alt_____

TIME (15 Min. periods)	MAJOR STREET _____								MINOR STREET _____							
	LEG _____				LEG _____				LEG _____				LEG _____			
	↵	↓	↳	PED	↵	↓	↳	PED	↵	↓	↳	PED	↵	↓	↳	PED

PED, VEHICLE BEHAVIORS

City_____

Date_____ Day_____

Alt_____

STREET NAME_____

TIME (15 Min. periods)	LEG_____							LEG_____						
	PED			VEH				PED			VEH			
	B	TV	VH	RE	AM	AS	A	B	TV	VH	RE	AM	AS	A

PED, VEHICLE COMPLIANCE

City_____
Date_____ Day_____
Alt._____

	MAJOR STREET _____														MINOR STREET		
	LEG _____							LEG _____									
TIME	VEH.		PED.					VEH.		PED.					VEH.		
(15Min. periods)	R / RTR	Y	PB	W	FDW	DW	UM	R / RTR	Y	PB	W	FDW	DW	UM	R / RTR	Y	Violated Stop

PED, VEHICLE COMPLIANCE

City _____
Date _____ Day _____
Alt. _____

	MAJOR STREET _____														MINOR STREET		
	LEG _____							LEG _____									
TIME	VEH.		PED.					VEH.		PED.					VEH.		
(15Min. periods)	DSFG	DGO		WWG	NWG	GNT	UM	DSFG	DGO		WWG	NWG	GNT	UM	R	Y	Violated Stop

INTERSECTION DELAY STUDY

POINT SAMPLE, STOPPED DELAY METHOD

Intersection _____ Study Traffic On _____

City and State _____ Weather _____

Day, Date _____ Observer _____

#1 Time Period _____ #2 Time Period _____

Intersection Leg _____ (N, S, E, W) Intersection Leg _____ (N, S, E, W)

INTERVAL BETWEEN SAMPLES = 13 SECS.

#1 START											NOT STOPPED
										30	
											STOPPED
										60	
#2 START											NOT STOPPED
										30	
											STOPPED
										60	

COMMENTS: _____

#1		#2	
ST =	SD/V =	ST =	SD/V =
SD =	AD/V =	SD =	AD/V =
AD =	% S =	AD =	% S =
TV =		TV =	

GAP STUDY

Study date_____ Location _____ Crosswalk across_____

End of survey (to nearest minute)_____
Start of survey (to nearest minute)_____
Total survey time (minutes)_____

Number of rows. "N"_____
Roadway width. "W"_____ft.
Adequate gap time. "G"_____secs.

Gap Size (Seconds)	Number of Gaps			Multiply by Gap Size	Computations
	Measured	Estimated	Total		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
Other:					

APPENDIX C

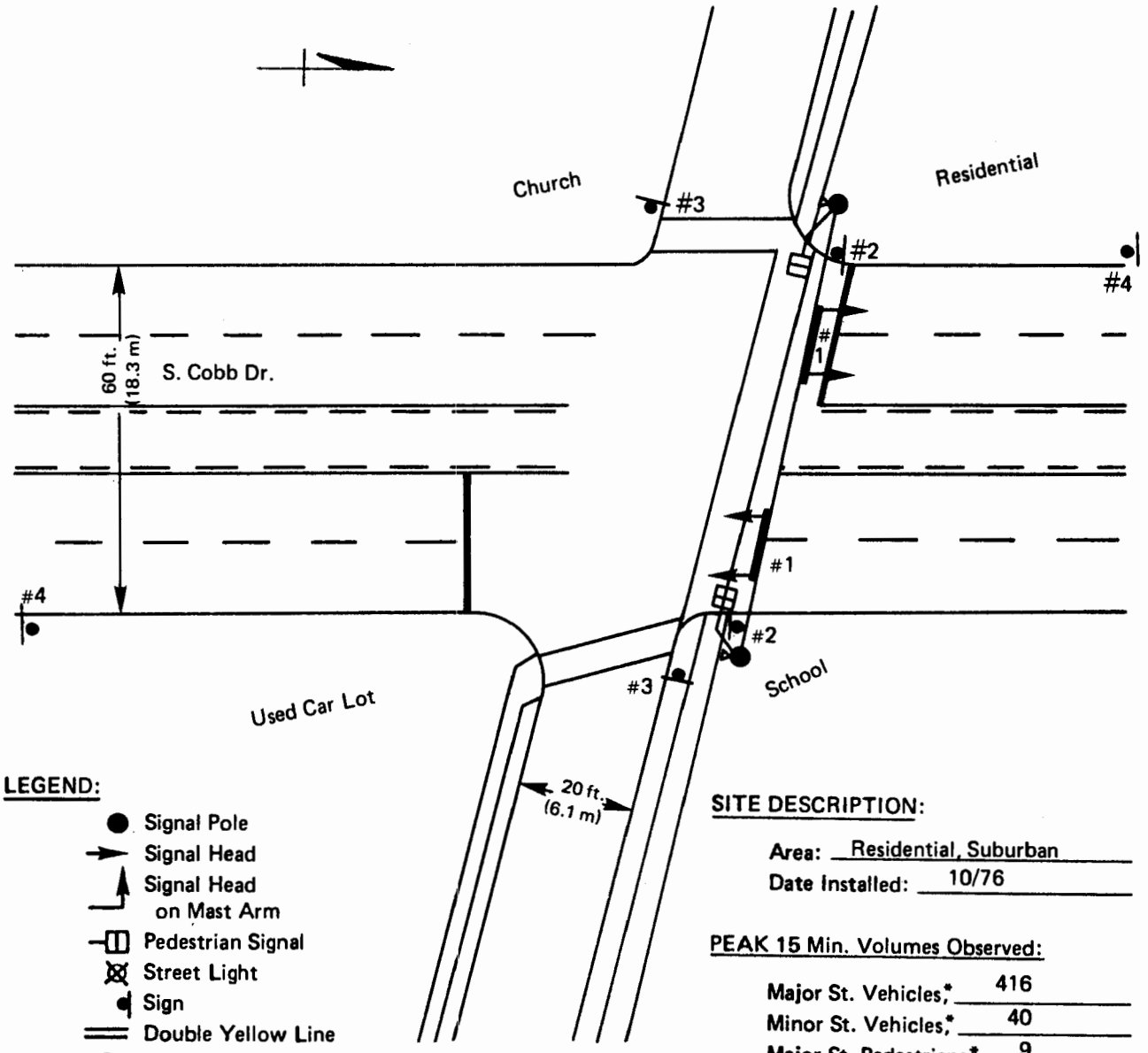
SITE DESCRIPTIONS

SITE DESCRIPTION

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign

SITE S. Cobb & Barber



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Suburban

Date Installed: 10/76

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 416

Minor St. Vehicles,* 40

Major St. Pedestrians,* 9

Remarks: Signs: #1 – Overhead "Stop for Pedestrians'
#2 – School X-Walk
#3 – Stop
#4 – Prepare to Stop

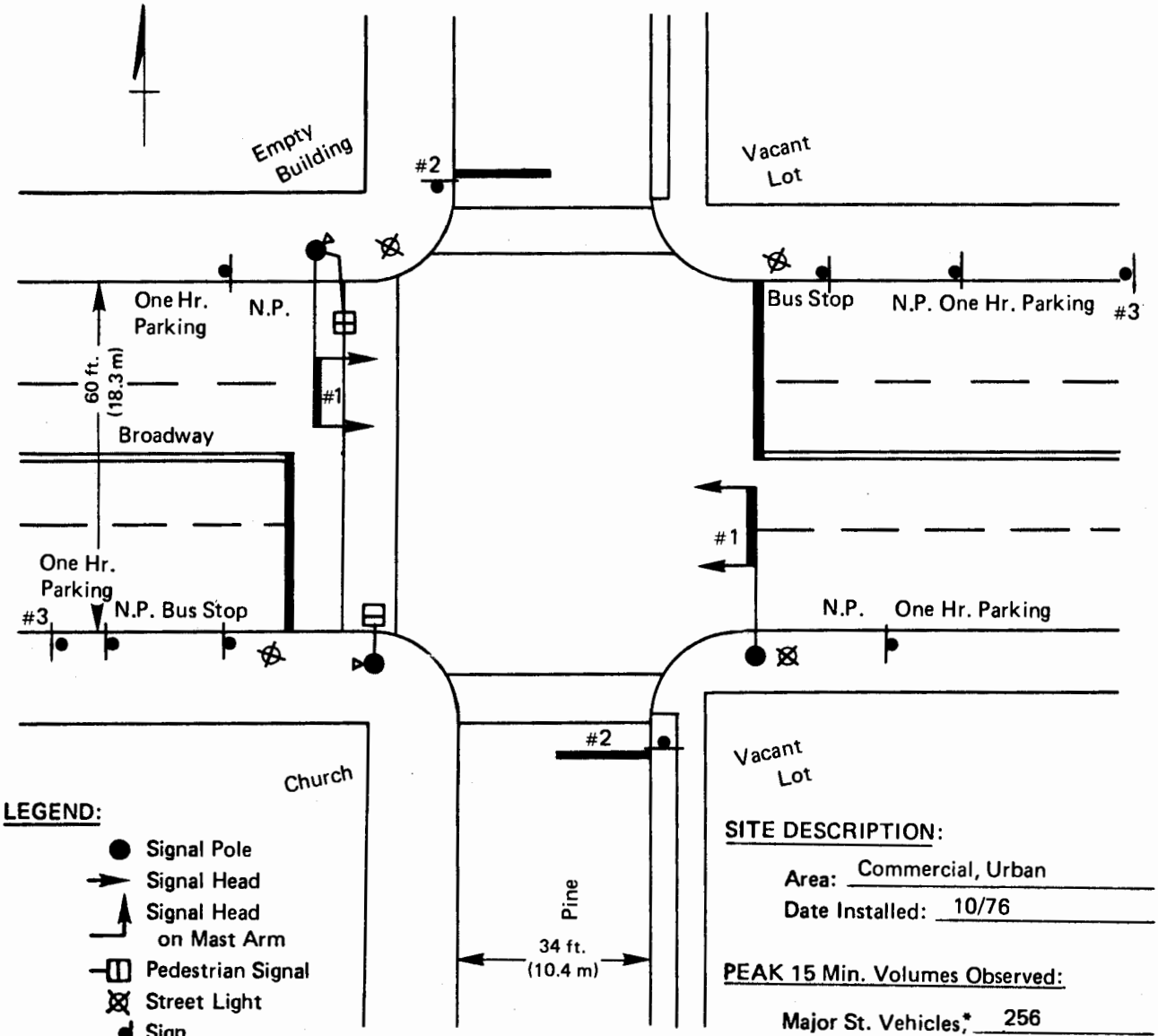
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign

SITE Broadway & Pine



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Commercial, Urban

Date Installed: 10/76

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 256

Minor St. Vehicles,* 43

Major St. Pedestrians,* 7

Remarks: Signs: #1 – Overhead "Stop for Pedestrians"
#2 – Stop
#3 – Prepare to Stop

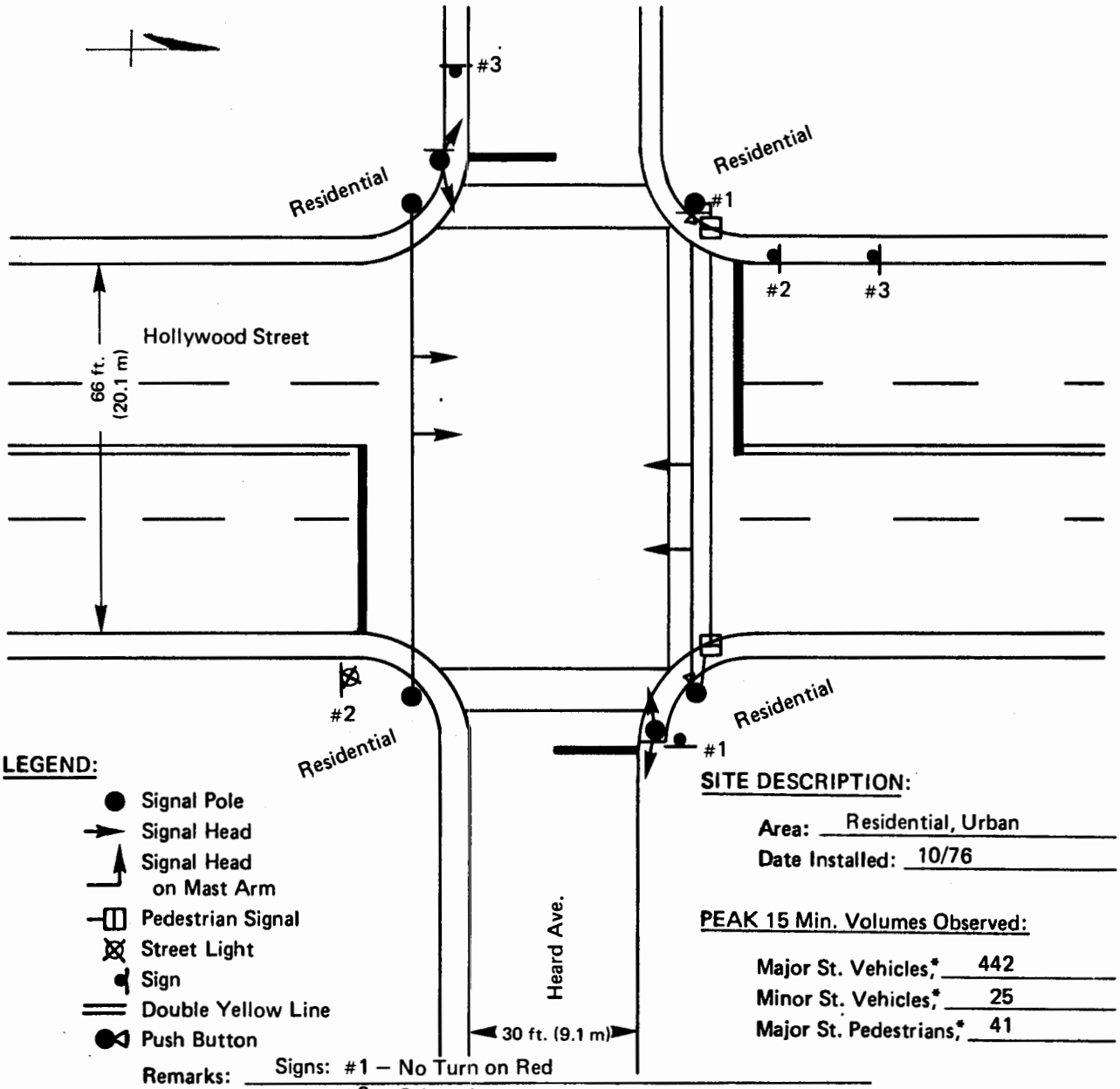
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Memphis

EXPERIMENT E-2, Flashing Yellow Signal & Flashing Red Beacon

SITE Hollywood & Heard



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 10/76

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 442

Minor St. Vehicles;* 25

Major St. Pedestrians;* 41

Remarks: Signs: #1 – No Turn on Red
#2 – School X-Walk
#3 – Bus Stop

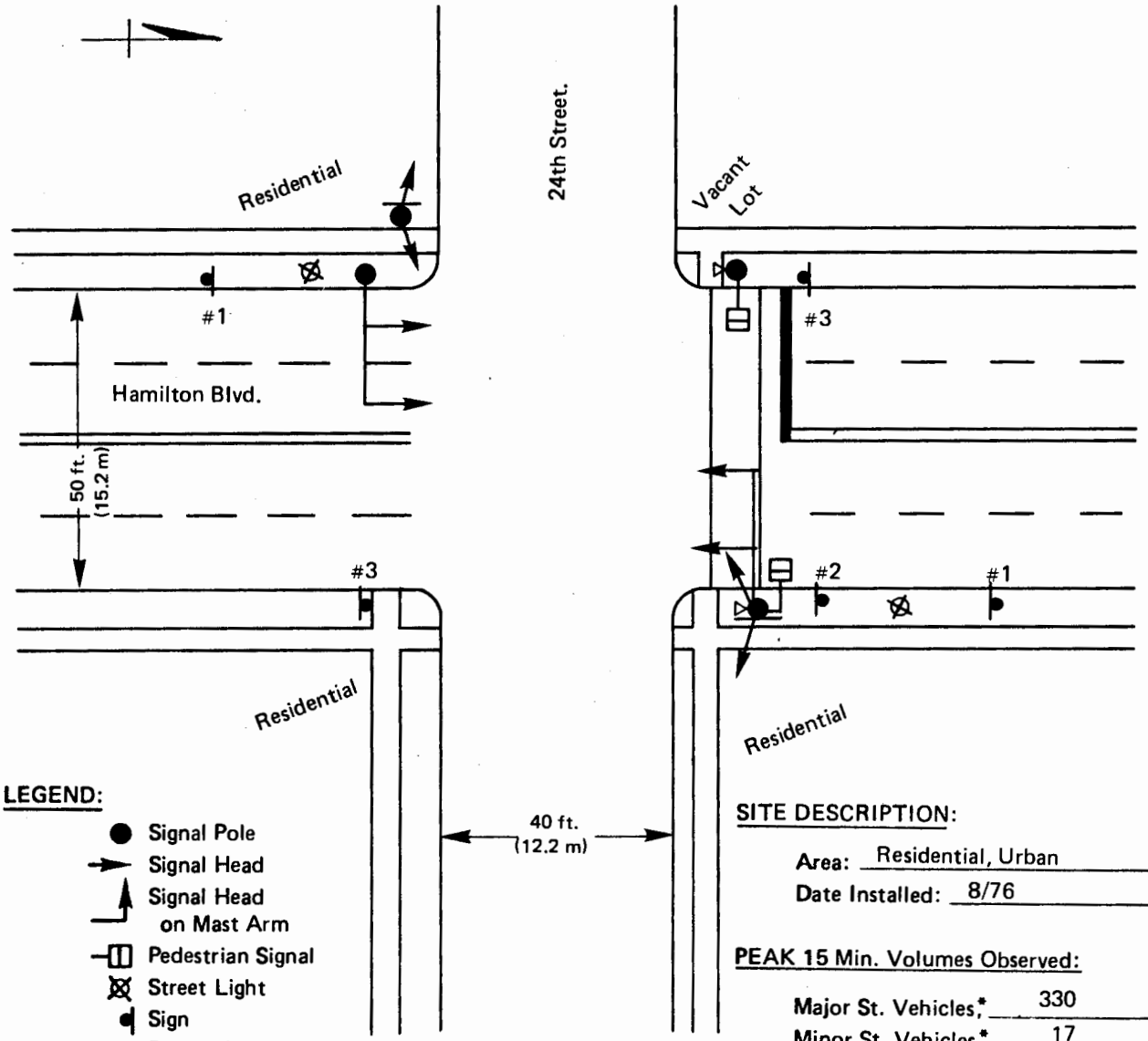
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Sioux City

EXPERIMENT E-2, Flashing Yellow Signal & Flashing Red Beacon

SITE Hamilton & 24th



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 8/76

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 330

Minor St. Vehicles,* 17

Major St. Pedestrians,* 20

Remarks: Signs: #1 – No Parking Anytime
#2 – Speed Limit 35
#3 – School X-Walk

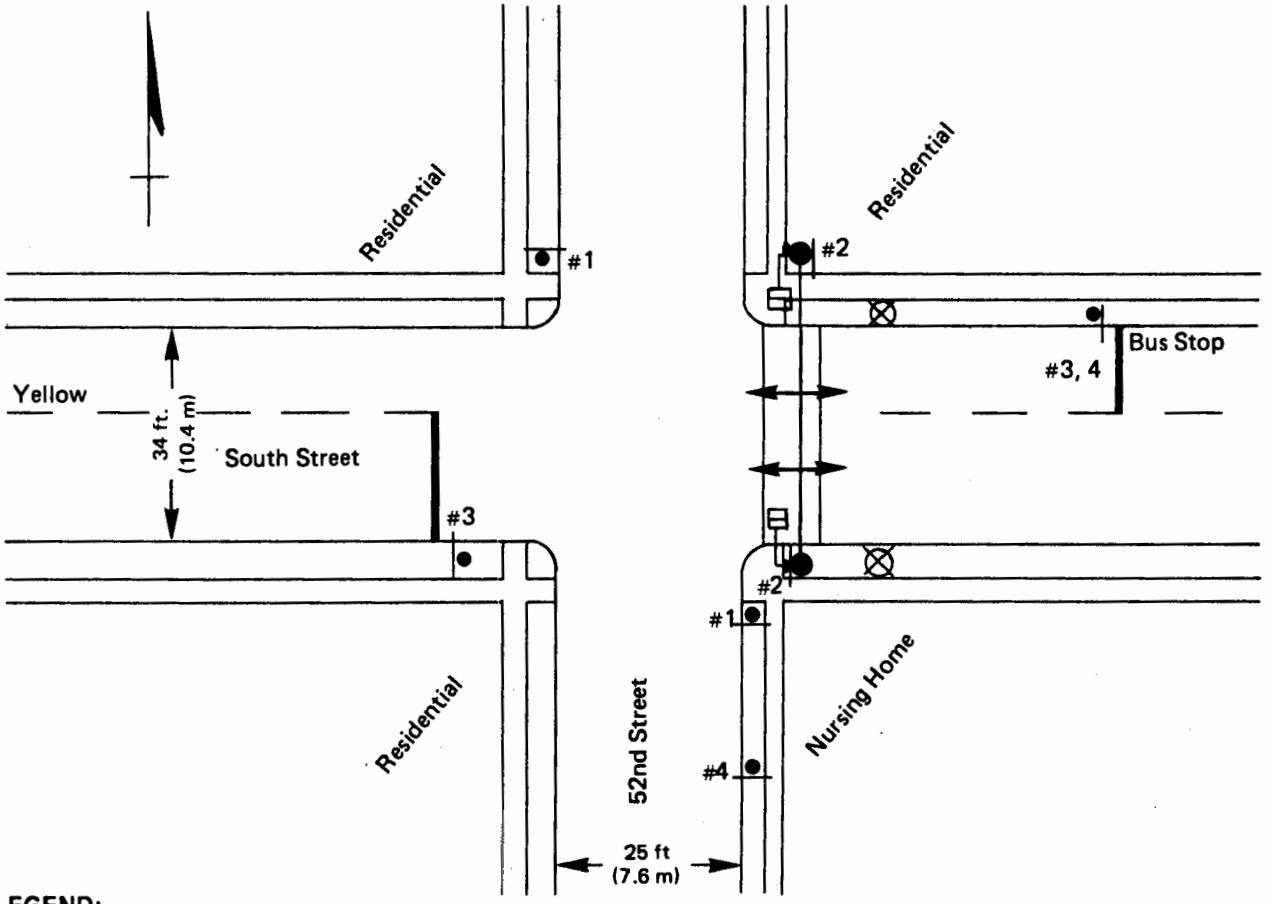
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Lincoln

EXPERIMENT E-3, Flashing Green Signal & Stop Sign

SITE South & 52nd



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

Remarks: Signs: #1 – Stop
#2 – School X-Walk
#3 – Stop Here on Red
#4 – No Parking

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 1965

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 208

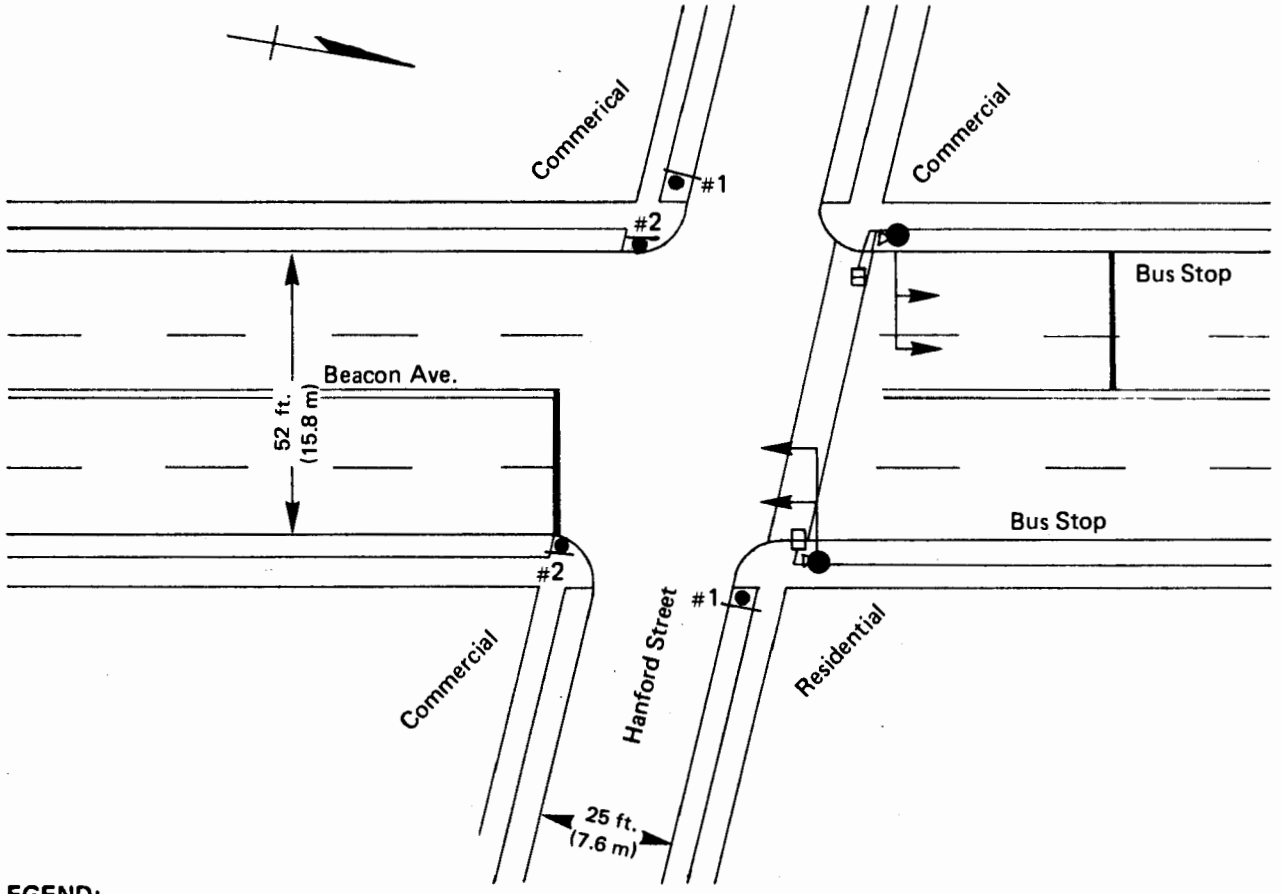
Minor St. Vehicles;* 26

Major St. Pedestrians;* 34

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Seattle
EXPERIMENT E-3, Flashing Green Signal & Stop Sign
SITE Beacon & Hanford



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Commercial, Urban
Date Installed: 8/71

PEAK 15 Min. Volumes Observed:

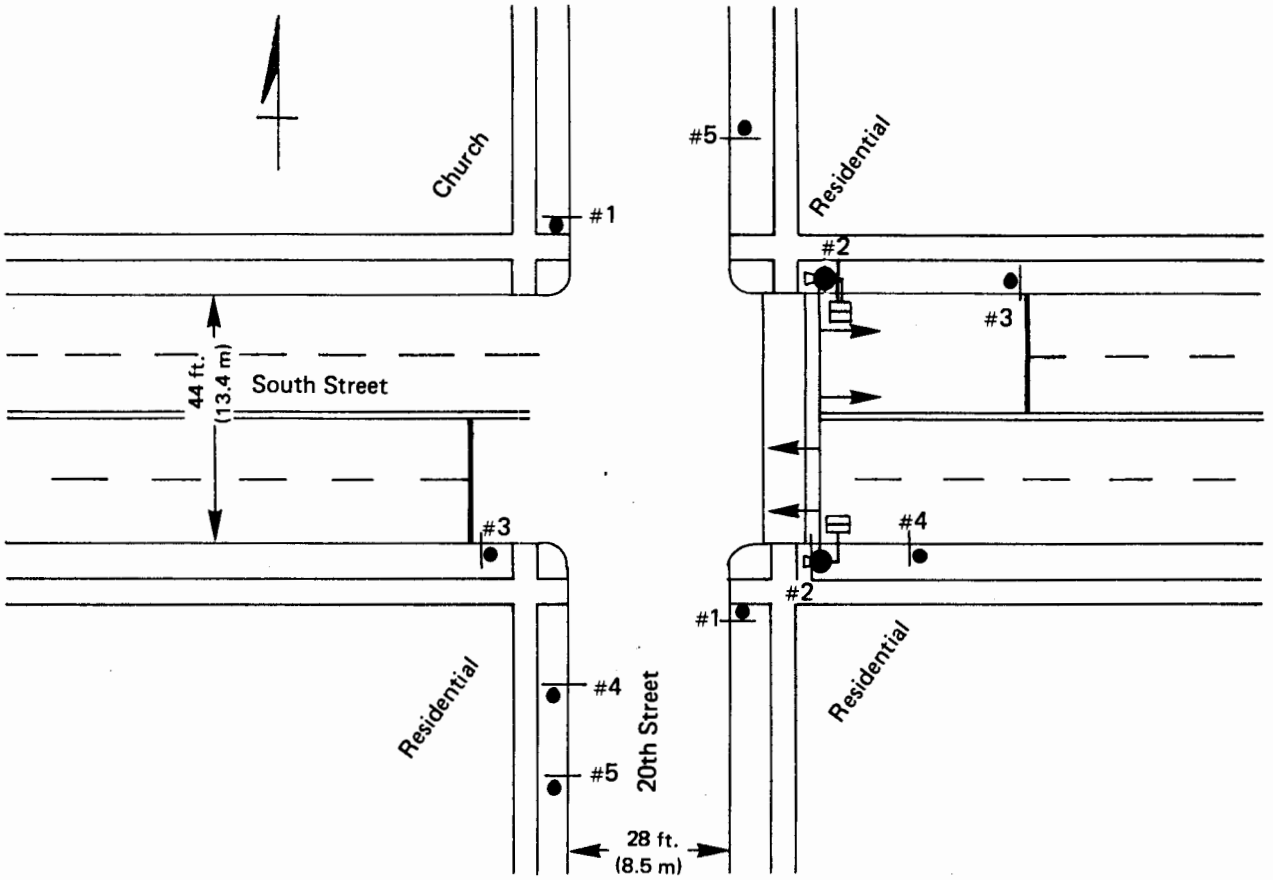
Major St. Vehicles,* 358
Minor St. Vehicles,* 15
Major St. Pedestrians,* 49

Remarks: Signs: #1 – Stop
#2 – Do Not Cross Here – Use Crosswalk

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Lincoln
EXPERIMENT E-4 (Sg-44) Signal & Stop Sign
SITE South & 20th



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban
Date Installed: 1965

PEAK 15 Min. Volumes Observed:

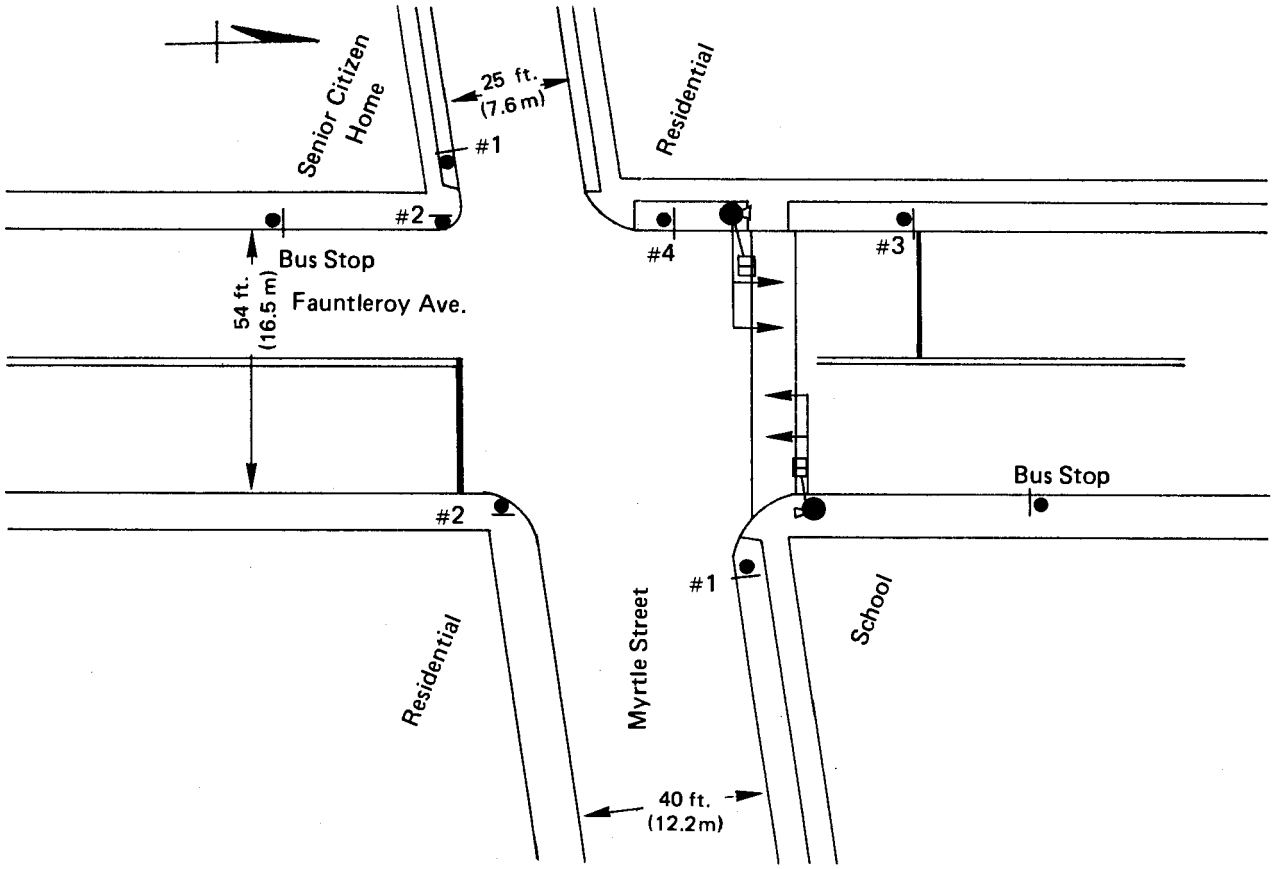
Major St. Vehicles,* 470
Minor St. Vehicles,* 33
Major St. Pedestrians,* 86

Remarks: Signs: #1 – Stop
#2 – School X-Walk
#3 – Stop Here on Red
#4 – No Parking
#5 – Bike Route

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Seattle
EXPERIMENT E-4, (Sg-44) Signal & Stop Sign
SITE Fauntleroy & Myrtle



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban
Date Installed: 8/71

PEAK 15 Min. Volumes Observed:

