A COMPARISON OF ACCIDENT EXPERIENCE AT INTERSECTIONS WITH FLASHING AND REGULAR TRAFFIC SIGNAL CONTROL DURING LOW-VOLUME TIME PERIODS

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ABSTRACT

A COMPARISON OF ACCIDENT EXPERIENCE
AT INTERSECTIONS WITH FLASHING
AND REGULAR TRAFFIC SIGNAL CONTROL
DURING LOW-VOLUME TIME PERIODS

By

Joseph Angelo Marson

Warrants have been developed to provide the traffic engineer with a means of determining the type of traffic control device which should be installed at an intersection. In the case of traffic signals, these warrants provide the minimum conditions under which signals may be justified. During the time periods when the signals are not justified, no warrants are provided to aid in selecting the proper traffic control strategy.

This research project investigated the two means of traffic control at signalized intersections during the low-volume hours; namely, full-color and flashing signal operation. Accident, geometric, and volume data for 170 intersections was collected for these two signal operations and a comparison was made to determine those conditions under which each signal operation could be used to minimize the accident potential. Statistical tests were used to compare intersection stratifications in terms of volume, intersection geometry, approach speed limit, and signal interconnection.

Joseph Angelo Marson

This study investigated only the effect of the signal control on accidents and did not consider the effect on delay and other variables. Comparative tables have been developed and recommendations have been made based on the results of the analysis to assist in determining which signal operation would be most efficient for a given set of conditions.

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I. INTRODUCTION

Traffic signals are usually installed at intersections to eliminate traffic conflicts, thereby increasing the efficiency and safety of intersections. Improper use of these devices, however, can produce the opposite effect. For this reason, warrants have been developed, and are continuously being upgraded, to aid the engineer in determining the probable effect of a sign installation and to promote uniformity in traffic signal installation practices. These warrants may be found in the "Manual of Uniform Traffic Control Devices for Streets and Highways."[1]

Although traffic signals may be installed when traffic conditions meet one or more of the warrants prescribed by this Manual, the use of such a device is often only essential for a certain portion of the day. One example of this is the situation where signals are installed based on the warrant for minimum intersecting traffic volumes. The warrant states that the required volumes must be present 8 hours per day. During the remaining 16 hours, the demand may not justify a traffic signal to prevent conflicts. Frequently, the signals are changed to flashing operation

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[1]National Joint Committee on Uniform Traffic Control Devices: Manual of Uniform Traffic Control Devices for Streets and Highways, U. S. Department of Commerce, Bureau of Public Roads, Washington D. C., (June, 1971).

during part of this period and serve as a two-way stop control.

The primary reason for operating traffic signals in this manner is to eliminate the unnecessary delay that would be imposed upon drivers. Vehicles waiting at a signalized intersection where there is little cross-street traffic are forced to wait when there may have been an opportunity to proceed through the intersection had there been a two-way stop control device. This motive for the use of such signal operations may be supplemented by additional reasons. For example, stopping traffic when there are no conflicting vehicles might very well encourage disobedience of signals indications. In addition, due to increased delay, drivers may also be induced to use less adequate routes in an attempt to avoid what they feel is unnecessary delay. The only argument which may exist in favor of retaining 24-hour full-color operation is that flashing operation may adversely affect the safety of the intersection.

Current practices vary widely in the use of flashing traffic signals. One criterion that has been used was set forth in the 1961 edition of the "Manual of Uniform Traffic Control Devices."[2] It states:

> When for a period of four or more consecutive hours any traffic volume drops to 50 percent or less of the stated volume warrants, it is

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[2]National Joint Committee on Uniform Traffic Control Devices: Manual of Uniform Traffic Control Devices for Streets and Highways, U. S. Department of Commerce, Bureau of Public Roads, Washington D. C., (June, 1961).

> desirable that flashing operation be substituted for conventional operation for the duration of such periods...

This criterion has since been eliminated from the Manual due to the lack of theoretically or emperically derived relationships to justify such warrants.

A survey reported in NCHRP Project 3-20 titled "Traffic Signal Warrants", which has not yet been published, indicates a lack of consistency and understanding in the use of flashing traffic signals.[3] Of the 94 jurisdictions responding to a questionnaire, 88 had specific criterion for the use of flashing traffic signals. Out of these 88, 26% never converted signals to flashing operation, 24% used criterion from the 1961 edition of the MUTCD, 28% used a reduction in volumes other than those set forth in the 1961 MUTCD and the remaining 22% had criterion not dependent on traffic volumes. Since one of the principle reasons for developing the Manual of Uniform Traffic Control Devices was to promote uniformity in the use of traffic control devices, this survey indicates the need to develop standards for the application of flashing traffic signals. Such standards should be based on statistical analyses that present evidence showing if and when applications of flashing traffic signals should occur.

Before safety based warrants can be established for the utilization of flashing traffic signals, it is necessary to

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[3] "Traffic Signal Warrants", Section 4.2: Criteria for Flashing Operations, National Cooperative Highway Research Program Project 3-20.

determine the accident experience with different methods of operation. Experience has shown that different types of accidents will occur under full-color and flashing operation of the signals. With full-color operation, the predominant type of accident is the rear-end accident, whereas angle accidents are more common during flashing operation.

Using criteria such as cost, if the accident situation is minimized by the use of flashing traffic signals during non-warranted periods, then full utilization of this operation should be made. If the opposite occurs, it would be necessary to consider accidents, delay of vehicles, and possibly other factors such as increased cost of operation, to determine if flashing operation is desirable.

The objective of this study was to compare the accident experience at intersections operating under regular and flashing traffic signals. More specifically this study investigated the conditions under which use of flashing operation can be made, as well as those conditions where it should not be used. These guidelines or warrants, however, were based strictly on accident data and did not consider the effect of delay and other costs incurred by the public (such as the additional energy cost of operating full-color signals).

II. REVIEW OF LITERATURE

As evidenced by the literature search, very little work has been conducted in studying this type of signal operation. In referring to flashing operation of traffic signals during night hours, Paul C. Box supports this view by stating that "more studies are needed on this type of operation, since flashing operation during off-peak hours is one way of reducing needless stops by drivers on the heavier travelled or higher-speed route."[4] The lack of attention given to this area has resulted in the varied use of flashing traffic signals as previously shown from the NCHRP 3-20 project.

There was only one study with sufficient data to justify the conclusions found in the published literature. A report titled "Accident Experience as Related to Regular and Flashing Operations of Traffic Signals" concludes that 24-hour full-color operation of traffic signals improves the accident situation which would otherwise be experienced with flashing operation.[5]

This conclusion is based on the results of a five month before and after study conducted in Washington, D. C. Three groups of signalized intersections were utilized in the analysis: 1) Group I contained 162 intersections which were

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[4]Paul C. Box, "Traffic Control and Roadway Elements - Their Relationships to Highway Safety", Revised: Chapter 4, Intersections; 1970 Automotive Safety Foundation, p. 8.

[5]Guido Radelat, "Accident Experience as Related to Regular and Flashing Operation of Traffic Signals", District of Columbia Staff Report; D. C. Department of Highways and Traffic, (June, 1966).

converted from flashing to full-color operation, 2) Group II contained 177 intersections with full-color operation located in the same streets as Group I intersections and no more than 2 blocks from an intersection in Group I, and 3) control Group III contained 402 signalized intersections located near Group I intersections, but on different streets or at least 2 blocks from any intersection in Group I.

Group III was used to correct the percent increase or decrease in accidents in Groups I and II by assuming that Group III intersections were far enough from the converted signals that they were independent from the accident standpoint. These corrections were made to reduce the effect of changing traffic conditions between the before and after periods in the analysis. Accident rates (such as the number of accidents divided by total entering vehicles) were not used in this study. Rather, the difference in total accidents between two corresponding time periods was calculated and the significance was analyzed. The use of Group III intersections was to account for the difference in volume between the before and after study period.

The total number of accidents in Group I intersections dropped from 64 to 35, a decrease of 45.3%. The control group (Group III) experienced a drop from 105 to 99 (-5.7%). Therefore, the adjusted percent change in Group I accidents using Group III as a control was 39.6%. Group II experienced a decrease in accidents from 70 to 46 (a decrease of 34.3%) which is an adjusted change of -28.6%.

The "t" test was the statistical test used in this study. The accident decrease experienced by Group I intersections proved to be significant at the 90% level, concluding that the change from flashing to full-color operation reduced the number of accidents. As might be expected, angle accidents showed the highest net reduction (65%), this reduction being significant at the 95% level. The only other sub-group of total accidents showing a significant decrease was personal injury accidents. There was a before-after decrease from 42 to 25, which was a corrected 47.7% change. This was significant at the 90% level. The decrease in property damage accidents (35.6%) was not statistically significant at the 90% level. Other types of accidents could not be statistically analyzed due to the insufficient number of cases in the other cells.

One other interesting point which the study showed was the effect on accidents in Group II intersections (non-converted signals) due to the change in operations of Group I intersections. Total and angle accidents were both significantly reduced by the change in operations of the nearby signals. This is believed to indicate that traffic behavior at one intersection is not an independent event, but is affected by the operation of other signals in nearby intersections.

The literature search revealed differences in stopped-time delay between regular signal control and flashing operation. Although the analogy of two-way stop control devices and flashing operation of signals is not valid for purposes of accident comparisons, it does hold true for differences in stopped-time delay. In this situation, the same number of stops, as well as the length of each is the same under flashing control or stop sign control. Therefore, it was possible to review the literature and compare the stopped-time delay for signalized and 2-way stop controlled intersections.

One study in this area was a series of field measurements by Volk[6] to determine the stopped-time delay for 2-way stop, 4-way stop, traffic actuated signal, and fixed-time signal control strategies. The results showed that for a two-way stop, the stopped-time delay was 0.96 hours during the average hour, whereas the fixed-time signal was considerably more with 1.67 hours of stopped-time delay during the average hour.

A simulation of traffic flow was done by Bleyl[7] to compare regular and flashing traffic signal operation. He compared the delay under signal control to that under flasher control for the volumes used as warrants in the 1961 Manual of Uniform Traffic Control Devices. Utilizing these specifications, more delay will occur with the regular signal control than with flashing operation for volumes below the 50% levels in these warrants.

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[6] Paul C. Box and Willard A. Alroth, "Warrants for Traffic Control Signals, Part II", Traffic Engineering, (Dec., 1967), pp. 22 - 29.

[7] R. L. Bleyl, "Simulation of Traffic Flow to Compare Regular and Flashing Traffic Signal Operation", Proceedings, Institute of Traffic Engineers, (1964), pp. 152 - 161.

Charles W. Dale conducted a cost analysis of intersection traffic controls in which a cost comparison was made of road user time cost.[8] It showed that for intersections with 60% of the total ADT on the major leg, the cost due to stopped-time delay of traffic signal-controlled intersections ranged from 1.46 to 1.74 times that of two-way stop-controlled intersections for ADT's ranging from 20,000 down to 5,000. Of course, a varying split of total ADT could have a different effect on the stopped-time delay.

As seen in the literature search, it was very clear that a substantial difference existed in stopped-time delay between regular signal control and two-way stop control. However, few studies comparing accidents at intersections under regular and flashing signal operations have been conducted. This study was intended to help clarify the relationship of accidents with these two traffic controls during the low demand hours and to determine if one signal operation was significantly better from the accident standpoint than the other. The ultimate goal of this study was to recognize certain conditions under which each signal control may be used to minimize accident potential.

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[8]Charles W. Dale, "A Cost Analysis of Intersection Traffic Controls", Traffic Engineering, (May, 1966), pp. 45 - 50.

III. DATA COLLECTION

Data for this study was obtained from two sources: the Michigan Department of State Highways and Transportation and the Macomb County Road Commission. A total of 169 intersections were used in this study, with the author collecting data from the Michigan Department of State Highways and Transportation on 85 intersections with flashing operation of traffic signals and 63 intersections with full-color operation. Data from fourteen intersections with flashing operation and seven with full-color operation were supplied by the Macomb County Road Commission.

In the case of those intersections under the jurisdiction of the MDSH & T, information for two consecutive calendar years was collected for all but a few of the intersections. In those few that remained, a one calendar-year period was considered. The study period for each intersection was contained within the period 1968-1972. The determination of which two-year period to consider was based on the most recent years in which complete information was available. The fact that some intersections had only a one-year study period was due to the changes in either signal data, or available volume and accident information.

Those intersections maintained by the Macomb County Road Commission had a study period of between six and eighteen months. This period fell in the interval of January, 1971 and December, 1972.

The MDSH & T Electrical Devices Unit retains an active file on each of approximately 1817 intersections in Michigan at which there is a signal under its control. Where vital information was not obtainable for the intersections and/or signals, these intersections were eliminated from consideration. Only 148 had complete information out of the nearly 500 intersections investigated.

For each of the intersections in this study, four major categories of data were collected:

1.) Signal Data

2.) Geometric Data

3.) Volume Data

4.) Accident Data

The forms used for collecting this information are shown in Figures 1 and 2. The information at the top of Figure 1 was used for identification purposes as well as for the retrieval of accident data from computer files. Data collected for each signal included the installation date, flashing operation hours (for the test group), conversion date and new hours (if the signal was converted to flashing operation or if the hours of flashing operation changed), the date on which flashing operation was discontinued, and whether or not the signal was isolated or part of a system. All of this information was obtainable from the files.