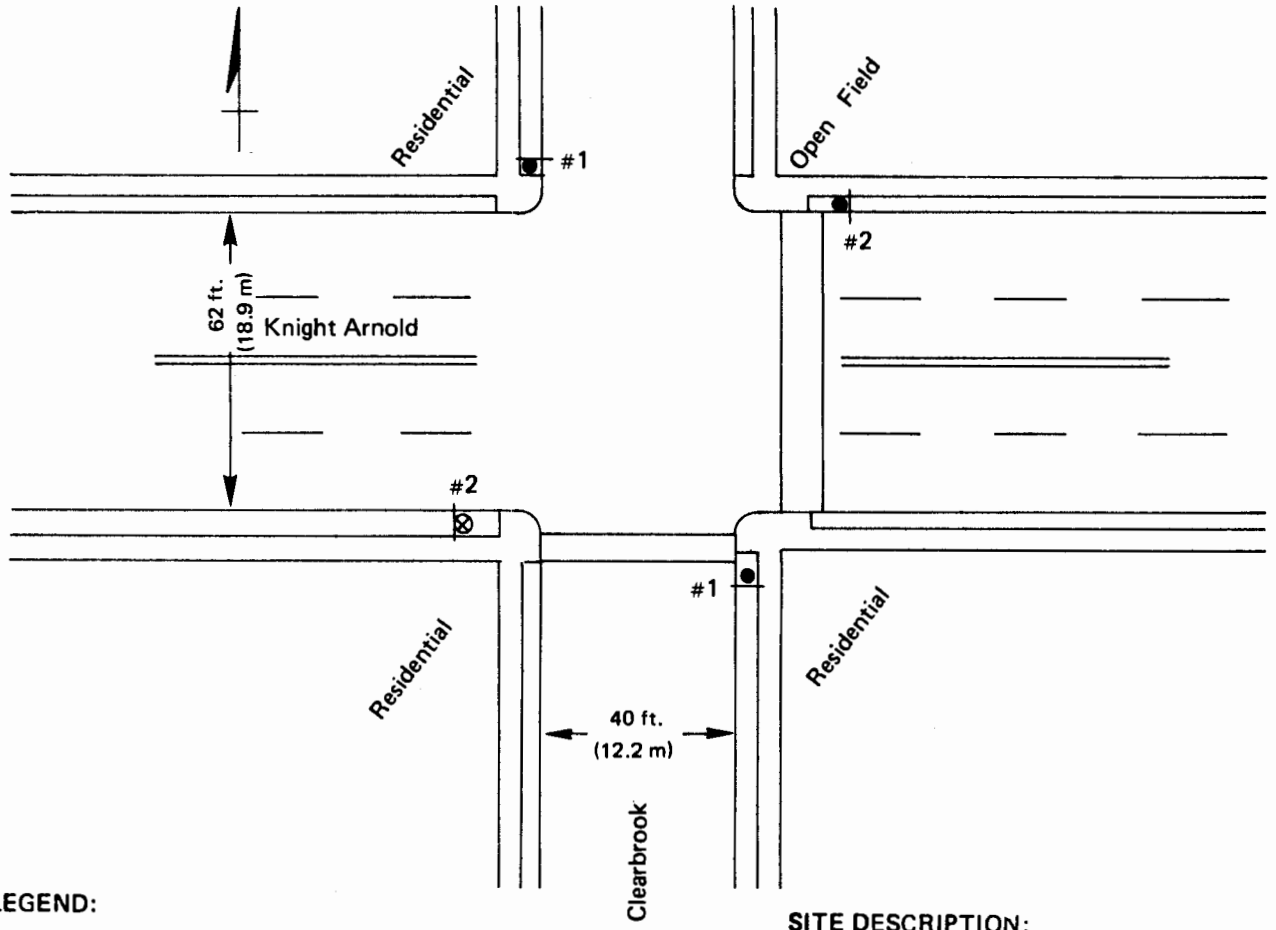
Major St. Vehicles;* 187
Minor St. Vehicles;* 16
Major St. Pedestrians;* 38

Remarks: Signs: #1 – Stop
#2 – Do not Cross Here – Use Crosswalk
#3 – No Parking South of Here
#4 – No Parking Anytime

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Memphis
EXPERIMENT E-5, Crossing Guard
SITE Knight Arnold & Clearbrook



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Suburban
Date Installed: 10/74

PEAK 15 Min. Volumes Observed:

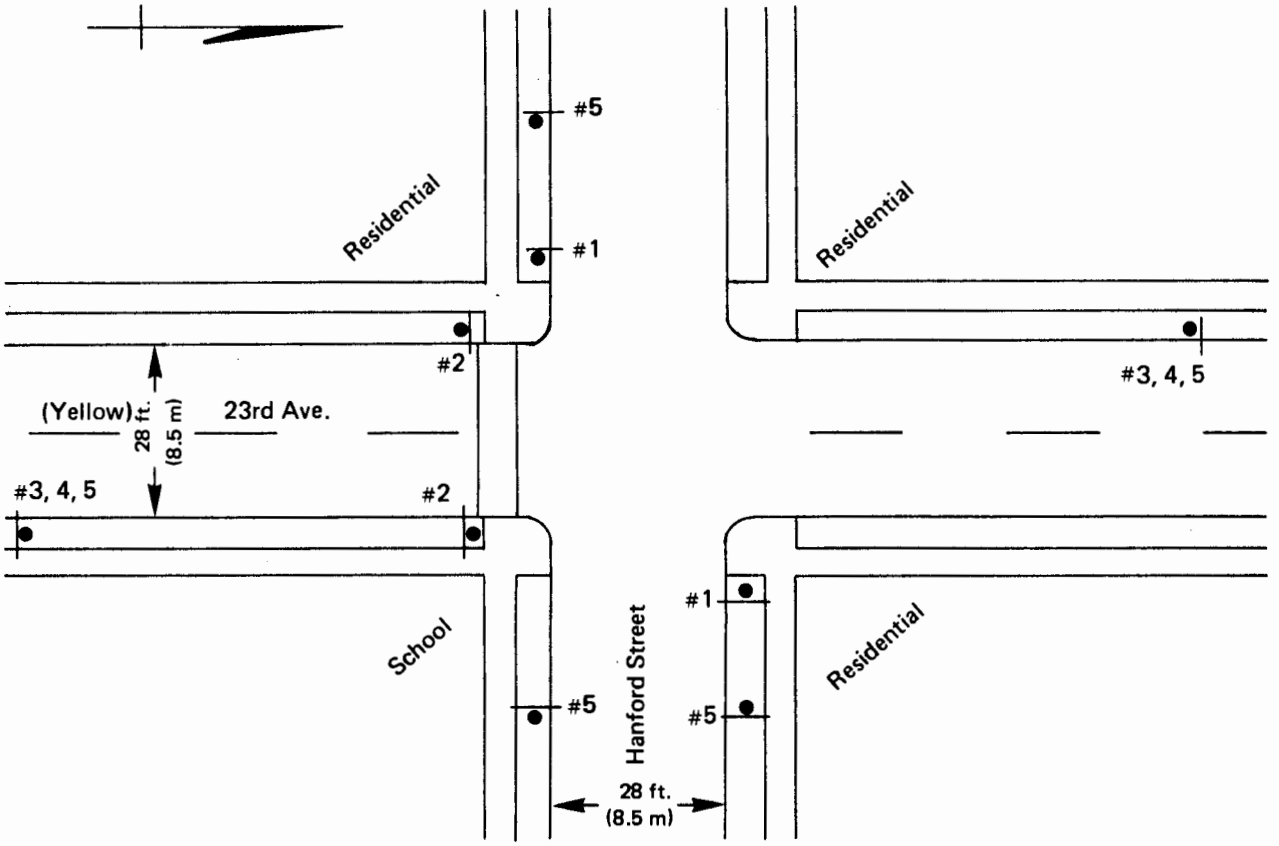
Major St. Vehicles;* 325
Minor St. Vehicles;* 50
Major St. Pedestrians;* 7

Remarks: Signs: #1 – Stop
#2 – School X-Walk

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Seattle
EXPERIMENT E-5, Crossing Guard
SITE 23rd & Hanford



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban
Date Installed: Not Available

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 260
Minor St. Vehicles,* 21
Major St. Pedestrians,* 128

Remarks: Signs: #1 – Stop
#2 – School X-Walk
#3 – School Crossing
#4 – Speed Limit 20
#5 – No Parking

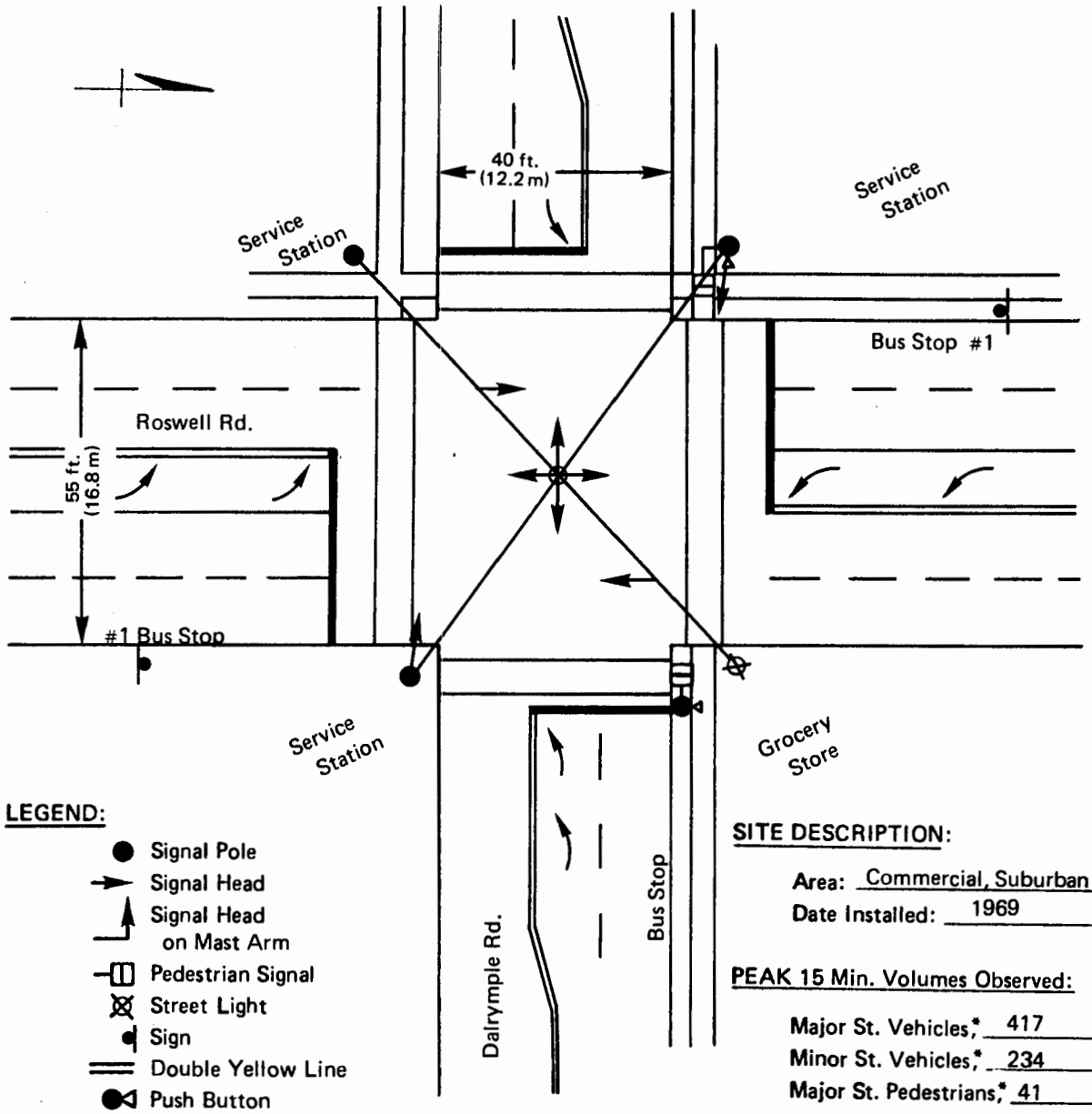
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Atlanta

EXPERIMENT C-1, Full Signalization (Semi-Actuated with Pedestrian Push-buttons)

SITE Roswell & Dalrymple



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Commercial, Suburban

Date Installed: 1969

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 417

Minor St. Vehicles,* 234

Major St. Pedestrians,* 41

Remarks: Signs: #1 – School X-Walk

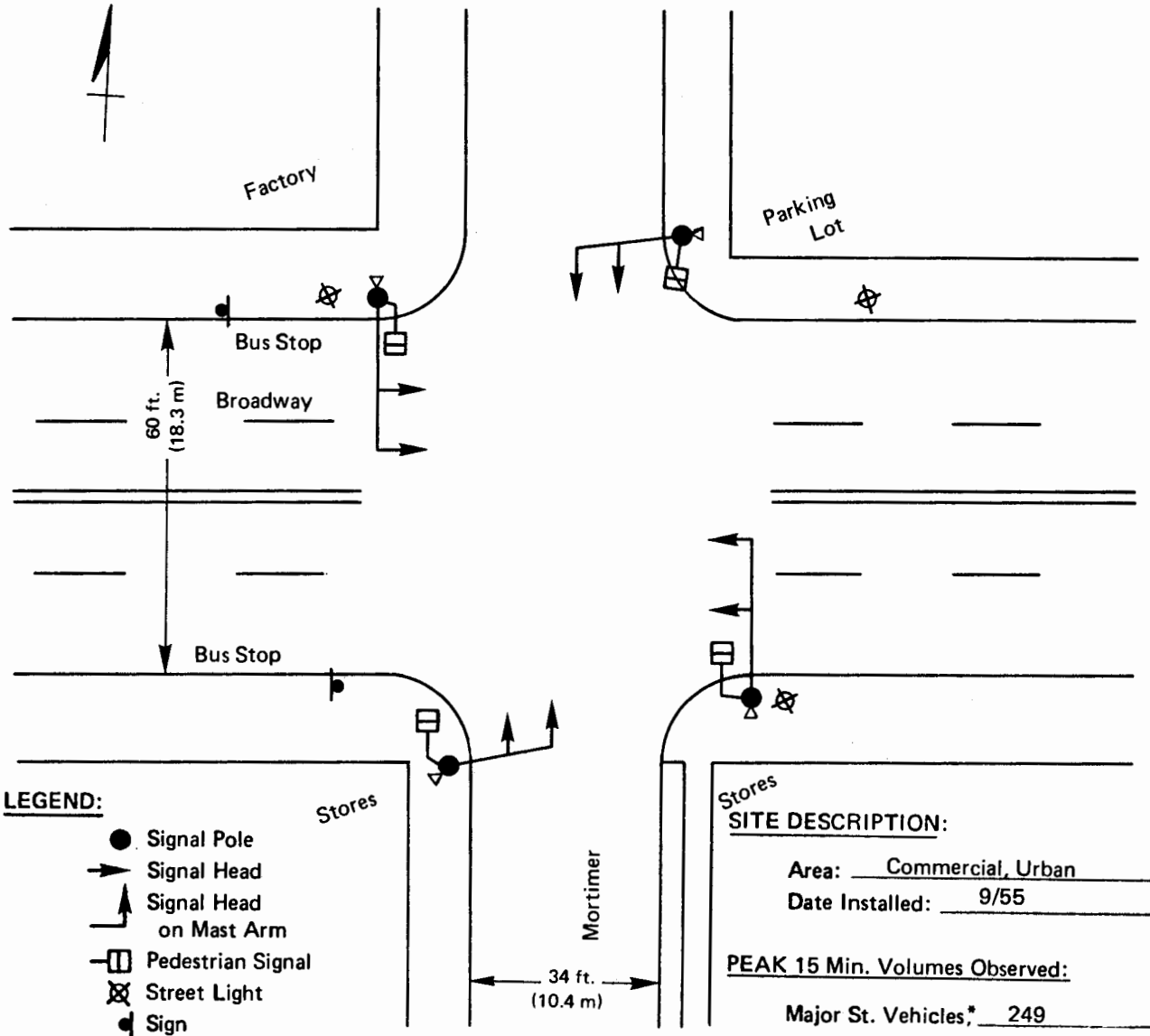
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Buffalo

EXPERIMENT C-1, Full Signalization (Semi-Actuated with Pedestrian Push-buttons)

SITE Broadway & Mortimer



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Commercial, Urban

Date Installed: 9/55

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 249

Minor St. Vehicles,* 65

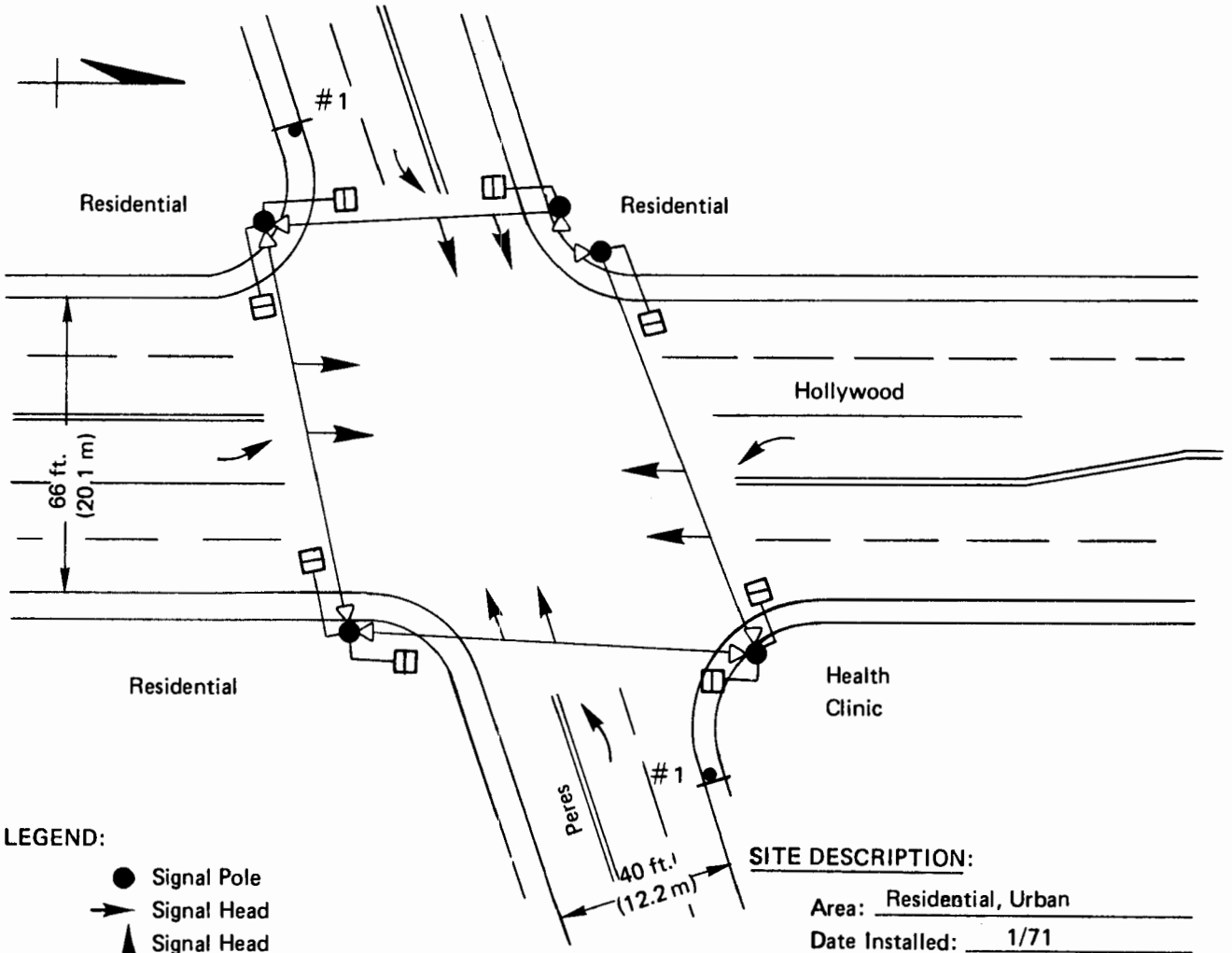
Major St. Pedestrians,* 56

Remarks: Stop and X-Walk Lines Worn Away

*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Memphis
EXPERIMENT C-2, Full Signalization (Full-Act.)
SITE Hollywood & Peres



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

Remarks: No Stop or X-Walk Lines
Ped. Pushbuttons for All Four Legs
Signs: #1–No Parking Anytime

SITE DESCRIPTION:

Area: Residential, Urban
Date Installed: 1/71

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 362
Minor St. Vehicles;* 133
Major St. Pedestrians;* 5

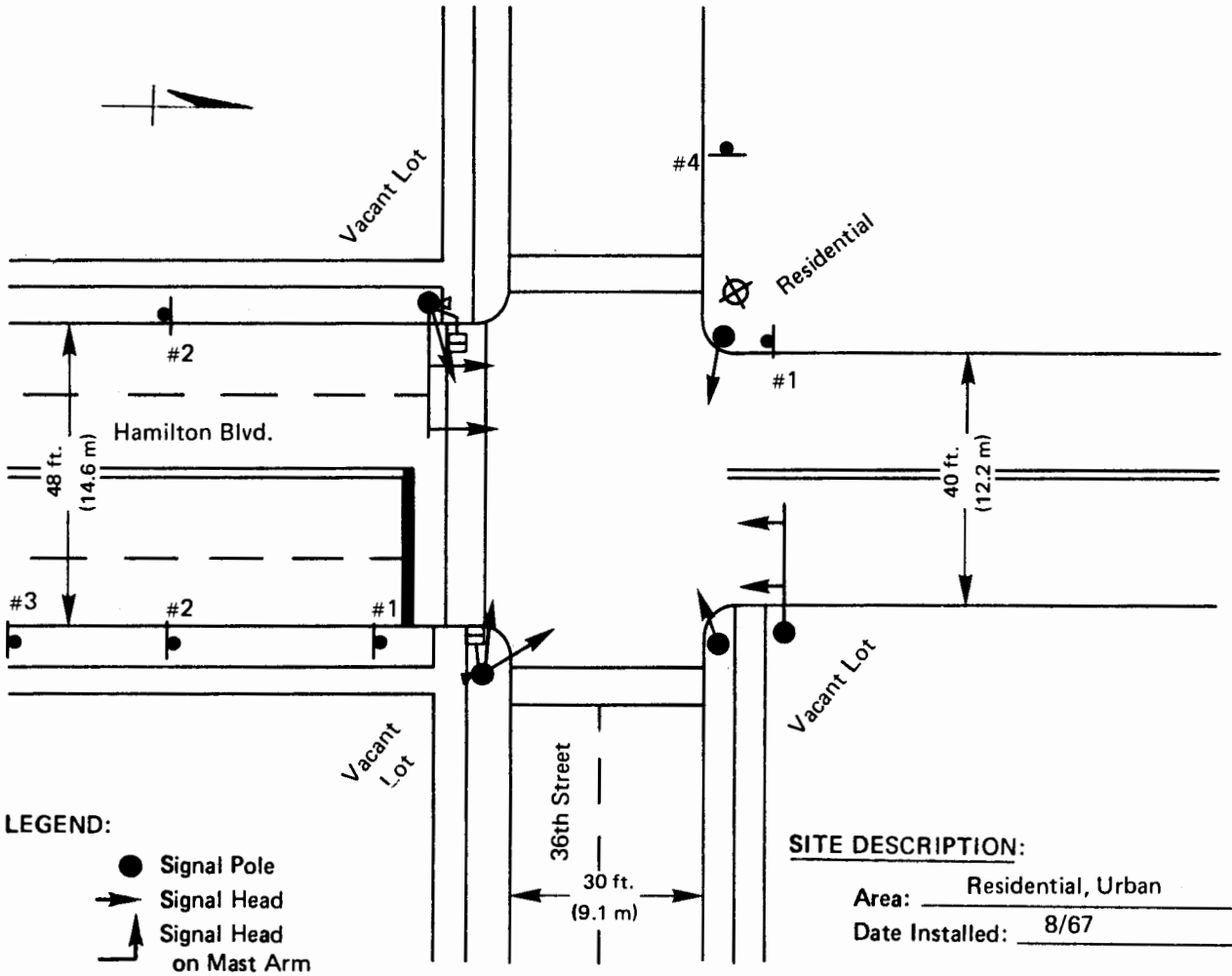
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Sioux City

EXPERIMENT C-2, Full Signalization (Semi-Actuated and Pedestrian Push Buttons)

SITE Hamilton & 36th



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 8/67

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 167

Minor St. Vehicles;* 118

Major St. Pedestrians;* 60

Remarks: Sign: #1 – School X-Walk
#2 – Speed Limit 35
#3 – No Parking
#4 – Speed Limit 25

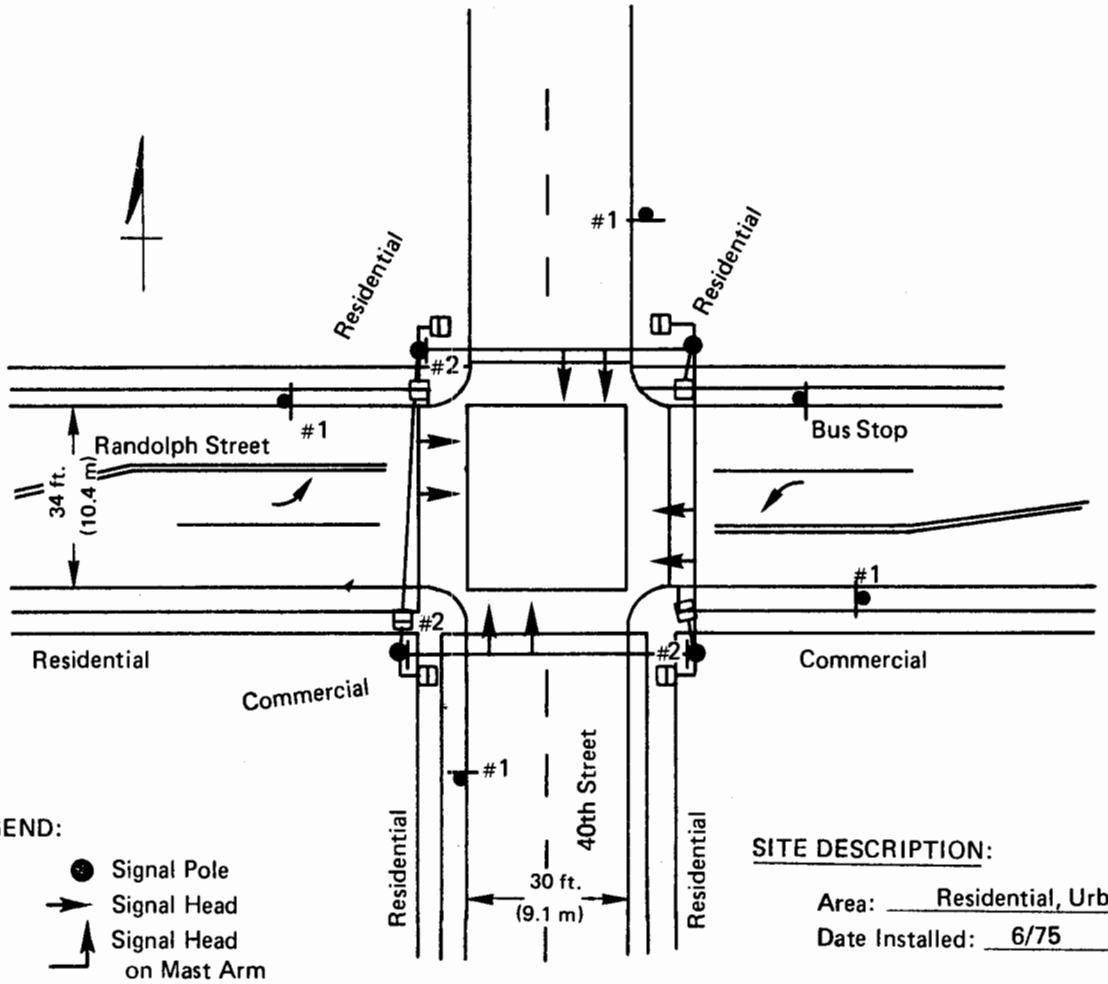
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Lincoln

EXPERIMENT C-3, Full Signalization (Pre-Timed)

SITE Randolph & 40th



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 6/75

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 175

Minor St. Vehicles,* 89

Major St. Pedestrians,* 9

Remarks: No Push Buttons for Pedestrians

Signs: #1 – Speed Limit 35, No Parking

#2 – Right Turn on Red After Stop

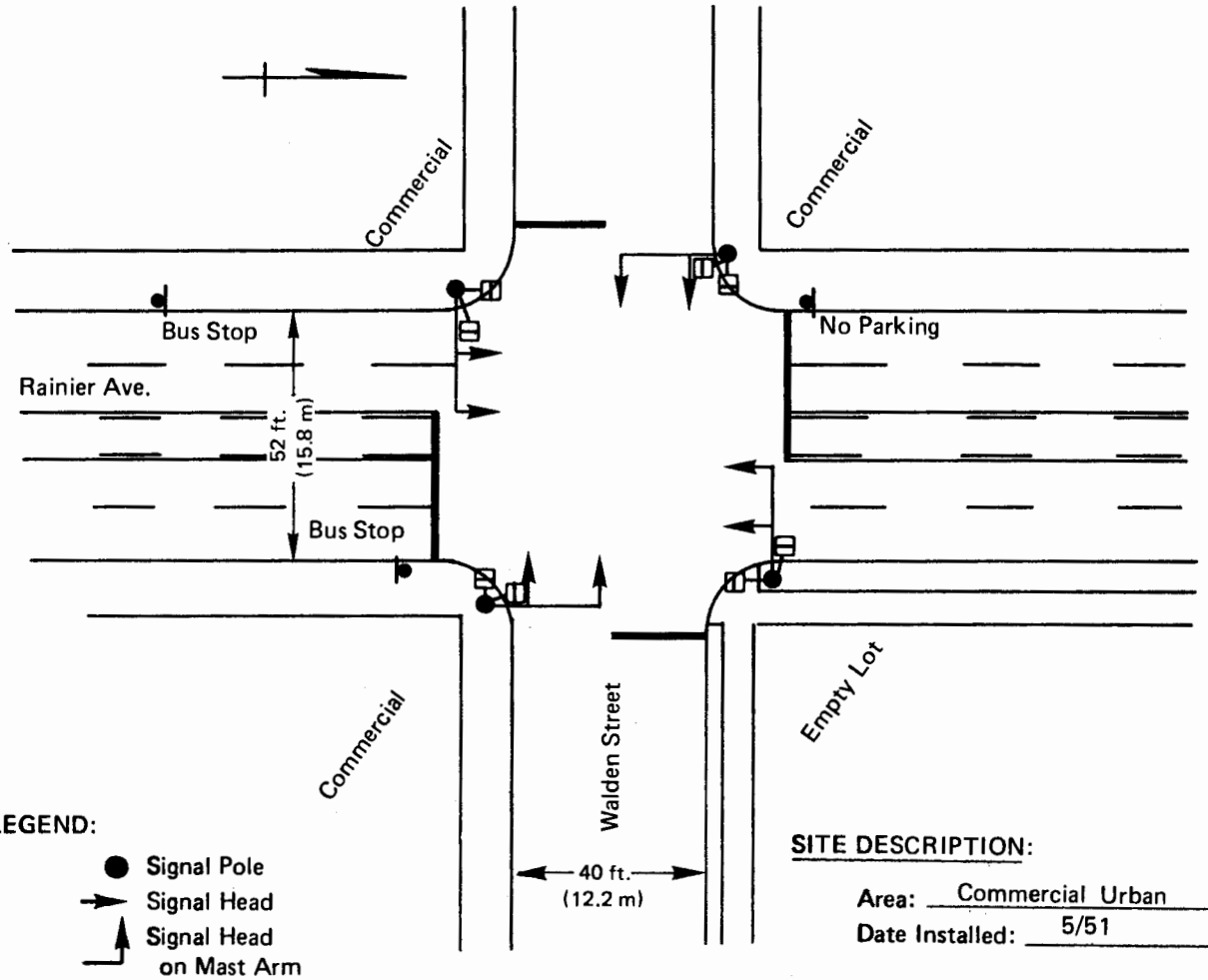
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Seattle

EXPERIMENT C-3, Full Signalization (Pre-Timed)

SITE Rainier & Walden



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

Remarks: No Ped. Push Buttons
No Crosswalk Markings

SITE DESCRIPTION:

Area: Commercial Urban

Date Installed: 5/51

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 456

Minor St. Vehicles,* 42

Major St. Pedestrians,* 23

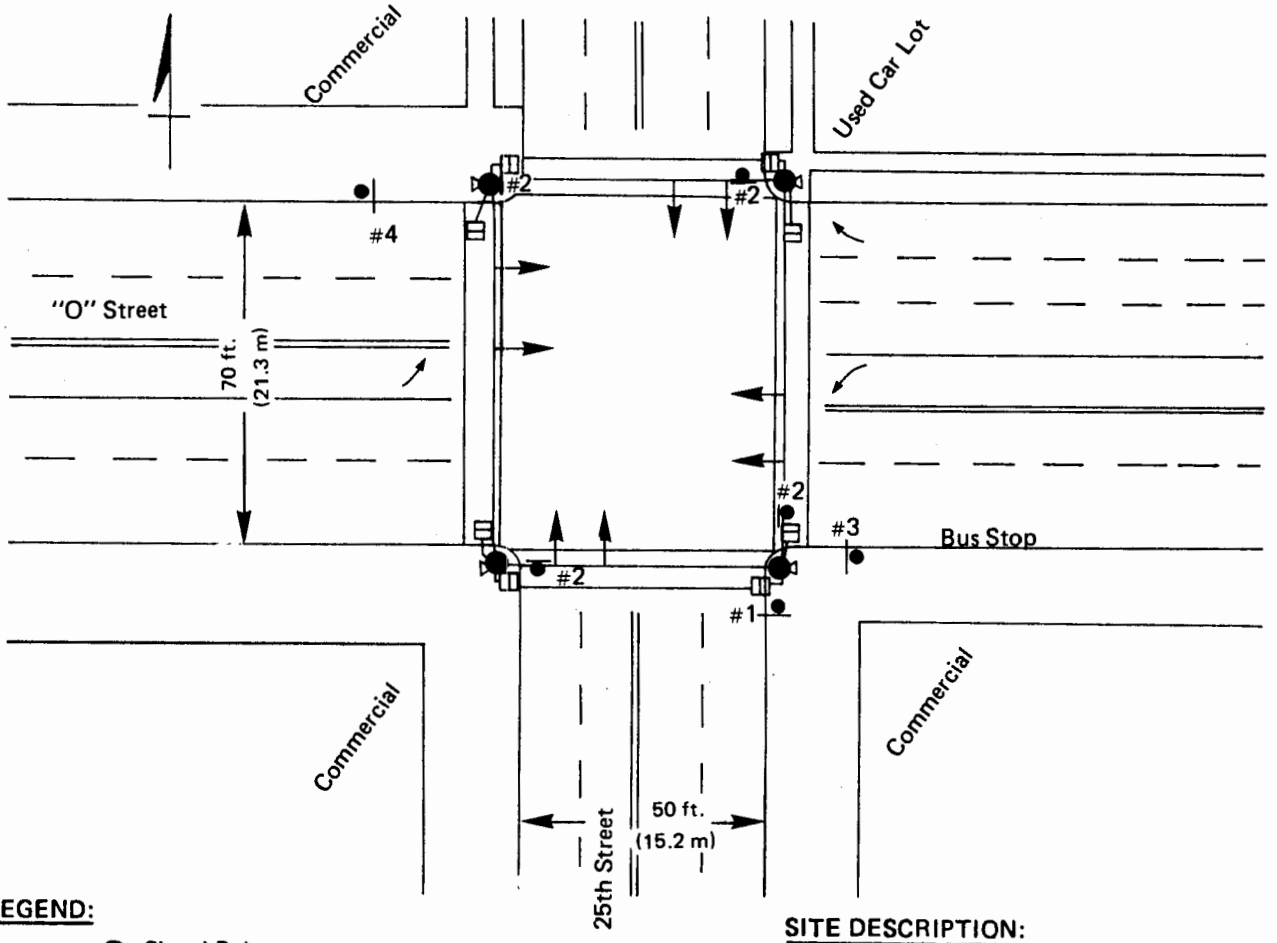
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Lincoln

EXPERIMENT C-4, Full Signalization (Semi-Actuated with Pedestrian Push-Button)

SITE "O" & 25th



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Commercial, Urban

Date Installed: 1967

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 474

Minor St. Vehicles;* 62

Major St. Pedestrians;* 33

Remarks: Ped. Push Buttons for Major Street Only

Signs: #1 – Right Lane Must Turn Right

#2 – Right Turn On Red After Stop

#3 – No Parking Anytime

#4 – 2 Hr. Parking

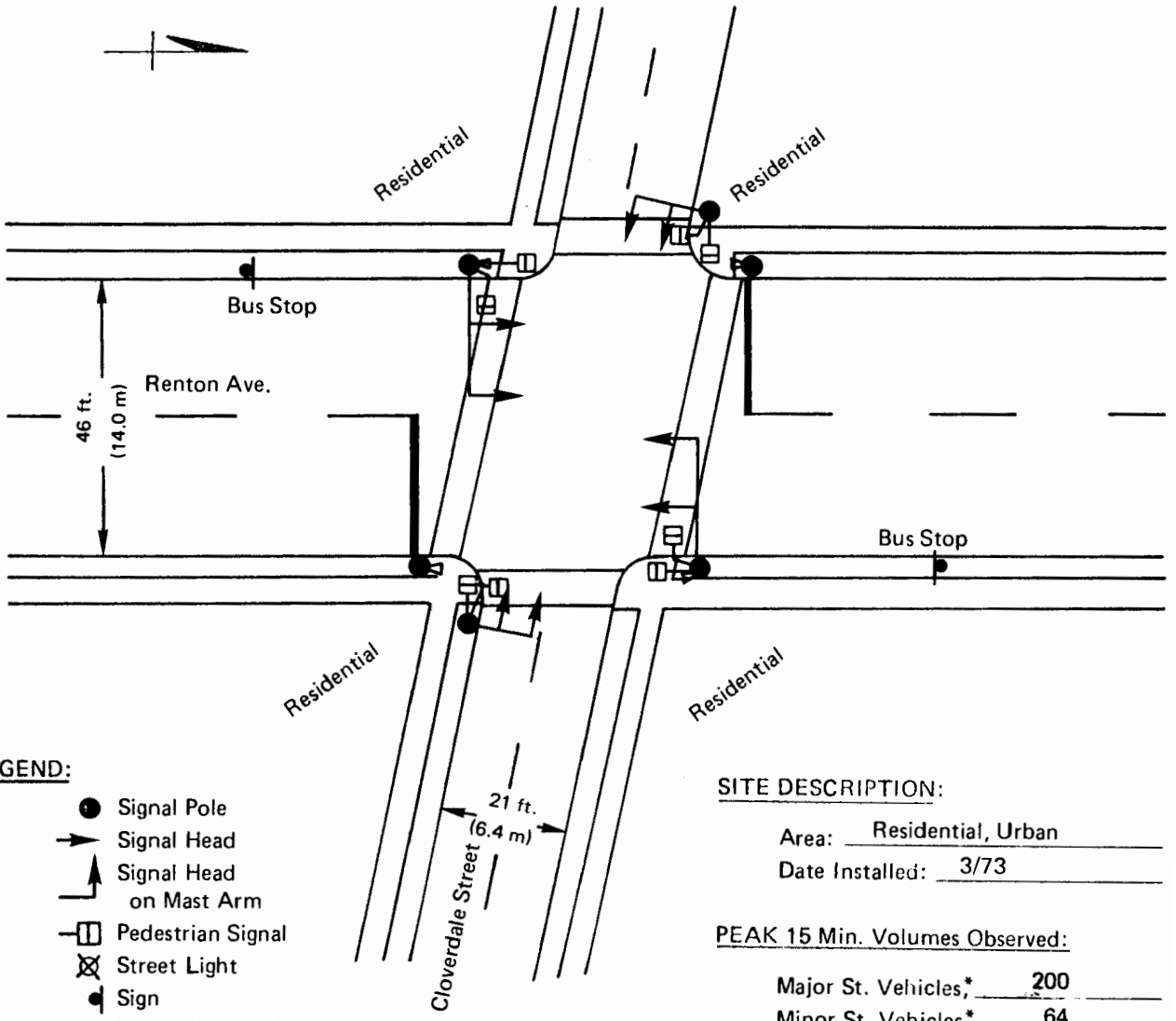
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Seattle

EXPERIMENT C-4, 5, Full Signalization (Semi-Actuated with Pedestrian Push-Buttons)

SITE Renton & Cloverdale



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Urban

Date Installed: 3/73

PEAK 15 Min. Volumes Observed:

Major St. Vehicles,* 200

Minor St. Vehicles,* 64

Major St. Pedestrians,* 34

Remarks: Ped. Push Buttons for Major Street Only

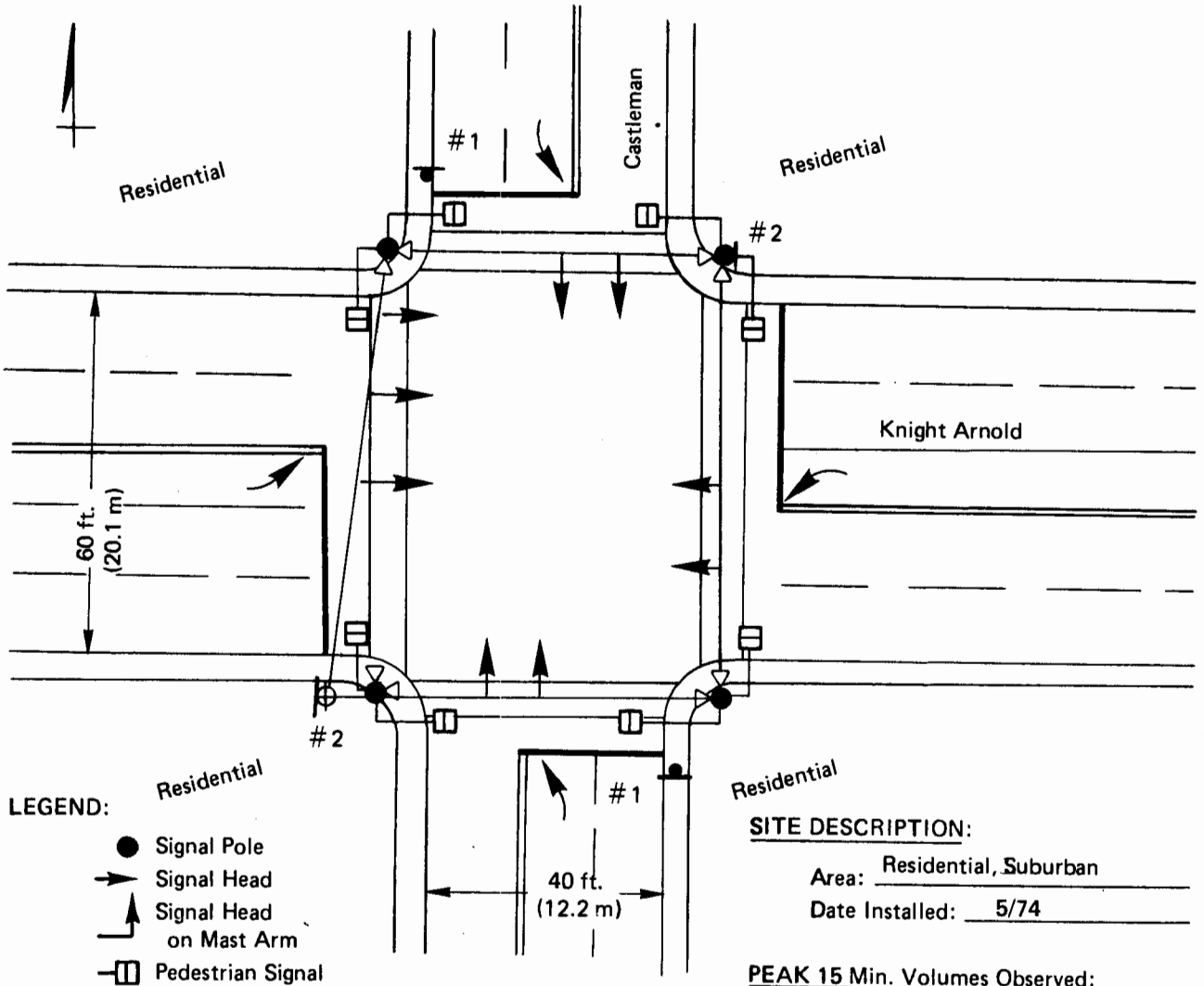
*See Appendix D. Pedestrian and Vehicle Volumes.

SITE DESCRIPTION

CITY Memphis

EXPERIMENT C-5, Full Signalization (Full-Act.)

SITE Knight Arnold & Castleman



LEGEND:

- Signal Pole
- Signal Head
- Signal Head on Mast Arm
- Pedestrian Signal
- Street Light
- Sign
- Double Yellow Line
- Push Button

SITE DESCRIPTION:

Area: Residential, Suburban

Date Installed: 5/74

PEAK 15 Min. Volumes Observed:

Major St. Vehicles;* 350

Minor St. Vehicles;* 95

Major St. Pedestrians;* 29

Remarks: Ped. Pushbuttons for All Four Legs
Signs: #1—No Parking Anytime
#2—School X-Walk

*See Appendix D. Pedestrian and Vehicle Volumes.

SIGNAL TIMING DATA
EXPERIMENTAL SITES

EXPERIMENT 1, SIGN & STOP SIGN

		DWELL	PED. ACT.				
MAJOR ST.	O.H. SIGN ADVANCE SIGN	DARK DARK	Y FY	FR FY	FR FY	FR FY	DARK DARK
MINOR ST.	PED SIGNAL STOP SIGN	DW –	DW –	DW –	Cross W/Care –	FDW –	DW –
TIMING (SEC.)	ATLANTA BUFFALO	– –	5 7	0 3	21 7	20 15	54 0

EXPERIMENT 2, F. YELLOW SIGNAL & F. RED BEACON

		DWELL	PED. ACT.					
MAJOR ST.	SIGNAL	FY	G	Y	R	R	R	FY
MINOR ST.	SIGNAL PED SIGNAL	FR DW	R DW	R DW	R DW	R W	R FDW	FR DW
TIMING (SEC.)	MEMPHIS SIOUX CITY	– –	11.9 11.7	4.9 5.8	1.4 0	9.1 13.7	17.5 13.0	25.2 20.8

EXPERIMENT 3, F. GREEN SIGNAL & STOP SIGN

		DWELL	PED. ACT.					
MAJOR ST.	SIGNAL	F.G.	F.G.	Y	R	R	R	FG
MINOR ST.	PED SIGNAL STOP SIGN	DW –	DW –	DW –	DW –	W –	FDW –	DW –
TIMING (SEC.)	LINCOLN SEATTLE	– –	1.8 4.2	3.0 3.6	3.0 1.8	9.0 11.4	9.6 13.2	33.6 25.8

EXPERIMENT 4, (SG-44) SIGNAL & STOP SIGN

		DWELL	PED. ACT.					
MAJOR ST.	SIGNAL	G	G	Y	R	R	R	G
MINOR ST.	PED SIGNAL STOP SIGN	DW –	DW –	DW –	DW –	W –	FDW –	DW –
TIMING (SEC.)	LINCOLN SEATTLE	– –	1.8 4.2	3.0 3.6	3.0 1.8	9.0 10.2	12.0 12.0	31.2 28.2

EXPERIMENT 5, CROSSING GUARD, HOURS ON DUTY

	A.M.	NOON	P.M.	HOURS PER. DAY
MEMPHIS	8:15–9:00	–	3:45–4:00	1
SEATTLE	8:15–9:00	11:00–12:30	2:30–3:00	2¾

SIGNAL TIMING DATA

CONTROL SITES (FULL SIGNALIZATION)

CONTROL 1, SEMI–ACTUATED

	MAJOR ST.			MINOR ST.							
	MIN. GREEN	CLEARANCE	ALL RED	INITIAL INTERVAL	VEH. INTERVAL	MAX. GREEN	CLEARANCE	ALL RED	WALK	FDW	DW
ATLANTA	45	4	0	12	4	30	3.5	0	12	0	3
BUFFALO	38	3	2	10	–	10	3	2	5	12	0

CONTROL 2

	MAJOR ST.							MINOR ST.						
	MIN. GREEN	INITIAL INTERVAL	VEH. INTERVAL	MAX. GREEN	CLEARANCE	WALK	FDW	INITIAL INTERVAL	VEH. INTERVAL	MAX. GREEN	CLEARANCE	ALL RED	WALK	FDW
MEMPHIS (FULL-ACT.)	–	12	3	31	4	12	8	4	2	23	4	1	7	14
SIOUX CITY (SEMI-ACT.)	30	–	–	–	4	–	–	3	4	20	3	0	9	10

CONTROL 3, PRE-TIMED

		MAJOR ST.				MINOR ST.			
		GREEN/ WALK	GREEN/ FDW	YELLOW/ FDW	RED/ DW	GREEN/ WALK	GREEN/ FDW	YELLOW/ FDW	RED/ DW
LINCOLN	OFF PEAK	24.6	8.4	3.0	24.0	12.6	8.4	3.0	36.0
	AM PEAK	27.0	9.0	3.0	21.0	9.6	8.4	3.0	39.0
	PM PEAK	27.6	8.4	3.0	21.0	9.6	8.4	3.0	39.0
SEATTLE	OFF PEAK	27.6	10.2	3.0	19.2	7.8	8.4	3.0	40.8
	PEAK	62.0	10.0	4.0	24.0	10.0	10.0	4.0	76.0

CONTROL 4, SEMI-ACTUATED

	MAJOR ST.							MINOR ST.			
	MIN. GREEN	CLEARANCE	ALL RED	FDW	INTIAL INTERVAL	VEH. INTERVAL	MAX. GREEN	CLEARANCE	ALL RED	WALK	FDW
LINCOLN	30	3	1	10	5	4	35	3	1	10	10
SEATTLE (C-4,5)	10	4	0	4	6	3	20	4	0	10	5

CONTROL 5

	MAJOR ST.										MINOR ST.						
	W/B Left Turn Advance			INITIAL INT.	VEH. INTERVAL	MAX. GREEN	Clearance	ALL RED	WALK	FDW	INITIAL INT.	VEH. INT.	MAX. GREEN	Clearance	ALL RED	WALK	FDW
	MIN. GREEN	MAX. GREEN	Clearance														
MEMPHIS (FULL-ACT.)	0	16	3.5	9	3.3	30	4	1	10	11	8	2	29	3.5	0.5	10	17

FOR SEATTLE C-5, SEE "CONTROL 4" ABOVE, SEATTLE C-4,5.

Note: All Timing Values are in Seconds.

COMPARISON OF TRAFFIC SIGNAL INSTALLATION COST ESTIMATES

(All Values in Dollars)

Base Condition: Stop Signs on Minor Street

Experiment	City	Improvement 1 Experimental Alternative	Improvement 2 Full Signalization (Semi-Actuated)	Cost Ratio 1/2*
Sign and Stop Sign	Atlanta	8,644	7,927	1.01
	Buffalo	13,055	24,500	0.53
F. Yellow Signal and F. Red Beacon	Memphis	6,178	19,688	0.31
	Sioux City	7,700	11,200	0.69
F. Green Signal and Stop Sign	Lincoln	12,441	28,626	0.43
	Seattle	18,645	38,600	0.48
(Sg-44) Signal and Stop Sign	Lincoln	12,616	31,473	0.40
	Seattle	19,545	39,040	0.50
Crossing Guard†	Memphis	1,361 / yr. (11,588**)	19,688	0.59**
	Seattle	2,952 / yr. (25,133**)	36,630	0.69**

* Assumes operating and maintenance costs equal.

** Estimated by converting the annual crossing guard cost to a present worth cost, assuming a service life of 20 yrs. and i = 10%.

† Crossing guard worked different number of hours per day.

APPENDIX D

VOLUME DATA SUMMARIES

VOLUME DATA SUMMARY

CITY Atlanta

EXPERIMENT E - 1, Sign & Stop Sign

SITE S. Cobb & Barber

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street S. Cobb				Major Street (Both Directions) Street S. Cobb				Minor Street (Both Directions) Street Barber			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	6	1	6	4	371	388	374	378	27	26	59	37
8:00	5	1	1	2	300	261	265	275	22	23	25	23
8:15	0	0	0	0	271	278	251	267	22	35	28	28
8:30	0	1	0	0	236	221	253	237	39	40	42	40*
8:45	3	3	3	3	234	265	279	259	46	37	36	40
9:00	0	0	1	0	199	206	211	205	14	14	14	14
9:15	0	0	0	0	175	201	224	200	14	15	16	15
9:30	0	0	0	0	202	227	231	220	10	6	12	9
9:45	0	0	0	0	237	256	245	246	13	9	16	13
TOTAL	14	6	11	10	2,225	2,303	2,333	2,287	207	205	248	220
11:00	0	0	0	0	267	280	304	284	18	16	18	17
11:15	0	0	0	0	292	292	322	302	10	12	11	11
11:30	0	0	0	0	328	310	311	316	16	17	10	14
11:45	0	0	0	0	351	351	369	357	12	48	19	26
12:00	0	0	0	0	313	372	377	354	6	11	16	11
12:15	0	0	0	0	342	359	347	349	17	16	22	18
12:30	0	0	0	0	323	358	300	327	18	23	21	21
12:45	0	0	0	0	314	397	330	347	14	16	11	14
TOTAL	0	0	0	0	2,530	2,719	2,660	2,636	111	159	128	132
2:00	0	0	0	0	351	356	320	342	16	22	18	19
2:15	6	12	10	9*	360	327	367	351	11	17	29	19
2:30	14	9	3	9	323	338	341	334	11	20	15	15
2:45	0	2	0	1	369	300	305	325	16	17	20	18
3:00	0	2	0	1	243	292	322	286	12	26	24	21
3:15	0	0	0	0	324	325	331	327	17	12	15	15
3:30	–	–	–	–	–	–	–	–	–	–	–	–
3:45	6	0	1	2	333	380	409	374	32	19	32	28
4:00	13	7	3	8	286	355	289	310	14	28	22	21
4:15	3	0	0	1	392	372	390	385	25	21	18	21
4:30	3	0	0	1	401	412	436	416*	20	19	17	19
4:45	0	0	0	0	394	424	353	390	26	21	11	19
TOTAL	45	32	17	31	3,876	3,881	3,863	3,873	200	222	221	214
DAILY TOTAL	59	38	28	41	8,631	8,903	8,856	8,797	518	586	597	567

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign

SITE Broadway & Pine

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Broadway				Major Street (Both Directions) Street Broadway				Minor Street (Both Directions) Street Pine			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	5	3	1	3	215	191	185	197	30	28	22	27
8:30	4	5	4	4	161	189	180	177	27	15	21	21
8:45	2	2	1	2	166	173	167	169	26	25	21	24
9:00	2	1	0	1	130	145	151	142	22	28	9	20
9:15	1	0	2	1	107	130	150	129	11	12	11	11
9:30	1	6	0	2	109	132	162	134	16	21	13	17
9:45	1	3	2	2	121	126	148	132	16	16	15	16
TOTAL	16	20	10	15	1,009	1,086	1,143	1,079	148	145	112	135
11:00	–	–	–	–	–	–	–	–	–	–	–	–
11:15	0	5	4	3	164	172	132	156	27	33	14	25
11:30	2	0	3	2	171	128	158	152	24	26	28	26
11:45	1	7	5	4	187	151	186	175	28	28	29	28
12:00	5	1	2	3	147	167	168	161	20	28	16	21
12:15	2	4	2	3	141	163	183	162	24	23	19	22
12:30	0	1	4	2	152	153	147	151	19	24	24	22
12:45	3	2	5	3	173	191	176	180	14	15	20	16
TOTAL	13	20	25	19	1,135	1,125	1,150	1,137	156	177	150	161
2:00	1	0	0	0	174	* 183	146	168	23	19	31	24
2:15	4	1	0	2	163	154	181	166	29	35	32	32
2:30	8	0	0	3	147	166	128	147	39	36	16	30
2:45	2	2	2	2	183	146	171	167	47	30	34	37
3:00	8	0	1	3	209	190	170	190	42	37	38	39
3:15	14	0	6	7	169	156	144	156	40	36	51	42
3:30	9	12	1	7*	145	162	163	157	21	35	38	31
3:45	1	3	2	2	169	167	170	169	27	29	22	26
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	3	0	3	2	197	163	169	176	33	33	37	34
4:30	4	0	5	3	257	239	272	256*	51	49	29	43*
4:45	4	3	5	4	222	199	188	203	30	27	31	29
TOTAL	58	21	25	35	2,035	1,925	1,902	1,954	382	366	359	369
DAILY TOTAL	87	61	60	69	4,179	4,136	4,195	4,170	686	688	621	665

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hollywood & Heard

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Hollywood				Major Street (Both Directions) Street Hollywood				Minor Street (Both Directions) Street Heard			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	3	13	24	23	383	321	667	627	21	8	24	28
8:30	17	12			246	265			18	14		
8:45	4	6	1	4	244	246	235	242	18	15	12	15
9:00	1	0	1	1	240	198	232	223	12	16	24	17
9:15	0	1	0	0	197	187	217	200	18	16	18	17
9:30	0	2	0	1	166	208	173	182	11	19	18	16
9:45	0	0	2	1	209	169	216	198	12	11	15	13
TOTAL	25	34	28	29	1,685	1,594	1,740	1,673	110	129	111	117
11:00	0	0	2	1	209	211	241	220	9	6	22	12
11:15	0	0	2	1	202	206	201	203	19	15	15	16
11:30	1	0	1	1	238	214	194	215	15	18	18	17
11:45	1	2	3	2	241	218	206	222	10	14	15	13
12:00	0	2	4	2	285	223	242	250	13	12	18	14
12:15	0	3	3	2	214	239	229	227	18	17	18	18
12:30	1	4	1	2	192	241	275	236	12	16	12	13
12:45	0	0	1	0	246	199	242	229	11	9	15	12
TOTAL	3	11	17	10	1,827	1,751	1,830	1,803	107	107	133	116
2:00	0	0	4	1	281	232	268	260	16	10	22	16
2:15	2	2	3	2	297	239	258	265	16	19	20	18
2:30	8	1	3	4	327	285	332	315	22	12	16	17
2:45	1	3	10	5	283	274	263	273	20	8	12	13
3:00	3	2	10	5	346	331	344	340	14	11	16	14
3:15	5	4	17	9	344	361	308	338	24	18	18	20
3:30	2	6	11	6	421	387	419	409	29	24	17	23
3:45	44	36	44	41*	440	345	359	381	32	22	20	25*
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	10	2	9	7	458	465	403	442*	25	21	15	20
4:30	–	–	–	–	–	–	–	–	–	–	–	–
4:45	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL	75	56	111	81	3,197	2,919	2,954	3,023	198	145	156	166
DAILY TOTAL	103	101	156	120	6,709	6,264	6,524	6,499	415	381	400	399

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hamilton & 24th

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Hamilton				Major Street (Both Directions) Street Hamilton				Minor Street (Both Directions) Street 24th			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	7	2	2	4	194	164	179	179	15	17	10	14
8:30	3	2	0	2	186	149	164	166	19	8	8	12
8:45	0	1	1	1	189	177	216	194	10	7	13	10
9:00	0	0	0	0	172	182	179	178	24	8	10	14
9:15	0	0	0	0	178	149	171	166	21	13	6	13
9:30	0	0	0	0	155	147	162	155	10	4	6	7
9:45	0	0	0	0	188	163	176	176	8	6	3	6
TOTAL	10	5	3	6	1,262	1,131	1,247	1,213	107	63	56	75
11:00	0	0	0	0	235	206	239	227	14	3	7	8
11:15	0	0	1	0	191	208	263	221	7	4	4	5
11:30	0	0	1	0	252	265	259	259	16	10	8	11
11:45	0	0	0	0	266	245	315	275	14	9	14	12
12:00	0	0	0	0	309	284	312	302	10	13	12	12
12:15	0	0	0	0	294	261	288	281	15	8	12	12
12:30	0	0	0	0	335	287	346	323	10	7	6	8
12:45	0	0	0	0	311	271	315	299	13	9	15	12
TOTAL	0	0	2	1	2,193	2,027	2,337	2,186	99	63	78	80
2:00	0	1	0	0	274	285	277	279	9	2	7	6
2:15	0	0	0	0	282	284	311	292	13	10	13	12
2:30	0	0	0	0	295	270	291	285	11	3	8	7
2:45	0	0	1	0	263	268	293	275	13	9	12	11
3:00	0	0	0	0	318	289	306	304	27	10	7	15
3:15	4	2	6	4	283	273	315	290	17	12	14	14
3:30	–	–	–	–	–	–	–	–	–	–	–	–
3:45	27	11	22	20*	312	347	330	330*	14	19	17	17
4:00	20	6	12	13	322	309	357	329	30	9	13	17*
4:15	0	0	2	1	313	310	344	322	16	7	16	13
4:30	4	0	0	1	320	298	351	323	24	14	17	18
4:45	1	1	1	1	321	330	332	328	15	6	15	12
TOTAL	56	21	44	40	3,303	3,263	3,507	3,358	189	101	139	143
DAILY TOTAL	66	26	49	47	6,758	6,421	7,091	6,757	395	227	273	298

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE South & 52nd

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street South				Major Street (Both Directions) Street South				Minor Street (Both Directions) Street 52nd			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	8	2	2	4	144	122	111	126	14	6	15	12
8:15	19	24	5	16	145	149	138	144	20	21	13	18
8:30	56	27	18	34*	128	107	125	120	19	17	34	23
8:45	3	0	1	1	116	122	113	117	13	12	14	13
9:00	0	0	0	0	111	92	102	102	8	3	14	8
9:15	2	0	0	1	113	98	77	96	1	7	4	4
9:30	0	0	0	0	81	81	67	76	3	3	3	3
9:45	0	0	0	0	109	102	81	97	13	7	5	8
TOTAL	88	53	26	56	947	873	814	878	91	76	102	90
11:00	2	0	0	1	117	112	86	105	16	8	4	9
11:15	5	1	2	3	96	98	99	98	11	12	14	12
11:30	11	9	6	9	106	112	102	107	12	12	12	12
11:45	0	0	0	0	126	92	110	109	7	5	8	7
12:00	1	1	0	1	133	143	116	131	13	5	6	8
12:15	0	0	0	0	108	118	86	104	5	7	4	5
12:30	1	0	0	0	122	100	114	112	5	12	10	9
12:45	2	0	0	1	116	127	110	118	9	11	8	9
TOTAL	22	11	8	14	924	902	823	883	78	72	66	72
2:00	1	0	0	0	97	112	106	105	11	10	9	10
2:15	0	1	2	1	150	128	111	130	20	12	13	15
2:30	0	1	0	0	126	104	135	122	10	15	12	12
2:45	41	29	4	25	126	132	91	116	20	12	19	17
3:00	36	15	39	30	144	134	156	145	23	17	24	21
3:15	9	3	19	10	176	158	143	159	35	17	27	26*
3:30	4	4	5	4	172	171	183	175	18	17	23	19
3:45	3	4	4	4	163	181	148	164	20	20	21	20
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	3	2	3	3	193	153	162	169	15	12	17	15
4:30	4	0	4	3	224	202	199	208*	18	22	17	19
4:45	2	3	0	2	209	211	204	208	8	14	16	13
TOTAL	103	62	80	82	1,780	1,686	1,638	1,701	198	168	198	188
DAILY TOTAL	213	126	114	151	3,651	3,461	3,275	3,462	367	316	366	350

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE Beacon & Hanford

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Beacon				Major Street (Both Directions) Street Beacon				Minor Street (Both Directions) Street Hanford			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	30	6	12	16	148	143	127	139	7	5	6	6
8:30	23	29	21	24	122	161	141	141	18	9	7	11
8:45	5	6	8	6	156	148	128	144	12	9	10	10
9:00	2	2	2	3	122	97	122	114	3	7	6	5
9:15	1	2	1	1	108	89	83	93	2	3	6	4
9:30	0	1	10	4	105	90	104	100	3	9	7	6
9:45	2	4	1	2	96	93	107	99	3	8	7	6
TOTAL	63	54	55	57	857	821	812	830	48	50	49	48
11:00	4	3	7	5	117	132	153	134	7	7	7	7
11:15	10	1	7	6	139	110	143	131	11	4	8	8
11:30	7	3	4	5	144	132	134	137	7	5	4	5
11:45	7	6	6	6	132	131	140	134	13	12	9	11
12:00	6	3	3	4	181	158	177	172	6	8	8	7
12:15	6	2	7	5	127	169	163	153	15	6	11	11
12:30	3	5	10	6	148	113	186	149	11	5	8	8
12:45	4	6	3	4	141	119	169	143	12	7	11	10
TOTAL	47	29	47	41	1,129	1,064	1,265	1,153	82	54	66	67
2:00	8	40	2	17	157	198	185	180	10	20	10	13
2:15	4	21	1	9	173	184	173	177	15	10	8	11
2:30	25	17	27	23	203	176	188	189	13	9	20	14
2:45	51	37	60	49*	198	192	187	192	11	15	8	11
3:00	38	35	17	30	220	206	184	203	10	7	5	7
3:15	7	17	14	13	194	199	205	199	17	11	11	13
3:30	23	5	10	13	229	234	257	240	14	14	9	12
3:45	20	10	14	15	265	301	258	275	12	13	13	13
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	18	24	14	19	301	373	303	326	18	12	15	15*
4:30	8	19	11	13	353	310	410	358*	19	8	14	12
4:45	23	7	12	14	337	340	378	352	18	19	7	15
TOTAL	225	232	182	213	2,630	2,713	2,728	2,690	152	138	120	137
DAILY TOTAL	335	315	284	311	4,616	4,598	4,805	4,673	282	242	235	253

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE South & 20th

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street South				Major Street (Both Directions) Street South				Minor Street (Both Directions) Street 20th			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	23	8	15	15	312	250	298	287	22	15	14	17
8:15	31	23	25	26	222	204	219	215	12	9	15	12
8:30	91	97	70	86*	236	224	199	220	38	32	29	33*
8:45	5	3	10	6	235	213	225	224	24	17	27	23
9:00	1	1	0	1	187	208	214	203	12	15	13	13
9:15	0	2	0	1	206	158	168	177	8	8	11	9
9:30	0	0	0	0	168	168	166	167	15	7	7	10
9:45	1	0	1	1	195	157	190	181	13	8	12	11
TOTAL	152	134	121	136	1,761	1,582	1,679	1,674	144	111	128	128
11:00	0	1	1	1	217	209	176	201	26	11	9	15
11:15	1	1	2	1	203	188	170	187	13	15	7	12
11:30	5	6	10	7	225	202	212	213	17	10	21	16
11:45	21	11	16	16	255	212	243	237	18	8	16	14
12:00	5	1	4	3	268	317	264	283	30	13	16	20
12:15	7	3	7	6	242	198	199	213	28	19	14	20
12:30	2	1	4	2	286	188	226	233	20	14	19	18
12:45	0	1	0	0	262	272	265	266	10	13	24	16
TOTAL	41	25	44	37	1,958	1,786	1,755	1,833	162	103	126	130
2:00	1	0	1	1	227	163	243	211	14	12	8	11
2:15	20	14	10	15	260	254	220	245	16	14	22	17
2:30	1	9	14	8	250	284	236	257	15	18	25	19
2:45	60	72	69	67	284	275	269	276	23	19	26	23
3:00	46	33	27	35	269	315	274	286	28	22	22	24
3:15	25	17	13	18	286	295	333	305	24	13	19	19
3:30	16	11	8	12	368	327	337	344	25	19	17	20
3:45	11	3	5	6	367	282	327	325	17	18	28	21
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	3	8	4	5	349	263	349	320	23	11	14	16
4:30	5	3	2	3	503	451	457	470*	23	21	25	20
4:45	1	2	2	2	387	380	414	394	14	13	20	16
TOTAL	189	172	155	172	3,550	3,289	3,459	3,433	222	180	216	206
DAILY TOTAL	382	331	320	344	7,269	6,657	6,893	6,940	528	394	470	464

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Fauntleroy				Major Street (Both Directions) Street Fauntleroy				Minor Street (Both Directions) Street Myrtle			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–		–			
8:00	1	5	9	5	149	137	150	145	8	13	13	11
8:15	10	25	3	13	180	98	83	120	7	5	7	6
8:30	17	12	16	15	174	101	141	139	21	15	13	16*
8:45	4	3	3	3	74	108	82	88	24	4	6	11
9:00	2	0	0	1	123	102	112	112	5	3	3	4
9:15	1	1	0	1	60	89	64	71	3	5	1	3
9:30	5	7	7	6	104	71	74	83	9	5	16	10
9:45	8	1	3	4	83	120	126	110	9	9	6	8
TOTAL	48	54	41	48	947	826	832	868	86	59	65	70
11:00	2	0	0	1	95	91	67	84	6	5	8	6
11:15	2	3	4	3	74	75	87	79	10	8	9	9
11:30	4	1	1	2	106	102	124	111	3	10	7	7
11:45	3	3	4	3	108	90	98	99	11	7	8	9
12:00	2	1	0	1	108	88	83	93	8	13	4	8
12:15	3	2	1	2	112	99	116	109	6	8	5	6
12:30	2	3	2	2	99	73	107	93	10	4	4	6
12:45	5	10	1	5	129	110	133	124	8	9	2	6
TOTAL	23	23	13	20	831	728	815	791	62	64	47	58
2:00	6	10	8	8	127	134	124	128	3	8	8	6
2:15	10	5	2	6	85	85	106	92	7	10	16	11
2:30	36	39	39	38*	136	124	150	137	16	14	11	14
2:45	8	8	4	7	147	125	118	130	11	9	11	10
3:00	4	5	6	5	136	117	106	120	7	12	12	10
3:15	0	2	4	2	166	154	143	154	6	11	12	10
3:30	2	1	4	2	114	128	138	127	13	11	17	14
3:45	3	2	1	2	155	134	127	139	13	5	9	9
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	0	3	2	2	161	161	158	160	10	9	14	11
4:30	1	6	6	4	207	183	171	187*	20	10	13	14
4:45	3	1	2	2	199	175	172	182	12	8	6	8
TOTAL	73	82	78	78	1,633	1,520	1,513	1,556	118	107	129	118
DAILY TOTAL	144	159	132	145	3,411	3,074	3,160	3,215	266	230	241	246

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Memphis

EXPERIMENT E-5, Crossing Guard

SITE Knight-Arnold & Clearbrook

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Knight Arnold				Major Street (Both Directions) Street Knight Arnold				Minor Street (Both Directions) Street Clearbrook			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45												
8:00	0	0	1	0	301	246	289	279	57	53	40	50*
8:15	2	1	7	3	305	248	252	268	48	49	44	47
8:30	6	1	1	3	251	216	208	225	46	36	30	37
8:45	0	0	1	0	197	178	208	194	29	28	34	30
9:00	1	0	0	0	135	149	162	149	16	24	30	23
9:15	0	0	0	0	126	133	174	144	27	22	18	22
9:30	0	0	0	0	164	153	188	168	16	17	17	17
9:45	0	0	0	0	176	151	185	171	17	21	15	18
TOTAL	9	2	10	7	1,655	1,474	1,666	1,598	256	250	228	245
11:00	0	0	0	0	202	183	208	198	12	22	25	20
11:15	0	0	0	0	202	197	240	213	18	17	24	20
11:30	0	1	0	0	266	227	242	245	23	31	24	26
11:45	0	0	0	0	249	224	270	248	16	13	24	18
12:00	–	–	–	–	–	–	–	–	–	–	–	–
12:15	0	1	0	0	265	278	257	267	28	17	24	23
12:30	0	0	0	0	274	242	305	274	27	31	28	29
12:45	0	0	0	0	258	243	230	244	31	27	15	24
TOTAL	0	2	0	1	1,716	1,594	1,752	1,687	155	158	164	159
2:00	–	–	–	–	–	–	–	–	–	–	–	–
2:15	2	0	0	1	274	288	261	274	29	43	34	35
2:30	1	0	0	0	251	230	253	245	24	36	35	32
2:45	0	0	1	0	241	261	273	258	36	35	31	34
3:00	0	0	0	0	282	302	300	295	44	40	38	41
3:15	4	0	0	1	278	330	315	308	45	35	40	40
3:30	–	–	–	–	–	–	–	–	–	–	–	–
3:45	11	1	10	7*	299	276	296	290	27	48	38	38
4:00	3	5	2	3	317	303	293	304	29	26	42	32
4:15	0	0	0	0	313	339	307	320	22	19	22	21
4:30	0	0	2	1	290	320	334	315	18	36	36	30
4:45	0	1	2	1	321	330	325	325*	32	36	25	31
TOTAL	21	7	17	15	2,866	2,979	2,957	2,934	306	354	341	334
DAILY TOTAL	30	11	27	23	6,237	6,047	6,375	6,220	717	762	733	737

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Seattle

EXPERIMENT E-5, Crossing Guard

SITE 23rd & Hanford

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street 23rd				Major Street (Both Directions) Street 23rd				Minor Street (Both Directions) Street Hanford			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	4	7	16	9	181	249	207	212	13	10	12	12
8:15	46	48	34	43	145	226	160	177	10	11	8	10
8:30	111	99	96	102	112	159	124	132	24	18	22	21*
8:45	27	29	35	30	125	137	130	131	17	15	15	16
9:00	0	0	4	1	89	111	83	94	7	7	5	6
9:15	1	1	3	2	55	108	101	88	10	8	7	8
9:30	0	1	0	0	84	94	82	87	7	7	6	7
9:45	0	0	0	0	59	83	82	75	6	7	5	6
TOTAL	189	185	188	187	850	1,167	969	995	94	83	80	86
11:00	–	–	–	–	–	–	–	–	–	–	–	–
11:15	17	2	13	11	87	77	73	79	14	9	17	13
11:30	1	2	1	1	74	99	83	85	6	12	12	10
11:45	3	2	6	4	88	71	82	80	5	9	20	11
12:00	9	8	10	9	111	108	97	105	13	20	13	15
12:15	5	10	3	6	73	85	96	85	9	7	9	8
12:30	2	2	0	1	99	107	103	103	5	14	8	9
12:45	1	1	1	1	70	85	89	81	5	7	10	7
TOTAL	38	27	34	33	602	632	623	619	57	78	89	75
2:00	–	–	–	–	–	–	–	–	–	–	–	–
2:15	3	11	8	7	74	122	118	105	9	10	18	12
2:30	213	7	165	128*	110	142	124	125	12	13	17	14
2:45	16	14	23	18	119	118	125	121	8	13	11	11
3:00	20	18	9	16	138	162	127	142	11	12	8	10
3:15	0	8	13	7	123	114	129	122	17	13	13	14
3:30	3	28	12	14	149	159	153	154	25	22	15	21
3:45	4	16	6	9	180	156	160	165	9	15	25	16
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	2	11	5	6	235	231	207	224	22	18	21	20
4:30	10	2	2	5	237	259	226	241	11	17	8	12
4:45	2	6	2	3	238	277	266	260*	28	9	15	17
TOTAL	273	121	245	213	1,603	1,740	1,635	1,659	152	142	151	148
DAILY TOTAL	500	333	467	433	3,055	3,539	3,227	3,274	303	303	320	309

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Atlanta

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Roswell & Dalrymple

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Roswell				Major Street (Both Directions) Street Roswell				Minor Street (Both Directions) Street Dalrymple			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	13	3	1	6	223	214	255	231	116	160	144	140
8:15	19	17	14	17	279	237	246	254	181	204	174	186
8:30	4	1	1	2	225	207	246	226	300	176	227	234*
8:45	3	5	1	3	219	223	162	201	128	109	117	118
9:00	2	2	3	2	166	166	176	169	100	88	67	85
9:15	0	0	0	0	163	164	167	165	121	76	70	89
9:30	0	2	1	1	175	178	155	169	91	68	62	74
9:45	1	0	0	0	178	170	177	175	84	77	84	82
TOTAL	42	30	21	31	1,628	1,559	1,584	1,590	1,121	958	945	1,008
11:00	1	2	1	1	175	204	206	195	93	83	82	86
11:15	0	1	0	0	206	199	220	208	81	68	80	76
11:30	1	1	0	1	203	267	197	222	85	87	66	79
11:45	0	4	2	2	220	241	234	232	106	102	86	98
12:00	0	0	0	0	235	251	251	246	67	95	93	85
12:15	1	4	0	2	258	242	220	240	110	79	100	96
12:30	2	4	0	2	211	243	221	225	85	90	87	87
12:45	5	5	2	4	267	202	242	237	75	89	92	85
TOTAL	10	21	5	12	1,775	1,849	1,791	1,805	702	693	686	694
2:00	0	2	0	1	212	208	262	227	89	87	81	86
2:15	5	3	0	3	246	254	239	246	115	106	116	112
2:30	0	0	3	1	236	258	247	247	114	112	100	109
2:45	0	3	0	1	253	260	251	255	117	122	112	117
3:00	4	1	7	4	269	278	257	268	138	127	133	133
3:15	38	41	43	41*	257	332	259	283	194	207	173	191
3:30	–	–	–	–	–	–	–	–	–	–	–	–
3:45	10	4	13	9	282	278	283	281	165	140	141	149
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	14	5	3	7	414	437	401	417*	136	118	111	122
4:30	16	7	7	10	305	343	304	317	127	133	134	131
4:45	1	2	0	1	317	302	283	301	125	139	118	127
TOTAL	88	68	76	77	2,791	2,950	2,786	2,842	1,320	1,291	1,219	1,277
DAILY TOTAL	140	119	102	120	6,194	6,358	6,161	6,238	3,143	2,942	2,850	2,978

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Buffalo

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Broadway & Mortimer

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Broadway				Major Street (Both Directions) Street Broadway				Minor Street (Both Directions) Street Mortimer			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	16	18	12	15	223	232	220	225	26	17	17	20
8:30	2	5	4	4	202	186	194	194	14	10	17	14
8:45	4	5	6	5	188	136	160	161	11	13	15	13
9:00	1	2	3	2	158	138	167	154	8	7	10	8
9:15	3	2	2	2	117	155	151	141	9	7	13	10
9:30	2	6	10	6	142	166	155	154	9	13	8	10
9:45	3	7	3	4	135	138	146	140	9	4	11	8
TOTAL	31	45	40	39	1,165	1,151	1,193	1,170	86	71	91	83
11:00	7	3	5	5	162	147	169	159	23	13	15	17
11:15	8	3	13	8	159	193	152	168	5	13	13	10
11:30	4	3	11	6	176	135	183	165	12	9	18	13
11:45	10	5	5	7	179	154	179	171	12	12	18	14
12:00	45	54	68	56*	166	160	147	158	24	16	20	20
12:15	35	22	26	28	167	156	181	168	18	25	23	22
12:30	17	7	17	14	195	189	195	193	17	17	21	18
12:45	9	4	5	6	181	173	211	188	24	20	12	19
TOTAL	135	101	150	129	1,385	1.307	1,417	1,370	135	125	140	133
2:00	5	3	11	6	177	173	171	174	9	14	17	13
2:15	9	7	6	7	163	159	187	170	17	8	19	15
2:30	11	13	13	12	168	174	152	165	16	11	13	13
2:45	4	9	11	8	151	177	167	165	20	15	16	17
3:00	15	16	12	14	188	179	191	186	23	21	13	19
3:15	11	12	17	13	180	157	184	174	19	13	16	16
3:30	19	8	28	18	192	177	191	187	27	23	24	25
3:45	14	8	18	13	198	179	201	193	21	19	17	19
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	18	9	8	12	201	194	199	198	30	18	27	25
4:30	12	8	12	11	261	244	241	249*	69	63	64	65*
4:45	20	10	12	14	226	198	207	210	26	25	24	25
TOTAL	138	103	148	130	2,105	2,011	2,091	2,069	277	230	250	252
DAILY TOTAL	304	249	338	297	4,655	4,469	4,701	4,608	498	426	481	468

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Memphis

CONTROL C-2, Full Signalization (Full-Act.)