A. Geometric Data

The Electrical Device Unit also maintains an up-to-date drawing of each intersection. These drawings provided a

FLASHING TRAFFIC SIGNAL ANALYSIS
(Intersection and Signal Information)

District:_____ County:___________ City/Village/Twp.:________________

	Control Section	Mileage Point	Signal Number
Major:	__________	______to_____	_____
	__________	______to_____	
Minor:	__________	______to_____	_____
	__________	______to_____	

Routes nos./names: Major____________________ Minor_________________

SIGNAL DATA

Signal is isolated/part of system

Installation date:__-__-__ Flashing operation hours:_____to_____

Conversion date: __-__-__ New flashing hours: _____to_____

Date of discontinued flashing operation: __-__-__

INTERSECTION GEOMETRIC DATA

4-leg Intersection ☐ Other(describe) ☐
"T" Intersection ☐ It is in urban/rural area

	Major	Minor
1. No. of approach thru lanes:	_____	_____
2. Approach speed limit:	_____mph	_____mph
3. Grade:	_____%	_____%
4. Sight distance:	_____ft.	_____ft.
5. One way street?	yes no	yes no
6. Divided?	yes no	yes no
7. Right turn flare/lane?	yes no	yes no
8. Left turn flare/lane?	yes no	yes no

Angle of Intersection: _____° Date of intersection diagram:__-__-__

VOLUME DATA

	Major	Minor	Date
1. Volume count(during flashing hrs):	_____veh	_____veh	
Volume count(during regular hrs):	_____veh	_____veh	__-__-__
2. Volume count(during flashing hrs):	_____veh	_____veh	
Volume count(during regular hrs):	_____veh	_____veh	__-__-__

	Before conversion		After Installation or after conversion	
	Major	Minor	Major	Minor
3. Average Daily Traffic:	_____veh	_____veh	_____veh	_____veh
4. Proportioned ADT:	_____veh	_____veh	_____veh	_____veh
5. Portion of ADT during flashing hours	_____veh	_____veh	_____veh	_____veh
6. Portion of ADT during regular hours	_____veh	_____veh	_____veh	_____veh

NOTES:

FIGURE 1 DATA COLLECTION FORM FOR INTERSECTION AND SIGNAL INFORMATION

FLASHING TRAFFIC SIGNAL ANALYSIS (Accident Data)

County__________ C.S.________ M.P.________ Signal No._______

Before conversion

Accident Period ___-___-___ ___-___-___		Accident Type						Severity			Total
		Sing.-veh		Multiple-veh				P.D.O.	Injury	Fatal	
		ran off rd	oth.	left turn	rear end	angle	oth.				
flash.	No. of Acc										
	Acc. Rate										
reg.	No. of Acc										
	Acc. Rate										

Accident Period ___-___-___ ___-___-___		Accident Type						Severity			Total
		Sing.-veh		Multiple-veh				P.D.O.	Injury	Fatal	
		ran off rd	oth.	left turn	rear end	angle	oth.				
flash.	No. of Acc										
	Acc. Rate										
reg.	No. of Acc										
	Acc. Rate										

After conversion OR After installation

Accident Period ___-___-___ ___-___-___		Accident Type						Severity			Total
		Sing.-veh		Multiple-veh				P.D.O.	Injury	Fatal	
		ran off rd	oth.	left turn	rear end	angle	oth.				
flash.	No. of Acc										
	Acc. Rate										
reg.	No. of Acc										
	Acc. Rate										

Accident Period ___-___-___ ___-___-___		Accident Type						Severity			Total
		Sing.-veh		Multiple-veh				P.D.O.	Injury	Fatal	
		ran off rd	oth.	left turn	rear end	angle	oth.				
flash.	No. of Acc										
	Acc. Rate										
reg.	No. of Acc										
	Acc. Rate										

FIGURE 2 DATA COLLECTION FORM FOR ACCIDENT INFORMATION

majority of the intersection geometric data as shown in Figure 1. These geometric features were used to stratify the intersections as a basis for testing the conditions under which flashing operation proved to be most effective. A check was made to assure that the geometry of the intersections did not alter during the period of study of each intersection.

B. Volume Data

Accident rates for the intersections were calculated using the total number of vehicles entering the intersection during the hours of analysis. Volume counts were obtained for each intersection with two sets of counts used and averaged when available for the analysis period. These counts revealed the total approach volumes on the major and minor roads during both the hours of flashing operation and the hours of full-color operation. For the "control" group (those on 24-hour, full-color operation), the period from 12:00 A.M. to 6:00 A.M. was used for the comparison period. This is the period when flashing operation of signals is most commonly used, simply because the lowest traffic volumes occur in this time period.

Since the traffic counts obtained were influenced by seasonal fluctuations it was necessary to obtain the Average Daily Traffic (ADT) on the major and minor streets. ADT's were not available for the minor streets in a majority of the intersections under state control; thus, the ratio of major to minor volume counts was used to obtain the minor ADT.

The final step in computing the necessary volumes needed for the accident rates was to determine that fraction of the ADT that occurred during the hours of flashing and full-color operation on both the major and minor road approaches. This was accomplished by segregating the traffic counts, such that estimates of four volumes were ultimately established:

1.) Major street volume during the flashing period
2.) Major street volume during the full-color period
3.) Minor street volume during the flashing period, and
4.) Minor street volume during the full-color period

C. Accident Data

A computer retrieval system was used in the accident data collection procedure except in the situation where ambiguity of the identification codes occurred, in which case individual accident reports were searched.

The categories of accident types and severities used in this study are shown in Figure 2. It was found through the use of a computer accident analysis program that the most frequent types of multiple-vehicle accidents at signalized intersections were angle, left-turn, and rear-end accidents. These three types accounted for 80.5% of all signalized intersection accidents on Michigan's truckline system and were used in the subsequent analysis.

One drawback in the use of a computer retrieval system is the difficulty in separating those accidents which occurred due to the intersection from those outside the influence of the intersection. The Michigan Department of State Highway's and Transportation's system allows one to specify the distance to be included in the definition of an intersection. For this study, it was presumed that any accident happening within 100 feet of an intersection was the result of the intersection. An example of the computer search of accident data may be seen in Figure 3.

In determining the severity classification of an accident, the "worst" case was tabulated for each involvement. For example, an accident with two fatalities and three injuries was tabulated as one fatal accident. The final result of the accident collection procedure was a listing of the number of accidents for each category occurring during hours of flashing operation in the test group and full-color operation (midnight to 6:00 A.M.) in the control group for each intersection. In addition to this, the <u>total</u> number of accidents for each intersection for the remainder of the 24-hour period (i.e. "daytime" period) was tabulated. This was done to provide a check of the similarity of accident distribution when both the test and control group were on full-color operation.

FIGURE 3 EXAMPLE OF COMPUTER LISTING OF ACCIDENT DATA FOR TWO INTERSECTIONS

024034 GENERAL ACCIDENT PROGRAM FLASHING TRAFFIC SIGNAL ANALYSIS---ACCIDENT DATA PAGE 4

010171-123171 CONTROL-33011 MOB-05.550 MOE-05.590

DIST	CONTROL SECTION	MILEAGE	AREA	LOC	DIRECTN V1	DIRECTN V2	DRIVER INTENT D1	DRIVER INTENT D2	MSP ACC TYPE	2VEH ACC TYPE	IMPACT PRIME	IMPACT SECND	CIRCM STNCE	WEATH	SURF COND	ALIGN	DATE	HOUR OF OCCURENCE	ACC REPORT NUMBER	SEVERITY PD	SEVERITY KLD	SEVERITY INJD
08	33011	05.550	2	99	S	S	03	01	M-VEH	R-END	FRNT-R	SIDE-L	OTHER	CLEAR	DRY	STR	05 11 71	02AM-03AM	092212	X		
08	33011	05.560	2	99	N	N	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	01 20 71	03PM-04PM	010051	X		
08	33011	05.560	2	99	N	N	03	01	M-VEH	R-END	FRNT-R	SIDE-L	OTHER	CLEAR	DRY	STR	04 03 71	03PM-04PM	076030	X		
08	33011	05.560	2	99	S	S	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	09 10 71	05PM-06PM	179784			2
08	33011	05.560	2	99	W	W	05	05	M-VEH	OTHER	REAR-R	FRNT-L	OTHER	CLEAR	DRY	STR	06 16 71	03PM-04PM	116241	X		
08	33011	05.570	2	52	W	S	01	08	M-VEH	PRKNG	REAR-R	FRNT-L	OTHER	CLEAR	WET	STR	01 04 71	03PM-04PM	005471	X		
08	33011	05.570	2	00	SW	S	05	01	M-VEH	ANGLE	SIDE-R	FRONT	OTHER	RAIN	WET	STR	12 14 71	03PM-04PM	231469	X		
08	33011	05.570	2	00	N	SW	01	05	M-VEH	ANGLE	FRNT-L	SIDE-L	SKID	SNOW	ICE	STR	12 14 71	10AM-11AM	231471			1
08	33011	05.570	2	00	W	N	01	01	M-VEH	ANGLE	FRNT-L	FRNT-R	OTHER	CLEAR	DRY	STR	02 13 71	02PM-03PM	041095	X		
08	33011	05.570	2	01	W	W	05	01	M-VEH	L-TRN	REAR-L	FRNT-R	OTHER	CLEAR	DRY	STR	08 23 71	05AM-06AM	157740	X		
08	33011	05.570	2	00	W	W	04	04	M-VEH	R-TRN	FRNT-L	REAR-R	OTHER	CLEAR	DRY	STR	08 24 71	02AM-03AM	157739	X		
08	33011	05.570	2	51	W	W	03	01	M-VEH	R-END	FRNT-R	SIDE-L	OTHER	CLEAR	WET	STR	03 23 71	07AM-08AM	059220	X		
08	33011	05.570	2	00	W	W	05	12	M-VEH	R-END	REAR-L	FRNT-R	OTHER	CLEAR	DRY	STR	11 12 71	10AM-11AM	215367	X		
08	33011	05.580	2	99	S	S	18	12	M-VEH	R-END	FRONT	REAR	SKID	CLEAR	WET	STR	03 22 71	05PM-06PM	054047	X		
08	33011	05.580	2	99	S	S	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	01 28 71	04PM-05PM	006137	X		
08	33011	05.590	2	99	N	N	01	12	M-VEH	R-END	FRONT	REAR	OTHER	CLEAR	DRY	STR	04 07 71	04PM-05PM	077301	X		
08	33011	05.590	2	99	S	S	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	WET	STR	01 15 71	08AM-09AM	010114	X		
08	33011	05.590	2	99	S	S	01	01	M-VEH	SS-SM	SIDE-L	FRNT-L	OTHER	CLEAR	DRY	STR	01 28 71	03PM-04PM	006651	X		

010171-123171 CONTROL-33011 MOB-05.630 MOE-05.670

DIST	CONTROL SECTION	MILEAGE	AREA	LOC	DIRECTN V1	DIRECTN V2	DRIVER INTENT D1	DRIVER INTENT D2	MSP ACC TYPE	2VEH ACC TYPE	IMPACT PRIME	IMPACT SECND	CIRCM STNCE	WEATH	SURF COND	ALIGN	DATE	HOUR OF OCCURENCE	ACC REPORT NUMBER	SEVERITY PD	SEVERITY KLD	SEVERITY INJD
08	33011	05.630	2	99	N	N	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	11 22 71	MDNT-01AM	221406	X		
08	33011	05.630	2	99	N	S	01	01	M-VEH	HD-ON	SIDE-L	FRNT-L	OTHER	CLEAR	DRY	STR	04 09 71	07AM-08AM	075828	X		
08	33011	05.640	2	99	S		18		FXOBJ		FRNT-L		OTHER	CLEAR	DRY	STR	07 13 71	10PM-11PM	134635	X		
08	33011	05.640	2	99	N	N	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	10 31 71	01AM-02AM	203106	X		
08	33011	05.640	2	99	N	N	12	01	M-VEH	R-END	REAR	FRONT	OTHER	CLEAR	DRY	STR	05 28 71	10AM-11AM	106867			2
08	33011	05.650	2	00	E	N	08	05	M-VEH	ANGLE	FRNT-L	SIDE-L	OTHER	CLEAR	DRY	STR	08 27 71	09PM-10PM	161272	X		
08	33011	05.650	2	00	NE	S	05	12	M-VEH	ANGLE	FRNT-L	FRONT	OTHER	CLEAR	DRY	STR	12 21 71	04PM-05PM	169576	X		
08	33011	05.650	2	51	E	E	12	01	M-VEH	R-END	REAR	FRONT	OTHER	RAIN	WET	STR	07 19 71	01AM-02AM	147011	X		
08	33011	05.650	2	00	E	N	01	07	M-VEH	OTHER	REAR-R	FRNT-L	OTHER	CLEAR	DRY	STR	01 12 71	10AM-11AM	010056	X		
08	33011	05.650	2	00	E	E	05	05	M-VEH	OTHER	FRNT-L	FRNT-R	OTHER	RAIN	WET	STR	09 27 71	07AM-08AM	173554	X		
08	33011	05.650	2	00	S	N	05	01	M-VEH	L-TRN	SIDE-R	FRNT-R	OTHER	RAIN	WET	STR	10 03 71	09PM-10PM	188369			1
08	33011	05.650	2	00	N	E	01	01	M-VEH	ANGLE	FRONT	SIDE-R	OTHER	CLEAR	DRY	STR	07 22 71	01AM-02AM	142093	X		
08	33011	05.650	2	00	S	N	05	18	M-VEH	L-TRN	FRNT-L	SIDE-L	SKID	CLEAR	DRY	STR	09 11 71	02PM-03PM	179786			1
08	33011	05.650	2	00	E	N	05	01	M-VEH	ANGLE	FRNT-R	FRNT-L	OTHER	RAIN	WET	STR	08 26 71	04PM-05PM	157738	X		
08	33011	05.650	2	00	E	S	01	01	M-VEH	ANGLE	FRONT	SIDE-R	OTHER	CLEAR	DRY	STR	01 14 71	05PM-06PM	010439			2
08	33011	05.650	2	00	N	N	01	04	M-VEH	R-TRN	FRNT-R	REAR-L	OTHER	CLEAR	DRY	STR	06 09 71	07PM-08PM	111171	X		
08	33011	05.650	2	00	N	S	12	05	M-VEH	L-TRN	REAR-L	REAR-L	OTHER	CLEAR	DRY	STR	03 05 71	07AM-08AM	054385	X		
08	33011	05.650	2	00	E	S	01	07	M-VEH	ANGLE	FRNT-L	REAR-R	OTHER	CLEAR	WET	STR	12 09 71	07PM-08PM	239754	X		
08	33011	05.650	2	00	S	E	01	05	M-VEH	ANGLE	FRNT-L	SIDE-L	OTHER	RAIN	WET	STR	07 25 71	09PM-10PM	142744	X		
08	33011	05.650	2	00	E	S	01	01	M-VEH	ANGLE	FRNT-L	FRONT	OTHER	CLEAR	DRY	STR	08 05 71	09AM-10AM	148623			3
08	33011	05.650	2	00	S	E	01	01	M-VEH	ANGLE	REAR-R	FRONT	OTHER	CLEAR	DRY	STR	08 10 71	NOON-01PM	148447	X		