SITE Hollywood & Peres

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Hollywood				Major Street (Both Directions) Street Hollywood				Minor Street (Both Directions) Street Peres			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	–	–	–	–	–	–	–	–	–	–	–	–
8:15	–	–	–	–	–	–	–	–	–	–	–	–
8:30	–	–	–	–	–	–	–	–	–	–	–	–
8:45	0	0	0	0	208	241	270	240	27	37	57	40
9:00	0	2	0	1	249	200	226	225	50	38	43	44
9:15	0	1	2	1	168	196	206	190	48	49	54	50
9:30	0	2	0	1	182	196	168	182	51	53	43	49
9:45	2	1	0	1	200	184	217	200	39	43	44	42
TOTAL	2	6	2	3	1,007	1,017	1,087	1,037	215	220	241	225
11:00	0	0	2	1	188	176	212	192	57	45	65	56
11:15	1	2	3	2	203	182	230	205	46	46	59	50
11:30	3	1	1	2	205	207	193	202	55	55	32	47
11:45	0	1	1	2	216	216	190	207	48	58	66	57
12:00	0	1	2	1	238	210	216	221	45	68	71	61
12:15	0	1	0	0	222	214	208	215	73	55	56	61
12:30	0	2	0	1	206	230	266	234	43	58	64	55
12:45	0	0	0	0	233	201	225	220	45	56	41	47
TOTAL	4	8	9	7	1,711	1,636	1,740	1,696	412	441	454	436
2:00	–	–	–	–	–	–	–	–	–	–	–	–
2:15	5	6	0	4	195	227	259	227	51	54	82	62
2:30	0	0	8	3	230	292	318	280	68	59	64	64
2:45	3	0	10	4	182	267	249	233	66	71	80	72
3:00	6	3	1	3	284	265	268	272	132	96	87	105
3:15	0	14	1	5*	267	296	307	290	81	88	81	83
3:30	3	0	6	3	248	372	318	313	113	143	131	129
3:45	2	2	6	3	171	308	309	263	80	90	98	89
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	1	2	1	1	326	382	378	362*	140	117	141	133*
4:30	–	–	–	–	–	–	–	–	–	–	–	–
4:45	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL	20	27	33	27	1,903	2,409	2,406	2,239	731	718	764	738
DAILY TOTAL	26	41	44	37	4,621	5,062	5,233	4,972	1,358	1,379	1,459	1,399

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Sioux City

CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 36th

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Hamilton				Major Street (Both Directions) Street Hamilton				Minor Street (Both Directions) Street 36th			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	22	12	12	15	140	118	118	125	115	113	120	116
8:15	22	21	20	21	102	86	100	96	82	77	85	81
8:30	11	5	11	9	122	79	110	104	84	75	78	79
8:45	0	0	0	0	104	108	120	111	78	47	60	62
9:00	0	0	0	0	100	82	89	90	90	45	45	55
9:15	0	0	0	0	77	70	76	74	58	43	39	47
9:30	0	0	0	0	74	57	84	72	48	29	44	40
9:45	0	0	0	0	74	62	82	73	37	34	30	34
TOTAL	55	38	43	45	793	662	779	745	578	462	501	514
11:00	0	0	0	0	84	71	82	79	35	36	43	38
11:15	0	0	0	0	87	91	87	88	43	43	51	46
11:30	0	0	0	0	100	89	107	99	42	46	50	46
11:45	0	0	0	0	92	97	112	100	57	42	46	48
12:00	0	0	0	0	135	96	112	114	56	31	47	45
12:15	0	0	0	0	106	91	115	104	81	48	50	60
12:30	0	0	0	0	127	94	112	111	54	55	45	51
12:45	0	0	5	2	120	91	122	111	57	52	53	54
TOTAL	0	0	5	2	851	720	849	807	425	353	385	388
2:00	0	0	0	0	114	101	96	104	54	53	52	53
2:15	0	0	5	2	107	90	125	107	60	41	52	51
2:30	0	0	0	0	106	102	98	102	49	52	48	50
2:45	0	0	0	0	107	101	102	103	70	48	55	58
3:00	0	0	0	0	131	115	134	127	56	67	43	55
3:15	1	1	0	1	156	129	159	148	65	60	71	65
3:30	57	56	67	60*	143	164	145	151	130	109	115	118*
3:45	9	5	5	6	170	159	159	163	102	73	73	83
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	0	2	3	2	134	134	158	158	67	54	66	62
4:30	2	1	3	2	170	143	187	167*	103	73	113	96
4:45	1	0	1	1	145	130	164	146	93	57	88	79
TOTAL	70	65	84	73	1,483	1,368	1,527	1,459	849	687	776	771
DAILY TOTAL	125	103	132	120	3,127	2,750	3,155	3,011	1,852	1,502	1,662	1,672

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Lincoln

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Randolph & 40th

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Randolph				Major Street (Both Directions) Street Randolph				Minor Street (Both Directions) Street 40th			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	0	0	0	0	118	119	106	114	68	46	41	52
8:15	1	3	3	2	111	118	117	115	62	59	54	58
8:30	9	14	3	9*	113	114	91	106	65	56	52	58
8:45	0	0	1	0	94	97	112	101	58	39	48	48
9:00	0	1	0	0	75	76	64	72	37	35	20	31
9:15	0	0	0	0	80	78	54	71	50	29	30	36
9:30	0	0	0	0	75	93	63	77	37	34	32	34
9:45	0	1	0	0	74	80	60	71	33	47	19	33
TOTAL	10	19	7	12	740	775	667	727	410	345	296	350
11:00	1	0	0	0	69	90	69	76	61	32	27	40
11:15	0	0	0	0	102	96	83	94	46	41	51	46
11:30	3	0	2	2	95	108	69	91	56	47	37	47
11:45	3	3	0	2	88	103	98	59	59	75	60	65
12:00	1	0	0	0	140	131	87	119	60	57	51	56
12:15	1	0	0	0	94	86	97	92	55	38	48	47
12:30	0	0	0	0	112	113	59	95	74	56	31	54
12:45	3	0	0	1	105	109	97	104	65	49	30	48
TOTAL	12	3	2	6	805	836	659	767	476	395	335	402
2:00	0	0	0	0	94	120	73	96	54	57	34	48
2:15	0	0	0	0	86	72	83	80	49	54	44	49
2:30	0	0	0	0	104	129	95	109	63	54	37	51
2:45	2	1	4	2	127	132	75	111	65	51	46	54
3:00	0	0	5	2	124	132	90	115	75	77	39	64
3:15	6	4	4	5	125	120	123	123	91	68	65	75
3:30	3	5	0	3	134	154	92	127	66	86	52	68
3:45	1	2	1	1	117	157	150	141	73	82	64	73
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	0	2	3	2	181	142	148	157	79	79	81	80
4:30	–	–	–	–	–	–	–	–	–	–	–	–
4:45	5	1	1	2	191	179	154	175*	87	88	91	89*
TOTAL	17	15	18	17	1,283	1,337	1,083	1,234	702	696	533	650
DAILY TOTAL	39	37	27	34	2,828	2,948	2,409	2,728	1,588	1,436	1,184	1,403

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Seattle

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Rainier & Walden

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Rainier				Major Street (Both Directions) Street Rainier				Minor Street (Both Directions) Street Walden			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	4	5	4	4	303	206	299	269	29	40	35	35
8:15	19	6	12	12	260	176	264	233	22	17	30	23
8:30	11	16	12	13	262	257	251	257	29	30	26	28
8:45	1	4	4	3	291	208	260	253	32	32	34	33
9:00	2	3	3	3	220	197	231	216	15	21	26	21
9:15	6	3	8	6	236	180	218	211	24	19	19	21
9:30	1	3	2	2	214	205	212	210	20	18	19	19
9:45	2	4	5	4	266	198	176	213	23	16	18	19
TOTAL	46	44	50	47	2,052	1,627	1,911	1,863	194	193	207	198
11:00	4	4	12	7	274	259	234	256	31	34	24	30
11:15	4	3	11	6	273	260	148	227	35	42	10	29
11:30	1	2	14	6	294	262	233	263	37	22	22	27
11:45	4	4	0	3	307	286	266	286	31	33	24	29
12:00	10	6	13	10	326	345	321	331	24	38	27	30
12:15	6	6	7	6	323	322	274	306	32	45	26	34
12:30	3	8	6	6	320	320	326	322	22	27	26	25
12:45	9	4	5	6	327	290	319	312	31	30	30	30
TOTAL	41	37	68	49	2,444	2,344	2,121	2,303	243	271	189	234
2:00	7	14	7	9	318	306	318	314	29	29	26	28
2:15	4	8	15	9	341	363	346	350	43	30	31	35
2:30	24	12	21	19	310	399	293	334	58	59	35	51
2:45	13	28	28	23*	376	369	402	382	39	40	35	38
3:00	8	15	19	14	357	415	337	370	41	39	37	39
3:15	15	26	11	17	410	393	370	391	44	37	36	39
3:30	16	7	17	13	353	413	369	378	37	50	33	40
3:45	5	10	4	6	388	430	389	402	41	53	30	41
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	6	9	3	6	453	449	377	426	44	47	35	42*
4:30	7	8	14	10	428	412	422	421	37	38	40	38
4:45	12	14	18	15	465	397	505	456*	39	42	37	39
TOTAL	117	151	157	142	4,199	4,346	4,128	4,224	452	464	375	430
DAILY TOTAL	204	232	275	237	8,695	8,317	8,160	8,391	889	928	771	863

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Lincoln

CONTROL C-4, Full Signalization (Semi-Act.)

SITE "O" & 25th

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street "O"				Major Street (Both Directions) Street "O"				Minor Street (Both Directions) Street 25th			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45												
8:00	26	6	3	12	243	327	407	326	29	20	25	25
8:15	8	20	15	14	229	282	342	284	30	15	32	26
8:30	5	2	15	7	256	224	257	246	34	36	32	34
8:45	5	8	7	7	281	330	284	298	23	29	29	27
9:00	1	2	1	1	250	253	228	244	24	21	14	20
9:15	2	5	2	3	292	266	257	272	19	21	10	17
9:30	5	3	3	4	272	278	249	266	11	20	10	14
9:45	2	4	0	2	271	287	257	272	13	20	21	18
TOTAL	54	50	46	50	2,094	2,247	2,281	2,207	183	182	173	179
11:00	0	0	2	1	366	336	322	341	23	32	21	25
11:15	4	0	4	3	353	321	317	330	25	37	30	31
11:30	4	4	2	3	340	351	355	349	27	35	20	27
11:45	10	2	0	4	360	372	358	363	19	28	19	22
12:00	8	0	0	3	401	399	370	390	43	34	25	34
12:15	0	1	1	1	354	337	285	325	19	34	23	25
12:30	1	6	3	3	371	339	320	343	26	31	12	23
12:45	8	1	2	4	372	434	308	371	30	32	20	27
TOTAL	35	15	14	21	2,917	2,889	2,635	2,814	212	263	170	215
2:00	–	–	–	–	–	–	–	–	–	–	–	–
2:15	4	3	3	3	383	413	336	377	26	36	37	33
2:30	8	1	1	3	388	435	361	395	30	55	35	40
2:45	46	28	25	33*	401	402	457	420	33	49	38	40
3:00	9	9	9	14	462	393	353	403	42	43	34	40
3:15	12	8	2	7	442	474	362	426	31	34	34	33
3:30	5	3	8	5	466	411	388	422	48	41	44	44
3:45	6	7	1	5	386	404	406	399	35	49	32	39
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	5	4	4	4	523	451	448	474*	41	61	25	42
4:30	7	4	4	5	497	463	450	470	39	76	41	52
4:45	7	1	1	3	449	473	420	447	65	73	47	62*
TOTAL	109	83	58	83	4,397	4,319	3,981	4,232	390	517	367	425
DAILY TOTAL	198	148	118	155	9,408	9,455	8,897	9,253	785	962	710	819

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Seattle

CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Renton				Major Street (Both Directions) Street Renton				Minor Street (Both Directions) Street Cloverdale			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	7	13	5	8	113	127	119	120	27	20	25	24
8:15	43	29	31	34*	110	129	102	114	23	26	29	26
8:30	3	12	10	8	128	130	116	125	42	34	42	39
8:45	0	4	0	1	93	102	88	94	12	22	13	16
9:00	1	1	1	1	88	92	85	88	14	10	12	12
9:15	1	2	1	1	81	89	71	80	7	14	7	9
9:30	2	4	1	2	101	86	79	89	15	14	11	13
9:45	0	1	0	0	90	68	62	73	21	19	21	20
TOTAL	57	66	49	57	804	823	722	783	161	159	160	160
11:00	3	2	0	2	127	87	104	106	24	17	10	17
11:15	0	1	0	0	101	79	104	95	21	21	24	22
11:30	2	1	0	1	112	103	102	106	15	26	31	24
11:45	0	0	2	1	105	103	119	109	23	24	22	23
12:00	2	0	3	2	129	103	127	120	18	28	31	26
12:15	1	3	3	2	129	91	127	116	24	15	25	21
12:30	0	0	0	0	109	110	122	114	18	25	30	24
12:45	0	1	1	1	114	125	106	115	26	31	19	25
TOTAL	8	9	9	8	926	801	911	879	169	187	192	183
2:00	8	1	0	3	152	113	107	124	26	28	19	24
2:15	0	5	4	3	143	142	122	136	28	29	31	29
2:30	11	10	9	10	144	125	171	147	55	27	45	42
2:45	23	24	23	23	147	139	147	144	46	38	41	42
3:00	5	7	7	6	149	129	144	141	44	40	40	41
3:15	8	2	7	6	147	153	143	148	33	39	30	34
3:30	2	3	8	4	160	131	150	147	45	53	42	47
3:45	4	2	7	4	199	167	205	190	37	36	52	42
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	1	0	6	2	173	192	168	178	50	55	51	52
4:30	7	0	2	3	193	170	199	187	59	58	57	58
4:45	2	2	0	1	218	188	193	200*	62	78	54	64*
TOTAL	71	54	73	66	1,825	1,649	1,749	1,741	485	481	462	476
DAILY TOTAL	136	128	131	132	3,555	3,273	3,382	3,403	815	827	814	819

†Beginning of 15 minute period.

*Peak 15 minute period.

VOLUME DATA SUMMARY

CITY Memphis

CONTROL C-5, Full Signalization (Full-Act.)

SITE Knight-Arnold & Castleman

Time†	Ped Volume				Vehicle Volume							
	Crossing Major Street Street Knight-Arnold				Major Street (Both Directions) Street Knight-Arnold				Minor Street (Both Directions) Street Castleman			
	Observation			Mean	Observation			Mean	Observation			Mean
	1	2	3		1	2	3		1	2	3	
7:45	–	–	–	–	–	–	–	–	–	–	–	–
8:00	2	0	0	1	335	249	281	288	79	52	61	64
8:15	0	0	0	0	309	275	296	293	87	100	99	95*
8:30	4	2	2	3	287	268	254	270	54	101	79	78
8:45	0	0	0	0	217	211	203	210	44	60	48	51
9:00	0	0	1	0	161	159	206	175	36	25	38	33
9:15	0	1	0	0	157	146	191	165	25	33	27	28
9:30	0	0	0	0	145	135	206	162	19	15	30	21
9:45	1	0	0	0	187	148	177	171	37	23	24	28
TOTAL	7	3	3	4	1,798	1,591	1,814	1,734	381	409	406	399
11:00	0	0	0	0	213	185	191	196	32	25	25	27
11:15	0	0	0	0	205	202	263	223	28	27	34	30
11:30	0	2	0	1	254	234	262	250	46	60	81	62
11:45	3	0	0	1	235	228	285	250	41	35	39	38
12:00	0	0	0	0	251	207	274	244	83	57	92	77
12:15	0	0	0	0	293	287	290	290	59	35	52	49
12:30	0	0	1	0	301	273	318	297	33	44	51	43
12:45	0	1	4	2	261	239	234	245	34	38	35	36
TOTAL	3	3	5	4	2,013	1,855	2,120	1,996	356	321	409	362
2:00	–	–	–	–	–	–	–	–	–	–	–	–
2:15	11	3	9	8	268	319	253	280	91	150	122	121
2:30	39	24	25	29*	264	250	294	269	63	69	83	72
2:45	4	2	1	2	243	268	289	267	36	55	58	50
3:00	1	2	1	1	279	309	304	297	74	81	70	75
3:15	0	4	3	2	300	339	337	325	72	76	85	78
3:30	9	1	2	4	346	283	318	316	91	69	96	85
3:45	1	1	0	1	323	248	324	298	69	47	65	60
4:00	–	–	–	–	–	–	–	–	–	–	–	–
4:15	1	0	0	0	359	362	325	349	33	61	57	50
4:30	4	0	1	2	345	359	347	350*	51	41	68	53
4:45	2	0	0	1	363	335	344	347	58	58	62	59
TOTAL	72	37	42	50	3,090	3,072	3,135	3,099	638	707	766	704
DAILY TOTAL	82	43	50	58	6,901	6,518	7,069	6,829	1,375	1,437	1,581	1,464

†Beginning of 15 minute period.

*Peak 15 minute period.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign — CONTROL C-1, Full Signalization (Semi-Act.)

SITE S. Cobb & Barber — SITE Roswell & Dalrymple

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
ATL 1 MAJ 1 (A)	1	2.7216	2.7216	20.3770[S]
TIME OF DAY (B)	2	2.9262	1.4631	10.9543[S]
VISIT NUMBER(C)	2	0.3386	0.1693	1.2674
AB	2	0.1224	0.0612	0.4583
AC	2	0.0445	0.0223	0.1666
BC	4	0.2476	0.0619	0.4635
ABC	4	0.2740	0.0685	0.5128
EXP. ERROR	138	18.4318	0.1336	
TOTAL	155	25.1068		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
ATL 1 MAJ 2 (A)	1	0.5044	0.5044	126.2494[S]
TIME OF DAY (B)	2	0.7083	0.3542	88.6426[S]
VISIT NUMBER(C)	2	0.0047	0.0023	0.5860
AB	2	0.0469	0.0234	5.8688[S]
AC	2	0.0031	0.0016	0.3900
BC	4	0.0026	0.0007	0.1646
ABC	4	0.0032	0.0008	0.1987
EXP. ERROR	138	0.5514	0.0040	
TOTAL	155	1.8246		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
ATL 1 MIN 4 (A)	1	23.9849	23.9849	944.0255[S]
TIME OF DAY (B)	2	0.4826	0.2413	9.4982[S]
VISIT NUMBER(C)	2	0.0032	0.0016	0.0629
AB	2	0.0516	0.0258	1.0154
AC	2	0.0570	0.0285	1.1213
BC	4	0.0498	0.0125	0.4905
ABC	4	0.0236	0.0059	0.2324
EXP. ERROR	138	3.5062	0.0254	
TOTAL	155	28.1590		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign — CONTROL C-1, Full Signalization (Semi-Act.)

SITE Broadway & Pine — SITE Broadway & Mortimer

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
BUFF 1 MAJ 3(A)	1	11.0458	13.0458	129.9817[S]
TIME OF DAY (B)	2	1.8806	0.9403	9.3685[S]
VISIT NUMBER(C)	2	0.2589	0.1295	1.2900
AB	2	0.6583	0.3292	3.2796
AC	2	0.1359	0.0680	0.6771
BC	4	0.8401	0.2100	2.0925
ABC	4	0.7128	0.1782	1.7756
EXP. ERROR	133	13.3487	0.1004	
TOTAL	150	30.8811		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
BUF 1 MAJ 6 (A)	1	0.0326	0.0326	7.1106
TIME OF DAY (B)	2	0.0937	0.0468	10.2183[S]
VISIT NUMBER(C)	2	0.0049	0.0025	0.5349
AB	2	0.0004	0.0002	0.0461
AC	2	0.0020	0.0010	0.2141
BC	4	0.0149	0.0037	0.8123
ABC	4	0.0068	0.0017	0.3728
EXP. ERROR	132	0.6049	0.0046	
TOTAL	149	0.7602		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
BUF 1 MIN 8 (A)	1	1.4565	1.4565	53.9574[S]
TIME OF DAY (B)	2	1.7367	0.8683	32.1686[S]
VISIT NUMBER(C)	2	0.0164	0.0082	0.3041
AB	2	0.0268	0.0134	0.4956
AC	2	0.1171	0.0586	2.1691
BC	4	0.0446	0.0112	0.4131
ABC	4	0.0507	0.0127	0.4695
EXP. ERROR	132	3.5631	0.0270	
TOTAL	149	7.0119		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon — CONTROL C-2, Full Signalization (Full-Act.)

SITE Hollywood & Heard — SITE Hollywood & Peres

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 2 MAJ 7 (A)	1	0.7479	0.7479	7.8583
TIME OF DAY (B)	2	5.9525	2.9262	30.7447[S]
VISIT NUMBER(C)	2	0.3655	0.1827	1.9200
AB	2	0.4025	0.2012	2.1144
AC	2	0.1492	0.0746	0.7839
BC	4	0.3503	0.0876	0.9201
ABC	4	0.1779	0.0445	0.4673
EXP. ERROR	108	10.2793	0.0952	
TOTAL	125	18.3251		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 2 MAJ 10(A)	1	0.0675	0.0675	16.2201[S]
TIME OF DAY (B)	2	0.7301	0.3651	87.7759[S]
VISIT NUMBER(C)	2	0.0093	0.0047	1.1208
AB	2	0.0446	0.0223	5.3584
AC	2	0.0260	0.0130	3.1236
BC	4	0.0123	0.0031	0.7384
ABC	4	0.0303	0.0076	1.8234
EXP. ERROR	108	0.4492	0.0042	
TOTAL	125	1.3692		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 2 MIN 12(A)	1	11.2000	11.2000	831.5757[S]
TIME OF DAY (B)	2	0.8814	0.4407	32.7197[S]
VISIT NUMBER(C)	2	0.0382	0.0191	1.4166
AB	2	0.2427	0.1214	9.0115[S]
AC	2	0.0214	0.0107	0.7933
BC	4	0.0757	0.0189	1.4055
ABC	4	0.0609	0.0152	1.1299
EXP. ERROR	108	1.4546	0.0135	
TOTAL	125	13.9748		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon — CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 24th — SITE Hamilton & 36th

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SC 2 MAJ 5 (A)	1	0.0731	0.0731	0.6991
TIME OF DAY (B)	2	1.0798	0.5399	5.1613
VISIT NUMBER(C)	2	0.1663	0.0831	0.7949
AB	2	0.4978	0.2489	2.3796
AC	2	0.0672	0.0336	0.3214
BC	4	0.1662	0.0415	0.3971
ABC	4	0.0254	0.0063	0.0606
EXP. ERROR	132	13.8073	0.1046	
TOTAL	149	15.8831		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SC 2 MAJ 14 (A)	1	5.1645	5.1645	1191.6777[S]
TIME OF DAY (B)	2	1.0531	0.5266	121.5008[S]
VISIT NUMBER(C)	2	0.0869	0.0435	10.0275[S]
AB	2	0.1010	0.0505	11.6517[S]
AC	2	0.0093	0.0047	1.0752
BC	4	0.0075	0.0019	0.4326
ABC	4	0.0021	0.0005	0.1228
EXP. ERROR	132	0.5721	0.0043	
TOTAL	149	6.9965		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SC 2 MIN 16 (A)	1	20.5671	20.5671	763.9661[S]
TIME OF DAY (B)	2	0.3078	0.1539	5.7168[S]
VISIT NUMBER(C)	2	0.7842	0.3921	14.5649[S]
AB	2	0.0113	0.0056	0.2093
AC	2	0.1681	0.0841	3.1225
BC	4	0.0930	0.0232	0.8636
ABC	4	0.0548	0.0137	0.5088
EXP. ERROR	132	3.5536	0.0269	
TOTAL	149	25.5400		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Full Stop Sign — CONTROL C-3, Full Signalization (Pre-timed)

SITE South & 52nd — SITE Randolph & 40th

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 3 MAJ 9 (A)	1	2.3767	2.3767	13.8968[S]
TIME OF DAY (B)	2	1.2024	0.6012	3.5155[S]
VISIT NUMBER(C)	2	0.1589	0.0794	0.4645
AB	2	0.1981	0.0990	0.5790
AC	2	0.0407	0.0204	0.1190
BC	4	0.1898	0.0474	0.2774
ABC	4	0.1512	0.0378	0.2210
EXP. ERROR	138	23.6011	0.1710	
TOTAL	155	27.9188		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 3 MAJ 18(A)	1	0.2491	0.2491	27.8370[S]
TIME OF DAY (B)	2	0.5584	0.2792	31.2047[S]
VISIT NUMBER(C)	2	0.1333	0.0666	7.4486[S]
AB	2	0.0033	0.0016	0.1837
AC	2	0.0288	0.0144	1.6102
BC	4	0.0017	0.0004	0.0477
ABC	4	0.0043	0.0011	0.1212
EXP. ERROR	138	1.2347	0.0089	
TOTAL	155	2.2137		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 3 MIN 20(A)	1	17.8505	17.8505	458.7450[S]
TIME OF DAY (B)	2	1.6851	0.8426	21.6530[S]
VISIT NUMBER(C)	2	0.1340	0.0670	1.7221
AB	2	0.1985	0.0993	2.5510
AC	2	0.1816	0.0908	2.3329
BC	4	0.0371	0.0093	0.2384
ABC	4	0.0522	0.0131	0.3354
EXP. ERROR	138	5.3698	0.0389	
TOTAL	155	25.5088		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign — CONTROL C-3, Full Signalization (Pre-timed)

SITE Beacon & Hanford — SITE Rainier & Walden

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 3 MAJ 11(A)	1	0.1097	0.1097	0.8516
TIME OF DAY (B)	2	6.8821	3.4410	26.7193[S]
VISIT NUMBER(C)	2	0.1072	0.0536	0.4163
AB	2	0.0729	0.0365	0.2831
AC	2	0.3586	0.1793	1.3924
BC	4	0.4049	0.1012	0.7859
ABC	4	0.0249	0.0062	0.0484
EXP. ERROR	138	17.7723	0.1288	
TOTAL	155	25.7326		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 3 MAJ 22(A)	1	2.5939	2.5939	380.3396[S]
TIME OF DAY (B)	2	1.9898	0.9949	145.8850[S]
VISIT NUMBER(C)	2	0.0075	0.0037	0.5471
AB	2	0.0690	0.0345	5.0612
AC	2	0.0168	0.0084	1.2316
BC	4	0.0237	0.0059	0.8670
ABC	4	0.0355	0.0089	1.3004
EXP. ERROR	138	0.9411	0.0068	
TOTAL	155	5.6773		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 3 MIN 24(A)	1	11.3380	11.3380	576.7357[S]
TIME OF DAY (B)	2	1.7809	0.8905	45.2951[S]
VISIT NUMBER(C)	2	0.0796	0.0398	2.0241
AB	2	0.0209	0.0105	0.5328
AC	2	0.0385	0.0192	0.9786
BC	4	0.1785	0.0446	2.2698
ABC	4	0.1801	0.0450	2.2903
EXP. ERROR	138	2.7129	0.0197	
TOTAL	155	16.3295		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — CONTROL C-4, Full Signalization (Semi-Act.)

SITE South & 20th — SITE "O" & 25th

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 4 MAJ 13(A)	1	0.9796	0.9796	3.8103
TIME OF DAY (B)	2	5.5454	2.7727	10.7843[S]
VISIT NUMBER(C)	2	0.4009	0.2005	0.7797
AB	2	0.4308	0.2154	0.8378
AC	2	0.3556	0.1778	0.6916
BC	4	0.4589	0.1147	0.4462
ABC	4	0.2566	0.0642	0.2495
EXP. ERROR	138	35.4806	0.2571	
TOTAL	155	43.9085		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 4 MAJ 26(A)	1	0.8130	0.8130	180.0292[S]
TIME OF DAY (B)	2	0.9556	0.4778	105.8081[S]
VISIT NUMBER(C)	2	0.0158	0.0079	1.7493
AB	2	0.0360	0.0180	3.9863
AC	2	0.0126	0.0063	1.3938
BC	4	0.0124	0.0031	0.6839
ABC	4	0.0076	0.0019	0.4203
EXP. ERROR	138	0.6232	0.0045	
TOTAL	155	2.4762		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
LIN 4 MIN 28(A)	1	2.4877	2.4877	118.2728[S]
TIME OF DAY (B)	2	1.2414	0.6207	29.5099[S]
VISIT NUMBER(C)	2	0.0600	0.0300	1.4267
AB	2	0.1879	0.0940	4.4677
AC	2	0.3884	0.1942	9.2324[S]
BC	4	0.0593	0.0148	0.7049
ABC	4	0.0329	0.0082	0.3916
EXP. ERROR	138	2.9026	0.0210	
TOTAL	155	7.3603		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Fauntleroy & Myrtle — SITE Renton & Cloverdale

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 4 MAJ 15(A)	1	0.3070	0.3070	1.7148
TIME OF DAY (B)	2	4.2448	2.1224	11.8564S
VISIT NUMBER(C)	2	0.0135	0.0068	0.0378
AB	2	0.2900	0.1450	0.8101
AC	2	0.1096	0.0548	0.3060
BC	4	0.3475	0.0869	0.4853
ABC	4	0.5492	0.1373	0.7670
EXP. ERROR	144	25.7774	0.1790	
TOTAL	161	31.6390		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 4 MAJ 30(A)	1	0.0263	0.0263	3.1509
TIME OF DAY (B)	2	1.0206	0.5103	61.3264S
VISIT NUMBER(C)	2	0.0110	0.0055	2.4613
AB	2	0.0605	0.0302	3.6316
AC	2	0.0000	0.0000	0.0034
BC	4	0.0280	0.0070	0.8420
ABC	4	0.0073	0.0018	0.2183
EXP. ERROR	144	1.1983	0.0083	

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 4 MIN 32(A)	1	10.6298	10.6298	260.6707S
TIME OF DAY (B)	2	2.6873	1.3436	35.4789S
VISIT NUMBER(C)	2	0.0339	0.0169	0.4469
AB	2	0.2843	0.1422	3.7537
AC	2	0.0481	0.0241	0.6353
BC	4	0.0919	0.0230	0.6064
ABC	4	0.1016	0.0254	0.6704
EXP. ERROR	138	5.2263	0.0379	
TOTAL	155	19.1031		

S — Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Memphis

EXPERIMENT E-5, Crossing Guard — CONTROL C-5, Full Signalization (Full-Act.)

SITE Knight-Arnold & Clearbrook — SITE Knight-Arnold & Castleman

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 5 MAJ 3?(A)	1	0.5488	0.5488	6.7517
TIME OF DAY (B)	2	1.3968	0.6984	8.5914S
VISIT NUMBER(C)	2	0.3261	0.1631	2.0061
AB	2	0.6198	0.3099	3.8122
AC	2	0.0334	0.0167	0.2055
BC	4	0.1858	0.0465	0.5715
ABC	4	0.0383	0.0096	0.1179
EXP. ERROR	126	10.2425	0.0813	
TOTAL	143	13.3917		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 5 MAJ 34(A)	1	0.0217	0.0217	3.1513
TIME OF DAY (B)	2	0.7523	0.3761	54.6343S
VISIT NUMBER(C)	2	0.0295	0.0147	2.1395
AB	2	0.0021	0.0011	0.1528
AC	2	0.0004	0.0002	0.0320
BC	4	0.0210	0.0052	0.7608
ABC	4	0.0003	0.0001	0.0122
EXP. ERROR	126	0.8675	0.0069	
TOTAL	143	1.6948		

MINOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
MEM 5 MIN 36(A)	1	2.2188	2.2188	77.5569S
TIME OF DAY (B)	2	0.9714	0.4857	16.9774S
VISIT NUMBER(C)	2	0.0367	0.0183	0.6414
AB	2	0.0860	0.0430	1.5028
AC	2	0.0251	0.0126	0.4393
BC	4	0.0415	0.0104	0.3627
ABC	4	0.0028	0.0007	0.0242
EXP. ERROR	126	3.6046	0.0286	
TOTAL	143	6.9868		

S – Significant at 0.01 level.

PEDESTRIAN, VEHICLE VOLUME ANOVA TABLES

CITY Seattle

EXPERIMENT E-5, Crossing Guard — CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE 23rd & Hanford — SITE Renton & Cloverdale

PEDESTRIAN VOLUME CROSSING MAJOR STREET

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 5 MAJ 19(A)	1	4.4315	4.4315	15.4242[S]
TIME OF DAY (B)	2	5.8193	2.9097	10.1273[S]
VISIT NUMBER(C)	2	0.1766	0.0883	0.3074
AB	2	0.0468	0.0234	0.0814
AC	2	0.0021	0.0011	0.0037
BC	4	0.1971	0.0493	0.1715
ABC	4	0.4647	0.1162	0.4044
EXP. ERROR	132	37.9247	0.2873	
TOTAL	149	49.0629		

MAJOR STREET VEHICLE VOLUME

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 5 MAJ 38(A)	1	0.0007	0.0007	0.0546
TIME OF DAY (B)	2	1.3586	0.6793	55.8435[S]
VISIT NUMBER(C)	2	0.0101	0.0050	0.4143
AB	2	0.1781	0.0890	7.3191[S]
AC	2	0.0568	0.0284	2.3348
BC	4	0.0447	0.0112	0.9183
ABC	4	0.0130	0.0032	0.2662
EXP. ERROR	132	1.6056	0.0122	
TOTAL	149	3.2674		

MINOR STREET VEHICLE VOLUME

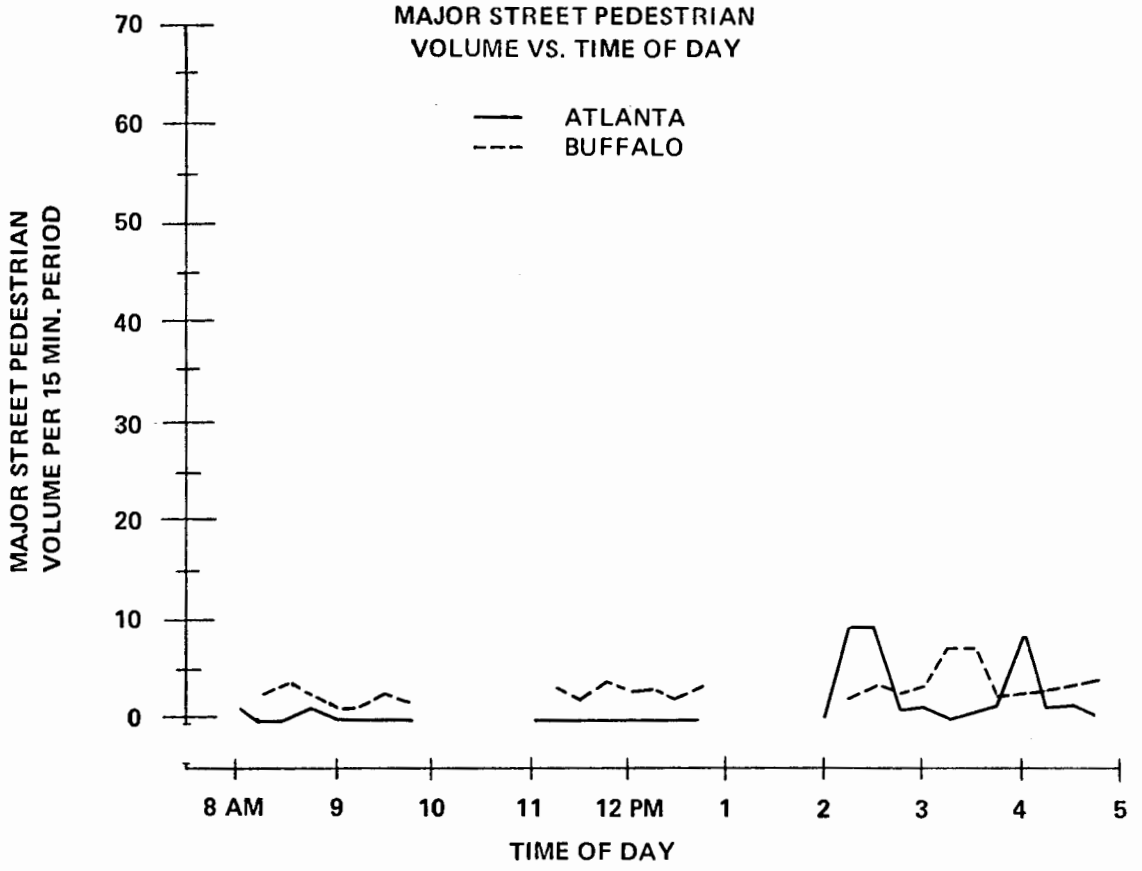
SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-RATIO (ALL FIXED)
SEA 5 MIN 40(A)	1	5.6780	5.6780	201.4249[S]
TIME OF DAY (B)	2	2.2586	1.1293	40.0617[S]
VISIT NUMBER(C)	2	0.0237	0.0119	0.4211
AB	2	0.3573	0.1786	6.3371[S]
AC	2	0.0023	0.0012	0.0409
BC	4	0.1775	0.0444	1.5745
ABC	4	0.0349	0.0087	0.3099
EXP. ERROR	132	3.7210	0.0282	
TOTAL	149	12.2534		

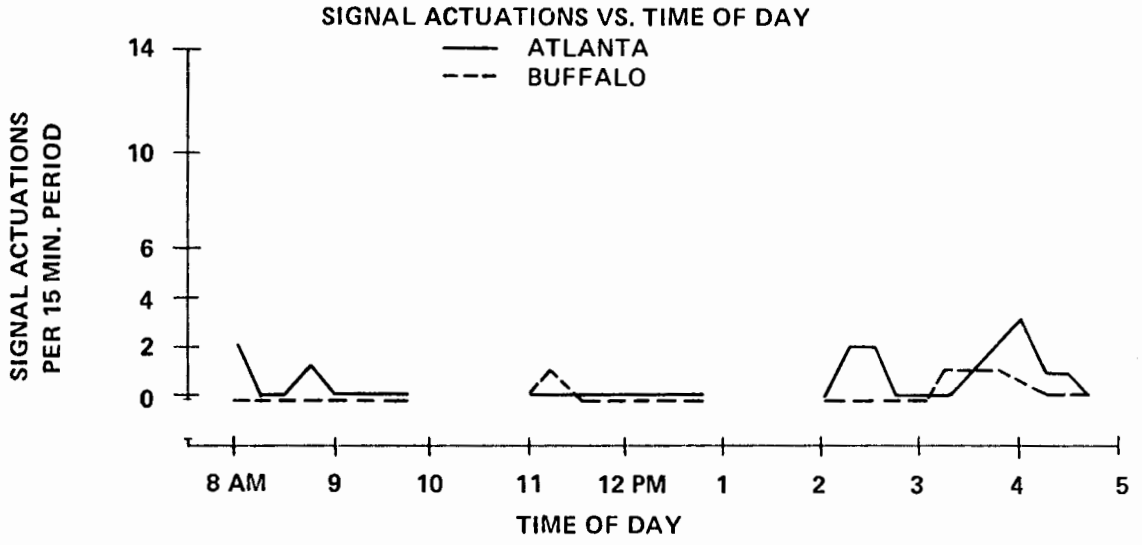
S – Significant at 0.01 level.

PEDESTRIAN VOLUME AND SIGNAL ACTUATIONS VS. TIME OF DAY

EXPERIMENT E-1, SIGN & STOP SIGN

CITY ATLANTA CITY BUFFALO

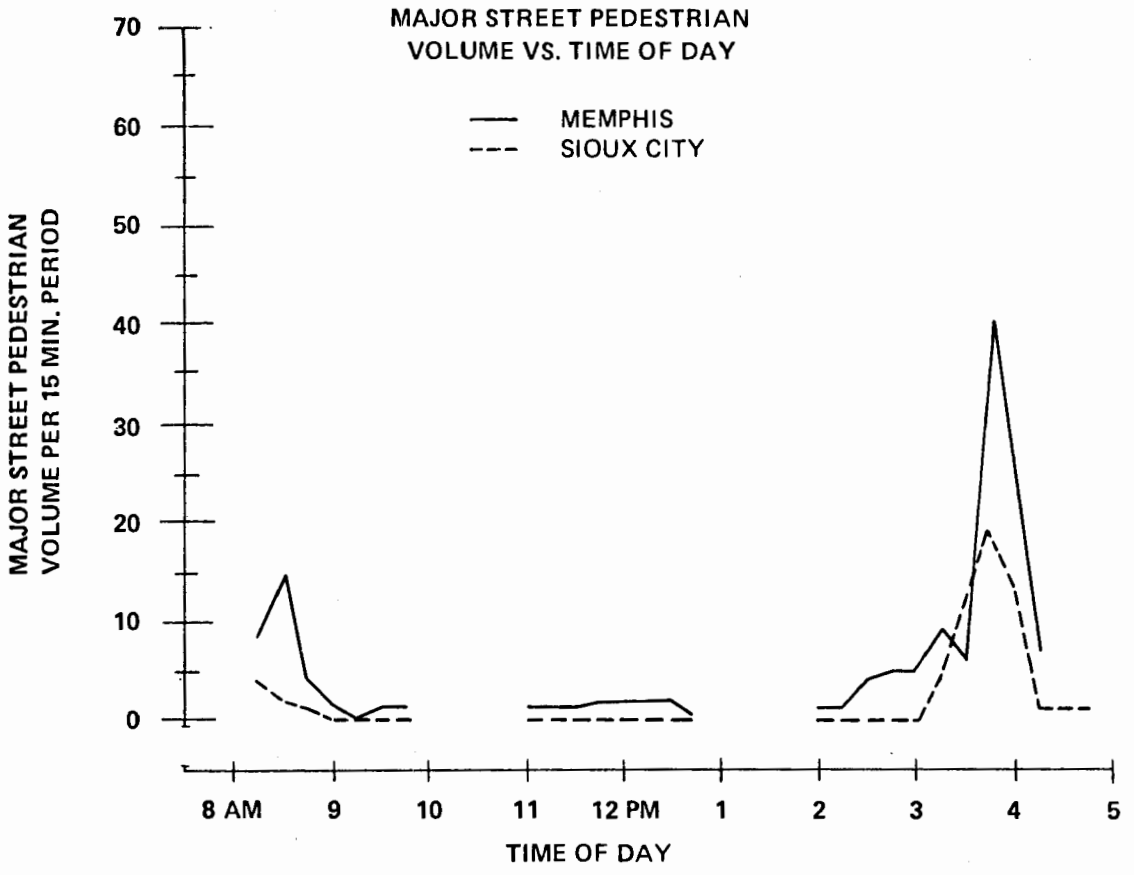


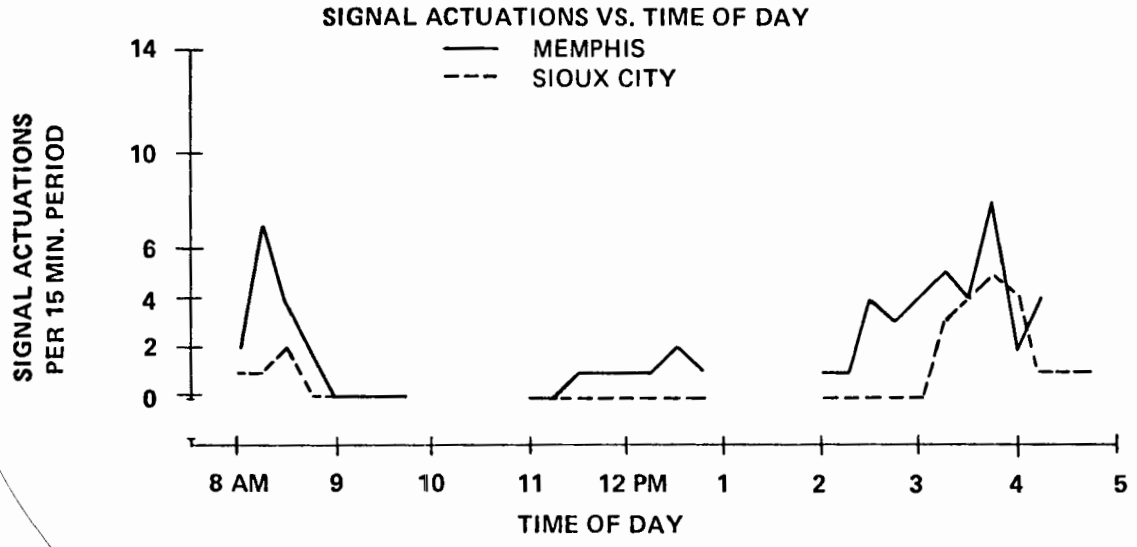


PEDESTRIAN VOLUME AND SIGNAL ACTUATIONS VS. TIME OF DAY

EXPERIMENT E-2, F. YELLOW SIGNAL & F, RED BEACON

CITY MEMPHIS CITY SIOUX CITY

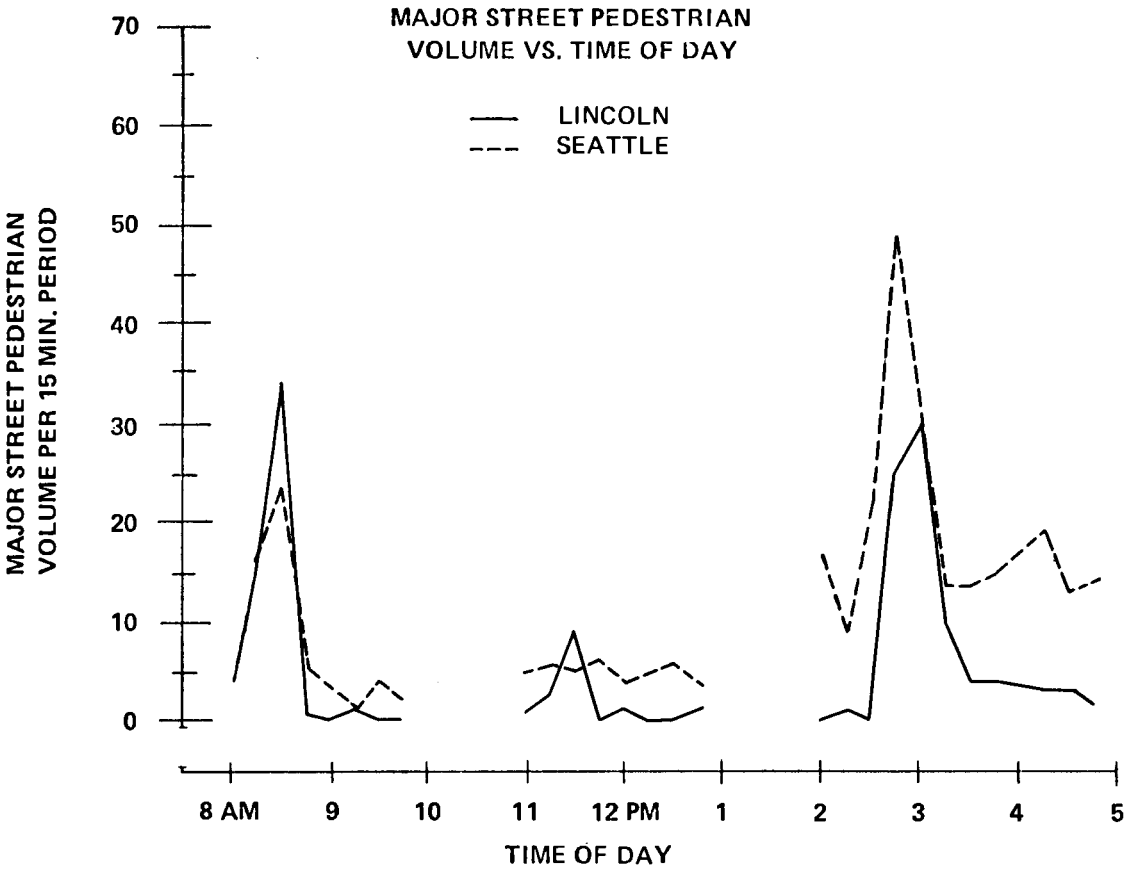


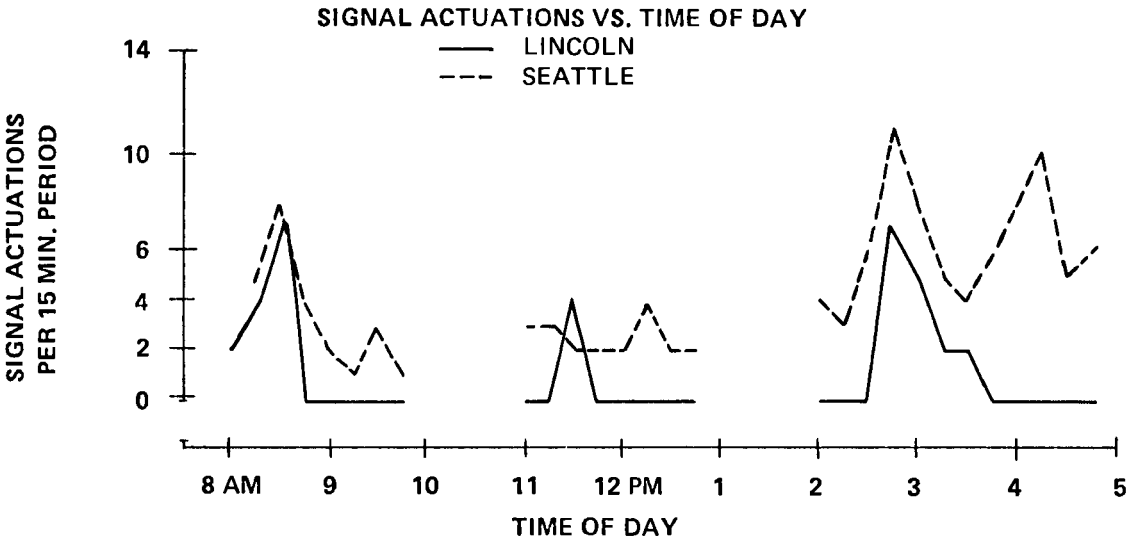


PEDESTRIAN VOLUME AND SIGNAL ACTUATIONS VS. TIME OF DAY

EXPERIMENT E-3, F. GREEN SIGNAL & STOP SIGN

CITY LINCOLN CITY SEATTLE

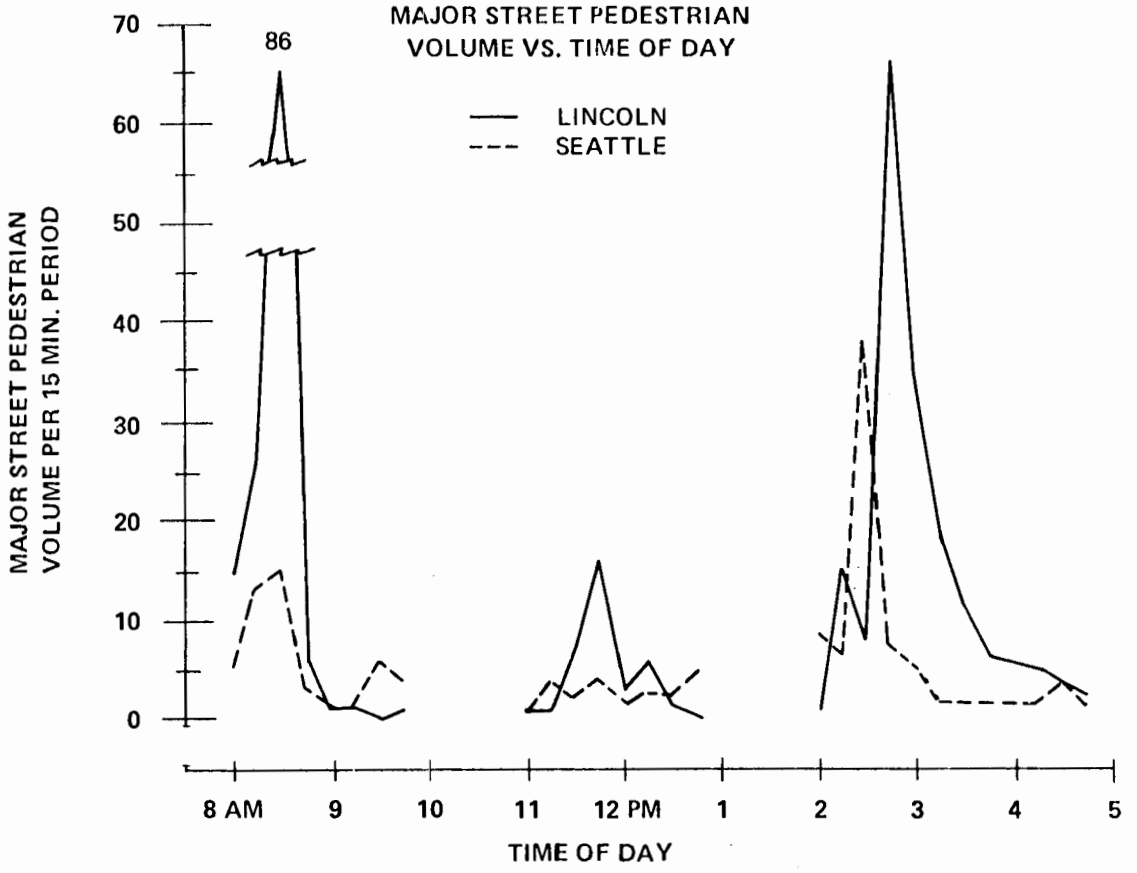


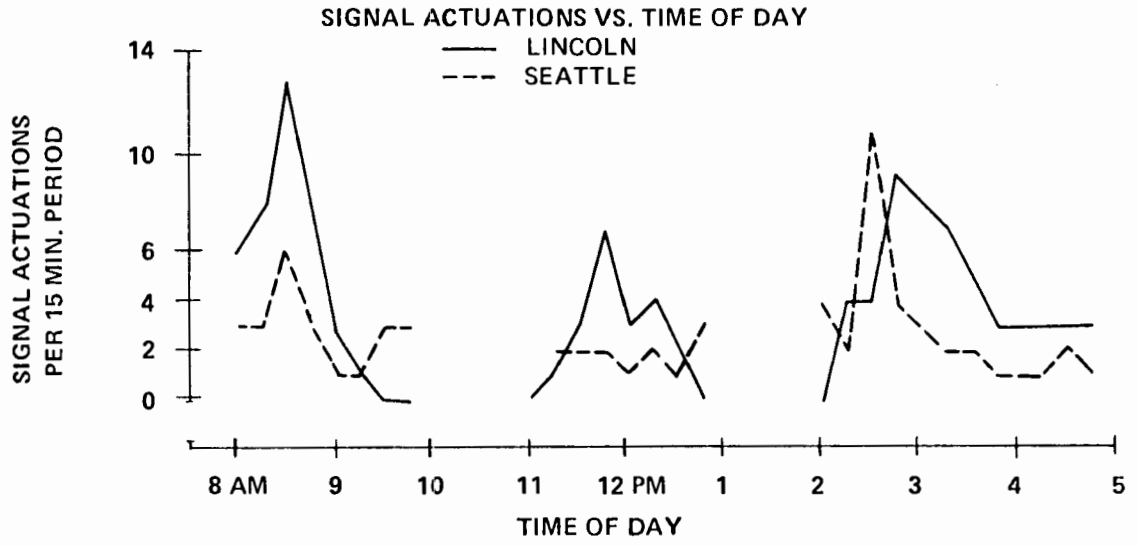


PEDESTRIAN VOLUME AND SIGNAL ACTUATIONS VS. TIME OF DAY

EXPERIMENT E-4, (Sg-44) SIGNAL & STOP SIGN

CITY LINCOLN CITY SEATTLE





APPENDIX E

VEHICLE DELAY DATA SUMMARIES

VEHICLE DELAY DATA SUMMARY

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign

SITE S. Cobb & Barber

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Roswell & Dalrymple

	Experiment				Control			
	Major St. — S. Cobb				Major St. — Roswell			
	Time of Observation* 7:45 AM				Time of Observation* 7:45 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	309	315	351	975	230	294	280	804
Total Stopped	20	16	40	76	73	136	89	298
Percent Stopped	6.5	5.1	11.4	7.8	31.7	46.3	31.8	37.1
Total Stop Time†	182	195	975	1,352	936	1,365	1,508	3,809
Stop Time Per† Stopped Veh.	9.1	12.2	24.4	17.8	12.8	10.0	16.9	12.8
Stop Time Per Veh.†	0.6	0.6	2.8	1.4	4.1	4.6	5.4	4.7
Time of Observation* 11:15 AM					Time of Observation* 11:15 AM			
Total Vehicles	261	285	249	795	204	205	199	608
Total Stopped	18	1	6	25	67	89	66	222
Percent Stopped	6.9	0.4	2.4	3.1	32.8	43.4	33.2	36.5
Total Stop Time	377	0	182	559	754	1,118	897	2,769
Stop Time Per Stopped Veh.	20.9	0	30.3	22.3	11.3	12.6	13.6	12.5
Stop Time Per Veh.	1.4	0	0.7	0.7	3.7	5.5	4.5	4.6
Time of Observation* 2:30 PM					Time of Observation* 2:15 PM			
Total Vehicles	335	290	332	957	240	246	230	716
Total Stopped	47	0	34	81	93	94	106	293
Percent Stopped	14.0	0	10.2	8.5	38.8	38.2	46.1	40.9
Total Stop Time	546	0	676	1,222	1,430	1,261	1,625	4,316
Stop Time Per Stopped Veh.	11.6	0	19.9	15.5	15.4	13.4	15.3	14.7
Stop Time Per Veh.	1.6	0	2.0	1.3	6.0	5.1	7.1	6.0
Time of Observation* 3:45 PM					Time of Observation* 3:45 PM			
Total Vehicles	419	319	318	1,056	281	259	264	804
Total Stopped	40	0	6	46	131	119	126	376
Percent Stopped	9.5	0	1.9	4.4	46.6	45.9	47.7	46.8
Total Stop Time	741	0	65	806	2,184	2,132	2,340	6,656
Stop Time Per Stopped Veh.	18.5	0	10.8	17.5	16.7	17.9	18.5	17.7
Stop Time Per Veh.	1.8	0	0.2	0.8	7.8	8.2	8.9	8.3

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign

SITE S. Cobb & Barber

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Roswell & Dalrymple

	Experiment				Control			
	Minor St. – Barber				Minor St. – Dalrymple			
	Time of Observation* 8:15 AM				Time of Observation* 8:15 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	25	22	17	64	205	138	90	433
Total Stopped	21	17	12	50	123	75	49	247
Percent Stopped	84.0	77.3	70.6	78.1	60.0	54.3	54.4	57.0
Total Stop Time†	286	208	260	754	2,054	1,339	1,027	4,420
Stop Time Per† Stopped Veh.	13.6	12.2	21.7	15.1	16.5	17.9	21.0	17.9
Stop Time Per Veh.†	11.4	9.5	15.3	11.8	10.0	9.7	11.4	10.2
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	25	7	8	40	85	100	87	272
Total Stopped	15	2	5	22	56	54	54	164
Percent Stopped	60.0	28.6	62.5	55.0	65.9	54.0	62.1	60.3
Total Stop Time	143	26	52	221	988	962	832	2,782
Stop Time Per Stopped Veh.	9.5	13.0	10.4	10.0	17.6	17.8	15.4	17.0
Stop Time Per Veh.	5.7	3.7	6.5	5.5	11.6	9.6	9.6	10.2
Time of Observation* 2:15 PM					Time of Observation* 2:30 PM			
Total Vehicles	19	17	7	43	125	82	125	332
Total Stopped	17	13	5	35	60	47	66	173
Percent Stopped	89.5	76.5	71.4	81.4	48.0	57.3	52.8	52.1
Total Stop Time	286	364	91	741	988	845	1,118	2,951
Stop Time Per Stopped Veh.	16.8	28.0	18.2	21.2	16.5	18.0	16.9	17.1
Stop Time Per Veh.	15.1	21.4	13.0	17.2	7.9	10.3	8.9	8.9
Time of Observation* 4:00 PM					Time of Observation* 4:00 PM			
Total Vehicles	25	30	22	77	165	119	133	417
Total Stopped	24	24	11	59	113	68	83	264
Percent Stopped	96.0	80.0	50.0	76.6	68.5	57.1	62.4	63.3
Total Stop Time	377	416	143	936	2,431	1,183	1,573	5,187
Stop Time Per Stopped Veh.	15.7	17.3	13.0	15.9	21.5	17.4	19.0	19.6
Stop Time Per Veh.	15.1	13.9	6.5	12.2	14.7	9.9	11.8	12.4

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign — CONTROL C-1, Full Signalization (Semi-Act.)

SITE Broadway & Pine — SITE Broadway & Mortimer

	Experiment				Control			
	Major St. – Broadway				Major St. – Broadway			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	211	186	168	565	232	210	229	671
Total Stopped	11	4	1	16	52	41	23	116
Percent Stopped	5.2	2.2	0.6	2.8	22.4	19.5	10.0	17.3
Total Stop Time†	78	52	13	143	715	715	195	1,625
Stop Time Per† Stopped Veh.	7.1	13.0	13.0	8.9	13.8	17.4	8.5	14.0
Stop Time Per Veh.†	0.4	0.3	0.1	0.3	3.1	3.4	0.9	2.4
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	137	116	134	387	143	154	146	443
Total Stopped	10	1	3	14	15	43	33	91
Percent Stopped	7.3	0.9	2.2	3.6	10.5	27.9	22.6	20.5
Total Stop Time	52	13	65	130	117	572	429	1,118
Stop Time Per Stopped Veh.	5.2	13.0	21.7	9.3	7.8	13.3	13.0	12.3
Stop Time Per Veh.	0.4	0.1	0.5	0.3	0.8	3.7	2.9	2.5
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	148	152	131	431	157	158	175	490
Total Stopped	16	4	2	22	37	52	23	112
Percent Stopped	10.8	2.6	1.5	5.1	23.6	32.9	13.1	22.9
Total Stop Time	156	0	0	156	260	507	208	975
Stop Time Per Stopped Veh.	9.8	0	0	7.1	7.0	9.8	6.3	8.7
Stop Time Per Veh.	1.1	0	0	0.4	1.7	3.2	1.2	2.0
Time of Observation* 4:00 PM					Time of Observation* 3:30 PM			
Total Vehicles	125	132	123	380	166	163	170	499
Total Stopped	9	3	3	15	27	39	21	87
Percent Stopped	7.2	2.3	2.4	3.9	16.3	23.9	12.4	17.4
Total Stop Time	91	26	0	117	364	650	208	1,222
Stop Time Per Stopped Veh.	10.1	8.7	0	7.8	13.5	16.7	9.9	14.0
Stop Time Per Veh.	0.7	0.2	0	0.3	2.2	4.0	1.2	2.4

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign

SITE Broadway & Pine

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Broadway & Mortimer

	Experiment				Control			
	Minor St. – Pine				Minor St. – Mortimer			
	Time of Observation* 8:30 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	24	19	29	72	15	10	17	42
Total Stopped	20	10	23	53	11	10	11	32
Percent Stopped	83.3	52.6	79.3	73.6	73.3	100.0	64.7	76.2
Total Stop Time†	91	143	364	598	273	247	299	819
Stop Time Per† Stopped Veh.	4.6	14.3	15.8	11.3	24.8	24.7	27.2	25.6
Stop Time Per Veh.†	3.8	7.5	12.6	8.3	18.2	24.7	17.6	19.5
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	27	31	34	92	17	6	15	38
Total Stopped	10	20	34	64	14	5	9	28
Percent Stopped	37.0	64.5	100.0	69.6	82.3	83.3	60.0	73.7
Total Stop Time	260	364	650	1,274	559	104	182	845
Stop Time Per Stopped Veh.	26.0	18.2	19.1	19.9	39.9	20.8	20.2	30.2
Stop Time Per Veh.	9.6	11.7	19.1	13.8	32.9	17.3	12.1	22.2
Time of Observation* 2:30 PM					Time of Observation* 2:30 PM			
Total Vehicles	37	36	36	109	18	9	15	42
Total Stopped	32	32	32	87	12	7	9	28
Percent Stopped	86.5	61.1	88.9	79.8	66.7	77.8	60.0	66.7
Total Stop Time	429	169	533	1,131	312	169	234	715
Stop Time Per Stopped Veh.	13.4	7.7	16.7	13.0	26.0	24.1	26.0	25.5
Stop Time Per Veh.	11.6	4.7	14.8	10.4	17.3	18.8	15.6	17.0
Time of Observation* 3:30 PM					Time of Observation* 4:00 PM			
Total Vehicles	28	28	20	76	103	110	130	343
Total Stopped	19	18	18	55	96	100	113	309
Percent Stopped	67.9	64.3	90.0	72.4	93.2	90.9	86.9	90.1
Total Stop Time	299	299	416	1,014	2,587	4,572	3,627	10,786
Stop Time Per Stopped Veh.	15.7	16.6	23.1	18.4	26.9	45.7	32.1	34.9
Stop Time Per Veh.	10.7	10.7	20.8	13.3	25.1	41.6	27.9	31.4

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hollywood & Heard

CONTROL C-2, Full Signalization (Full-Act.)