D. Data Reduction

To determine the accident rates for each intersection, the following formula was utilized:

$$\text{Accident rate} = \frac{A}{(V_M\ V_m) \times (D) \times (10^{-6})}$$

where:

A = number of accidents for the individual intersection study period

V_M = approach volume for the major road during the hours under study for one day

V_m = approach volume for the minor road during the hours under study for one day

D = number of days contained in the individual intersection's study period (Note: For the majority of intersections D = 730)

The accident rates were expressed in number of accidents per million entering vehicles. Rates were determined for all intersections for each of the ten categories previously shown in Figure 2. In addition to this, the accident rate for the "total" category was computed for the "daylight" period for all intersections. To facilitate the handling of the large amount of data all the information for analysis was stored on a computer file. This made it possible to analyze the data in whatever manner desirable. A summary of the data collected and reduced is presented in Appendix A & B. Each record in Appendix A represents the accident and geometric data for one intersection. Appendix B contains a breakdown of the major and minor street approach volumes by time of day.

IV. ANALYSIS OF DATA

A statistical computing program, CONSTAT, was used to analyze the data. The CONSTAT program was developed by the statistical research laboratory of the University of Michigan. This package consists of a set of statistical analysis subroutines.

A summary of the accident data was prepared and the means and standard deviations of the two groups of data for the various accident rates are shown in Table 1. The first row is a comparison of all accidents which occurred during the "daytime" period. The remaining rows in Table 1 are comparisons for the night-time period.

Before two groups of data may be statistically compared for differences, a test of whether or not these groups came from the same population should be made. The method employed in this study was a test of the accident rates for the daylight period when both groups of signals had full-color operation. This was to determine if the accident histories of the two groups were the same, thereby justifying the use of the full-color intersections as a control group. In this study, in addition to the accident information obtained for comparing flashing and regular operation, data was collected on the total number of accidents in the test group (flashing intersections) and control group occurring during the daylight hours. Since the two groups have full-color operation of signals during this period of day, they should exhibit similar accident characteristics.

TABLE 1

MEAN AND STANDARD DEVIATION OF
ACCIDENT RATES FOR THE TEST AND CONTROL GROUP

Accident Classification	Test Group (N=99)		Control Group (N=70)	
	Mean	Standard Deviation	Mean	Standard Deviation
Daytime - Total	1.82	1.20	1.69	0.76
Night-time - Total	2.78	3.83	2.42	1.99
Severity:				
Fatal	0.04	0.25	0.00	0.00
Injury	1.21	3.38	0.89	1.08
P.D.O.	1.57	1.79	1.54	1.29
Multiple Vehicle:				
Left-turn	0.40	1.72	0.22	0.38
Rear-end	0.55	0.93	0.96	1.23
Angle	1.16	2.14	0.61	0.74
Single Vehicle:				
Ran-off-road	0.27	0.74	0.29	0.66

These rates were derived from the accidents and volumes which occurred when the test group signals were on full-color operation and for the period 6:00 A.M. to midnight in the case of the control group.

The test chosen for this comparison utilizes the Mann-Whitney U-statistic. This U-test (also called the Wilcoxon rank-sum test) ranks the combined data and then compares the sum of the ranks assigned to the individual groups to determine if there is a significant difference between the means of the samples. The usual test employed for this type of examination is the t-test, which requires that the two groups being compared be normally distributed. Since this was not the case with this data, the U-test with its more lenient requirements was used. The necessary conditions for this test is that the population be continuous and each sample size be greater than 8. Both tests insure the same reliability of the results, even though the t-test has more stringent requirements.

The U-statistic is derived by the following equation:

$$U = \frac{n_1 n_2 + n_1 \ (n_1 + 1)}{2} - R_1$$

where:

n_1 = size of first sample

n_2 = size of second sample

R_1 = sum of ranks assigned to values of the first sample

The value of U represents the total number of observations from the first sample which precede each of the observations in the second sample. Tables are available which permit the determination of the significance of this U-statistic. If the size of each sample exceeds 8, the sampling distribution of U can be approximated closely with a normal distribution, $z = (U - \mu u)/\sigma_u$, where z is practically normally distributed with a mean of zero and a standard deviation of one.

This test was applied to the two groups of intersections for the daylight period. The results showed that there was no significant difference at the 90% level of confidence (Mann-Whitney Normalized U-statistic = -0.05). Therefore, it can be concluded that the two groups of intersections come from the same population.

In the analysis of the night-time accident data for the same two groups of data, a normalized U-statistic of -0.35 was obtained. This implies that flashing operation of signals at night has no significant effect on the overall accident rate (90% level of confidence).

The next step in this analysis was to classify the accident types and severities to determine if the two signal operations affect these accident rates.

A. Accident Types and Severities - All Intersections

A comparison of the total number of accidents is not a complete measure of the effectiveness of various types of operations. It was therefore necessary to analyze accident types and severities to determine if and where important differences occurred.

This investigation was conducted on all intersections for the severity and accident type classifications previously described in this report. The results of the U-test are shown in Table 2. For each accident classification, the normalized U-statistic (commonly called the Z-statistic), test and control group mean accident rate, and the corresponding rank sums are given. In addition to this, the results of the test at a 90% level of confidence are shown.

A significant difference occurred only in rear-end accidents, which showed a higher level of rear-end accidents with regular operation. The means of the fatal, injury, left-turn and angle classifications appeared to be considerably larger in the test group (flash) than the control group, although these did not prove to be significant. In only one classification (rear-end accidents) did the mean of the control group appear to be relatively larger than the test group mean, and it was significant at the 90% level of confidence.

Although only one classification of accidents was found to be significant, it was believed that stratifying intersections based on specific characteristics could produce situations under which each signal operation is most efficient. This was the objective of the remainder of the study.

B. Accident - Volume Correlation

It has been demonstrated in numerous past studies that a strong relationship exists between accidents and the volume of traffic. The relationship most commonly used for

TABLE 2

RESULTS OF U-TEST FOR SEVERITY AND ACCIDENT TYPE CLASSIFICATIONS DURING NIGHT-TIME PERIOD

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Severity:				
Fatal	-1.465	0.04	0.00	No
Injury	-0.893	1.29	0.89	No
P.D.O.	-0.830	1.57	1.54	No
Multiple Vehicle:				
Left-turn	-1.398	0.04	0.22	No
Rear-end	-2.736	0.55	0.96	Yes
Angle	-0.792	1.16	0.61	No
Single Vehicle:				
Ran-off-road	-0.738	0.27	0.29	No

No. Intersections in Test Group = 99

No. Intersections in Control Group = 70

* 90% level of confidence

accidents occurring at intersections has been the number of accidents per total approach volume. Other studies have indicated that the product of the two intersecting volumes proves to be a better indicator in determining the expected accident occurance. Due to the various relationships that have been used in the literature, an attempt was made to determine the best correlation from a wide range of accident-volume relationships for the data collected in this study.

The first step in this process was to specify various meaningful volume relationships (based on the literature investigated), that might lead to a good correlation with accidents. It was decided to test the following variables:

1.) Total major street volume
2.) Total minor street volume
3.) Total night volume
4.) Total day volume
5.) Total 24-hour volume
6.) Product of total minor street and major street volume
7.) Product of major street night and minor street night volume
8.) Major street night volume per lane
9.) Minor street night volume per lane
10.) Total major street volume per lane
11.) Total minor street volume per lane
12.) Log (total major street volume)
13.) Log (total minor street volume)
14.) Log (total night volume)
15.) Log (total 24-hour volume)

Four measures of night accidents were correlated with these volume relationships.

1.) Accident rate (as previously defined in this study)
2.) Log of accident rate
3.) Number of accidents per intersection
4.) Log of the number of accidents

A plot of the total night volumes (volume variable 3) against the night accident rate (accident variable 1) for each of the two signal operations is presented in Figure 4 and 5. Each plot shows a considerable scatter of the data points for the variables used. The correlation analysis was conducted for these variables and the remaining variables with the results shown in Tables 3 and 4.

Tables 3 and 4 are for the intersections on flashing operation and regular operation, respectively. It may be seen that good correlation was not found between the volume and the accident rate or the log of the accident rate for either signal operation. Only in a few instances (such as the log of the accident rate versus the log of the total night volume) was there a significant correlation. The best correlation existing for both signal operations appears in the following functions:

1.) Log (number of accidents) = f (log(total 24-hour volume))

2.) Log (number of accidents) = f (log(total major street volume))

The correlation coefficients for the first relationship are 0.374 and 0.392 for flashing and regular operation respectively. The corresponding correlation coefficients for the second relationship are 0.348 and 0.472. The square of the correlation coefficient is an indicator of the linear relationship which exists between the independent and dependent variables. The square of the correlation ratios previously mentioned shows that a strong relationship does not exist and, thus, cannot be used to define the volume