SITE Hollywood & Peres

	Experiment				Control			
	Major St. – Hollywood				Major St. – Hollywood			
	Time of Observation* 8:30 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	277	324	278	879	237	332	285	854
Total Stopped	48	68	63	179	67	97	65	229
Percent Stopped	17.3	21.0	22.7	20.4	28.3	29.2	22.8	26.8
Total Stop Time†	897	1,001	1,066	2,964	455	897	429	1,781
Stop Time Per† Stopped Veh.	18.7	14.7	16.9	16.6	6.8	9.2	6.6	7.8
Stop Time Per Veh.†	3.2	3.1	3.8	3.4	1.9	2.7	1.5	2.1
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	236	187	245	668	209	189	219	617
Total Stopped	8	2	15	25	88	56	70	214
Percent Stopped	3.4	1.1	6.1	3.7	42.1	29.6	32.0	34.9
Total Stop Time	52	26	247	325	624	559	455	1,638
Stop Time Per Stopped Veh.	6.5	13.0	16.5	13.0	7.1	10.0	6.5	7.7
Stop Time Per Veh.	0.2	0.1	1.0	0.5	3.0	3.0	2.1	2.7
Time of Observation* 2:30 PM					Time of Observation* 2:30 PM			
Total Vehicles	324	304	305	933	246	273	306	825
Total Stopped	46	11	9	66	109	96	107	312
Percent Stopped	14.2	3.6	3.0	7.1	44.3	35.2	35.0	37.8
Total Stop Time	650	91	169	910	1,157	598	715	2,470
Stop Time Per Stopped Veh.	14.1	8.3	18.8	13.8	10.6	6.2	6.7	7.9
Stop Time Per Veh.	2.0	0.3	0.6	1.0	4.7	2.2	2.3	3.0
Time of Observation* 4:00 PM					Time of Observation* 4:00 PM			
Total Vehicles	–	318	395	713	306	265	355	926
Total Stopped	–	49	89	138	141	120	133	394
Percent Stopped	–	15.4	22.5	19.4	46.1	45.3	37.5	42.5
Total Stop Time	–	897	1,690	2,587	1,482	1,183	1,326	3,991
Stop Time Per Stopped Veh.	–	18.3	19.0	18.7	10.5	9.9	10.0	10.1
Stop Time Per Veh.	–	2.8	4.3	3.6	4.8	4.5	3.7	4.3

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hollywood & Heard

CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hollywood & Peres

	Experiment				Control			
	Minor St. — Heard				Minor St. — Peres			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	18	7	9	34	41	65	52	158
Total Stopped	13	5	8	26	24	45	27	96
Percent Stopped	72.2	71.4	88.9	76.5	58.5	69.2	51.9	60.8
Total Stop Time†	325	169	156	650	546	598	429	1,573
Stop Time Per† Stopped Veh.	25.0	33.8	19.5	25.0	22.8	13.3	15.9	16.4
Stop Time Per Veh.†	18.1	24.1	17.3	19.1	13.3	9.2	8.3	10.0
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	18	7	6	31	54	40	42	136
Total Stopped	12	3	3	18	36	29	29	94
Percent Stopped	66.7	42.9	50.0	58.1	66.7	72.5	69.0	69.1
Total Stop Time	156	78	65	299	403	559	494	1,456
Stop Time Per Stopped Veh.	13.0	26.0	21.7	16.6	11.2	19.3	17.0	15.5
Stop Time Per Veh.	8.7	11.1	10.8	9.6	7.5	14.0	11.8	10.7
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	16	10	12	38	80	67	79	226
Total Stopped	14	8	10	32	45	45	47	137
Percent Stopped	87.5	80.0	83.3	84.2	56.3	67.2	59.5	60.6
Total Stop Time	195	169	325	689	585	669	702	1,956
Stop Time Per Stopped Veh.	13.9	21.1	32.5	21.5	13.0	14.9	14.9	14.3
Stop Time Per Veh.	12.2	16.9	27.1	18.1	7.3	10.0	8.9	8.7
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	28	22	25	75	113	135	128	376
Total Stopped	24	13	23	60	64	114	72	250
Percent Stopped	85.7	59.1	92.0	80.0	56.6	84.4	56.3	66.5
Total Stop Time	1,937	273	1,248	3,458	806	1,365	1,131	3,302
Stop Time Per Stopped Veh.	80.7	21.0	54.3	57.6	12.6	12.0	15.7	13.2
Stop Time Per Veh.	69.2	12.4	49.9	46.1	7.1	10.1	8.8	8.8

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hamilton & 24th

CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 36th

	Experiment				Control			
	Major St. — Hamilton				Major St. — Hamilton			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	221	181	199	601	118	114	100	332
Total Stopped	6	8	6	20	53	42	29	124
Percent Stopped	2.7	4.4	3.0	3.3	44.9	36.8	29.0	37.3
Total Stop Time†	104	182	156	468	57.2	611	338	1,521
Stop Time Per† Stopped Veh.	17.3	22.8	26.0	23.4	10.8	14.5	11.7	12.3
Stop Time Per Veh.†	0.5	1.0	0.8	0.8	4.8	5.4	3.4	4.6
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	196	192	212	600	85	94	86	265
Total Stopped	8	0	6	14	22	29	11	62
Percent Stopped	4.1	0	2.8	2.3	25.9	30.9	12.8	23.4
Total Stop Time	156	0	65	221	221	195	104	520
Stop Time Per Stopped Veh.	19.5	—	10.8	15.8	10.0	6.7	9.5	8.4
Stop Time Per Veh.	0.8	0	0.3	0.4	2.6	2.1	1.2	2.0
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	254	266	287	807	35	99	129	263
Total Stopped	18	4	1	23	14	36	30	80
Percent Stopped	7.1	1.5	0.3	2.9	40.0	36.4	23.3	30.4
Total Stop Time	286	39	13	338	130	390	273	793
Stop Time Per Stopped Veh.	15.9	9.8	13.0	14.7	9.3	10.8	9.1	9.9
Stop Time Per Veh.	1.1	0.1	0.0	0.4	3.7	3.9	2.1	3.0
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	303	320	341	964	154	59	169	382
Total Stopped	66	50	66	182	78	32	80	190
Percent Stopped	21.8	15.6	19.4	18.9	50.6	54.2	47.3	49.7
Total Stop Time	754	546	1,027	2,327	1,118	312	1,092	2,522
Stop Time Per Stopped Veh.	11.4	10.9	15.6	12.8	14.3	9.8	13.7	13.3
Stop Time Per Veh.	2.5	1.7	3.0	2.4	7.3	5.3	6.5	6.6

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hamilton & 24th

CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 36th

	Experiment				Control			
	Minor St. – 24th				Minor St. – 36th			
	Time of Observation* 8:30 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	13	13	7	33	52	–	57	109
Total Stopped	13	6	5	24	22	–	35	57
Percent Stopped	100.0	46.2	71.4	72.7	42.3	–	61.4	52.3
Total Stop Time†	156	52	78	286	312	–	468	780
Stop Time Per† Stopped Veh.	12.0	8.7	15.6	11.9	14.2	–	13.4	13.7
Stop Time Per Veh.†	12.0	4.0	11.1	8.7	6.0	–	8.2	7.2
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	12	6	11	29	46	40	34	120
Total Stopped	10	5	11	26	27	20	20	67
Percent Stopped	83.3	83.3	100.0	89.7	58.7	50.0	58.8	55.8
Total Stop Time	143	39	182	364	377	286	247	910
Stop Time Per Stopped Veh.	14.3	7.8	16.5	14.0	14.0	14.3	12.4	13.6
Stop Time Per Veh.	11.9	6.5	16.5	12.6	8.2	7.2	7.3	7.6
Time of Observation* 2:30 PM					Time of Observation* 2:30 PM			
Total Vehicles	11	9	8	28	73	49	40	162
Total Stopped	11	3	5	19	44	32	25	101
Percent Stopped	100.0	33.3	62.5	67.9	60.3	65.3	62.5	62.3
Total Stop Time	169	39	65	273	767	663	195	1,625
Stop Time Per Stopped Veh.	15.4	13.0	13.0	14.4	17.4	20.7	7.8	16.1
Stop Time Per Veh.	15.4	4.3	8.1	9.8	10.5	13.5	4.9	10.0
Time of Observation* 4:00 PM					Time of Observation* 4:00 PM			
Total Vehicles	14	8	14	36	53	46	67	166
Total Stopped	12	7	12	31	35	33	44	112
Percent Stopped	85.7	87.5	85.7	86.1	66.0	71.7	65.6	67.5
Total Stop Time	390	52	338	780	546	520	689	1,755
Stop Time Per Stopped Veh.	32.5	7.4	28.2	25.2	15.6	15.8	15.7	15.7
Stop Time Per Veh.	27.9	6.5	24.1	21.7	10.3	11.3	10.3	10.6

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE South & 52nd

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Randolph & 40th

	Experiment				Control			
	Major St. — South				Major St. — Randolph			
	Time of Observation* 8:15 AM				Time of Observation* 8:15 AM			
	1 **	2	3	Total	1	2	3	Total
Total Vehicles	145	115	121	381	100	102	95	297
Total Stopped	36	20	12	68	26	34	29	89
Percent Stopped	24.8	17.4	9.9	17.8	26.0	33.3	30.5	30.0
Total Stop Time†	550	234	117	901	234	507	273	1,014
Stop Time Per† Stopped Veh.	15.3	11.7	9.8	13.3	9.0	14.9	9.4	11.4
Stop Time Per Veh.†	3.8	2.0	1.0	2.4	2.3	5.0	2.9	3.4
Time of Observation* 11:15 AM					Time of Observation* 11:15 AM			
Total Vehicles	112	87	103	302	86	87	56	229
Total Stopped	1	3	1	5	29	22	12	63
Percent Stopped	0.9	3.4	1.0	1.7	33.7	25.3	21.4	27.5
Total Stop Time	30	78	0	108	650	260	182	1,092
Stop Time Per Stopped Veh.	30.0	26.0	0.0	21.6	22.4	11.8	15.2	17.3
Stop Time Per Veh.	0.3	0.9	0.0	0.4	7.6	3.0	3.3	4.8
Time of Observation* 2:15 PM					Time of Observation* 2:15 PM			
Total Vehicles	115	119	110	344	85	105	94	284
Total Stopped	0	0	0	0	20	21	22	63
Percent Stopped	0	0	0	0	23.5	20.0	23.4	22.2
Total Stop Time	0	0	0	0	208	377	234	819
Stop Time Per Stopped Veh.	–	–	–	–	10.4	18.0	10.6	13.0
Stop Time Per Veh.	0	0	0	0	2.4	3.6	2.5	2.9
Time of Observation* 3:45 PM					Time of Observation* 3:45 PM			
Total Vehicles	161	154	146	461	107	123	116	346
Total Stopped	25	16	8	49	32	45	55	132
Percent Stopped	15.5	10.4	5.5	10.6	29.9	36.6	47.4	38.2
Total Stop Time	435	169	78	682	481	702	754	1,937
Stop Time Per Stopped Veh.	17.4	10.6	9.8	13.9	15.0	15.6	13.7	14.7
Stop Time Per Veh.	2.7	1.1	0.5	1.5	4.5	5.7	6.5	5.6

†Time in sec.

*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 Min. Observation Period.
15 Sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Stop Sign

CONTROL C-3, Full Signalization (Pre-Timed)

SITE South & 52nd

SITE Randolph & 40th

	Experiment				Control			
	Minor St. — 52nd				Minor St. — 40th			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1**	2	3	Total	1	2	3	Total
Total Vehicles	5	16	18	39	49	54	59	162
Total Stopped	2	9	4	15	23	20	31	74
Percent Stopped	40.0	56.3	22.2	38.5	46.9	37.0	52.5	45.7
Total Stop Time†	15	65	104	184	598	377	481	1,456
Stop Time Per† Stopped Veh.	7.5	7.2	26.0	12.3	26.0	18.9	15.5	19.7
Stop Time Per Veh.†	3.0	4.1	5.8	4.7	12.2	7.0	8.2	9.0
Time of Observation* 11:45 AM					Time of Observation* 11:45 AM			
Total Vehicles	11	8	7	26	62	47	34	143
Total Stopped	9	3	6	18	30	16	16	62
Percent Stopped	81.8	37.5	85.7	69.2	48.4	63.0	47.1	43.3
Total Stop Time	30	26	39	95	662	325	247	1,234
Stop Time Per Stopped Veh.	3.3	8.7	6.5	5.3	22.1	20.3	15.4	19.9
Stop Time Per Veh.	2.7	3.3	5.6	3.7	10.7	6.9	7.3	8.6
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	10	13	12	35	47	40	40	127
Total Stopped	7	10	8	25	15	13	18	46
Percent Stopped	70.0	76.9	66.7	71.4	31.9	32.5	45.0	36.2
Total Stop Time	75	52	52	179	338	338	299	975
Stop Time Per Stopped Veh.	10.7	5.2	6.5	7.2	22.5	26.0	16.6	21.2
Stop Time Per Veh.	7.5	4.0	4.3	5.1	7.2	8.5	7.5	7.7
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	30	20	14	64	50	62	62	174
Total Stopped	26	15	12	53	24	32	39	95
Percent Stopped	86.7	75.0	85.7	82.8	48.0	51.6	62.9	54.6
Total Stop Time	390	195	104	689	455	585	949	1,989
Stop Time Per Stopped Veh.	15.0	13.0	8.7	13.0	19.0	18.3	24.3	20.9
Stop Time Per Veh.	13.0	9.8	7.4	10.8	9.1	9.4	15.3	11.4

† Time in sec.

* Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 min. observation period.
15 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE Beacon & Hanford

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Rainier & Walden

	Experiment				Control			
	Major St. – Beacon				Major St. – Rainier			
	Time of Observation* 8:15 AM				Time of Observation* 8:15 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	128	121	125	374	243	226	217	686
Total Stopped	20	37	35	92	43	33	44	120
Percent Stopped	15.6	30.6	28.0	24.6	17.7	14.6	20.3	17.5
Total Stop Time†	234	507	572	1,313	663	416	494	1,573
Stop Time Per† Stopped Veh.	11.7	13.7	16.3	14.3	15.4	12.6	11.2	13.1
Stop Time Per Veh.†	1.8	4.2	4.6	3.5	2.7	1.8	2.3	2.3
Time of Observation* 11:15 AM					Time of Observation* 11:15 AM			
Total Vehicles	130	133	119	382	238	269	257	764
Total Stopped	13	3	10	26	57	51	58	166
Percent Stopped	10.0	2.3	8.4	6.8	23.9	19.0	22.6	21.7
Total Stop Time	208	52	234	494	611	338	455	1,404
Stop Time Per Stopped Veh.	16.0	17.3	23.4	19.0	10.7	6.6	7.8	8.5
Stop Time Per Veh.	1.6	0.4	2.0	1.3	2.6	1.3	1.8	1.8
Time of Observation* 2:30 PM					Time of Observation* 2:15 PM			
Total Vehicles	185	167	174	526	308	345	300	953
Total Stopped	39	58	28	125	71	82	68	221
Percent Stopped	21.1	34.7	16.1	23.8	23.1	23.8	22.7	23.2
Total Stop Time	416	819	429	1,664	793	533	741	2,067
Stop Time Per Stopped Veh.	10.7	14.1	15.3	13.3	11.2	6.5	10.9	9.4
Stop Time Per Veh.	2.2	4.9	2.5	3.2	2.6	1.5	2.5	2.2
Time of Observation* 4:00 PM					Time of Observation* 4:00 PM			
Total Vehicles	270	251	252	773	372	375	400	1,147
Total Stopped	52	44	38	134	81	113	121	315
Percent Stopped	19.3	17.5	15.1	17.3	21.8	30.1	30.3	27.5
Total Stop Time	962	715	832	2,509	1,482	1,014	1,326	2,822
Stop Time Per Stopped Veh.	18.5	16.3	21.9	18.7	18.3	9.0	11.0	12.1
Stop Time Per Veh.	3.6	2.8	3.3	3.2	4.0	2.7	3.3	3.3

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE Beacon & Hanford

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Rainier & Walden

	Experiment				Control			
	Minor St. — Hanford				Minor St. — Walden			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	6	5	13	24	22	16	17	55
Total Stopped	3	5	9	17	16	10	13	39
Percent Stopped	50.0	100.0	69.2	70.8	72.7	62.5	76.5	70.9
Total Stop Time†	13	91	65	169	481	182	299	962
Stop Time Per† Stopped Veh.	4.3	18.2	7.2	9.9	30.1	18.2	23.0	24.7
Stop Time Per Veh.†	2.2	18.2	5.0	7.0	21.9	11.4	17.6	17.5
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	9	2	4	15	43	27	27	97
Total Stopped	8	2	4	14	30	17	18	65
Percent Stopped	88.9	100.0	100.0	93.3	69.8	63.0	66.7	67.0
Total Stop Time	91	26	65	182	585	377	364	1,326
Stop Time Per Stopped Veh.	11.4	13.0	16.3	13.0	19.5	22.2	20.2	20.4
Stop Time Per Veh.	10.1	13.0	16.3	12.1	13.6	14.0	13.5	13.7
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	18	10	4	32	51	24	38	113
Total Stopped	18	10	1	29	41	17	27	85
Percent Stopped	100.0	100.0	25.0	90.6	80.4	70.8	71.1	75.2
Total Stop Time	156	130	13	299	767	312	533	1,612
Stop Time Per Stopped Veh.	8.7	13.0	13.0	10.3	18.7	18.4	19.7	19.0
Stop Time Per Veh.	8.7	13.0	3.3	9.3	15.0	13.0	14.0	14.3
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	14	10	10	34	33	62	56	151
Total Stopped	14	10	8	32	23	45	39	107
Percent Stopped	100.0	100.0	80.0	94.1	69.7	72.6	69.6	70.9
Total Stop Time	117	117	143	377	858	1,144	1,066	3,068
Stop Time Per Stopped Veh.	8.4	11.7	17.9	11.8	37.3	25.4	27.3	28.7
Stop Time Per Veh.	8.4	11.7	14.3	11.1	26.0	18.5	19.0	20.3

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE South & 20th

CONTROL Full Signalization (Semi-Act.)

SITE "O" & 25th

	Experiment				Control			
	Major St. – South				Major St. – "O"			
	Time of Observation* 8:30 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	254	228	186	668	266	223	243	732
Total Stopped	57	74	58	189	45	33	65	143
Percent Stopped	22.4	32.5	31.2	28.3	16.9	14.8	26.7	19.5
Total Stop Time†	819	1,066	897	2,782	663	390	910	1,963
Stop Time Per† Stopped Veh.	14.4	14.4	15.5	14.7	14.7	11.8	14.0	13.7
Stop Time Per Veh.†	3.2	4.7	4.8	4.2	2.5	1.7	3.7	2.7
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	212	196	164	572	337	330	261	928
Total Stopped	0	6	0	6	97	65	33	195
Percent Stopped	0	3.1	0	1.0	28.8	19.7	12.6	21.0
Total Stop Time	0	65	0	65	1,365	793	442	2,600
Stop Time Per Stopped Veh.	–	10.8	–	10.8	14.1	12.2	13.4	13.3
Stop Time Per Veh.	0	0.3	0	0.1	4.1	2.4	1.7	2.8
Time of Observation* 2:30 PM					Time of Observation* 2:30 PM			
Total Vehicles	231	226	195	652	304	390	333	1,027
Total Stopped	32	25	17	74	100	121	95	316
Percent Stopped	13.9	11.1	8.7	11.3	32.9	31.0	28.5	30.8
Total Stop Time	416	260	247	923	1,339	1,898	884	4,121
Stop Time Per Stopped Veh.	13.0	10.4	14.5	12.5	13.4	15.7	9.3	13.0
Stop Time Per Veh.	1.8	1.2	1.3	1.4	4.4	4.9	2.7	4.0
Time of Observation* 4:00 PM					Time of Observation* 4:00 PM			
Total Vehicles	272	362	314	948	408	419	372	1,199
Total Stopped	20	48	31	99	117	207	109	433
Percent Stopped	7.4	13.3	9.9	10.4	28.7	49.4	29.3	36.1
Total Stop Time	234	585	468	1,287	1,651	4,875	1,430	7,956
Stop Time Per Stopped Veh.	11.7	12.2	15.1	13.0	14.1	23.6	13.1	18.4
Stop Time Per Veh.	0.9	1.6	1.5	1.4	4.0	11.6	3.8	6.6

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE South & 20th

CONTROL Full Signalization (Semi-Act.)

SITE "O" & 25th

	Experiment				Control			
	Minor St. – 20th				Minor St. – 25th			
	Time of Observation* 8:45 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	16	20	16	52	21	22	12	55
Total Stopped	13	12	12	37	14	15	9	38
Percent Stopped	81.3	60.0	75.0	71.2	66.7	68.2	75.0	69.1
Total Stop Time†	104	156	169	429	234	364	286	88.4
Stop Time Per† Stopped Veh.	8.0	13.0	14.1	11.6	16.7	24.3	31.8	23.3
Stop Time Per Veh.†	6.5	7.8	10.6	8.3	11.1	16.5	23.8	16.1
Time of Observation* 11:30 AM					Time of Observation* 11:30 AM			
Total Vehicles	13	11	10	34	23	23	20	66
Total Stopped	11	2	10	23	18	18	9	45
Percent Stopped	84.6	18.2	100.0	67.6	78.3	78.3	45.0	68.2
Total Stop Time	39	52	91	182	390	442	299	1,131
Stop Time Per Stopped Veh.	3.5	26.0	9.1	7.9	21.7	24.6	33.2	25.1
Stop Time Per Veh.	3.0	4.7	9.1	5.4	17.0	19.2	15.0	17.1
Time of Observation* 2:45 PM					Time of Observation* 2:45 PM			
Total Vehicles	21	10	12	43	37	28	36	101
Total Stopped	17	10	11	38	21	21	20	62
Percent Stopped	81.0	100.0	91.7	88.4	56.8	75.0	55.6	61.4
Total Stop Time	455	117	143	715	312	481	286	1,079
Stop Time Per Stopped Veh.	26.8	11.7	13.0	18.8	14.9	22.9	14.3	17.4
Stop Time Per Veh.	21.7	11.7	11.9	16.6	8.4	17.2	7.9	10.7
Time of Observation* 4:15 PM					Time of Observation* 4:00 PM			
Total Vehicles	19	8	26	53	51	48	34	133
Total Stopped	17	5	20	42	27	29	23	79
Percent Stopped	89.5	62.5	76.9	79.2	52.9	60.4	67.6	59.4
Total Stop Time	78	65	286	429	585	533	949	2,067
Stop Time Per Stopped Veh.	4.6	13.0	14.3	10.2	21.7	18.4	41.3	26.2
Stop Time Per Veh.	4.1	8.1	11.0	8.1	11.5	11.1	27.9	15.5

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

CONTROL C-45, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

	Experiment				Control			
	Major St. Fauntleroy				Major St. Renton			
	Time of Observation* 8:15 AM				Time of Observation* 8:30 AM			
	1 **	2	3	Total	1 **	2	3	Total
Total Vehicles	172	126	78	376	115	94	96	305
Total Stopped	46	39	18	103	16	32	10	58
Percent Stopped	26.7	31.0	23.1	27.4	13.9	34.0	10.4	19.0
Total Stop Time†	615	364	221	1,200	255	364	65	684
Stop Time Per† Stopped Veh.	13.4	9.3	12.3	11.7	15.9	11.4	6.5	11.8
Stop Time Per Veh.†	3.6	2.9	2.8	3.2	2.2	3.8	0.7	2.2
	Time of Observation* 11:30 AM				Time of Observation* 11:30 AM			
Total Vehicles	109	89	86	284	106	77	102	285
Total Stopped	12	3	0	15	28	5	10	43
Percent Stopped	11.0	3.4	0	5.3	26.4	6.5	9.8	15.1
Total Stop Time	165	13	0	178	300	52	39	391
Stop Time Per Stopped Veh.	13.8	4.3	–	11.8	10.7	10.4	3.9	9.1
Stop Time Per Veh.	1.5	0.1	0	0.6	2.8	0.7	0.4	1.4
	Time of Observation* 2:30 PM				Time of Observation* 2:30 PM			
Total Vehicles	102	136	109	347	114	120	117	351
Total Stopped	12	29	18	59	25	26	26	77
Percent Stopped	11.8	21.3	16.5	17.0	21.9	21.7	22.2	21.9
Total Stop Time	165	273	325	763	240	286	221	747
Stop Time Per Stopped Veh.	13.8	9.4	18.1	12.9	9.6	11.0	8.5	9.7
Stop Time Per Veh.	1.6	2.0	3.0	2.2	2.1	2.4	1.9	2.1
	Time of Observation* 4:00 PM				Time of Observation* 4:00 PM			
Total Vehicles	176	78	214	468	190	172	149	511
Total Stopped	12	2	7	21	27	30	26	83
Percent Stopped	6.8	2.6	3.3	4.5	14.2	17.4	17.4	16.2
Total Stop Time	165	13	78	256	165	260	169	594
Stop Time Per Stopped Veh.	13.8	6.5	11.1	12.2	6.1	8.7	6.5	7.2
Stop Time Per Veh.	0.9	0.2	0.4	0.5	0.9	1.5	1.1	1.2

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 min. observation period.
15 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

	Experiment				Control			
	Minor St. – Myrtle				Minor St. – Cloverdale			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1 **	2	3	Total	1 **	2	3	Total
Total Vehicles	13	8	10	31	26	19	16	61
Total Stopped	8	6	7	21	12	5	7	24
Percent Stopped	61.5	75.0	70.0	67.7	46.2	26.3	43.8	39.3
Total Stop Time†	75	143	208	426	300	65	117	482
Stop Time Per† Stopped Veh.	9.4	23.8	29.7	20.3	25.0	13.0	16.7	20.0
Stop Time Per Veh.†	5.8	17.9	20.8	13.7	11.5	3.4	7.3	7.9
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	15	7	2	24	24	39	16	79
Total Stopped	11	4	2	17	15	18	10	43
Percent Stopped	73.3	57.1	100.0	70.8	62.5	46.2	62.5	54.4
Total Stop Time	105	39	26	170	210	351	221	782
Stop Time Per Stopped Veh.	9.5	9.8	13.0	10.0	14.0	19.5	22.1	18.2
Stop Time Per Veh.	7.0	5.6	13.0	7.1	8.8	9.0	13.8	9.9
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	11	7	4	22	48	29	34	111
Total Stopped	6	7	4	17	30	17	18	65
Percent Stopped	54.5	100.0	100.0	77.3	62.5	58.6	52.9	58.6
Total Stop Time	60	104	52	216	420	273	338	1,031
Stop Time Per Stopped Veh.	10.0	14.9	13.0	12.7	14.0	16.1	18.8	15.9
Stop Time Per Veh.	5.5	14.9	13.0	9.8	8.8	9.4	9.9	9.3
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	13	5	6	24	42	42	42	126
Total Stopped	6	3	6	15	17	19	30	66
Percent Stopped	46.2	60.0	100.0	62.5	40.5	45.2	71.4	52.4
Total Stop Time	75	65	26	166	300	299	520	1,119
Stop Time Per Stopped Veh.	12.5	21.7	4.3	11.1	17.6	15.7	17.3	17.0
Stop Time Per Veh.	5.8	13.0	4.3	6.9	7.1	7.1	12.4	8.9

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 min. observation period.
15 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Memphis

EXPERIMENT E-5, Crossing Guard

SITE Knight-Arnold & Clearbrook

CONTROL C-5, Full Signalization (Full-Act.)

SITE Knight-Arnold & Castleman

	Experiment				Control			
	Major St. – Knight-Arnold				Major St. – Knight-Arnold			
	Time of Observation* 8:30 AM				Time of Observation* 8:30 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	212	205	232	649	231	207	245	683
Total Stopped	21	15	51	87	93	52	72	217
Percent Stopped	9.9	7.3	22.0	13.4	40.3	25.1	29.4	31.8
Total Stop Time†	221	78	767	1,066	1,469	806	741	3,016
Stop Time Per† Stopped Veh.	10.5	5.2	15.0	12.3	15.8	15.5	10.3	13.9
Stop Time Per Veh.†	1.0	0.4	3.3	1.6	6.4	3.9	3.0	4.4
	Time of Observation* 11:30 AM				Time of Observation* 11:30 AM			
Total Vehicles	236	187	89	512	216	235	204	655
Total Stopped	5	1	2	8	59	62	43	164
Percent Stopped	2.1	0.5	2.2	1.6	27.3	26.4	21.1	25.0
Total Stop Time	26	0	0	26	442	637	390	1,469
Stop Time Per Stopped Veh.	5.2	0.0	0.0	3.3	7.5	10.3	9.1	9.0
Stop Time Per Veh.	0.1	0.0	0.0	0.1	2.0	2.7	1.9	2.2
	Time of Observation* 2:30 PM				Time of Observation* 2:30 PM			
Total Vehicles	–	240	195	435	248	241	199	688
Total Stopped	–	2	1	3	109	87	59	255
Percent Stopped	–	0.8	0.5	0.7	44.0	36.1	29.6	37.1
Total Stop Time	–	26	0	26	1,313	1,040	676	3,029
Stop Time Per Stopped Veh.	–	13.0	0.0	8.7	12.0	12.0	11.5	11.9
Stop Time Per Veh.	–	0.1	0.0	0.1	5.3	4.3	3.4	4.4
	Time of Observation* 3:45 PM				Time of Observation* 4:00 PM			
Total Vehicles	274	166	244	684	274	318	268	860
Total Stopped	30	3	44	77	119	66	61	246
Percent Stopped	10.9	1.8	18.0	11.3	43.4	20.8	22.8	28.6
Total Stop Time	377	26	650	1,053	1,157	650	546	2,353
Stop Time Per Stopped Veh.	12.6	8.7	14.8	13.7	9.7	9.8	9.0	9.6
Stop Time Per Veh.	1.4	0.2	2.7	1.5	4.2	2.0	2.0	2.7

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Memphis

EXPERIMENT E-5, Crossing Guard

CONTROL C-5, Full Signalization (Full-Act.)

SITE Knight-Arnold & Clearbrook

SITE Knight-Arnold & Castleman

	Experiment				Control			
	Minor St. – Clearbrook				Minor St. – Castleman			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1	2	3	Total	1	2	3	Total
Total Vehicles	54	43	45	142	83	64	80	227
Total Stopped	42	30	28	100	47	43	51	141
Percent Stopped	77.8	69.8	62.2	70.4	56.6	67.2	63.8	62.1
Total Stop Time†	624	273	559	1,456	962	780	754	2,496
Stop Time Per† Stopped Veh.	14.9	9.1	20.0	14.6	20.5	18.1	14.8	17.7
Stop Time Per Veh.†	11.6	6.3	12.4	10.3	11.6	12.2	9.4	11.0
Time of Observation* 11:00 AM					Time of Observation* 11:00 AM			
Total Vehicles	20	13	21	54	32	21	13	66
Total Stopped	18	6	8	32	24	16	8	48
Percent Stopped	90.0	46.2	38.1	59.3	75.0	76.2	61.5	72.7
Total Stop Time	143	52	78	273	390	143	65	598
Stop Time Per Stopped Veh.	7.9	8.6	9.8	8.5	16.3	8.9	8.1	12.5
Stop Time Per Veh.	7.2	4.0	3.7	5.1	12.2	6.8	5.0	9.1
Time of Observation* 2:00 PM					Time of Observation* 2:00 PM			
Total Vehicles	–	32	30	62	97	107	139	343
Total Stopped	–	23	26	49	67	73	91	231
Percent Stopped	–	71.9	86.7	79.0	69.1	68.2	65.5	67.3
Total Stop Time	–	156	273	429	910	1,157	1,326	3,393
Stop Time Per Stopped Veh.	–	6.8	10.5	8.8	13.6	15.8	14.6	14.7
Stop Time Per Veh.	–	4.9	9.1	6.9	9.4	10.8	9.5	9.9
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	24	29	31	84	84	85	44	213
Total Stopped	24	21	27	72	34	55	28	117
Percent Stopped	100.0	72.4	87.1	85.7	40.5	64.7	63.6	54.9
Total Stop Time	416	221	767	1,404	468	988	546	2,002
Stop Time Per Stopped Veh.	17.3	10.5	28.4	19.5	13.8	18.0	19.5	17.1
Stop Time Per Veh.	17.3	7.6	24.7	16.7	5.6	11.6	12.4	9.4

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-5, Crossing Guard

SITE 23rd & Hanford

CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

	Experiment				Control			
	Major St. – 23rd				Major St. – Renton			
	Time of Observation* 8:15 AM				Time of Observation* 8:30 AM			
	1**	2	3	Total	1**	2	3	Total
Total Vehicles	113	195	142	450	115	94	96	305
Total Stopped	8	52	17	77	16	32	10	58
Percent Stopped	7.1	26.7	12.0	17.1	13.9	34.0	10.4	19.0
Total Stop Time†	90	767	221	1,078	255	364	65	684
Stop Time Per† Stopped Veh.	11.3	14.8	13.0	14.0	15.9	11.4	6.5	11.8
Stop Time Per Veh.†	0.8	3.9	1.6	2.4	2.2	3.8	0.7	2.2
	Time of Observation* 11:30 AM				Time of Observation* 11:30 AM			
Total Vehicles	101	91	95	287	106	77	102	285
Total Stopped	1	7	0	8	28	5	10	43
Percent Stopped	1.0	7.7	0	2.8	26.4	6.5	9.8	15.1
Total Stop Time	0	39	0	39	300	52	39	391
Stop Time Per Stopped Veh.	0.0	5.6	–	4.9	10.7	10.4	3.9	9.1
Stop Time Per Veh.	0.0	0.4	0	0.1	2.8	0.7	0.4	1.4
	Time of Observation* 2:30 PM				Time of Observation* 2:30 PM			
Total Vehicles	133	102	111	346	114	120	117	351
Total Stopped	14	15	14	43	25	26	26	77
Percent Stopped	10.5	14.7	12.6	12.4	21.9	21.7	22.2	21.9
Total Stop Time	285	156	195	636	240	286	221	747
Stop Time Per Stopped Veh.	20.4	10.4	13.9	14.8	9.6	11.0	8.5	9.7
Stop Time Per Veh.	2.1	1.5	1.8	1.8	2.1	2.4	1.9	2.1
	Time of Observation* 3:45 PM				Time of Observation* 4:00 PM			
Total Vehicles	177	182	186	545	190	172	149	511
Total Stopped	4	9	3	16	27	30	26	83
Percent Stopped	2.3	4.9	1.6	2.9	14.2	17.4	17.4	16.2
Total Stop Time	0	65	13	78	165	260	169	594
Stop Time Per Stopped Veh.	0.0	7.2	4.3	4.9	6.1	8.7	6.5	7.2
Stop Time Per Veh.	0.0	0.4	0.1	0.1	0.9	1.5	1.1	1.2

† Time in sec.

* Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 min. observation period.
15 sec. observation interval.

VEHICLE DELAY DATA SUMMARY

CITY Seattle

EXPERIMENT E-5, Crossing Guard — **CONTROL** C-4, 5, Full Signalization (Semi-Act.)

SITE 23rd & Hanford — **SITE** Renton & Cloverdale

	Experiment				Control			
	Minor St. — Hanford				Minor St. — Cloverdale			
	Time of Observation* 8:00 AM				Time of Observation* 8:00 AM			
	1 **	2	3	Total	1 **	2	3	Total
Total Vehicles	12	5	10	27	26	19	16	61
Total Stopped	8	4	10	22	12	5	7	24
Percent Stopped	75.0	80.0	100.0	81.5	46.2	26.3	43.8	39.3
Total Stop Time†	120	117	130	367	300	65	117	482
Stop Time Per† Stopped Veh.	15.0	29.3	13.0	16.7	25.0	13.0	16.7	20.0
Stop Time Per Veh.†	10.0	23.4	13.0	13.6	11.5	3.4	7.3	7.9
Time of Observation* 11:30 AM					Time of Observation* 11:00 AM			
Total Vehicles	17	6	7	30	24	39	16	79
Total Stopped	17	3	7	27	15	18	10	43
Percent Stopped	100.0	50.0	100.0	90.0	62.5	46.2	62.5	54.4
Total Stop Time	90	13	78	181	210	351	221	782
Stop Time Per Stopped Veh.	5.3	4.3	11.1	6.7	14.0	19.5	22.1	18.2
Stop Time Per Veh.	5.3	2.2	11.1	6.0	8.8	9.0	13.8	9.9
Time of Observation* 2:15 PM					Time of Observation* 2:00 PM			
Total Vehicles	13	8	14	35	48	29	34	111
Total Stopped	10	6	12	28	30	17	18	65
Percent Stopped	76.9	75.0	85.7	80.0	62.5	58.6	52.9	58.6
Total Stop Time	105	78	130	313	420	273	338	1,031
Stop Time Per Stopped Veh.	10.5	13.0	10.8	11.2	14.0	16.1	18.8	15.9
Stop Time Per Veh.	8.1	9.8	9.3	8.9	8.8	9.4	9.9	9.3
Time of Observation* 3:30 PM					Time of Observation* 3:30 PM			
Total Vehicles	11	18	20	49	42	42	42	126
Total Stopped	11	15	20	46	17	19	30	66
Percent Stopped	100.0	83.3	100.0	93.9	40.5	45.2	71.4	52.4
Total Stop Time	90	234	247	571	300	299	520	1,119
Stop Time Per Stopped Veh.	8.2	15.6	12.4	12.4	17.6	15.7	17.3	17.0
Stop Time Per Veh.	8.2	13.0	12.4	11.7	7.1	7.1	12.4	8.9

†Time in sec.
*Beginning of observation period.
13 min. observation period.
13 sec. observation interval.

** 15 min. observation period.
15 sec. observation interval.

APPENDIX F

COMPLIANCE DATA SUMMARIES

COMPLIANCE DATA SUMMARY

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign

SITE S. Cobb & Barber

CONTROL C-1, Full Signalization (Semi-Act.)

SITE Roswell & Dalrymple

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	59	100.0	112	80.0
	2	38	100.0	92	77.3
	3	26	92.9	83	81.3
	Total	123	98.4	287	79.5
	Z^5	5.014**			
Pedestrians Using Unmarked X-Walk	1	0	0.0	28	20.0
	2	0	0.0	27	22.7
	3	2	7.1	19	18.6
	Total	2	1.6	74	20.5
	Z^5	−5.014**			
N^1	1	59		140	
	2	38		119	
	3	28		102	
	Total	125		361	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		F. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	251	2.91	9	0.15
	2	235	2.64	16	0.25
	3	111	1.25	5	0.08
	Total	597	2.27	30	0.16
	Z^5	19.266**			
N^2	1	8,631		6,194	
	2	8,903		6,358	
	3	8,856		6,161	
	Total	26,290		18,713	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	61	11.78	0	0.00
	2	111	18.94	12	0.41
	3	103	17.25	12	0.42
	Total	275	16.17	24	0.27
	Z^5	36.378**			
N^3	1	518		3,143	
	2	586		2,942	
	3	597		2,850	
	Total	1,701		8,935	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N4/Freq.	Freq.	N4/Freq.
Push Button Actuations	1	22	2.7	7	16.0
	2	17	2.2	4	23.0
	3	17	1.5	1	83.0
	Total	56	2.2	12	23.9
	Z^5	10.315**			
		Freq.	Percent	Freq.	Percent
Permissive	1	51	86.4	14	12.5
	2	32	84.2	3	3.3
	3	22	84.6	1	1.2
	Total	105	85.4	18	6.3
	Z^5	16.015**			
Clearance	1	1	1.7		
	2	0	0.0		
	3	0	0.0		
	Total	1	0.8		
	Z^5				
Prohibited	1	7	11.9	98	87.5
	2	6	15.8	89	96.7
	3	4	15.4	82	98.8
	Total	17	13.8	269	93.7
	Z^5	−16.143**			
N^4	1	59		112	
	2	38		92	
	3	26		83	
	Total	123		287	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z – The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign

SITE Broadway & Pine

CONTROL C-1, Full Signalization (Pre-Timed)

SITE Broadway & Mortimer

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	69	79.3	304	100.0
	2	42	68.9	249	100.0
	3	30	50.0	338	100.0
	Total	141	67.8	891	100.0
	Z^5	17.485**			
Pedestrians Using Unmarked X-Walk	1	18	20.7		
	2	19	31.1		
	3	30	50.0		
	Total	67	32.2		
	Z^5				
N^1	1	87		304	
	2	61		249	
	3	60		338	
	Total	208		891	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		F. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	9	0.22	4	0.09
	2	7	0.17	41	0.92
	3	3	0.07	17	0.36
	Total	19	0.15	62	0.45
	Z^5	-4.690**			
N^2	1	4,179		4,655	
	2	4,136		4,469	
	3	4,195		4,701	
	Total	12,510		13,825	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	93	13.56	2	0.40
	2	147	21.37	3	0.70
	3	128	20.61	5	1.04
	Total	368	18.45	10	0.71
	Z^5	16.203**			
N^3	1	686		498	
	2	688		426	
	3	621		481	
	Total	1,995		1,405	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Freq.
Push Button Actuations	1	10	6.9	6	50.6
	2	3	14.0	3	83.0
	3	3	10.0	2	169.0
	Total	16	8.8	11	81.0
	Z^5	6.992**			
		Freq.	Percent	Freq.	Percent
Permissive	1	7	10.1	6	2.0
	2	3	7.1	1	0.4
	3	0	0.0	1	0.3
	Total	10	7.1	8	0.9
	Z^5	5.222**			
Clearance	1	0	0.0	0	0.0
	2	0	0.0	0	0.0
	3	0	0.0	0	0.0
	Total	0	0.0	0	0.0
	Z^5				
Prohibited	1	62	89.9	298	98.0
	2	39	92.9	248	99.6
	3	30	100.0	337	99.7
	Total	131	92.9	883	99.1
	Z^5	-5.222**			
N^4	1	69		304	
	2	42		249	
	3	30		338	
	Total	141		891	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z – The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hollywood & Heard

CONTROL C-2, Full Signalization (Full-Act.)

SITE Hollywood & Peres

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	97	94.2	26	100.0
	2	96	95.0	41	100.0
	3	147	94.2	94	100.0
	Total	340	94.4	111	100.0
	Z^5	−2.538*			
Pedestrians Using Unmarked X-Walk	1	6	5.8		
	2	5	5.0		
	3	9	5.8		
	Total	20	5.6		
	Z^5				
N^1	1	103		26	
	2	101		41	
	3	156		44	
	Total	360		111	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	7	0.10	28	0.61
	2	8	0.13	5	0.10
	3	28	0.43	5	0.10
	Total	43	0.22	38	0.25
	Z^5	−0.767			
N^2	1	6,709		4,621	
	2	6,264		5,062	
	3	6,524		5,233	
	Total	19,997		14,916	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		F. or S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	74	17.83	6	0.44
	2	80	21.00	3	0.22
	3	98	24.50	0	0.00
	Total	252	21.61	9	0.21
	Z^5	30.052**			
N^3	1	415		1,358	
	2	381		1,379	
	3	400		1,459	
	Total	1,166		4,196	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Freq.
Push Button Actuations	1	41	2.4	3	8.7
	2	51	1.9	12	3.4
	3	74	2.0	10	4.4
	Total	116	2.0	25	4.4
	Z^5	2.288*			
		Freq.	Percent	Freq.	Percent
Permissive	1	89	91.8	3	11.5
	2	82	85.4	12	29.3
	3	133	90.5	14	31.8
	Total	304	89.4	29	26.1
	Z^5	13.172**			
Clearance	1	3	3.1	0	0.0
	2	1	1.0	0	0.0
	3	1	0.7	0	0.0
	Total	5	1.5	0	0.0
	Z^5	1.285			
Prohibited	1	5	5.2	23	88.5
	2	13	13.5	29	70.7
	3	13	8.8	30	68.2
	Total	31	9.1	82	73.9
	Z^5	−13.670**			
N^4	1	97		26	
	2	96		41	
	3	147		44	
	Total	340		111	

LEGEND:

[1] Total number of pedestrians observed.

[2] Total number of major street vehicles observed.

[3] Total number of minor street vehicles observed.

[4] Pedestrians using marked X-Walk.

[5] Z — The Z statistic for a two tailed test based on total values.

* Significant at 0.05 level.

** Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hamilton & 24th

CONTROL C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 36th

Pedestrian Compliance
Marked vs. Unmarked X Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	48	72.7	119	95.2
	2	26	100.0	100	97.1
	3	47	95.9	124	93.9
	Total	121	85.8	343	95.3
	Z^5	−3.642**			
Pedestrians Using Unmarked X-Walk	1	18	27.3	6	4.8
	2	0	0.0	3	2.9
	3	2	4.1	8	6.0
	Total	20	14.2	17	4.7
	Z^5	3.642**			
N^1	1	66		125	
	2	26		103	
	3	49		132	
	Total	141		360	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	5	0.07	4	0.13
	2	0	0.00	14	0.51
	3	3	0.04	3	0.10
	Total	8	0.03	21	0.23
	Z^5	−6.105**			
N^2	1	6,758		3,127	
	2	6,421		2,750	
	3	7,091		3,155	
	Total	20,270		9,032	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		F. or S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	52	13.16	1	0.05
	2	54	23.79	1	0.07
	3	31	11.36	1	0.06
	Total	137	15.31	3	0.06
	Z^5	27.654**			
N^3	1	395		1,852	
	2	227		1,502	
	3	273		1,662	
	Total	895		5,016	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N4/Freq.	Freq.	N4/Freq.
Push Button Actuations	1	25	1.9	15	7.9
	2	16	1.6	16	6.3
	3	19	2.5	18	6.9
	Total	60	2.0	49	7.0
	Z^5	7.875**			
		Freq.	Percent	Freq.	Percent
Permissive	1	30	62.5	50	42.0
	2	22	84.6	43	43.0
	3	27	57.4	47	37.9
	Total	79	65.3	140	40.8
	Z^5	4.636**			
Clearance	1	0	0.0	3	7.5
	2	3	0.0	3	3.0
	3	3	6.4	11	8.9
	Total	3	1.7	17	5.0
	Z^5	−1.577			
Prohibited	1	18	37.5	66	55.5
	2	4	15.4	54	54.0
	3	17	36.2	66	53.2
	Total	39	32.2	186	54.2
	Z^5	−4.163**			
N^4	1	48		119	
	2	26		100	
	3	47		124	
	Total	121		343	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z – The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE South & 52nd

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Randolph & 40th

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	176	82.6	39	100.0
	2	119	94.4	37	100.0
	3	93	81.6	27	100.0
	Total	388	85.7	103	100.0
	Z^5	−4.091**			
Pedestrians Using Unmarked X-Walk	1	37	17.4		
	2	7	5.6		
	3	21	18.4		
	Total	65	14.3		
	Z^5				
N^1	1	213		39	
	2	126		37	
	3	114		27	
	Total	453		103	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	9	0.25	1	0.04
	2	1	0.03	11	0.37
	3	2	0.06	10	0.42
	Total	12	0.12	22	0.27
	Z^5	−2.567*			
N^2	1	3,651		2,828	
	2	3,461		2,948	
	3	3,275		2,409	
	Total	10,387		8,185	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	15	4.09	0	0.00
	2	64	20.25	5	0.35
	3	78	21.31	2	0.17
	Total	157	14.97	7	0.17
	Z^5	25.135**			
N^3	1	357		1,588	
	2	316		1,436	
	3	366		1,184	
	Total	1,049		4,208	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Freq.
Push Button Actuations	1	39	4.5		
	2	42	2.8		
	3	33	2.8		
	Total	114	3.4		
	Z^5				
		Freq.	Percent	Freq.	Percent
Permissive	1	130	73.9	38	97.4
	2	99	83.2	35	94.6
	3	60	64.5	19	70.4
	Total	289	74.5	92	89.3
	Z^5	−3.210**			
Clearance	1	10	5.7	0	0.0
	2	5	4.2	1	2.7
	3	8	8.6	1	3.7
	Total	23	5.9	2	1.9
	Z^5	1.636			
Prohibited	1	36	20.4	1	2.6
	2	15	6.7	1	2.7
	3	25	26.9	7	25.9
	Total	76	19.6	9	8.7
	Z^5	2.587**			
N^4	1	176		39	
	2	119		37	
	3	93		27	
	Total	388		103	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z — The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign

SITE Beacon & Hanford

CONTROL C-3, Full Signalization (Pre-Timed)

SITE Rainier & Walden

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	316	94.3	204	100.0
	2	286	90.8	232	100.0
	3	265	93.3	275	100.0
	Total	867	92.8	711	100.0
	Z^5	7.295**			
Pedestrians Using Unmarked X-Walk	1	19	5.7		
	2	29	9.2		
	3	19	6.7		
	Total	67	7.2		
	Z^5				
N^1	1	335		204	
	2	315		232	
	3	284		275	
	Total	934		711	

Vehicle Compliance
Major Street

Violation of		Experiment S. Red		Control S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	26	0.56	11	0.13
	2	3	0.07	5	0.06
	3	13	0.27	8	0.10
	Total	42	0.30	24	0.10
	Z^5	6.460**			
N^2	1	4,616		8,695	
	2	4,598		8,317	
	3	4,805		8,160	
	Total	14,019		25,172	

Vehicle Compliance
Minor Street

Violation of		Experiment Stop Sign		Control S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	11	3.90	0	0.00
	2	26	10.74	0	0.00
	3	14	5.96	2	0.26
	Total	51	6.72	2	0.08
	Z^5	12.903**			
N^3	1	282		889	
	2	242		928	
	3	235		771	
	Total	759		2,588	

Pedestrian Complaince
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Freq.
Push Button Actuations	1	97	3.3		
	2	123	2.3		
	3	122	2.2		
	Total	342	2.5		
	Z^5				
		Freq.	Percent	Freq.	Percent
Permissive	1	254	80.4	189	92.7
	2	233	81.5	205	88.4
	3	237	89.4	247	89.8
	Total	724	83.5	641	90.2
	Z^5	3.846**			
Clearance	1	15	4.7	8	3.9
	2	34	11.9	15	6.4
	3	11	4.2	17	6.2
	Total	60	6.9	40	5.6
	Z^5	1.050			
Prohibited	1	47	14.9	7	3.4
	2	19	6.6	12	5.2
	3	17	6.4	11	4.0
	Total	83	9.6	30	4.2
	Z^5	4.105**			
N^4	1	316		204	
	2	286		232	
	3	265		275	
	Total	867		711	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z – The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE South & 20th

CONTROL C-4, Full Signalization (Semi-Act.)

SITE "O" & 25th

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	291	93.6	201	100.0
	2	315	95.2	149	100.0
	3	306	95.6	118	100.0
	Total	912	94.8	468	100.0
	Z^5	−5.022**			
Pedestrians Using Unmarked X-Walk	1	20	6.4		
	2	16	4.8		
	3	14	4.4		
	Total	50	5.2		
	Z^5				
N^1	1	311		201	
	2	331		149	
	3	320		118	
	Total	962		468	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	2	0.02	7	0.07
	2	3	0.05	12	0.13
	3	0	0.00	7	0.08
	Total	5	0.02	26	0.09
	Z^5	−2.942**			
N^2	1	7,269		9,408	
	2	6,657		9,455	
	3	6,893		8,897	
	Total	20,819		27,760	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	22	4.17	0	0.00
	2	78	19.80	2	0.21
	3	116	24.68	2	0.28
	Total	216	15.52	4	0.16
	Z^5	21.719**			
N^3	1	528		785	
	2	394		962	
	3	470		710	
	Total	1,392		2,457	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Freq.
Push Button Actuations	1	91	5.2	65	3.1
	2	90	3.5	60	2.5
	3	98	3.1	38	3.1
	Total	279	3.3	163	2.9
	Z^5	−1.597			
		Freq.	Percent	Freq.	Percent
Permissive	1	227	78.0	135	67.2
	2	257	81.6	90	60.4
	3	253	82.7	67	56.8
	Total	737	80.8	292	62.4
	Z^5	7.438**			
Clearance	1	40	13.8	5	2.5
	2	21	6.7	5	3.3
	3	32	10.4	–	–
	Total	93	10.2	10	2.9
	Z^5	4.313**			
Prohibited	1	24	8.2	61	30.3
	2	37	11.7	54	36.2
	3	21	6.9	51	43.2
	Total	82	9.0	166	35.5
	Z^5	−12.129**			
N^4	1	291		201	
	2	315		149	
	3	306		118	
	Total	912		468	

LEGEND:

[1] Total number of pedestrians observed.

[2] Total number of major street vehicles observed.

[3] Total number of minor street vehicles observed.

[4] Pedestrians using marked X-Walk.

[5] Z – The Z statistic for a two tailed test based on total values.

* Significant at 0.05 level.

** Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	136	94.4	136	100.0
	2	157	98.7	128	100.0
	3	128	97.0	131	100.0
	Total	421	96.8	395	100.0
	Z^5	−3,596**			
Pedestrians Using Unmarked X-Walk	1	8	5.6		
	2	2	1.3		
	3	4	3.0		
	Total	14	3.2		
	Z^5				
N^1	1	144		136	
	2	159		128	
	3	132		131	
	Total	435		395	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		S. Red		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	4	0.12	1	0.03
	2	0	0.00	8	0.24
	3	3	0.09	5	0.15
	Total	7	0.07	14	0.14
	Z^5	−1.443			
N^2	1	3,411		3,555	
	2	3,074		3,273	
	3	3,160		3,382	
	Total	9,645		10,210	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	46	17.29	3	0.37
	2	68	29.57	1	0.12
	3	9	3.73	2	0.26
	Total	123	16.69	6	0.24
	Z^5	21.247**			
N^3	1	266		815	
	2	230		827	
	3	241		814	
	Total	737		2,456	

Pedestrian Compliance
Marked X-Walk

		Experiment		Control	
		Freq.	N^4/Freq.	Freq.	N^4/Fr.
Push Button Actuations	1	68	2.0	41	3.3
	2	75	2.1	39	3.3
	3	66	1.9	45	2.9
	Total	209	2.0	125	3.2
	Z^5	5.226**			
		Freq.	Percent	Freq.	Percent
Permissive	1	122	89.7	101	74.3
	2	144	91.7	65	50.8
	3	119	93.0	71	54.2
	Total	385	91.4	237	60.0
	Z^5	10.546**			
Clearance	1	2	1.5	4	2.9
	2	6	3.8	1	0.8
	3	0	0.0	2	1.5
	Total	8	1.9	7	1.8
	Z^5	0.136			
Prohibited	1	12	8.8	31	22.8
	2	7	4.5	62	48.4
	3	9	7.0	58	44.3
	Total	28	6.7	151	38.2
	Z^5	−10.894**			
N^4	1	136		136	
	2	157		128	
	3	128		131	
	Total	421		395	

LEGEND:

[1]Total number of pedestrians observed.

[2]Total number of major street vehicles observed.

[3]Total number of minor street vehicles observed.

[4]Pedestrians using marked X-Walk.

[5]Z – The Z statistic for a two tailed test based on total values.

*Significant at 0.05 level.

**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Memphis

EXPERIMENT E-5, Crossing Guard

SITE Knight-Arnold & Clearbrook

CONTROL C-5, Full Signalization (Full-Act.)

SITE Knight-Arnold & Castleman

Pedestrian Compliance
Marked vs. Unmarked X-Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	27	90.0	82	100.0
	2	8	72.7	43	100.0
	3	23	85.2	50	100.0
	Total	58	85.3	175	100.0
	Z^8	−5.181**			
Pedestrians Using Unmarked X-Walk	1	3	10.0		
	2	3	27.3		
	3	4	14.8		
	Total	10	14.7		
	Z^8				
N^1	1	30		82	
	2	11		43	
	3	27		50	
	Total	68		175	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		Order To Stop		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	1	0.02	2	0.03
	2	0	0.00	0	0.00
	3	1	0.02	4	0.06
	Total	2	0.01	6	0.03
	Z^8	−1.315			
N^2	1	6,237		6,901	
	2	6,047		6,518	
	3	6,375		7,069	
	Total	18,679		20,478	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	93	12.97	5	0.36
	2	189	24.80	1	0.07
	3	170	23.19	1	0.06
	Total	452	20.43	7	0.16
	Z^8	30.582**			
N^3	1	717		1,375	
	2	762		1,437	
	3	733		1,581	
	Total	2,212		4,393	

Pedestrian Complaince
Marked X-Walk

		Control	
		Freq.	N^5/Freq.
Push Button Actuations	1	17	4.8
	2	6	7.2
	3	10	5.0
	Total	33	5.3

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
$Permissive^4$	1	19	70.4	21	25.6
	2	5	62.5	6	14.0
	3	19	82.6	9	18.0
	Total	43	74.1	36	20.6
	Z^8	7.468**			
Clearance	1			14	17.1
	2			0	0.0
	3			0	0.0
	Total			14	8.0
$Prohibited^5$	1	0	0.0	47	57.3
	2	0	0.0	37	86.0
	3	0	0.0	41	82.0
	Total	0	0.0	125	71.4
	Z^8	−9.454**			
Guard Not Present	1	8	29.6		
	2	3	37.5		
	3	4	17.4		
	Total	15	25.9		
N^6	1	27		82	
	2	8		43	
	3	23		50	
	Total	58		175	
Unmarked X-Walk					
Guard Present	1	0	0.0		
	2	2	66.7		
	3	0	0.0		
	Total	2	20.0		
Guard Not Present	1	3	100.0		
	2	1	33.3		
	3	4	100.0		
	Total	8	80.0		
N^7	1	3			
	2	3			
	3	4			
	Total	10			

LEGEND:

[1]Total number of pedestrians observed.
[2]Total number of major street vehicles observed.
[3]Total number of minor street vehicles observed.
[4]Crossed with guard at experiment site.
[5]Crossed without guard at experiment site.
[6]Pedestrians using marked X-Walk.
[7]Pedestrians using unmarked X-Walk.
[8]Z—The Z statistic for a two-tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

COMPLIANCE DATA SUMMARY

CITY Seattle

EXPERIMENT E-5, Crossing Guard

SITE 23rd & Hanford

CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Renton & Cloverdale

Pedestrian Compliance
Marked vs. Unmarked X Walk

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Pedestrians Using Marked X-Walk	1	481	96.2	136	100.0
	2	303	91.0	128	100.0
	3	439	94.0	131	100.0
	Total	1,223	94.1	395	100.0
	Z^8	4.951**			
Pedestrians Using Unmarked X-Walk	1	19	3.8		
	2	30	9.0		
	3	28	6.0		
	Total	77	5.9		
	Z^8				
N^1	1	500		136	
	2	333		128	
	3	467		131	
	Total	1,300		395	

Vehicle Compliance
Major Street

Violation of		Experiment		Control	
		Order To Stop		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	3	0.10	1	0.03
	2	0	0.00	8	0.24
	3	1	0.03	5	0.15
	Total	4	0.04	14	0.14
	Z^8	-2.277*			
N^2	1	3,055		3,555	
	2	3,539		3,273	
	3	3,227		3,382	
	Total	9,821		10,210	

Vehicle Compliance
Minor Street

Violation of		Experiment		Control	
		Stop Sign		S. Red	
		Freq.	Percent	Freq.	Percent
Violations	1	15	4.95	3	0.37
	2	29	9.57	1	0.12
	3	22	6.88	2	0.26
	Total	66	7.13	6	0.24
	Z^8	12.366**			
N^3	1	303		815	
	2	303		827	
	3	320		814	
	Total	926		2,456	

Pedestrian Complaince
Marked X-Walk

		Control	
		Freq.	N^5/Freq.
Push Button Actuations	1	41	3.3
	2	39	3.3
	3	33	2.9
	Total	125	3.2

		Experiment		Control	
		Freq.	Percent	Freq.	Percent
Permissive[4]	1	438	91.1	101	74.3
	2	197	65.0	65	50.8
	3	375	85.4	71	54.2
	Total	1,010	82.6	237	60.0
	Z^8	9.283**			
Clearance	1			4	2.9
	2			1	0.8
	3			2	1.5
	Total			7	1.8
Prohibited[5]	1	4	0.8	31	22.8
	2	2	0.7	62	48.4
	3	2	0.5	58	44.3
	Total	8	0.7	151	38.2
	Z^8	-21.810**			
Guard Not Present	1	39	8.1		
	2	104	34.3		
	3	62	14.1		
	Total	205	16.8		
N^6	1	481		136	
	2	303		128	
	3	439		131	
	Total	1,223		395	

Unmarked X-Walk

Guard Present	1	7	36.8
	2	11	36.7
	3	14	50.0
	Total	32	41.6
Guard Not Present	1	12	63.2
	2	19	63.3
	3	14	50.0
	Total	45	58.4
N^7	1	19	
	2	30	
	3	28	
	Total	77	

LEGEND:

[1] Total number of pedestrians observed.
[2] Total number of major street vehicles observed.
[3] Total number of minor street vehicles observed.
[4] Crossed with guard at experiment site.
[5] Crossed without guard at experiment site.
[6] Pedestrians using marked X-Walk.
[7] Pedestrians using unmarked X-Walk.
[8] Z – The Z statistic for a two-tailed test based on total values.
* Significant at 0.05 level.
** Significant at 0.01 level.

APPENDIX G

BEHAVIOR AND GAP DATA SUMMARIES

BEHAVIOR DATA SUMMARY

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign — CONTROL C-1, Full Signalization (Semi-Act.)

SITE S. Cobb & Barber — SITE Roswell & Dalrymple

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	0	0.00	0	0.00	2	7.14	2	1.60	-0.727
	Control	2	1.43	7	5.88	1	0.98	10	2.77	
TV	Exp.	0	0.00	0	0.00	2	7.14	2	1.60	-4.237**
	Control	38	27.14	11	9.24	9	8.82	58	16.07	
VH	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-2.825**
	Control	15	10.71	0	0.00	7	6.86	22	6.09	
N^1	Exp.	59		38		28		125		
	Control	140		119		102		361		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-4.743**
	Control	1	0.01	11	0.17	4	0.06	16	0.09	
A	Exp.	0	0.00	8	0.09	0	0.00	8	0.03	-5.182**
	Control	5	0.06	26	0.41	3	0.05	34	0.18	
N^2	Exp.	8,532		8,903		8,856		26,291		
	Control	6,194		6,358		6,161		18,713		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-1, Sign & Stop Sign — STREET WIDTH 60 Ft. (18.3 m)

ADEQUATE GAP TIME (G) 20 Sec.

CROSSING S. Cobb — GAP STUDY PERIOD 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	2	4	0	2*	Min. 15
	^{2}D	94.7	88.0	100.0	94.2*	Max. 66.7
12:00 PM	Acceptable Gaps	1	0	0	1 *	Min. 15
	D	97.8	100.0	96.7	98.2*	Max. 66.7
3:00 PM	Acceptable Gaps	0	1	1	1 *	Min. 15
	D	100.0	97.2	97.7	98.3*	Max. 66.7

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign **CONTROL** C-1, Full Signalization (Semi-Act.)

SITE Broadway & Pine **SITE** Broadway & Mortimer

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	23	26.44	2	3.28	17	28.33	42	20.19	5.558
	Control	13	4.28	8	3.21	46	13.61	67	7.52	
TV	Exp.	3	3.45	1	1.64	1	1.67	5	2.40	0.350
	Control	1	0.33	11	4.42	6	1.78	18	2.02	
VH	Exp.	21	24.14	9	14.75	22	36.67	52	25.00	2.625**
	Control	81	26.64	8	3.21	64	18.93	153	17.17	
N^1	Exp.	87		61		60		208		
	Control	304		249		338		891		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-1.904
	Control	2	0.04	2	0.04	0	0.00	4	0.03	
A	Exp.	9	0.22	8	0.19	1	0.02	18	0.14	1.572
	Control	0	0.00	10	0.22	1	0.02	11	0.08	
N^2	Exp.	4,179		4,136		4,195		12,510		
	Control	4,655		4,469		4,701		13,825		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-1, Sign & Stop Sign **STREET WIDTH** 60 Ft. (18.3 m)

ADEQUATE GAP TIME (G) 20 Sec.

CROSSING Broadway **GAP STUDY PERIOD** 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	13	4	8	8 *	Min. 15
	^2D	74.8	88.0	70.2	77.7*	Max. 66.7
12:00 PM	Acceptable Gaps	10	3	8	7 *	Min. 15
	D	79.8	89.8	74.9	81.5*	Max 66.7
3:00 PM	Acceptable Gaps	7	3	12	7 *	Min. 15
	D	81.7	92.3	68.0	80.7*	Max. 66.7

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon CONTROL C-2, Full Signalization (Full-Act.)

SITE Hollywood & Heard SITE Hollywood & Peres

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	0	0.00	7	6.93	6	3.85	13	3.61	-1.605
	Control	0	0.00	5	12.20	3	6.82	8	7.21	
TV	Exp.	2	1.94	0	0.00	2	1.28	4	1.11	-5.806**
	Control	4	15.38	5	12.20	6	13.64	15	13.51	
VH	Exp.	2	1.94	9	8.91	5	3.21	16	4.44	-1.841
	Control	2	7.69	2	4.88	6	13.64	10	9.01	
N^1	Exp.	103		101		156		360		
	Control	26		41		44		111		
RE	Exp.	0	0.00	1	0.02	0	0.00	1	0.00	-1.659
	Control	1	0.02	2	0.04	1	0.02	4	0.03	
A	Exp.	6	0.09	4	0.07	2	0.03	12	0.06	-0.435
	Control	1	0.02	6	0.12	4	0.08	11	0.07	
N^2	Exp.	6,709		6,264		6,524		19,497		
	Control	4,621		5,062		5,233		14,916		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon STREET WIDTH 66 Ft. (20.1 m)

ADEQUATE GAP TIME (G) 22 Sec.

CROSSING Hollywood GAP STUDY PERIOD 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	1	2	1	1 *	Min. 15
	[2]D	97.4	94.4	97.4	96.4*	Max. 63.3
12:00 PM	Acceptable Gaps	0	1	2	1 *	Min. 15
	D	100.0	97.3	94.4	97.2*	Max. 63.3
3:00 PM	Acceptable Gaps	0	0	0	0 *	Min. 15
	D	100.0	100.0	100.0	100.0*	Max. 63.3

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Sioux City

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon **CONTROL** C-2, Full Signalization (Semi-Act.)

SITE Hamilton & 24th **SITE** Hamilton & 36th

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	1	1.52	1	3.85	9	18.36	11	7.80	2.726**
	Control	1	0.80	7	6.79	1	0.78	9	2.50	
TV	Exp.	0	0.00	0	0.00	1	2.04	1	0.71	-3.576**
	Control	13	10.40	9	8.74	14	10.61	36	10.00	
VH	Exp.	6	9.09	0	0.00	7	14.29	13	9.22	3.098**
	Control	6	4.80	3	2.91	1	0.78	10	2.78	
N^1	Exp.	66		26		49		141		
	Control	125		103		132		360		
RE	Exp.	0	0.00	2	0.03	0	0.00	2	0.01	0.945
	Control	0	0.00	0	0.00	0	0.00	0	0.00	
A	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	—
	Control	0	0.00	0	0.00	0	0.00	0	0.00	
N^2	Exp.	6,758		6,421		7,091		20,270		
	Control	3,127		2,750		3,155		9,032		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z — The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon **STREET WIDTH** 50 Ft. (15.2 m)

ADEQUATE GAP TIME (G) 17 Sec.

CROSSING Hamilton **GAP STUDY PERIOD** 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	9	6	10	8 *	Min. 15
	^2D	81.4	85.1	76.7	81.1*	Max. 71.7
12:00 PM	Acceptable Gaps	3	6	6	5 *	Min. 15
	D	93.1	83.0	87.1	87.7*	Max. 71.7
3:00 PM	Acceptable Gaps	1	1	3	2 *	Min. 15
	D	98.0	98.1	93.6	96.6*	Max. 71.7

[1]Number of acceptable gaps, ≥G.
[2]D — Pedestrian delay — percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, F. Green Signal & Stop Sign **CONTROL** C-3, Full Signalization (Pre-Timed)

SITE South & 52nd **SITE** Randolph & 40th

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	3	1.41	7	5.56	5	4.39	15	3.31	1.282
	Control	0	0.00	0	0.00	1	3.70	1	0.97	
TV	Exp.	4	1.88	0	0.00	3	2.63	7	1.55	-1.538
	Control	2	5.13	1	2.70	1	3.70	4	3.88	
VH	Exp.	7	3.29	2	1.59	2	1.75	11	2.43	0.295
	Control	1	2.56	0	0.00	1	3.70	2	1.94	
N^1	Exp.	213		126		114		453		
	Control	39		37		27		103		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-1.906
	Control	3	0.10	0	0.00	0	0.00	3	0.03	
A	Exp.	4	0.11	0	0.00	1	0.03	5	0.05	2.034*
	Control	0	0.00	0	0.00	0	0.00	0	0.00	
N^2	Exp.	3,651		3,461		3,275		10,387		
	Control	2,828		2,948		2,409		8,185		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-3, F. Green Signal & Stop Sign **STREET WIDTH** 34 Ft. (10.4 m)

ADEQUATE GAP TIME (G) 13 Sec

CROSSING South **GAP STUDY PERIOD** 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	25	16	19	20	Min. 15
	[2]D	38.1	52.7	50.0	46.9	Max. 78.3
12:00 PM	Acceptable Gaps	21	16	12	16	Min. 15
	D	58.9	55.6	65.7	60.1	Max. 78.3
3:00 PM	Acceptable Gaps	21	13	11	15	Min. 15
	D	52.7	73.2	74.9	66.9	Max. 78.3

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, F. Green Signal & Stop Sign **CONTROL** C-3, Full Signalization (Pre-Timed)

SITE Beacon & Hanford **SITE** Rainier & Walden

Behavior	Site	Site Observation 1 Freq.	1 Percent	2 Freq.	2 Percent	3 Freq.	3 Percent	Total Freq.	Total Percent	Z^3
B	Exp.	6	1.79	1	0.32	1	0.35	8	0.86	-1.299
	Control	2	0.98	4	1.14	5	1.82	11	1.55	
TV	Exp.	3	0.90	12	3.81	3	1.06	18	1.93	-7.584**
	Control	16	7.84	18	8.82	42	15.27	76	10.69	
VH	Exp.	15	4.48	9	2.86	17	5.99	41	4.39	2.705**
	Control	5	2.45	2	0.98	7	2.55	14	1.97	
N^1	Exp.	335		315		284		934		
	Control	204		232		275		711		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-1.976*
	Control	3	0.03	1	0.01	3	0.03	7	0.05	
A	Exp.	4	0.09	0	0.00	0	0.00	4	0.03	2.068*
	Control	0	0.00	1	0.01	0	0.00	1	0.00	
N^2	Exp.	4,616		4,598		4,805		14,019		
	Control	8,695		8,317		8,160		25,172		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-3, F. Green Signal & Stop Sign **STREET WIDTH** 52 Ft. (15.9 m)

ADEQUATE GAP TIME (G) 18 Sec

CROSSING Beacon **GAP STUDY PERIOD** 15 MIN

Time	Variable	Site Observation 1	2	3	Mean	MUTCD Warrant 4
9:00 AM	[1]Acceptable Gaps	18	11	14	14 *	Min. 15
	[2]D	48.8	70.2	55.1	58.0	Max. 70.0
12:00 PM	Acceptable Gaps	9	14	10	11 *	Min. 15
	D	70.4	59.3	70.9	66.9	Max. 70.0
3:00 PM	Acceptable Gaps	2	3	3	3 *	Min. 15
	D	94.5	93.3	93.0	93.6*	Max. 70.0

[1]Number of acceptable gaps, ⩾G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — CONTROL C-4, Full Signalization (Semi-Act.)

SITE South & 20th — SITE "O" & 25th

Behavior	Site	Site Observation 1 Freq.	1 Percent	2 Freq.	2 Percent	3 Freq.	3 Percent	Total Freq.	Total Percent	Z^3
B	Exp.	15	3.93	2	0.60	3	0.94	20	2.08	-2.946**
	Control	14	6.97	5	0.74	4	3.39	23	4.91	
TV	Exp.	13	3.40	8	2.42	8	2.50	29	3.01	-1.030
	Control	2	1.00	9	4.48	8	6.78	19	4.06	
VH	Exp.	2	0.52	19	5.74	10	3.13	31	3.22	-0.809
	Control	10	4.98	9	4.48	0	0.00	19	4.06	
N^1	Exp.	382		331		320		962		
	Control	201		149		118		468		
RE	Exp.	0	0.00	4	0.06	0	0.00	4	0.02	-1.036
	Control	4	0.04	4	0.04	2	0.02	10	0.04	
A	Exp.	3	0.04	2	0.03	3	0.04	8	0.04	2.423*
	Control	0	0.00	1	0.01	1	0.01	2	0.01	
N^2	Exp.	7,269		6,657		6,893		20,819		
	Control	9,408		9,455		8,897		27,760		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — STREET WIDTH 44 Ft. (13.4 m)

ADEQUATE GAP TIME (G) 15 Sec.

CROSSING South — GAP STUDY PERIOD 15 MIN

Time	Variable	Site Observation 1	2	3	Mean	MUTCD Warrant 4
9:00 AM	[1]Acceptable Gaps	13	1	7	7 *	Min. 15
	^2D	72.8	97.9	84.5	85.1*	Max 75.0
12:00 PM	Acceptable Gaps	7	2	1	3 *	Min. 15
	D	86.7	96.0	97.8	93.5*	Max. 75.0
3:00 PM	Acceptable Gaps	3	0	1	1 *	Min. 15
	D	94.8	100.0	98.2	97.7*	Max. 75.0

[1]Number of acceptable gaps, ⩾G.
[2]D – Pedestrian delay -- percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — CONTROL C-4, 5, Full Signalization (Semi-Act.)

SITE Fauntleroy & Myrtle — SITE Renton & Cloverdale

Behavior	Site	Site Observation 1 Freq.	1 Percent	2 Freq.	2 Percent	3 Freq.	3 Percent	Total Freq.	Total Percent	Z^3
B	Exp.	2	1.39	0	0.00	4	3.03	6	1.38	-2.563*
	Control	12	8.82	2	1.56	3	2.29	17	4.30	
TV	Exp.	1	0.69	0	0.00	2	1.52	3	0.69	-1.427
	Control	3	2.21	2	1.56	2	1.53	7	1.78	
VH	Exp.	3	2.08	3	1.89	0	0.00	6	1.38	-0.168
	Control	1	0.74	3	2.34	2	1.53	6	1.52	
N^1	Exp.	144		159		132		435		
	Control	136		128		131		395		
RE	Exp.	0	0.00	0	0.00	1	0.03	1	0.01	0.040
	Control	0	0.00	1	0.03	0	0.00	1	0.01	
A	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-1.375
	Control	1	0.03	0	0.00	1	0.03	2	0.02	
N^2	Exp.	3,411		3,074		3,160		9,645		
	Control	3,555		3,273		3,382		10,210		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign — STREET WIDTH 54 Ft. (16.5 m)

ADEQUATE GAP TIME (G) 18 Sec.

CROSSING Fauntleroy — GAP STUDY PERIOD 15 MIN

Time	Variable	Site Observation 1	2	3	Mean	MUTCD Warrant 4
9:00 AM	[1]Acceptable Gaps	17	14	13	15	Min. 15
	^2D	44.1	65.1	62.1	57.1	Max. 70.0
12:00 PM	Acceptable Gaps	9	14	11	11 *	Min. 15
	D	64.2	60.3	68.8	64.4	Max. 70.0
3:00 PM	Acceptable Gaps	6	7	9	7 *	Min. 15
	D	79.7	84.3	74.8	79.6*	Max. 70.0

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Memphis

EXPERIMENT E-5, Crossing Guard **CONTROL** C-5, Full Signalization (Full Act.)

SITE Knight-Arnold & Clearbrook **SITE** Knight-Arnold & Castleman

Behavior	Site	Site Observation								Z^3
		1		2		3		Total		
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	1	3.33	6	54.54	2	7.4	9	13.23	0.797
	Control	6	7.32	0	0.00	11	22.00	17	9.71	
TV	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-2.830**
	Control	7	8.54	0	0.00	12	24.00	19	10.86	
VH	Exp.	7	23.33	4	36.36	3	11.11	14	20.59	0.411
	Control	19	23.17	5	11.63	8	16.00	32	18.29	
N^1	Exp.	30		11		27		68		
	Control	82		43		50		175		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-0.958
	Control	0	0.00	1	0.02	0	0.00	1	0.00	
A	Exp.	1	0.02	3	0.05	0	0.00	4	0.02	0.933
	Control	0	0.00	0	0.00	2	0.03	2	0.01	
N^2	Exp.	6,237		6,047		6,395		18,679		
	Control	6,901		6,518		7,059		20,478		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-5, Crossing Guard **STREET WIDTH** 62 Ft. (18.9 m)

ADEQUATE GAP TIME (G) 21 Sec.