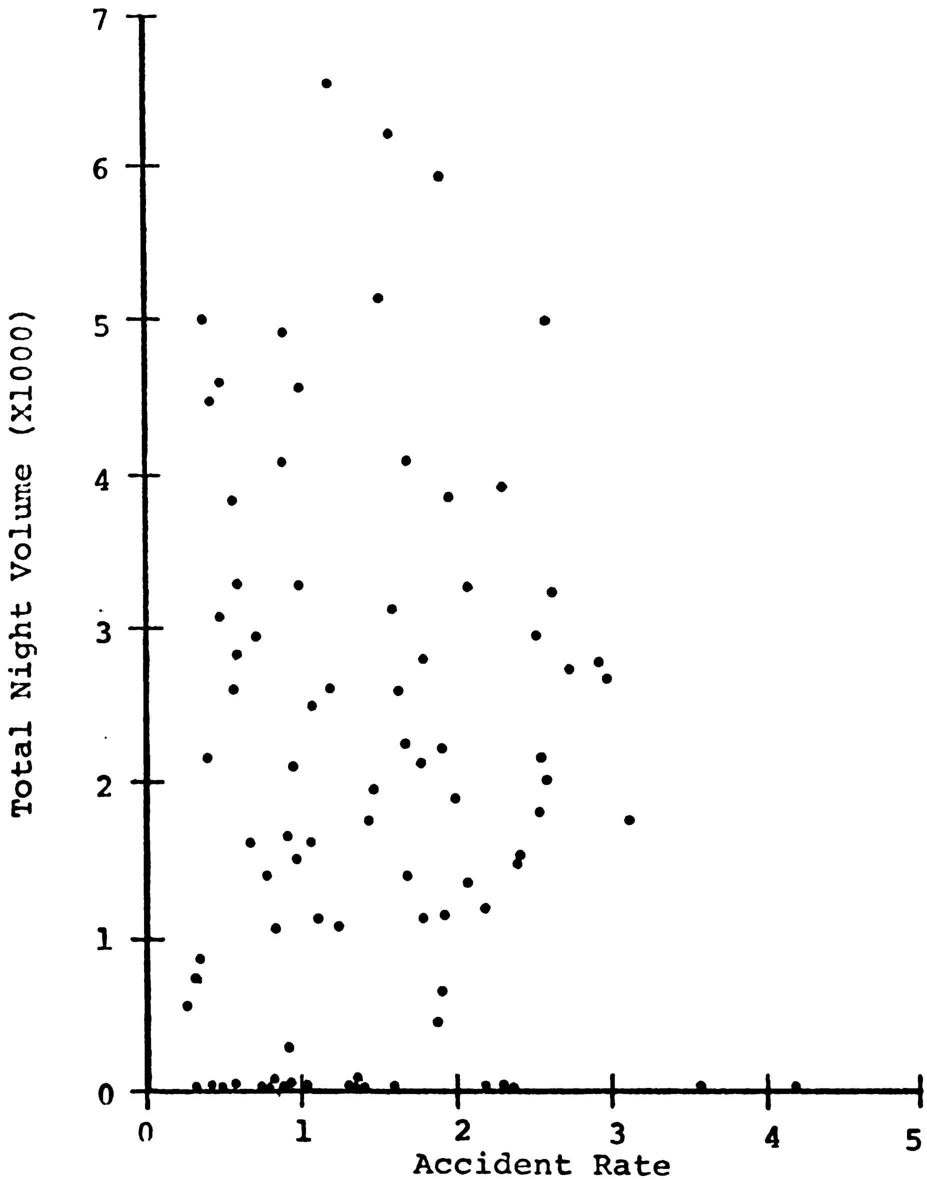

FIGURE 4 PLOT OF NIGHT ACCIDENT RATE VERSUS TOTAL NIGHT VOLUME FOR INTERSECTIONS UNDER FLASHING SIGNAL OPERATION

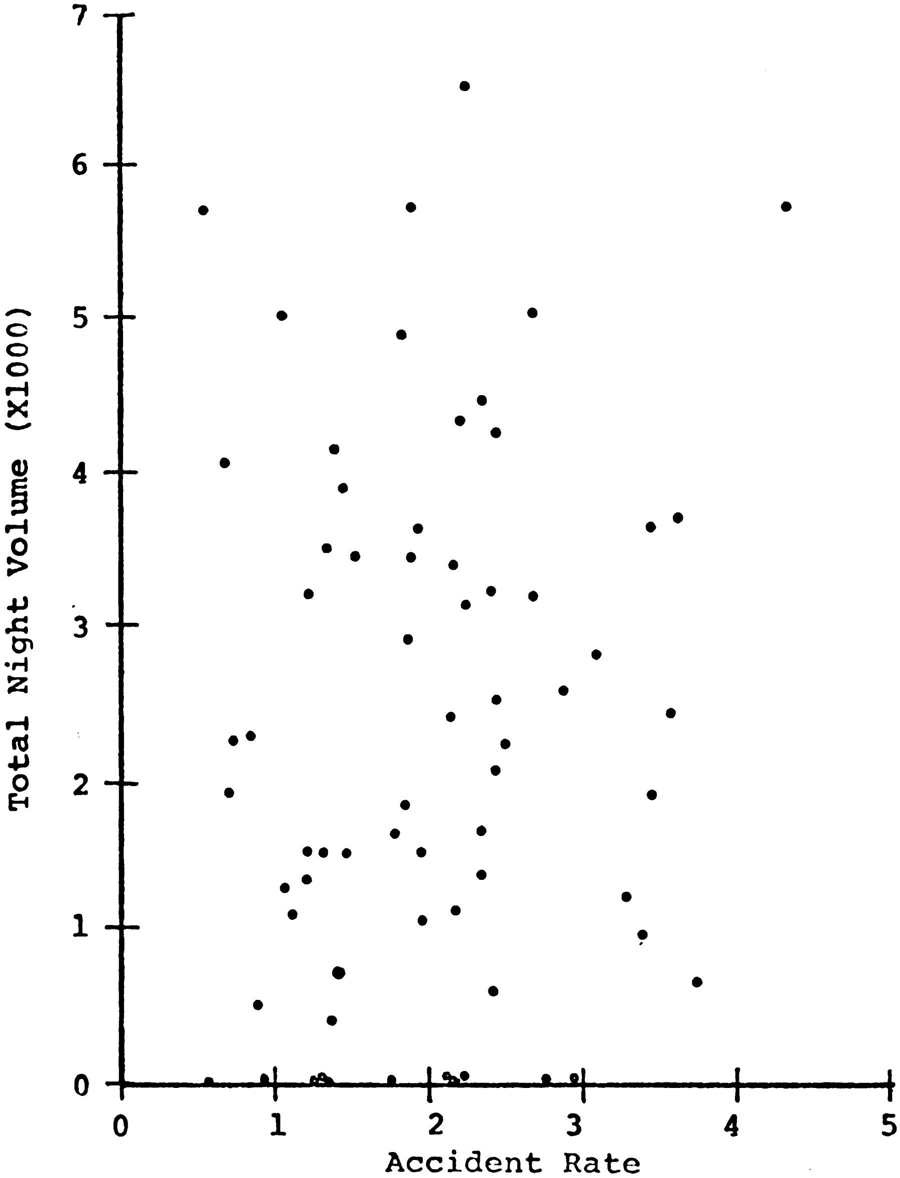

FIGURE 5 PLOT OF NIGHT ACCIDENT RATE VERSUS TOTAL NIGHT VOLUME FOR INTERSECTIONS UNDER REGULAR SIGNAL OPERATION

TABLE 3

CORRELATION COEFFICIENTS OF NIGHT-TIME ACCIDENTS VERSUS VOLUME FOR THE TEST GROUP

Volume Relation*	Accident Rate	Log (Accident Rate)	Number of Accidents	Log (Number of Accidents)
$M_n + M_d$	-0.037	0.082	0.302	0.306
$m_n + m_d$	0.030	0.063	0.257	0.302
$M_n + m_n$	-0.203	-0.515	0.113	0.087
$M_d + m_d$	0.011	0.033	0.320	0.355
$M_n + M_d + m_n + m_d$	-0.013	-0.027	0.324	0.355
$(M_n + M_d) X (m_n + m_d)$	0.017	0.054	0.269	0.333
$M_n X m_n$	-0.100	-0.276	0.084	0.075
M_n/L_M	-0.226	-0.480	0.062	0.111
m_n/L_m	-0.064	-0.200	0.107	0.120
$(M_n + M_d)/L_M$	-0.047	-0.018	0.217	0.344
$(m_n + m_d)/L_m$	-0.002	-0.050	0.148	0.196
Log $(M_n + M_d)$	-0.057	-0.121	0.347	0.348
Log $(m_n + m_d)$	0.074	0.154	0.267	0.330
Log $(M_n + m_n)$	-0.261	-0.558	0.247	0.227
Log $(M_n + M_d + m_n + m_d)$	-0.034	-0.078	0.358	0.374
	N=99	N=75	N=99	N=75

* See legend on following page

Legend:

M_n = Major street night volume

M_d = Major street day volume

m_n = Minor street night volume

m_d = Minor street day volume

L_M = Number of lanes on major street approach

L_m = Number of lanes on minor street approach

N = Sample size

Note: Those intersections with zero accidents were removed such that the log of the number of accidents and accident rates could be derived. Thus, 75 intersections remained.

TABLE 4

CORRELATION COEFFICIENTS OF NIGHT-TIME ACCIDENTS VERSUS VOLUME FOR THE CONTROL GROUP

Volume Relation	Accident Rate	Log (Accident Rate)	Number of Accidents	Log (Number of Accidents)
$M_n + M_d$	0.123	0.073	0.442	0.457
$m_n + m_d$	0.026	-0.153	0.138	-0.024
$M_n + m_n$	0.082	-0.125	0.543	0.461
$M_d + m_d$	0.121	-0.008	0.438	0.382
$M_n + M_d + m_n + m_d$	0.121	-0.018	0.460	0.401
$(M_n + M_d)$ X $(m_n + m_d)$	0.120	-0.010	0.416	0.320
M_n X m_n	0.076	-0.124	0.493	0.348
M_n/L_M	0.000	-0.091	0.337	0.341
m_n/L_m	-0.020	-0.240	-0.101	-0.101
$(M_n + M_d)/L_M$	0.028	0.020	0.279	0.325
$(m_n + m_d)/L_m$	-0.035	-0.255	0.013	-0.253
Log $(M_n + M_d)$	0.129	0.062	0.443	0.472
Log $(m_n + m_d)$	0.030	-0.136	0.120	-0.032
Log $(M_n + m_n)$	0.114	-0.122	0.526	0.478
Log $(M_n + M_d + m_n + m_d)$	0.122	-0.051	0.452	0.392
	N=70	N=58	N=70	N=58

range over which each signal control could be most effective.

At this point, it was believed that a better relationship could be obtained if the severity of the accidents could be tested against the same volume relationships. One means of accomplishing this could be to correlate an estimate of the total accident cost for each of the intersections against the volume. This analysis was conducted by using accident severity weightings as determined by Dr. Paul Abramson in a study of accident costs at intersections.[9]

In this report, accident costs from various past studies were used as a basis for developing a quantitative measure of the accident histories of intersections. The result of the study was the following set of factors for urban intersections:

Accident Type	Factor
Pedestrian	6.5
Right-angle	1.3
Rear-end	1.0
Left-turn	1.3
Other	1.4

Thus, to determine the accident history profile of an intersection, the factors are multiplied by the number of corresponding types of accidents and summed to give a single figure of merit for that intersection.

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[9] Paul Abramson, "An Accident Evaluation Analysis", Transportation Research Board Record 486, (1974), p. 33.

For this study, the factors were applied to the number of accidents at each intersection for both the test and control group. This accident severity weighting as well as the log of the accident severity weighting was correlated with the volume relationships previously used. The results of this analysis is presented in Table 5. A comparison of the correlation coefficients obtained here with those in Tables 5 and 6 indicate little or no improvement in the ability to relate volume with accidents.

The analysis of accidents and accident cost weightings as related to volume demonstrates that a strong linear relationship does not exist.

C. Accident Types and Severities-Intersection Classifications

In an analysis of accidents at intersections, it is advantageous to investigate various intersection characteristics to determine the relationship between these characteristics and accidents. This may help to identify those situations in which flashing operation and full-color operation will be most beneficial.

C.1. Volume Analysis

As mentioned earlier in this report, volume data was collected for analysis, as the larger the conflicting volumes the higher the probability of two vehicles arriving simultaneously. Thus, it was believed this information may provide an insight into the most effective signal operation for various levels of volume.

TABLE 5

CORRELATION COEFFICIENTS OF ACCIDENT SEVERITY WEIGHTINGS VERSUS VOLUME

Volume Relation	Flashing Operation: Accident Cost Weighting	Flashing Operation: Log (Accident Cost Weighting)	Regular Operation: Accident Cost Weighting	Regular Operation: Log (Accident Cost Weighting)
M_n+M_d	0.295	0.296	0.424	0.441
m_n+m_d	0.263	0.305	0.152	0.003
M_n+m_n	0.116	0.069	0.522	0.426
M_d+m_d	0.317	0.351	0.430	0.385
$M_n+M_d+m_n+m_d$	0.322	0.350	0.451	0.401
$(M_n+M_d) X (m_n+m_d)$	0.272	0.331	0.415	0.331
$M_n X m_n$	0.090	0.071	0.485	0.331
M_n/L_M	0.067	0.101	0.294	0.281
m_n/L_m	0.116	0.128	-0.117	-0.096
$(M_n+M_d)/L_M$	0.214	0.341	0.242	0.284
$(m_n+m_d)/L_m$	0.153	0.201	-0.023	-0.235
Log (M_n+M_d)	0.342	0.339	0.429	0.452
Log (m_n+m_d)	0.270	0.338	0.140	0.000
Log (M_n+m_n)	0.250	0.219	0.509	0.441
Log $(M_n+M_d+m_n+m_d)$	0.355	0.371	0.446	0.393
	N=99	N=75	N=69	N=58

This volume data was obtained for the "day" period and the "night" period for all intersections and was used to form the ratio of the major ADT and minor ADT. The intersections were grouped according to this ratio into the following categories:

a. Intersections with (Major ADT/Minor ADT) less than 2.0.

b. Intersections with (Major ADT/Minor ADT) between 2.0 and 4.0.

c. Intersections with (Major ADT/Minor ADT) greater than 4.0.

The U-test was again used as the test for investigating any significant differences in accident rates. The results of these tests may be seen in Tables 6 through 8.

Table 6 indicates the results of the U-test for those intersections with a volume ratio less than 2.0. There were 21 and 30 intersections in the test and control group respectively. A check of the daytime accident rates indicated that the intersections were of similar characteristics and could be tested in the "night" period.* The results for the various accident classifications indicated a number of significant differences, with the left-turn accidents in the flashing group being significantly greater than the regular group. The control group (regular operation) had a significantly greater accident rate in the property damage, rear-end,

*This check implies only that the "total" night accidents could be compared and does not necessarily indicate that the other individual accident classifications are statistically the same in the "daylight" period, although this assumption was made.

TABLE 6

RESULTS OF U-TEST FOR INTERSECTIONS WITH RATIO OF TOTAL MAJOR/TOTAL MINOR VOLUME LESS THAN 2.0

Classification of Accident	Normalized U-Statistic	Mean Accident Rate Test Group	Mean Accident Rate Control Group	Significant*
Total Day	-1.05	2.27	1.78	No
Total Night	-1.45	2.91	2.36	No
Severity:				
Fatal	-1.36	0.11	0.00	No
Injury	-1.11	1.88	0.81	No
P.D.O.	-2.20	0.92	1.55	Yes
Multiple Vehicle:				
Left-turn	-1.86	0.78	0.27	Yes
Rear-end	-2.47	0.28	0.83	Yes
Angle	-0.70	1.33	0.73	No
Single Vehicle:				
Ran-off-road	-1.92	0.07	0.26	Yes

No. Intersections in Test Group = 21

No. Intersections in Control Group = 39

* 90% level of confidence

TABLE 7

RESULTS OF U-TEST FOR INTERSECTIONS WITH RATIO OF TOTAL MAJOR/TOTAL MINOR VOLUME BETWEEN 2.0 AND 4.0

Classification of Accident	Normalized U-Statistic	Mean Accident Rate Test Group	Mean Accident Rate Control Group	Significant*
Total Day	-0.84	1.67	1.53	No
Total Night	-1.19	3.20	2.21	No
Severity:				
Fatal	---	0.00	0.00	--
Injury	-0.11	1.16	1.00	No
P.D.O.	-1.26	2.03	1.24	No
Multiple Vehicle:				
Left-turn	-0.64	0.29	0.20	No
Rear-end	-1.07	0.63	0.94	No
Angle	-1.78	1.46	0.45	Yes
Single Vehicle:				
Ran-off-road	-0.14	0.39	0.35	No

No. Intersections in Test Group = 42

No. Intersections in Control Group = 23

* 90% level of confidence

TABLE 8

RESULTS OF U-TEST FOR INTERSECTIONS WITH RATIO OF TOTAL MAJOR/TOTAL MINOR VOLUME GREATER THAN 4.0

		Mean Accident Rate		
Classification of Accident	Normalized U-Statistic	Test Group	Control Group	Significant*
Total Day	-0.55	1.73	1.70	No
Total Night	-1.68	2.22	3.31	Yes
Severity:				
Fatal	-0.67	0.04	0.00	No
Injury	-1.09	0.89	1.00	No
P.D.O.	-1.73	1.40	2.35	Yes
Multiple Vehicle:				
Left-turn	-0.93	0.30	0.05	No
Rear-end	-2.37	0.62	1.63	Yes
Angle	-0.38	0.71	0.50	No
Single Vehicle:				
Ran-off-road	-0.12	0.24	0.28	No

No. Intersections in Test Group = 36

No. Intersections in Control Group = 8

* 90% level of confidence

and ran-off-road classifications. Although there are mixed results related to the type of accident, the accident severity index favors flashing operation.

The results of the test for intersections with a volume ratio between 2.0 and 4.0 are shown in Table 7. A comparison could again be made since there was no significant difference in the "daytime" accident rates of the test and control groups. Although all of the mean accident rates of the test group were greater than the control group (except the rear-end rate), only the angle accident rates proved to be significant.

The remaining group of intersections - those with volume ratios greater than 4.0 - were tested for significant differences. As it may be seen from Table 8, the "day" period showed no difference, implying that a comparison could be made for the "night" period. The control group accident rates proved to be significantly greater than those of the test group in the categories of total night accidents, P.D.O. accidents, and rear-end accidents. There were no test group rates that were significantly greater than the control group rates. The angle accidents in the test group did not appear significant, which is probably due to the small level of conflict between minor and major street traffic.

As a result of these tests on intersection accident rates for varying ratios of major street volume to minor street volume, it appeared that for large ratios (greater than 4.0) flasher operation had significantly fewer accidents.

The intersections with volume ratios less than 2.0 indicated significant differences which were beneficial to both signal operations. Due to this split in significant differences, the desirable type of operation was not immediately discernable.

It is important to note that consideration was not given to the magnitudes of the volumes, which may have proved to be more effective in delineating the efficient uses of each type of operation. It was felt that this type of analysis would be more biased, due to the fact that it is a common practice of having signals at intersections with large volumes under regular operation and those with low cross street volumes under flashing operation. An analysis on volumes rather than volume ratios would have been appropriate had this been a before/after analysis or had there not been standards used in determining which intersections would operate under the two signal options.

C.2. Intersection Geometry Analysis

The next variable to be tested for its effect on accidents was the intersection geometry. Aside from traffic volume, the physical configuration of an intersection probably has the greatest influence on the accident potential. Two geometric considerations were used in this analysis: 1) The effect of a one or two-way street with and without medians and 2) the effect of the angle of intersection.

C.2.a. Median and Direction Flow

The intersection types used in this analysis are as follows:

1.) Four-leg intersections where one or both of the roads are a one-way street.

2.) "T" intersections, where both streets are two-way.

3.) Four-leg intersections where both streets are two-way undivided.

4.) Four-leg intersections where both streets are two-way and one or both are divided.

As before, the Wilcoxon rank-sum test was used to compare the differences between flashing operation, and regular operation of the signals. Tables 9 through 11 indicate the results of the tests. The Type 1 (refer to Table 9) intersections showed only one accident classification which was significantly different between the test and control group. The "rear-end" accident rate for intersections with regular operation was greater than those with flashing operation. Each group tested had a sample size of 12 intersections. The intersections with flashing operation had an average main street volume of 19,700 vehicles per day as opposed to intersections with regular operation, which had an average of 21,000 vehicles per day. It should also be noted that the control group had a mean accident rate greater than the test group for angle accidents,

TABLE 9

RESULTS OF U-TEST FOR TYPE 1 INTERSECTIONS

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-1.328	1.47	1.90	No
Total Night	-0.751	2.60	2.95	No
Severity:				
Fatal	---	0.00	0.00	--
Injury	-1.443	0.40	1.09	No
P.D.O.	-0.289	2.20	1.86	No
Multiple Vehicle:				
Left-turn	-0.260	0.58	0.35	No
Rear-end	-2.194	0.17	0.64	Yes
Angle	-0.924	0.64	0.92	No
Single Vehicle:				
Ran-off-road	-0.289	1.06	0.68	No

No. Intersections in Test Group = 12

No. Intersections in Control Group = 12

* 90% level of confidence

TABLE 10

RESULTS OF U-TEST FOR TYPE 3 INTERSECTIONS

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.417	1.84	1.65	No
Total Night	-0.701	2.83	2.16	No
Severity:				
Fatal	---	0.00	0.00	--
Injury	-0.180	1.07	0.84	No
P.D.O.	-0.794	1.79	1.35	No
Multiple Vehicle:				
Left-turn	-1.854	0.22	0.26	Yes
Rear-end	-1.009	0.73	0.88	No
Angle	-1.531	1.23	0.53	No
Single Vehicle:				
Ran-off-road	-0.279	0.08	0.12	No

No. Intersections in Test Group = 61

No. Intersections in Control Group = 31

* 90% level of confidence

TABLE 11

RESULTS OF U-TEST FOR TYPE 4 INTERSECTIONS

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.026	1.98	1.71	No
Total Night	-0.182	1.79	2.01	No
Severity:				
Fatal	-1.168	0.32	0.00	No
Injury	-0.260	0.66	0.72	No
P.D.O.	-0.675	0.81	1.30	No
Multiple Vehicle:				
Left-turn	-0.130	0.13	0.12	No
Rear-end	-0.701	0.39	0.95	No
Angle	-0.493	0.85	0.53	No
Single Vehicle:				
Ran-off-road	-0.130	0.18	0.20	No

No. Intersections in Test Group = 11

No. Intersections in Control Group = 15

* 90% level of confidence

which is the opposite of what has occurred in other test results.

The sample sizes for Type 2 intersections were 11 and 4 for the test and control groups, respectively. These intersections did not have similar mean accident rates for the daytime period and, therefore, could not be compared for the two signal operations. The most common type of intersection is the Type 3 intersection (both streets two-way undivided) and the test results for these intersections is shown in Table 10. Only one accident classification was significantly different. Left-turn accidents in the control group occurred more frequently than those in the test group.

The last type of intersection which was investigated were those with at least one divided street (see Table 11). There were no accident rates having significant differences for Type 4 intersections. As with the previous intersection types, it does not appear as though the accident rate comparisons justify the use of one signal operation over the other solely on the basis of the intersection geometry.

C.2.b. Angle of Intersection

The angle of the intersection was analyzed separately from the other physical characteristics because it has a major influence in the accident potential of an intersection. This is due to the sight restriction or inconvenience it places upon drivers when attempting to cross a street.

The intersections in this study were placed into two categories - those intersections which meet at angles greater than 70° and those which meet at angles 70° or less. The U-test was conducted for both the test and control groups to determine if any differences in the night-time accident rates occurred as a result of the angle. The results are shown in Tables 12 and 13.

There were 85 and 56 intersections in the test and control group respectively, which met at angles greater than 70°. Table 12 shows that a significant difference occurred in the left-turn and rear-end categories. The left-turn accident classification showed that the accident rate for signals under regular operation was less than that for flashing operation. Flashing signal operation proved to be more favorable in the rear-end category. No other accident classification showed a significant difference between the two signal operations. As such, neither operation was considered favorable for the angle tested.

Table 13 shows the results for the test and control group with extreme intersecting angles. There were 11 intersections in the test group (flashing operation) and 13 in the control group. None of the accident classifications showed a

TABLE 12

RESULTS OF U-TEST FOR INTERSECTIONS WITH LEGS WHICH MEET AT ANGLES GREATER THAN 70°

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.634	1.79	1.74	No
Total Night	-0.133	2.85	2.37	No
Severity:				
Fatal	-1.152	0.02	0.00	No
Injury	-0.978	1.28	0.93	No
P.D.O.	-0.285	1.59	1.45	No
Multiple Vehicle:				
Left-turn	-2.002	0.40	0.27	Yes
Rear-end	-2.322	0.56	0.87	Yes
Angle	-0.232	1.16	0.65	No
Single Vehicle:				
Ran-off-road	-0.021	0.30	0.24	No

No. Intersections in Test Group = 85

No. Intersections in Control Group = 56

* 90% level of confidence

TABLE 13

RESULTS OF U-TEST FOR INTERSECTIONS WITH LEGS MEETING AT ANGLES LESS THAN OR EQUAL TO 70°

Classification of Accident	U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	44.5	2.03	1.33	No
Total Night	63	3.02	2.17	No
Severity:				
Fatal	65	0.21	0.00	No
Injury	60	1.03	0.44	No
P.D.O.	68	1.78	1.72	No
Multiple Vehicle:				
Left-turn	57	0.52	0.04	No
Rear-end	58	0.66	1.09	No
Angle	38	1.43	0.31	No
Single Vehicle:				
Ran-off-road	52	0.08	0.54	No

No. Intersections in Test Group = 11

No. Intersections in Control Group = 13

* 90% level of confidence

significant difference between the test and control group, although in every classification except "single vehicle ran-off-road" the intersection under flashing operation had a higher mean accident rate than those under regular operation. It should be noted that this was also true of the daytime accident rate, thus indicating that these intersections are more accident prone for reasons other than the angle of the intersecting streets.

C.3. Speed Analysis

The speed of a vehicle approaching an intersection not only affects the drivers' ability to avoid a possible conflict, but also influences the decision made by cross street traffic. Such is the case of two-way stop control, in which the stopped vehicles must decide if the gap in traffic is acceptable for a safe crossing. For this reason, a study of the speed at the intersections was conducted.

Since it was infeasible to obtain the 85th percentile approach speed for traffic at the intersections under study, the posted speed limits were obtained for both the major and minor streets. For the intersections under MDSH & T control, this data was gathered from the sign inventory division. The speed limit was obtained for all but a few of the major streets (since the major streets are under MDSH & T control) but data was available for only half of the minor streets.

The major street speed was the variable used in this analysis since it logically would have the greatest effect on the accident potential. It was decided to arbitrarily segregate the approach speeds into categories. After viewing the speeds for the intersections under study, the following two categories were chosen: 1) those intersections with a major street approach speed less than or equal to 40 mph, and 2) those greater than 40 mph.

The results of the U-test which was conducted are given in Tables 14 and 15. Only the left-turn accident category proved to be significant for speeds less than or equal to 40 mph (Table 14). The test group had a higher mean accident rate in this category which did not appear to be considerable (0.27 for the test group as opposed to 0.26 for the control group). It did not appear as though one signal operation was favorable over another for speeds under 40 mph.

Intersections with speeds greater than 40 mph also showed only one category of a significantly greater accident rate are shown in Table 15. Rear-end accidents at intersections under regular signal operation had a considerably higher mean accident rate than did the test group (1.26 and 0.29, respectively). It appears for this reason, rear-end accident reduction could be attained by flashing signal operations. It was suspected, however, that this significant difference was due in part to other independent variables such as the volume (since volume has a great effect on rear-end accidents). Thus, without analyzing a combination of variables in this particular situation, it was difficult to conclude that one signal operation was more effective than the other.

TABLE 14

RESULTS OF U-TEST FOR INTERSECTIONS WITH MAJOR STREETS HAVING SPEEDS LESS THAN OR EQUAL TO 40 M.P.H.

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.92	1.63	1.68	No
Total Night	-0.65	2.93	2.27	No
Severity:				
Fatal	-0.88	0.01	0.00	No
Injury	-0.04	1.04	0.75	No
P.D.O.	-0.49	1.93	1.54	No
Multiple Vehicle:				
Left-turn	-1.89	0.27	0.26	Yes
Rear-end	-1.27	0.66	0.86	No
Angle	-1.52	1.26	0.54	No
Single Vehicle:				
Ran-off-road	-0.52	0.29	0.32	No

No. Intersections in Test Group = 57

No. Intersections in Control Group = 44

* 90% level of confidence

TABLE 15

RESULTS OF U-TEST FOR INTERSECTIONS WITH MAJOR STREETS HAVING SPEEDS GREATER THAN 40 M.P.H.