CROSSING Knight-Arnold GAP STUDY PERIOD 15 MIN

Time	Variable	Site Observation				MUTCD Warrant 4
		1	2	3	Mean	
9:00 AM	[1]Acceptable Gaps	5	6	1	4 *	Min. 15
	[2]D	83.9	82.8	96.8	87.8*	Max. 65.0
12:00 PM	Acceptable Gaps	0	0	4	1 *	Min. 15
	D	100.0	100.0	89.0	96.3*	Max. 65.0
3.00 PM	Acceptable Gaps	0	1	1	1 *	Min. 15
	D	100.0	97.7	97.6	98.4*	Max. 65.0

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

BEHAVIOR DATA SUMMARY

CITY Seattle

EXPERIMENT E-5, Crossing Guard — **CONTROL** C-4, 5, Full Signalization (Semi-Act.)

SITE 23rd & Hanford — **SITE** Renton & Cloverdale

Behavior	Site	Site Observation 1		2		3		Total		Z^3
		Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
B	Exp.	5	1.00	11	3.30	2	0.43	18	1.38	-3.574**
	Control	12	8.82	2	1.56	3	2.29	17	4.30	
TV	Exp.	1	0.20	1	0.30	0	0.00	2	0.15	-3.880**
	Control	3	2.21	2	1.57	2	1.53	7	1.78	
VH	Exp.	16	3.20	29	8.71	10	2.14	55	4.73	2.534*
	Control	1	0.74	3	2.34	2	1.53	6	1.52	
N^1	Exp.	500		333		467		1,300		
	Control	136		128		131		395		
RE	Exp.	0	0.00	0	0.00	0	0.00	0	0.00	-1.032
	Control	0	0.00	1	0.03	0	0.00	1	0.01	
A	Exp.	4	0.13	0	0.00	0	0.00	0	0.00	-1.421
	Control	1	0.03	0	0.00	1	0.03	2	0.02	
N^2	Exp.	3,055		3,539		3,227		9,821		
	Control	3,555		3,273		3,382		10,210		

[1]Total number of pedestrians observed crossing major street.
[2]Total number of major street vehicles observed.
[3]Z – The Z statistic for a two tailed test based on total values.
*Significant at 0.05 level.
**Significant at 0.01 level.

VEHICLE GAP STUDY

(Experiment Site Only)

EXPERIMENT E-5, Crossing Guard — **STREET WIDTH** 28 Ft. (8.5 m)

ADEQUATE GAP TIME (G) 11 Sec.

CROSSING 23rd — **GAP STUDY PERIOD** 15 MIN

Time	Variable	Site Observation 1	2	3	Mean	MUTCD Warrant 4
9:00 AM	[1]Acceptable Gaps	28	23	29	27	Min. 15
	^2D	32.6	56.1	37.6	42.1	Max. 81.7
12:00 PM	Acceptable Gaps	33	23	21	26	Min. 15
	D	24.8	39.1	43.1	35.6	Max. 81.7
3:00 PM	Acceptable Gaps	23	26	18	22	Min. 15
	D	54.3	47.6	61.6	54.5	Max. 81.7

[1]Number of acceptable gaps, ≥G.
[2]D – Pedestrian delay – percentage of time ped. cannot cross safely.
*Meets warrant 4, school crossing, MUTCD.

APPENDIX H

DRIVER UNDERSTANDING DATA

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Sign - Major) E-1

City: _____

Date: _____

Leg: _____

Time: _____

Driver #: _____

morning,
Good afternoon, we are conducting a traffic survey. Would you help us by answering some short questions?

1. At the intersection you just passed, were there any traffic signs, lights, or signals?

   ____ yes ____ no (go to 7) ___ don't know

2. What message was on the sign?

   ____ Stop for Pedestrians ___ don't know

3. What is the purpose of this traffic control device?

   ____ to help cars on the side street ____ all three
   ____ to help cars on the main street ____ don't know
   ____ to help pedestrians

4. When are you required to stop at this intersection?

   ____ pedestrian present ____ flashing red light
   ____ pedestrian and red light ____ pedestrian or flashing red light
   ____ never ____ always

5. Are you required to stop for a flashing red light at this intersection?

   ____ yes ____ no ___ only when pedestrian present

6. What causes the lights in the sign to flash red for this street?

   ____ cars ____ pedestrians ____ controller(timing)
   ____ don't know

7. What controls traffic on the side street at this intersection?

   ____ stop sign ____ traffic light ____ don't know

8. How many times per week do you pass through this intersection?
   0-5 6-10 11-15 16-20 20+

   Driver Age: 0-15 16-30 31-45 46-60 Over 60

   Driver Sex: M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Flashing Yellow - Major)

E-2

City: _____

Date: _____

Leg: _____ _____

Time: _____

Driver # : _____

morning,
Good afternoon, we are conducting a traffic survey. Would you help us by answering some short questions?

1. Was there a traffic light at the intersection you just passed?
   ____ yes ____ no (go to #7)

2. At the intersection you just passed, what is the purpose of the traffic light?

   ____ to help traffic on the main street ____ to help pedestrians
   ____ to help traffic on the side street ____ all three
   ____ don't know

3. Was the traffic light steady or flashing? What color?

   ____ steady ____ flashing ____ don't know
   ____ red ____ yellow ____ green ____ don't know

4. What does a flashing yellow light mean to you?

   ____ slow down ____ caution ____ same as green ____ go
   ____ don't know

5. What causes the traffic light you just passed to turn red for the main street?

   ____ cars ____ pedestrians ____ controller (timing)
   ____ don't know

6. What exactly controls traffic on the side street? (If you were driving down the side street what would you see?)

   ____ stop sign ____ traffic light ____ flashing/solid red
   ____ don't know beacon

7. How many times per week do you drive through this intersection?

   0-5 6-10 11-15 16-20 20+

   What is your approximate age:

   0-15 16-30 31-45 46-60 Over 60

   Driver Sex M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Flashing Green - Major)
E-3

City: _____

Date: _____

Leg: _____

Time: _____

Driver #: _____

Good morning, afternoon, we are conducting a traffic survey. Would you help us by answering some short questions?

1. Was there a traffic light at the intersection you just passed?

   ____ yes ____ no(go to #7)

2. At the intersection you just passed, what is the purpose of the traffic light?

   ____ to help traffic on the main street ____ to help pedestrians
   ____ to help traffic on the side street ____ all three
   ____ don't know

3. Was the traffic light steady or flashing? What color?

   ____ steady ____ flashing ____ don't know
   ____ red ____ yellow ____ green ____ don't know

4. What does a flashing green light mean to you?

   ____ slow down ____ caution ____ same as green ____ go
   ____ don't know

5. What causes the traffic light you just passed to turn red for the main street?

   ____ cars ____ pedestrians ____ controller(timing)
   ____ don't know

6. Does this traffic light control traffic on the side street?

   ____ yes ____ no ____ don't know

7. What exactly controls traffic on the side street?

   ____ stop sign ____ traffic light ____ don't know

8. How many times per week do you drive through this intersection?

   0-5 6-10 11-15 16-20 20+

   What is your approximate age:
   0-15 16-30 31-45 46-60 Over 60

   Driver Sex M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Solid Green) E-4

City: _____

Date: _____

Leg: _____

Time: _____

Driver #: _____

Good morning, afternoon, we are conducting a traffic survey. Would you help us by answering some short questions?

1. Was there a traffic light at the intersection you just passed?

   ___ yes ___ no (go to #5)

2. At the intersection you just passed what is the purpose of the traffic light?

   ____ to help traffic on this street ____ to help traffic on the main street

   ____ to help pedestrians ____ all three

   ____ don't know

3. What causes the traffic light you just passed to turn red for the main street?

   ____ cars ____ pedestrians ____ controller (timing)

   ____ don't know

4. Does the traffic light control traffic from the side street?

   ____ yes ___ no ____ don't know

5. What exactly controls traffic on the side street?

   ____ stop sign ____ light ____ don't know'

6. How many times per week do you drive through this intersection?

   0-5 6-10 11-15 16-20 20+

   Age 0-15 16-30 31-45 46-60 Over 60

   Sex M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Sign - Minor) E-1

City: _____

Date: _____

Leg: _____

Time: _____

Driver #: _____

morning,
Good afternoon, we are conducting a traffic survey. Would you help us by answering some short questions?

1. Was there a traffic control device other than a stop sign at the intersection you just passed?

   ____ yes ____ no (go to #6)

2. At the intersection you just passed, what is the purpose of that traffic control device?

   ____ to help traffic on the side street ____ all three

   ____ to help traffic on the main street ____ don't know

   ____ to help pedestrians Other/Comment

3. What does a flashing red signal mean to you?

   ____ slow down ____ caution ____ stop and go ____ stop

   ____ don't know

4. What causes the traffic control device at this intersection to flash red?

   ____ cars ____ pedestrians ___ controller (timing)

   ____ don't know

5. Does this traffic control device control traffic on the side street?

   ____ yes ____ no ____ don't know

6. How many times per week do you drive through this intersection?
   0-5 6-10 11-15 16-20 20+

   What is your approximate age?
   0-15 16-30 31-45 46-60 Over 60

   Driver Sex: M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
Flashing Yellow - Minor
E-2

City: _____

Date: _____

Leg: _____

Time: _____

Driver # : _____

morning,
Good afternoon, we are conducting a traffic survey. Would you help us by answering seven short questions?

1. Was there a traffic light for the main street at the intersection you just passed?

   ____ yes ____ no

2. What controls the traffic on the side street?

   ____ stop sign ____ flashing/solid beacon ___ traffic lights
   ____ don't know

3. At the intersection you just passed, what is the purpose of the traffic light?

(read) _____ to help traffic on the side street ____ all three
(read) _____ to help traffic on the main street
(read) _____ to help pedestrians

4. What does a flashing red signal mean to you?

   ____ slow down ____ caution ____ same as stop sign
   ____ stop and go ____ stop ____ don't know

5. What causes the traffic light at this intersection to turn solid red for both the main and side streets?

   ____ cars ____ pedestrians ____ controller (timing)
   ____ don't know

6. What should you do when you see a solid red light on this side street?

   ____ stop and remain stopped (wait for flashing red) ____ stop and go ____ don't know
   ____ STOP

7. How many times per week do you drive through this intersection?

   0-5 6-10 11-15 16-20 20+

   What is your approximate age?

   0-15 16-30 31-45 46-60 60+

   Driver Sex M F

U.S. Office of Management and Budget
Approval No. 004R2453
Approval Expires 12/31/76

SCHOOL-PEDESTRIAN CROSSING DESIGN

DRIVER DATA SHEET
(Flashing Green - Minor)
E-3

City: _____

Date: _____

Leg: _____

Time: _____

Driver #: _____

morning,
Good afternoon, we are conducting a traffic survey. Would you help us by answering seven short questions?

1. Was there a traffic light at the intersection you just passed?

   ___ Yes ____ No (go to 6)

2. At the intersection you just passed, what is the purpose of the traffic signal?

   ____ to help traffic on the side street ____ all three

   ____ to help traffic on the main street ____ don't know

   ____ to help pedestrians

   Comment/Other

3. What does a flashing green signal mean to you?

   ____ slow down ____ caution ____ same as green ____ go

   ____ don't know

4. What causes the traffic light at this intersection to turn red for the main street?

   ____ cars ____ pedestrians ____ controller(timing)

   ____ don't know

5. Does this traffic light control traffic on the side street?

   ____ yes ____ no ____ don't know

6. What exactly controls traffic on the side street?

   ____ stop sign ____ traffic light ____ don't know

7. How many times per week do you drive through this intersection?

   0-5 6-10 11-15 16-20 20+

   What is your approximate age?
   0-15 16-30 31-45 46-60 Over 60

   Driver Sex: M F

DRIVER UNDERSTANDING DATA SUMMARY

CITY Atlanta

EXPERIMENT E-1, Sign & Stop Sign

SITE S. Cobb & Barber

Drivers approached intersection on *Major* street

Question 1. At the intersection you just passed, were there any signs, lights, or signals?

Answer	Frequency	Percent	N
Yes *	21	60	
No (Go to Question #7)	4	11	35
Dont know (Go to Question #7)	10	29	

Question 2. What message was on the sign?

Answer	Frequency	Percent	N
Stop for pedestrians *	8	38	
Pedestrian crossing	0	0	21
Dont know	13	62	

Question 3. What is the purpose of this traffic control device?

Answer	Frequency	Percent	N
To help traffic on the main street	1	5	
To help traffic on the side street	2	10	
To help pedestrians *	13	62	21
All three	2	10	
Dont know	3	13	

Question 4. When are you required to stop at this intersection?

Answer	Frequency	Percent	N
Pedestrian present	6	29	
Flashing red light	6	29	
Pedestrian and F. red light	3	14	
Pedestrian or F. red light *	4	18	21
Always	0	0	
During school only	1	5	
Dont know	1	5	

Question 5. Are you required to stop for a flashing red light at this intersection?

Answer	Frequency	Percent	N
Yes *	15	71	
No	2	10	21
Only when pedestrian present	3	14	
Dont know	1	5	

Question 6. What causes the lights in the sign to flash red for this street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	9	43	21
Controller (Timing)	3	14	
Dont know	9	43	

Question 7. What controls traffic on the side street at this intersection?

Answer	Frequency	Percent	N
Stop sign *	15	43	
Traffic light	7	20	35
Dont know	13	37	

Question 8. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
19	7	7	2

Sex			Age		
M	F	16-30	31-45	45-60	60+
22	13	14	13	8	0

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Buffalo
EXPERIMENT E-1, Sign & Stop Sign
SITE Broadway & Pine

Drivers approached intersection on *Major* street

Question 1. At the intersection you just passed, were there any signs, lights, or signals?

Answer	Frequency	Percent	N
Yes *	23	66	
No (Go to Question #7)	7	20	35
Dont know (Go to Question #7)	5	14	

Question 2. What message was on the sign?

Answer	Frequency	Percent	N
Stop for pedestrians *	13	57	
Pedestrian crossing	7	30	23
Dont know	3	13	

Question 3. What is the purpose of this traffic control device?

Answer	Frequency	Percent	N
To help traffic on the main street	3	13	
To help traffic on the side street	2	9	
To help pedestrians *	14	61	23
All three	3	13	
Dont know	1	4	

Question 4. When are you required to stop at the intersection?

Answer	Frequency	Percent	N
Pedestrian present	10	43	
Flashing red light	7	31	
Pedestrian and F. red light	0	0	23
Pedestrian or F. red light *	5	22	
Always	1	4	
During school only	0	0	
Dont know	0	0	

Question 5. Are you required to stop for a flashing red light at this intersection?

Answer	Frequency	Percent	N
Yes *	22	96	
No	0	0	23
Only when pedestrian present	1	4	
Dont know	0	0	

Question 6. What causes the lights in the sign to flash red for this street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	6	26	23
Controller (Timing)	8	35	
Dont know	9	39	

Question 7. What controls traffic on the side street at this intersection?

Answer	Frequency	Percent	N
Stop sign *	16	46	
Traffic light	0	0	35
Dont know	19	54	

Question 8. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
21	12	0	2

Sex		Age			
M	F	16-30	31-45	46-60	60+
33	2	11	13	10	1

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Memphis

EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon

SITE Hollywood & Heard

Drivers approached intersection on *Major* street.

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	30	93	32
No (Go to Question # 7)	2	6	

Question 2. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the main street	4	13	
To help traffic on the side street	4	13	
To help pedestrians *	13	43	30
All three	7	24	
Slow traffic	0	0	
Dont know	2	7	

Question 3. Was the traffic light steady or flashing? What color?

Answer	Frequency	Percent	N
Steady	1	3	
Flashing *	27	90	30
Dont know	2	7	

Answer	Frequency	Percent	N
Red	1	3	
Yellow *	27	90	30
Green	0	0	
Dont know	2	7	

Question 4. What does a flashing yellow light mean to you?

Answer	Frequency	Percent	N
Slow down *	7	23	
Caution *	23	77	
Same as green	0	0	30
Go	0	0	
Dont know	0	0	

Question 5. What causes the traffic light you just passed to turn red for the main street?

Answer	Frequency	Percent	N
Cars	5	17	
Pedestrians *	10	33	30
Controller (Timing)	5	17	
Dont know	10	33	

Question 6. What exactly controls traffic on the side street?

Answer	Frequency	Percent	N
Stop sign	3	10	
Traffic light	2	7	30
Flashing / solid red beacon *	15	50	
Dont know	10	33	

Question 7. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
17	5	8	2

Sex		Age			
M	F	16-30	31-45	46-60	60+
23	19	10	12	10	0

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Sioux City
EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon
SITE Hamilton & 24th

Drivers approached intersection on *Major* street

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	34	97	35
No (Go to Question # 7)	1	3	

Question 2. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the main street	6	18	
To help traffic on the side street	9	26	
To help pedestrians *	8	24	34
All three	2	6	
Slow traffic	7	20	
Dont know	2	6	

Question 3. Was the traffic light steady or flashing? What color?

Answer	Frequency	Percent	N
Steady	4	12	
Flashing *	28	82	34
Dont know			

Answer	Frequency	Frequency	N
Red	0	0	
Yellow *	28	82	34
Green	4	12	
Dont know	2	6	

Question 4. What does a flashing yellow light mean to you?

Answer	Frequency	Percent	N
Slow down *	6	18	
Caution *	28	82	
Same as green	0	0	34
Go	0	0	
Dont know	0	0	

Question 5. What causes the traffic light you just passed to turn red for the main street?

Answer	Frequency	Percent	N
Cars	3	9	
Pedestrians *	18	53	34
Controller (Timing)	6	18	
Dont know	7	20	

Question 6. What exactly controls traffic on the side street?

Answer	Frequency	Percent	N
Stop sign	12	35	
Traffic light	9	26	34
Flashing / solid red beacon *	7	21	
Dont know	6	18	

Question 7. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
24	1	5	5

Sex		Age			
M	F	16-30	31-45	46-60	60+
21	14	9	18	3	5

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, Flashing Green Signal & Stop Sign

SITE South & 52nd

Drivers approached intersection on *Major* street.

Question 1. At the intersection you just passed, what is the purpose of the traffic signal?

Answer	Frequency	Percent	N
Help traffic on the main street	2	7	
Help traffic on the minor street	1	3	
Help pedestrians *	18	62	29
All three of the above	2	7	
Dont know	6	21	

Question 2. When you went through the intersection was the green signal steady or flashing?

Answer	Frequency	Percent	N
Steady	7	24	
Flashing *	20	69	20
Dont know	2	7	

Question 3. What does a flashing green signal mean to you?

Answer	Frequency	Percent	N
Caution *	12	42	
Same as solid green	4	14	
Go	2	7	
Slow down *	2	7	
Out of order	4	14	29
Pedestrian crossing, same as yellow *	1	3	
Stop	2	7	
Proceed	1	3	
Dont know	1	3	

Question 4. What causes the traffic light you just passed to turn red for the major street. (The street you are on)?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	18	62	29
Controller (Timing)	7	24	
Dont know	4	14	

Question 5. Does a traffic light control traffic on the minor street?

Answer	Frequency	Percent	N
Yes	10	34	
No *	13	45	29
Dont know	6	21	

Question 6. What exactly controls traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	11	38	
Signal	5	17	29
Amber signal	1	3	
Dont know	12	42	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
22	3	2	2

Sex		Age			
M	F	16-30	31-45	46-60	60+
15	14	10	12	6	1

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Seattle
EXPERIMENT E-3, Flashing Green Signal & Stop Sign
SITE Beacon & Hanford

Drivers approached intersection on *Major* street.

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	35	100	35
No (Got to Question #7)	0	0	

Question 2. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the main street	3	9	
To help traffic on the minor street	4	11	
To help pedestrians *	16	46	35
All three	6	17	
Slow traffic	1	3	
Dont know	5	14	

Question 3. Was the traffic light steady or flashing? What color?

Answer	Frequency	Percent	N
Steady	5	14	
Flashing *	27	77	35
Dont know	3	9	

Answer	Frequency	Percent	N
Red	1	3	
Yellow	0	0	35
Green *	33	94	
Dont know	1	3	

Question 4. What does a flashing green light mean to you?

Answer	Frequency	Percent	N
Slow down *	4	11	
Caution *	19	54	
Same as green	8	23	35
Might turn red	1	3	
Dont know	3	9	

Question 5. What causes the traffic light you just passed to turn red for the main street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	14	40	35
Controller (Timing)	12	34	
Dont know	9	26	

Question 6. Does this traffic light control traffic on the minor street?

Answer	Frequency	Percent	N
Yes	18	51	
No *	8	23	35
Dont know	9	26	

Question 7. What exactly controls traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	8	23	
Traffic light	4	11	35
Dont know	23	66	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
28	3	2	2

Sex		Age			
M	F	16-30	31-45	46-60	60+
20	15	11	15	6	3

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Lincoln

EXPERIMENT E-4, (Sg-44), Signal & Stop Sign

SITE South St. & 20th St.

Drivers approached intersection on *Major* street

Question 1. At the intersection you just passed, what is the purpose of the traffic signal?

Answer	Frequency	Percent	N
Help traffic on the minor street	3	10	
Help traffic on this street	3	10	
Help pedestrians *	20	67	30
All three of the above	4	13	
Dont know	0	0	

Question 2. What causes the traffic signal you just passed to turn red for this street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	20	67	30
Controller (Timing)	6	20	
Dont know	4	13	

Question 3A. Does the traffic signal control traffic from the side street?

Answer	Frequency	Percent	N
Yes	15	50	
No *	12	40	30
Dont know	3	10	

Question 3B. If NO, what does control traffic from the minor street?

Answer	Frequency	Percent	N
Stop sign *	6	50	12
Dont know	6	50	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
12	8	3	7

Sex		Age			
M	F	16-30	31-45	46-60	60+
15	15	14	7	8	1

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

Drivers approached intersection on *Major* street.

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	29	83	35
No (Go to Question #5)	6	17	

Question 2. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the major street	1	3	
To help traffic on the minor street	1	3	
To help pedestrians *	27	94	29
All three of the above	0	0	
Dont know	0	0	

Question 3. What causes the traffic light you just passed to turn red for the major street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	19	66	29
Controller (Timing)	7	24	
Dont know	3	10	

Question 4. Does the traffic light control traffic from the minor street?

Answer	Frequency	Percent	N
Yes	12	41	
No *	17	59	29
Dont know	0	0	

Question 5. What exactly controls traffic from the minor street?

Answer	Frequency	Percent	N
Stop sign *	17	49	
Traffic light	6	17	35
Dont know	12	34	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
15	5	5	10

Sex		Age			
M	F	16-30	31-45	46-60	60+
19	16	7	15	9	4

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Atlanta
EXPERIMENT E-1, Sign & Stop Sign
SITE S. Cobb & Barber

Drivers approached intersection on *Minor* street

Question 1. Was there a traffic control device other than a stop sign at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	13	93	14
No (Go to Question #6)	1	7	

Question 2. At the intersection you just passed, what is the purpose of that traffic control device?

Answer	Frequency	Percent	N
To help traffic on the side street	0	0	
To help traffic on the main street	0	0	
To help pedestrians *	13	100	13
All three	0	0	
Dont know	0	0	

Question 3. What does a flashing red signal mean to you?

Answer	Frequency	Percent	N
Slow down	0	0	
Caution	1	8	
Stop and go *	0	0	13
Stop *	12	92	
Dont know	0	0	

Question 4. What causes the traffic control device to flash red?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	5	39	13
Controller (Timing)	2	15	
Dont know	6	46	

Question 5. Does this traffic control device control traffic on the side street?

Answer	Frequency	Percent	N
Yes	4	31	
No *	7	54	13
Dont know	2	15	

Question 6. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
6	2	4	2

Sex		Age			
M	F	16-30	31-45	46-60	60+
9	5	4	8	2	0

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Buffalo

EXPERIMENT E-1, Sign & Stop Sign

SITE Broadway & Pine

Drivers approached intersection on *Minor* street

Question 1. Was there a traffic control device other than a stop sign at the intersection you just passed?

Answer	Frequency	Percent	N
Yes*	7	47	15
No (Go to Question #6)	8	53	

Question 2. At the intersection you just passed, what is the purpose of that traffic control device?

Answer	Frequency	Percent	N
To help traffic on the side street	1	14	
To help traffic on the main street	1	14	
To help pedestrians*	2	29	7
All three	3	43	
Dont know	0	0	

Question 3. What does a flashing red signal mean to you?

Answer	Frequency	Percent	N
Slow down	0	0	
Caution	1	14	
Stop and go*	4	57	7
Stop*	2	29	
Dont know	0	0	

Question 4. What causes the traffic control device to flash red?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians*	2	29	7
Controller (timing)	1	14	
Dont know	4	57	

Question 5. Does this traffic control device control traffic on the side street?

Answer	Frequency	Percent	N
Yes	3	42	
No*	2	29	7
Dont know	2	29	

Question 6. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
7	4	3	1

Sex		Age			
M	F	16-30	31-45	46-60	60+
12	3	4	5	6	0

*Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Memphis
EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon
SITE Hollywood & Heard

Drivers approached intersection on *Minor* street

Question 1. Was there a traffic light for the main street at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	8	89	9
No	1	11	

Question 2. What controls traffic on the side street?

Answer	Frequency	Percent	N
Stop sign	0	0	9
Flashing / solid red beacon *	7	78	
Dont know	2	22	

Question 3. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the side street	1	11	9
To help traffic on the main street	0	0	
To help pedestrians *	7	78	
All three	1	11	
Dont know	0	0	

Question 4. What does a flashing red signal mean to you?

Answer	Frequency	Percent	N
Slow down	0	0	9
Caution	0	0	
Same as stop sign *	0	0	
Stop and go *	3	33	
Stop *	6	67	
Dont know	0	0	

Question 5. What causes the traffic light at this intersection to turn solid red for both the main and side streets?

Answer	Frequency	Percent	N
Cars	1	11	9
Pedestrians *	4	45	
Controller (Timing)	1	11	
Dont know	3	33	

Question 6. What should you do when you see a solid red light on this side street?

Answer	Frequency	Percent	N
Stop and remain stopped *	2	22	9
Stop *	4	45	
Stop and go	3	33	
Dont know	0	0	

Question 7. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
6	2	0	1

Sex		Age			
M	F	16-30	31-45	46-60	60+
8	1	3	3	3	0

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Sioux City
EXPERIMENT E-2, F. Yellow Signal & F. Red Beacon
SITE Hamilton & 24th

Drivers approached intersection on *Minor* street

Question 1. Was there a traffic light for the main street at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	6	86	7
No	1	14	

Question 2. What controls traffic on the side street?

Answer	Frequency	Percent	N
Stop sign	1	17	6
Flashing/solid red beacon *	5	83	
Dont know	0	0	

Question 3. At the intersection you just passed, what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the side street	0	0	6
To help traffic on the main street	0	0	
To help pedestrians *	3	50	
All three	1	17	
Dont know	2	33	

Question 4. What does a flashing red signal mean to you?

Answer	Frequency	Percent	N
Slow down	0	0	6
Caution	0	0	
Same as stop sign *	1	17	
Stop and go *	3	50	
Stop *	2	33	
Dont know	0	0	

Question 5. What causes the traffic light at this intersection to turn solid red for both the main and side streets?

Answer	Frequency	Percent	N
Cars	0	0	6
Pedestrians *	1	17	
Controller (Timing)	1	17	
Dont know	4	66	

Question 6. What should you do when you see a solid red light on this side street?

Answer	Frequency	Percent	N
Stop and remain stopped *	1	17	6
Stop *	5	83	
Stop and go	0	0	
Dont know	0	0	

Question 7. Drivers' exposure to intersection

Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
3	0	1	3

Sex		Age			
M	F	16-30	31-45	46-60	60+
6	1	2	3	2	0

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Lincoln

EXPERIMENT E-3, Flashing Green Signal & Stop Sign

SITE South

Drivers approached intersection on *Minor* street.

Question 1. At the intersection you are approaching what exactly controls traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	16	80	
Traffic signal	4	20	20
Dont know	0	0	

Question 2. What controls traffic on the main street?

Answer	Frequency	Percent	N
Traffic signal *	17	85	
Nothing	1	5	20
Dont know	2	10	

Question 3. At this intersection what is the purpose of the traffic signal?

Answer	Frequency	Percent	N
Help traffic on the minor street	0	0	
Help traffic on the major street	0	0	
Help pedestrians *	15	75	20
All three of the above	5	25	
Dont know	0	0	

Question 4. What causes the traffic signal at this intersection to turn red for the main street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	17	85	20
Controller (Timing)	3	15	
Dont know	0	0	

Question 5. What does a flashing green signal mean to you?

Answer	Frequency	Percent	N
Caution *	12	60	
Same as green	2	10	
Go	1	5	20
Pedestrian cross walk	1	5	
Dont know	4	20	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
9	2	3	6

Sex		Age			
M	F	16-30	31-45	46-60	60+
10	10	3	8	8	1

* Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Seattle

EXPERIMENT E-3, Flashing Green Signal & Stop Sign

SITE Beacon & Hanford

Drivers approached intersection on *Minor* street.

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	5	63	8
No (Go to Question #6)	3	37	

Question 2. At the intersection you just passed, what is the purpose of the traffic signal?

Answer	Frequency	Percent	N
To help traffic on the minor street	0	0	
To help traffic on the major street	0	0	
To help pedestrians *	2	40	5
All three	1	20	
Dont know	2	40	

Question 3. What does a flashing green signal mean to you?

Answer	Frequency	Percent	N
Caution *	0	0	
Slow down *	1	20	
Same as green	1	20	5
Go	0	0	
Dont know	3	60	

Question 4. What causes the traffic light at this intersection to turn red for the main street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	2	40	5
Controller (Timing)	0	0	
Dont know	3	60	

Question 5. Does this traffic light control traffic on the side street?

Answer	Frequency	Percent	N
Yes	1	20	
No *	3	60	5
Dont know	1	20	

Question 6. What exactly controls the traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	6	75	
Traffic light	0	0	8
Dont know	2	25	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
4	4	0	0

Sex		Age			
M	F	16-30	31-45	46-60	60+
7	1	3	3	2	

*Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Lincoln
EXPERIMENT E-4, (Sg-44) Signal & Stop Sign
SITE South & 20th

Drivers approached intersection on *Minor* street.

Question 1. Are there traffic lights at the intersection you are approaching?

Answer	Frequency	Percent	N
Yes *	13	62	21
No (Go to Question #5)	8	38	

Question 2. At the intersection you are approaching what is the purpose of the traffic light?

Answer	Frequency	Percent	N
Help traffic on the minor street	1	8	
Help traffic on the main street	1	8	
Help pedestrians *	10	76	13
All three of the above	0	0	
Dont know	1	8	

Question 3. What causes the traffic light at this intersection to turn red for the major street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	12	92	13
Controller (Timing)	0	0	
Dont know	1	8	

Question 4. Does this traffic light control traffic on the minor street?

Answer	Frequency	Percent	N
Yes	4	31	
No *	8	61	13
Dont know	1	8	

Question 5. What exactly controls traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	19	90	
Pedestrian signal	1	5	
Traffic light	0	0	21
Dont know	1	5	

Question 6. What exactly controls the traffic on the major street?

Answer	Frequency	Percent	N
Traffic light *	17	81	
Nothing	1	5	21
Pedestrian signal *	1	5	
Dont know	2	9	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
11	2	2	7

Sex		Age			
M	F	16-30	31-45	46-60	60+
12	9	11	4	5	1

*Correct answer

DRIVER UNDERSTANDING DATA SUMMARY

CITY Seattle

EXPERIMENT E-4, (Sg-44) Signal & Stop Sign

SITE Fauntleroy & Myrtle

Drivers approached intersection on *Minor* street

Question 1. Was there a traffic light at the intersection you just passed?

Answer	Frequency	Percent	N
Yes *	13	100	13
No (Go to Question #5)	0	0	

Question 2. At the intersection you just passed what is the purpose of the traffic light?

Answer	Frequency	Percent	N
To help traffic on the minor street	0	0	
To help traffic on the main street	0	0	
To help pedestrians *	13	100	13
All three of the above	0	0	
Dont know	0	0	

Question 3. What causes the traffic light you just passed to turn red for the main street?

Answer	Frequency	Percent	N
Cars	0	0	
Pedestrians *	11	85	
Controller (Timing)	0	0	13
Dont know	2	15	

Question 4. Does the traffic light control traffic from the side street?

Answer	Frequency	Percent	N
Yes	2	15	
No *	10	77	13
Dont know	1	8	

Question 5. What exactly controls traffic on the minor street?

Answer	Frequency	Percent	N
Stop sign *	10	77	
Traffic light	0	0	13
Dont know	3	23	

Drivers Exposure to Intersection			
Frequency of Trips Through the Intersection Per Week			
0-5	6-10	11-15	16+
5	3	5	0

Sex		Age			
M	F	16-30	31-45	46-60	60+
3	10	7	2	3	1

* Correct answer

APPENDIX I

t-TEST FOR RANK SCORES

RANK SCORE DATA ANALYSIS

The rank score data obtained from the comparison among the five school-pedestrian crossing designs was tested for significant differences in mean rank scores between the five designs (Table I-1). The rank scores are distributed rectangularly over the values 1, 2, 3, 4, and 5. Under the assumption that a rectangular population is approximately normal,* the t-test was used to identify significant differences between the mean rank scores of the five school-pedestrian crossing designs.

Table I-1
Rank Scores for School-Pedestrian Crossing Designs

Measure of Effectiveness	E-1 Sign and Stop Sign	E-2 F. Yellow Signal and F. Red Beacon	E-3 F. Green Signal and Stop Sign	E-4 (Sg-44) Signal and Stop Sign	E-5 Crossing Guard
Pedestrian Hesitation or Reversal	5	3	2	1	4
Turning Vehicle Hazard	5	2	3	4	1
Vehicle Hazard	5	3	2	1	4
Rear End Conflict	2	4	2	5	2
Angle Conflict	5	3	4	2	1
Pedestrian Compliance	5	4	3	1	2
Vehicle Violation of the Prohibited Interval	5	4	3	2	1
Major Street, Stop Time Per Vehicle	1	3	5	4	2
Minor Street, Stop Time Per Vehicle	4	5	1	2	3
TOTAL	37	31	25	22	20
Mean	4.111	3.444	2.777	2.444	2.222
Standard Deviation	1.536	0.882	1.202	1.509	1.202

Rank scores were obtained from Table 13.

The form of the t-test used was:

$$t = \frac{|\bar{R}_j - \bar{R}_k|}{S_p\sqrt{\frac{2}{N}}} \qquad \begin{aligned} j &\neq k \\ j &= 1, 2, 3, 4, 5 \\ k &= 1, 2, 3, 4, 5 \end{aligned}$$

$$\bar{R}_j = \frac{\sum_{i=1}^{9} R_{ij}}{N}$$

*Edwards, Allen L., Experimental Design in Psychological Research, Holt, Rinehart, & Winston, 1060, pp. 112.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—724-[illegible]-1283

R_{ij} = rank score for the ith score and the jth school-pedestrian crossing design.

N = 9, nine MOE's for each school-pedestrian crossing design.

$$S_p^2 = \frac{S_j^2 + S_k^2}{2}$$

$$S_j^2 = \frac{\sum_{i=1}^{9} (R_{ij} - \bar{R}_j)^2}{N-1}$$

Degrees of Freedom = $2(N-1) = 16$

The critical value is equal to 2.120 at the 0.05 level of significance. The hypothesis tested is that the mean rank scores between any two designs are equal.

Table I-2 shows the results of the t-test for the comparison among the school-population crossing designs. The hypothesis is rejected if the computed t-value was greater than 2.120. Therefore, if the hypothesis is accepted, there is no significant difference between the mean rank scores of the two school-pedestrian crossing designs being compared.

Table I-2
t-Test for Significant Differences in Mean Rank Scores

Design	E-1 Sign and Stop Sign	E-2 F. Yellow Signal and F. Red Beacon	E-3 F. Green Signal and Stop Sign	E-4 (Sg-44) Signal and Stop Sign	E-5 Crossing Guard
E-1, Sign and Stop Sign	–	1.130	2.052	2.323*	2.906*
E-2, F. Yellow Signal and F. Red Beacon	–	–	1.342	1.716	–2.459*
E-3, F. Green Signal and Stop Sign	–	–	–	0.518	1.079
E-4, (Sg.-44) Signal and Stop Sign	–	–	–	–	0.345
E-5, Crossing Guard	–	–	–	–	–

*Significant at the 0.05 level.

FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff, contract programs, and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent, national problems, which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP, together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials, to develop extender or substitute materials for materials in short supply, and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs, fabrication processes, and construction techniques, to provide safe, efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice, or, as it has been commonly identified, "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management, to augment the utilization of resources, and to increase operational efficiency and safety in the maintenance of highway facilities.

---

* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.


FEMA