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.72	2.09	1.75	No
Total Night	-1.08	2.37	2.45	No
Severity:				
Fatal	-1.02	0.08	0.00	No
Injury	-1.31	1.56	1.23	No
P.D.O.	-1.47	0.73	1.23	No
Multiple Vehicle:				
Left-turn	-0.19	0.64	0.16	No
Rear-end	-2.89	0.29	1.26	Yes
Angle	-0.42	1.00	0.61	No
Single Vehicle:				
Ran-off-road	-0.72	0.16	0.03	No

No. Intersections in Test Group = 35

No. Intersections in Control Group = 18

* 90% level of confidence

C.4. Signal Interconnect Analysis

The Washington D. C. study which was discussed in the literature review revealed the effect on accidents due to the change in signal operation at nearby intersections. The "total" and "angle" accident figures were significantly reduced by the change in operation of nearby signals, leading to the hypothesis that traffic behavior at one intersection is affected by signal operation at other intersections.

In the data collection process of this study, the intersections were classified into two groups: 1) those which had signals interconnected with nearby signals and 2) those which were isolated intersections. Once again the U-test was used to determine the effect this variable had on the accident experience at the intersections studied. The first test was made on the isolated intersections as shown in Table 16. There were 14 intersections in the test group and 9 in the control group. Although the mean accident rates for all classifications (except rear-end accidents) in the test group were greater than those in the control group, none proved to be significantly greater.

Table 17 shows the results of the U-test for those intersections with signals which are interconnected. There were 79 and 60 intersections in the test and control group respectively. It should be noted that the mean accident rates for both groups were similar to one another, contrary to what was found in the isolated intersection analysis. The "rear-end" accident category was the only one found to have a significant difference between the two groups of data.

TABLE 16

RESULTS OF U-TEST FOR TEST VERSUS CONTROL GROUP INTERSECTIONS WHICH ARE ISOLATED

Classification of Accident	U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	50.0	2.52	1.75	No
Total Night	48.0	4.25	1.52	No
Severity:				
Fatal	58.5	0.16	0.00	No
Injury	57.0	3.15	0.94	No
P.D.O.	54.5	1.08	0.59	No
Multiple Vehicle:				
Left-turn	60.0	1.43	0.12	No
Rear-end	59.5	0.67	0.94	No
Angle	51.0	1.57	0.23	No
Single Vehicle:				
Ran-off-road	58.5	0.18	0.00	No

No. Intersections in Test Group = 14

No. Intersections in Control Group = 9

* 90% level of confidence

Note: Since most of these intersections had zero accidents, the same ranking occurred in the U-Test.

TABLE 17

RESULTS OF U-TEST FOR TEST VERSUS CONTROL GROUP INTERSECTIONS WHICH ARE INTERCONNECTED

Classification of Accident	Normalized U-Statistic	Mean Accident Rate: Test Group	Mean Accident Rate: Control Group	Significant*
Total Day	-0.54	1.70	1.67	No
Total Night	-0.31	2.73	2.59	No
Severity:				
Fatal	-1.24	0.02	0.00	No
Injury	-0.75	0.96	0.89	No
P.D.O.	-0.71	1.77	1.71	No
Multiple Vehicle:				
Left-turn	-1.37	0.24	0.24	No
Rear-end	-2.61	0.57	0.98	Yes
Angle	-0.98	1.17	0.68	No
Single Vehicle:				
Ran-off-road	-0.74	0.30	0.34	No

No. Intersections in Test Group = 79

No. Intersections in Control Group = 60

* 90% level of confidence

This may be due to the platooning effect which occurs with syncronized traffic signals. The vehicles are grouped together when approaching the intersections; in the control group this proved to be hazardous, whereas in the test group it presented no problems. Therefore, there may be some justification for operating signals in the flashing manner where necessary if they are a part of a system.

V. SUMMARY AND CONCLUSIONS

This study was conducted to compare the night-time accident experience at signalized intersections under full-color and flashing operation, as a basis for identifying those conditions under which each signal operation could be used to minimize the accident potential. The study involved the analysis of accidents at 99 intersections with flashing traffic signal control and 70 intersections with full-color signal control.

The mean accident rate for the test group and control group during the daylight hours (hours of full-color operation) was found to be 1.82 and 1.69 accidents per million vehicles, respectively. During the night-time hours, the accident rates were 2.78 and 2.42 for the test and control group. Neither of these differences proved to be significant at the 90% level of confidence.

The data was then stratified into various intersection classifications based on volume, geometry and traffic control features. A correlation of total night accidents versus total entering volume showed no significant correlation for either the test or control group. A similar correlation analysis was conducted using accident cost factors in place of total accidents in an attempt to find if a better correlation could be obtained. This analysis showed little or no improvement in correlating the two variables.

A test was then made to determine if the volume ratio (Major ADT/Minor ADT) had a differential effect on the two accident rates. The data was stratified into three volume ratio classifications: less than 2.0, 2.0 - 4.0, and greater than 4.0. Only those intersections with a volume ratio greater than 4.0 showed all significant differences in favor of one signal operation. For these intersections, the test group had a significantly lower accident rate in the total night, P.D.O., and rear-end accident categories.

The next variable tested was the intersection geometry. The Type 1 intersections (four-leg intersections where one or both of the roads are a one-way street) showed a significant difference in only the rear-end accident classification. The control group had a mean accident rate of 0.64 accidents per million vehicles as opposed to a rate of 0.17 for the test group. For Type 3 intersections (four-leg intersections where both streets are two-way undivided) the control group had a significantly greater left-turn accident rate than the test group (0.26 and 0.22, respectively). The other geometric consideration--angle of intersection--did not favor either signal operation.

A speed analysis was conducted to determine the effect on the accident rate of speed limits less than or greater than 40 mph. The control group had a significantly higher rear-end accident rate than the test group for those main streets with speed limits greater than 40 mph. It was hypothesized that the difference was due to 1) the difficulty in stopping at higher speeds, and 2) the average volume in the control group being higher than the test group.

The final analysis of the data considered the effect of interconnected signals. Those intersections which were isolated showed no significant differences between the test and control group for any of the accident classifications. The majority of the intersections were interconnected (n = 79, 60 for the test and control group, respectively) and only the rear-end accident classification showed a significant difference. The control group had a mean accident rate of 0.98 and the test group had a mean rate of 0.57.

A summary of the results of the analysis are presented in Table 18. The four accident rate classifications which were most important in this analysis (total night, rear-end, angle, and P.D.O. accident rates) are shown for both the test and control group. This table indicates those situations under which either the test or control group accident rate proved to be significantly different than the other group.

The results of the analysis do not define a clear advantage of one signal operation over the other. They do, however, indicate certain situations under which one operation may reduce the potential for certain types and severities of accidents.

It is recommended that one use the results of the analysis and the accident history of an intersection to determine if it would be advantageous to utilize flashing signal operation for the night-time period. For example, accidents may be reduced at an intersection with a volume ratio greater than 4.0 and a high incidence of rear-end

TABLE 18

SUMMARY OF MEAN ACCIDENT RATES FOR VARIABLES USED IN STUDY

Variable		Total Night Accident Rate		Rear-end Accident Rate		Angle Accident Rate		Property Damage Accident Rate	
		Test	Control	Test	Control	Test	Control	Test	Control
All Intersections		2.78	2.42	0.55	0.96*	1.16	0.61	1.57	1.54
Volume Ratio	<2.0	2.91	2.36	0.28	0.83*	1.33	0.73	0.92	1.55*
	2.0-4.0	3.20	2.21	0.63	0.94	1.46*	0.45	2.03	1.24
	>4.0	2.22	3.31*	0.62	1.63*	0.71	0.50	1.40	2.35*
Inter-section Type	1	2.60	2.95	0.17	0.64*	0.64	0.92	2.20	1.86
	3	2.83	2.16	0.73	0.88	1.23	0.53	1.79	1.35
	4	1.79	2.01	0.39	0.95	0.85	0.53	0.81	1.30
Angle	≤70	3.02	2.17	0.66	1.09	1.43	0.31	1.78	1.72
	>70	2.85	2.37	0.56	0.87*	1.16	0.65	1.59	1.45
System	Part	2.73	2.59	0.57	0.98*	1.17	0.68	1.77	1.71
	Isolated	4.25	1.52	0.67	0.94	1.57	0.23	1.08	0.59
Speed Limit	≤40	2.93	2.27	0.66	0.86	1.26	0.54	1.93	1.54
	>40	2.37	2.45	0.29	1.26*	1.00	0.61	0.73	1.23

Note: (*) indicates group with significantly greater accident rate.

accidents by changing to flashing operation. One should then monitor the accident situation to assure that the number of angle accidents did not increase significantly. This should lead to a reduction in the total night, rear-end, and P.D.O. accident rates for that intersection, as indicated in Table 18. Similarly, this procedure could be applied to other intersection variables and accident types.

APPENDIX A

Accident Rates and Geometric Data

ACCIDENT RATES AND GEOMETRIC DATA

EXPLANATION OF TABLE CATEGORIES

Note: Accident rates are expressed as number of accidents per million vehicles entering intersection

1.) Intersection identification number

2.) Night-time single-vehicle ran-off-road

3.) Night-time single-vehicle other

4.) Night-time multiple-vehicle left-turn

5.) Night-time multiple-vehicle rear-end

6.) Night-time multiple-vehicle angle

7.) Night-time multiple-vehicle other

8.) Night-time property damage

9.) Night-time injury

10.) Night-time fatal

11.) Night-time total

12.) Day-time total

13.) System: 0 means signal is isolated
1 means signal is interconnected

14.) Number of Approaches: 3 means intersection has three legs
4 means intersection has four legs
0 means intersection has other than three or four legs

15.) Major Speed: Speed limit (mph) on major street approaches

16.) Minor Speed: Speed limit (mph) on minor street approaches

17.)	Major # Dir.:	1 means major street is one-way
		2 means major street is two-way
18.)	Minor # Dir.:	1 means major street is one-way
		2 means major street is two-way
19.)	Major Div.:	0 means major street is divided
		1 means major street is undivided
20.)	Minor Div.:	0 means major street is divided
		1 means major street is undivided
21.)	Inter. Angle:	Angle (in degrees) of intersection of major and minor street

Note: Number of night accidents is that occurring in a 2 year period. For those few which were not, the number of accidents was proportioned to represent a 2 year period.

22.)	Left-turn:	Night-time multiple-vehicle left-turn
23.)	Rear-end:	Night-time multiple-vehicle rear-end
24.)	Angle:	Night-time multiple-vehicle angle
25.)	Other:	Night-time other

Inters. I.D. Number	ACCIDENT RATE: NIGHT-TIME: SINGLE VEHICLE: RAN OFF ROAD	SINGLE VEHICLE: OTHER	MULTIPLE VEHICLE: LEFT TURN	MULTIPLE VEHICLE: REAR END	MULTIPLE VEHICLE: ANGLE	MULTIPLE VEHICLE: OTHER	SEVERITY: PROP. DAM.	SEVERITY: INJ.	SEVERITY: FATAL	NIGHT-TIME TOTAL	DAY-TIME TOTAL	SYSTEM	# APPRCH.	MAJOR SPEED	MINOR SPEED	MAJOR # DIR.	MINOR # DIR.	MAJOR DIV.	MINOR DIV.	INTER ANGLE	NUMBER OF NIGHT ACCIDENTS: LEFT TURN	REAR-END	ANGLE	OTHER
41012025F	0.38	0.00	0.38	0.00	0.38	0.38	1.14	0.38	0.00	1.52	1.15	1	4	35		2	2	1	1	50	3	0	0	0
41043002F	0.00	0.00	0.00	3.10	0.00	0.00	2.06	5.15	0.00	5.15	0.52	0	4	25	25	2	2	1	1	90	3	0	0	0
41043007F	2.50	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	2.50	2.21	0	3	55		2	2	0	1	90	2	0	0	0
41051001F	0.00	0.00	0.00	1.02	1.02	1.02	3.06	0.00	0.00	3.06	1.62	1	4	55	45	2	2	1	1	90	3	0	1	1
41051005F	1.02	0.00	0.00	1.02	0.00	0.00	2.04	0.00	0.00	2.04	2.45	1	4	50		2	2	1	1	90	3	0	1	0
41051013F	0.00	0.00	0.00	0.45	0.00	0.00	0.45	0.00	0.00	0.45	1.52	1	4	50		2	2	1	1	90	3	0	1	0
41061002F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.22	1	4	45		2	2	0	0	90	4	0	0	0
41062001F	0.00	0.00	0.00	1.47	1.47	0.00	1.47	1.47	0.00	2.95	1.50	1	4	40		2	2	1	1	90	3	0	1	1
41062003F	0.00	0.00	0.00	3.28	0.00	3.28	6.55	0.00	0.00	6.55	3.28	1	4	40		2	2	1	1	90	3	0	1	0
41062004F	0.00	0.00	0.00	1.10	0.00	1.10	2.21	0.00	0.00	2.21	1.71	1	4	40		2	2	1	1	90	3	0	1	0
41062005F	0.00	2.57	0.00	1.28	0.00	0.00	3.85	0.00	0.00	3.85	1.35	1	4	40		2	2	1	1	90	3	0	1	0
41062006F	0.00	0.00	1.87	3.73	1.87	0.00	1.87	5.60	0.00	7.47	1.25	1	4	45		2	2	1	1	90	3	1	2	1
41063001F	0.00	0.00	0.00	1.08	1.08	0.00	1.08	1.08	0.00	2.15	0.76	1	4	40		2	2	1	1	35	3	0	1	1
41063002F	0.00	0.00	0.84	0.00	2.52	0.00	1.68	1.68	0.00	3.36	1.53	1	4	40		2	2	1	1	90	3	1	0	3
41063004F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	1	4	40		2	2	1	1	90	3	0	0	0
41131025F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	1	3	40		2	1	1	1	90	2	0	0	0
33011003F	0.00	0.27	0.27	0.00	0.54	0.00	0.81	0.27	0.00	1.08	1.00	1	4	30	25	2	2	1	1	90	3	1	0	2
33032008F	0.00	0.71	0.00	0.71	0.00	0.00	0.71	0.00	0.71	1.41	1.22	1	4	35	25	2	2	0	1	80	4	0	1	0
33032012F	0.00	0.00	0.00	1.56	7.02	0.78	4.68	4.68	0.00	9.36	3.44	1	4	40	35	2	2	1	1	90	3	0	2	0
33032016F	0.00	0.00	0.52	1.05	1.05	0.00	2.10	0.52	0.00	2.62	1.44	1	4	35	35	2	2	1	1	90	3	1	2	2
33034000F	0.00	0.56	0.00	0.56	0.00	0.00	0.56	0.56	0.00	1.12	1.39	1	4	45	25	2	2	1	1	70	3	0	1	0
33042005F	0.93	0.00	0.46	0.93	0.93	0.00	3.25	0.00	0.00	3.25	2.00	1	4	35	25	1	2	1	1	90	1	1	2	2
33042013F	0.55	0.00	0.55	0.00	0.55	0.00	1.09	0.55	0.00	1.64	0.85	1	4	35	25	1	2	1	1	90	1	0	1	1
33043004F	0.57	0.00	0.00	0.00	2.85	1.14	2.85	1.14	0.57	4.56	1.54	1	4	50	30	2	2	0	1	80	4	0	0	5
33043010F	0.54	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.54	1.40	1	4	40	25	2	2	1	1	55	3	0	0	0
33061001F	0.00	0.00	0.43	0.43	0.00	0.00	0.86	0.00	0.00	0.86	1.11	1	4	30	25	1	2	1	1	90	1	1	1	2
33061002F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	1	4	30	25	1	2	1	1	90	1	0	0	0
33061023F	0.52	0.00	0.00	0.52	0.00	0.00	0.00	1.04	0.00	1.04	0.53	1	4	30	30	1	1	1	1	90	0	0	1	0
33061034F	1.97	0.00	0.00	0.00	1.32	0.00	1.97	1.32	0.00	3.29	0.51	1	4	30	25	1	2	1	1	75	1	0	0	2
33062003F	0.00	0.53	0.00	0.00	1.06	0.00	0.53	1.06	0.00	1.59	1.45	1	4	30	25	2	2	1	1	90	3	0	0	2
33081010F	0.00	0.00	0.00	0.00	2.55	0.00	2.55	0.00	0.00	2.55	1.07	1	3	30	30	2	2	1	1	50	2	0	0	1
33082003F	0.00	0.00	0.00	1.73	0.86	0.00	0.86	1.73	0.00	2.59	1.20	1	4	25	25	2	2	0	1	85	4	0	2	1
33082004F	0.00	0.00	0.00	2.84	4.73	0.00	6.62	0.95	0.00	7.57	2.39	1	4	35	30	2	2	1	1	70	3	0	3	5
33082005F	0.00	0.00	0.00	0.00	0.00	2.82	2.82	0.00	0.00	2.82	2.14	0	4	30		2	2	1	1	90	3	0	0	0
33082011F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05	1	0	35		2	2	1	1	70	0	0	0	0
33082016F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0	4	45		2	2	1	1	75	3	0	0	0

INTERS. I.D. NUMBER	ACCIDENT RATE: NIGHT-TIME: SINGLE VEHICLE: RAN OFF ROAD	SINGLE VEHICLE: OTHER	MULTIPLE VEHICLE: LEFT TURN	MULTIPLE VEHICLE: REAR END	MULTIPLE VEHICLE: ANGLE	MULTIPLE VEHICLE: OTHER	SEVERITY: PROP. DAM.	SEVERITY: INJ.	SEVERITY: FATAL	NIGHT-TIME TOTAL	DAY-TIME TOTAL	SYSTEM	# APPRCH.	MAJOR SPEED	MINOR SPEED	MAJOR # DIR.	MINOR # DIR.	MAJOR DIV.	MINOR DIV.	INTER ANGLE	NUMBER OF NIGHT ACCIDENTS: LEFT TURN	REAR-END	ANGLE	OTHER
33082023F	0.71	0.00	0.00	0.71	0.00	0.71	2.14	0.00	0.00	2.14	2.70	1	3	40		2	2	1	1	90	2	0	1	0
38072005F	0.00	0.00	0.00	0.00	1.88	0.00	1.25	0.63	0.00	1.88	0.88	1	4	45		2	2	0	1	55	4	0	0	3
38083011F	0.00	0.75	4.48	2.98	2.98	0.00	5.97	5.22	0.00	11.2	1.73	0	4	35		2	2	1	1	70	3	6	4	4
37011004F	0.00	0.00	0.00	2.28	4.55	0.00	4.55	2.28	0.00	6.84	3.10	1	4	30		2	2	1	1	90	3	0	1	2
37011007F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	1	4	40		2	2	1	1	90	3	0	0	0
37011010F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	1	4	35		2	2	1	1	90	3	0	0	0
37012001F	0.00	1.25	0.00	2.50	0.00	0.00	2.50	1.25	0.00	3.75	2.31	1	4	30	25	2	2	1	1	90	3	0	2	0
37012002F	2.29	0.00	0.00	0.00	2.29	0.00	2.29	2.29	0.00	4.58	1.48	1	4	30		2	2	1	1	90	3	0	0	1
37012003F	0.00	0.00	0.00	1.90	1.90	0.00	3.80	0.00	0.00	3.80	1.38	1	4	30	35	2	2	1	1	90	3	0	1	1
37012007F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	1	4	30		2	1	1	1	90	1	0	0	0
37021001F	4.91	0.00	4.91	0.00	0.00	0.00	9.82	0.00	0.00	9.82	1.31	1	4	35		2	1	1	1	90	1	1	0	0
37021004F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	1	4	30		2	1	1	1	90	1	0	0	0
54012001F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	1	3	35	25	2	2	1	1	90	2	0	0	0
00031001F	0.00	0.00	0.00	1.65	0.00	0.00	1.65	0.00	0.00	1.65	0.72	1	4	35		2	2	1	1	90	3	0	1	0
00031002F	0.00	0.00	1.35	0.00	2.70	0.00	1.35	2.70	0.00	4.05	1.07	1	4	35		2	2	1	1	90	3	1	0	2
00031003F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	1	4	30		2	2	1	1	90	3	0	0	0
00032001F	0.00	0.00	1.13	0.00	0.00	0.00	1.13	0.00	0.00	1.13	0.86	1	3	30		2	2	1	1	90	2	1	0	0
00032003F	0.82	0.00	0.00	0.00	5.77	0.82	5.77	1.65	0.00	7.41	1.67	1	4	40		2	2	1	1	90	3	0	0	7
00032005F	0.00	0.00	0.00	0.00	3.32	1.66	3.32	1.66	0.00	4.99	2.68	1	4	40		2	2	1	1	90	3	0	0	2
09032007F	0.00	0.00	0.00	0.00	1.53	0.00	0.00	1.53	0.00	1.53	0.81	1	4	40	45	2	1	0	1	90	1	0	0	2
00032008F	1.37	0.00	0.00	0.00	1.37	0.00	1.37	1.37	0.00	2.75	1.79	1	4	40	35	2	1	0	1	90	1	0	0	1
00032009F	0.00	0.00	0.00	0.00	2.02	0.00	1.05	0.97	0.00	2.02	2.08	1	4	40		2	2	1	1	90	3	0	0	3
00032014F	1.49	0.00	0.00	1.49	0.00	0.00	1.49	1.49	0.00	1.49	1.37	1	3	40		2	2	1	1	90	2	0	2	0
00042010F	0.00	0.00	0.00	0.00	1.30	0.00	1.30	0.00	0.00	1.30	1.15	1	4	35		2	2	1	1	85	3	0	0	1
00042011F	0.00	0.00	0.00	0.00	1.72	0.00	1.72	0.00	0.00	1.72	1.47	1	4	35	25	2	2	1	1	35	3	0	0	1
00042028F	0.00	0.00	0.00	0.00	0.63	0.00	0.63	0.00	0.00	0.63	1.47	1	4	35		2	2	1	1	90	3	0	0	1
00042020F	0.00	0.68	0.00	0.68	0.68	0.68	1.36	1.36	0.00	2.72	1.54	1	4	35		2	2	1	1	85	3	0	1	1
00071001F	0.00	0.00	0.00	0.00	1.34	0.00	1.34	0.00	0.00	1.34	0.20	1	4	25		2	2	1	1	80	3	0	0	1
00071003F	0.00	0.00	0.00	0.00	2.29	0.00	0.00	0.00	2.29	2.29	1.98	0	4	45		2	2	0	1	60	4	0	0	1
30041004F	0.00	0.00	0.00	1.63	0.00	1.63	1.63	1.63	0.00	3.25	3.55	1	4			2	2	1	1	80	3	0	1	0
30042002F	0.00	1.55	0.52	0.52	0.00	0.00	3.10	0.00	0.00	3.10	2.33	1	4			1	2	1	1	90	1	1	1	0
30042013F	2.06	0.00	0.00	0.00	1.98	0.00	4.04	0.00	0.00	4.04	1.78	1	4			1	2	1	1	90	1	0	0	2
30051002F	1.39	0.00	0.00	0.00	3.48	0.00	2.10	2.79	0.00	4.88	0.97	1	4			1	1	1	1	90	0	0	0	5
30081004F	0.00	0.00	1.02	1.02	1.02	1.02	3.05	1.02	0.00	4.05	2.85	1	4			2	2	1	1	90	3	2	2	2
30081008F	0.00	0.65	0.00	0.00	1.30	0.00	1.30	0.65	0.00	1.95	0.00	1	4			2	2	1	1	90	3	0	0	2
61022001F	0.00	2.64	0.00	0.00	7.92	0.00	2.64	7.92	0.00	10.5	1.72	1	4	25		2	2	1	1	90	3	0	0	3

INTERS. I.D. NUMBER	ACCIDENT RATE: NIGHT-TIME: SINGLE VEHICLE: RAN OFF ROAD	SINGLE VEHICLE: OTHER	MULTIPLE VEHICLE: LEFT TURN	MULTIPLE VEHICLE: REAR END	MULTIPLE VEHICLE: ANGLE	MULTIPLE VEHICLE: OTHER	SEVERITY: PROP. DAM.	SEVERITY: INJ.	SEVERITY: FATAL	NIGHT-TIME TOTAL	DAY-TIME TOTAL	SYSTEM	# APPRCH.	MAJOR SPEED	MINOR SPEED	MAJOR # DIR.	MINOR # DIR.	MAJOR DIV.	MINOR DIV.	INTER ANGLE	NUMBER OF NIGHT ACCIDENTS: LEFT TURN	REAR-END	ANGLE	OTHER
51073002F	0.00	0.00	0.00	3.23	0.00	0.00	3.23	0.00	0.00	3.23	1.52	0	4			2	2	1	1	75	3	0	1	0
51151002F	1.30	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	1.30	1.33	1	4	45		2	2	0	1	90	4	0	0	0
51151004F	0.00	0.00	1.42	0.00	1.42	0.00	0.00	2.84	0.00	2.84	0.39	1	4	50		2	2	0	1	90	4	1	0	1
51151005F	0.00	0.00	0.00	1.82	0.00	0.91	1.82	0.91	0.00	2.73	1.71	1	4	50		2	2	0	1	90	4	0	2	0
53031016F	0.00	0.00	0.00	0.00	1.36	0.00	0.00	1.36	0.00	1.36	1.00	1	4	50		2	2	1	1	90	3	0	0	1
25051017F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.59	0.00	4.59	1.53	1	0	45		2	2	1	1	60	0	1	1	1
25052028F	0.00	1.24	0.00	2.47	2.47	0.00	1.24	4.94	0.00	6.18	2.12	1	4	35		2	2	1	1	90	3	0	2	2
25052033F	0.00	0.00	0.00	0.00	0.00	1.73	0.87	0.87	0.00	1.73	1.58	1	4	25		2	2	1	1	90	3	0	0	0
25072019F	0.00	0.00	0.00	0.53	0.00	1.60	1.07	1.07	0.00	2.13	1.74	1	4	45		2	2	1	1	90	3	0	1	0
25072020F	0.00	0.00	0.00	0.00	0.00	0.71	0.71	0.00	0.00	0.71	2.81	1	4	50		2	2	1	1	90	3	0	0	0
25072027F	0.00	0.00	0.55	0.00	0.55	0.17	1.30	0.17	0.00	2.27	1.02	1	4	45		2	2	1	1	90	3	2	0	2
25072035F	0.00	0.00	1.98	0.00	3.06	0.00	3.06	1.92	0.00	5.05	2.05	1	4	50		2	2	1	1	90	3	1	0	2
25072036F	0.00	0.00	0.00	0.00	0.00	1.10	1.10	0.00	0.00	1.13	1.98	1	4	45		2	2	1	1	85	3	0	0	0
* 00000001F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58		3	55	55	2	2	1	1		2	0	0	0
* 00000002F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34		4	45	45	2	2	1	1	90	3	0	0	0
* 00000003F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82		4	45	30	2	2	1	1	90	3	0	0	0
* 00000004F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55		4	45	40	2	2	1	1	90	3	0	0	0
* 00000005F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.77		4	50	40	2	2	1	1	75	3	0	0	0
* 00000006F	0000	0000	15.6	0000	15.6	0000	0000	31.2	0000	31.2	5.42	0	3	55	40	2	2	0	1	90	2	2	0	2
* 00000007F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.71	0	4	55	45	2	2	0	1	30	4	0	0	0
* 00000008F	0000	0000	0000	0.28	0000	0000	0000	0.28	0000	0.28	3.54	1	3	50	30	2	2	0	1	90	2	0	1	0
* 00000009F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45		4	55	55	2	2	0	1		4	0	0	0
* 00000010F	0000	0000	0000	0000	1.05	0000	1.05	0000	0000	1.05	1.05	0	4	50	25	2	2	1	1	90	3	0	0	1
* 00000011F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.87	0	4	50	55	2	2	1	1	90	3	0	0	0
* 00000012F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53	0	4	45	45	2	2	1	1	90	3	0	0	0
* 00000013F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0	4	55	55	2	2	1	1	90	3	0	0	0
* 00000014F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55	0	3	45	45	2	2	1	1		2	0	0	0

INTER. I.D. NUMBER	ACCIDENT RATE: NIGHT-TIME: SINGLE VEHICLE: RAN OFF ROAD	SINGLE VEHICLE: OTHER	MULTIPLE VEHICLE: LEFT TURN	MULTIPLE VEHICLE: REAR END	MULTIPLE VEHICLE: ANGLE	MULTIPLE VEHICLE: OTHER	SEVERITY: PROP. DAM.	SEVERITY: INJ.	SEVERITY: FATAL	NIGHT-TIME TOTAL	DAY-TIME TOTAL	SYSTEM	# APPRCH.	MAJOR SPEED	MINOR SPEED	MAJOR # DIR.	MINOR # DIR.	MAJOR DIV.	MINOR DIV.	INTER ANGLE	NUMBER OF NIGHT ACCIDENTS: LEFT TURN	REAR-END	ANGLE	OTHER
41014001R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0	4			2	2	1	1	50	3	0	0	0
41014013R	0.00	0.00	1.08	0.00	0.00	0.00	1.08	0.00	0.00	1.08	0.91	0	4			2	2	1	1	90	3	1	0	0
41051004R	0.00	1.01	1.01	1.01	2.01	0.00	2.01	3.02	0.00	5.03	2.43	1	4	50	50	2	2	1	1	90	3	1	1	2
41061001R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0	4	55	40	2	2	1	1	90	3	0	0	0
41062002R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	1	4	40		2	2	1	1	90	3	0	0	0
33011002R	0.00	0.00	0.55	2.81	0.55	0.00	2.81	1.12	0.00	3.93	2.20	1	4	30	30	2	2	1	1	90	3	1	5	1
33032007R	0.00	0.00	0.00	0.79	0.79	0.00	0.79	0.79	0.00	1.58	2.04	1	4	30	25	2	2	0	1	75	4	0	1	1
33033001R	0.75	0.00	0.00	0.00	0.75	0.00	0.75	0.75	0.00	1.50	1.54	1	4	35	25	1	2	1	1	90	1	0	0	1
33033002R	0.00	0.00	0.53	0.00	0.00	0.00	0.53	0.00	0.00	0.53	0.84	1	4	35	30	1	2	1	1	90	1	1	0	0
33033007R	0.00	0.00	0.00	0.97	0.97	0.00	1.94	0.00	0.00	1.94	3.95	1	4	35	25	1	2	1	1	80	1	0	1	1
33034001R	0.00	0.00	0.55	0.55	0.00	0.56	2.24	0.00	0.00	2.24	2.01	1	4	35	35	1	1	1	1	85	0	1	1	0
33034002R	0.00	0.00	1.21	0.55	1.68	0.00	1.12	2.24	0.00	3.35	2.72	1	4	35	30	1	2	1	1	90	1	2	1	3
33034005R	0.50	0.00	0.00	1.18	1.77	0.50	3.54	0.50	0.00	4.13	2.35	1	4	35	30	1	2	1	1	90	1	0	[illegible]	[illegible]
33034008R	0.00	0.00	0.00	0.00	0.55	0.55	1.10	0.00	0.00	1.10	2.17	1	4	35	35	1	1	1	1	90	0	0	0	1
33034013R	0.64	0.00	0.64	0.00	0.00	0.00	1.27	0.00	0.00	1.27	1.62	1	4	35	35	1	1	1	1	80	0	1	0	0
33042001R	1.42	0.71	0.00	0.71	2.13	0.71	2.85	2.85	0.00	5.69	1.55	1	4	35	30	1	2	1	1	30	1	0	1	3
33042004R	2.30	0.00	0.00	1.15	0.00	0.00	1.15	2.30	0.00	3.45	1.41	1	4	35	25	1	2	1	1	90	0	0	1	0
33042008R	0.58	0.00	0.58	1.15	0.58	0.58	2.32	1.16	0.00	3.48	1.05	1	4	35	30	1	2	1	0	90	1	1	2	1
33042012R	0.00	0.00	0.00	2.22	0.00	0.00	1.48	0.74	0.00	2.22	0.53	1	3	35	30	1	1	1	1	85	0	0	3	0
33043001R	0.00	0.00	0.00	4.00	0.00	0.00	4.00	0.00	0.00	4.05	0.44	1	4	35	35	1	1	1	1	35	0	0	4	0
33061020R	0.00	0.00	0.64	0.64	1.27	0.00	1.27	1.27	0.00	2.54	1.35	1	4	30	30	1	2	1	1	90	1	1	1	2
33061024R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	1	4	30	25	1	2	1	1	90	1	0	0	0
33062001R	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.96	0.00	0.95	1.33	1	4	30	30	2	2	1	0	90	4	0	0	1
33032001R	0.78	0.00	0.00	5.44	0.00	0.78	5.45	1.55	0.00	6.00	3.23	1	4	25	25	2	2	0	0	70	4	0	7	0
33171003R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	1	4	40	35	2	1	0	1	90	1	0	0	0
33072002R	0.00	0.00	0.00	0.00	1.55	1.55	1.55	1.55	0.00	3.10	2.35	1	4	25	35	2	2	1	1	90	3	0	0	1
33072003R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	1	4	25		2	2	1	1	70	3	0	0	0
33072004R	0.00	0.00	0.00	0.00	1.68	0.00	1.68	0.00	0.00	1.68	1.35	1	4	25		2	2	1	1	90	3	0	0	1
33072008R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	1	4	30		2	2	1	1	90	3	0	0	0
00032002R	0.00	0.00	0.97	1.95	1.95	0.00	2.92	1.95	0.00	4.87	0.54	1	4	30		2	2	1	1	90	3	1	2	2
30041001R	1.24	0.00	0.00	1.24	1.24	1.24	3.73	1.24	0.00	4.97	2.05	1	4			2	1	0	1	45	1	0	1	1
30051001R	0.00	0.00	0.00	2.61	2.61	1.30	3.91	2.61	0.00	6.52	1.80	1	0			1	1	1	1	90	0	0	2	2
30051003R	0.73	0.00	0.00	0.73	1.45	0.73	2.18	1.46	0.00	3.64	2.23	1	4			1	1	1	1	90	0	0	1	2
61151001R	0.72	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.72	1.00	1	4	40		2	2	0	1	90	4	0	0	0
61031018R	0.00	0.00	0.00	1.81	0.00	0.00	3.61	0.00	0.00	3.61	2.31	1	4			2	2	1	1	90	3	0	2	1
63021007R	1.87	0.00	0.00	0.00	0.00	0.00	1.87	0.00	0.00	1.87	1.30	1	4			2	2	1	1	60	3	0	0	0

INTERS. I.D. NUMBER	ACCIDENT RATE: NIGHT-TIME: SINGLE VEHICLE: RAN OFF ROAD	SINGLE VEHICLE: OTHER	MULTIPLE VEHICLE: LEFT TURN	MULTIPLE VEHICLE: REAR END	MULTIPLE VEHICLE: ANGLE	MULTIPLE VEHICLE: OTHER	SEVERITY: PROP. DAM.	SEVERITY: INJ.	SEVERITY: FATAL	NIGHT-TIME TOTAL	DAY-TIME TOTAL	SYSTEM	# APPRCH.	MAJOR SPEED	MINOR SPEED	MAJOR # DIR.	MINOR # DIR.	MAJOR DIV.	MINOR DIV.	INTER ANGLE	NUMBER OF NIGHT ACCIDENTS: LEFT TURN	REAR-END	ANGLE	OTHER
53021012R	1.85	0.00	0.00	0.00	1.85	0.00	1.86	1.86	0.00	3.72	1.51	1	3			2	2	1	1	55	2	0	0	1
53031003R	0.00	0.48	0.00	3.34	1.43	0.48	2.38	3.34	0.00	5.72	1.34	1	4	55		2	2	0	1	90	4	0	7	3
53031005R	0.00	0.00	0.00	0.93	1.37	0.00	2.33	0.47	0.00	2.80	0.93	1	4	55		2	2	0	1	90	4	0	2	4
53031006R	0.00	0.41	0.00	0.00	0.00	0.81	0.81	0.41	0.00	1.22	1.77	1	4	55		2	2	0	1	90	4	0	0	0
53041002R	0.00	0.00	0.00	0.95	0.95	0.47	2.37	0.00	0.00	2.37	1.87	1	4	40		2	2	1	1	45	3	0	2	2
53041005R	0.00	0.00	0.00	0.64	0.00	0.00	0.64	0.00	0.00	0.64	1.84	1	4	35		2	2	1	1	90	3	0	1	0
53041007R	1.22	0.00	0.00	0.61	0.00	0.00	1.22	0.61	0.00	1.83	1.52	1	4	35		2	2	1	1	50	3	0	1	0
53043011R	1.48	0.00	0.00	0.00	0.00	0.00	1.48	0.00	0.00	1.48	1.45	1	4	40		1	2	1	1	90	4	0	0	0
53001010R	0.59	0.00	0.59	0.59	1.75	0.00	1.76	1.76	0.00	3.52	3.33	1	4	45		2	2	1	1	90	3	1	1	3
53131008R	0.00	0.00	0.64	1.91	0.00	0.64	1.27	1.91	0.00	3.18	2.52	1	4	35		2	2	1	1	80	3	1	3	0
53132003R	0.00	1.20	0.00	0.00	0.00	0.00	0.00	1.20	0.00	1.20	1.07	1	4	25		2	2	1	1	90	3	0	0	0
53151016R	3.62	0.00	1.21	1.21	0.60	0.60	4.22	3.02	0.00	7.24	2.12	1	4	40		2	1	1	1	90	1	2	2	1
53151020R	0.00	0.00	0.39	3.15	0.39	0.39	3.15	1.18	0.00	4.33	1.71	1	3	40		2	2	0	0	90	2	1	8	1
25051005R	0.00	0.00	1.27	0.64	0.64	0.64	1.91	1.27	0.00	3.18	0.93	1	4	35		2	2	1	1	75	3	2	1	1
25052021R	0.00	0.00	0.70	0.00	0.00	0.70	0.70	0.70	0.00	0.70	1.22	1	4	30		2	2	1	1	90	3	1	0	0
25072001R	0.00	0.00	0.51	1.53	0.00	0.00	1.53	0.51	0.00	2.04	0.49	1	4	45	45	2	2	1	1	40	3	1	3	0
25072003R	0.00	0.00	0.00	1.00	0.50	1.00	2.50	0.00	0.00	2.50	0.55	1	4	45	25	2	2	1	1	90	3	0	2	1
25072004R	0.00	0.00	0.80	2.41	0.80	0.40	2.41	2.01	0.00	4.41	1.24	1	4	45		2	2	1	0	90	4	2	6	2
25072005R	0.00	0.00	0.37	0.73	0.00	1.10	1.46	0.73	0.00	2.20	1.10	1	4	40	35	2	2	1	1	90	3	1	2	0
25072006R	0.00	0.00	0.00	1.19	1.19	0.00	1.98	0.40	0.00	2.38	1.50	1	4	35		2	2	1	1	90	3	0	3	3
25072007R	0.00	0.00	0.38	1.13	0.00	0.00	1.51	0.00	0.00	1.51	1.22	1	4	35		2	2	1	1	90	3	1	3	0
25072008R	0.00	0.00	0.95	1.27	0.95	0.00	2.54	0.63	0.00	3.17	1.00	1	4	35		2	2	1	0	90	4	3	4	3
25072018R	0.00	0.00	0.00	0.88	0.44	0.00	0.88	0.44	0.00	1.33	1.01	1	3	45		2	2	1	1	90	2	0	2	1
25072022R	0.00	0.00	0.00	2.40	0.00	0.41	1.24	1.56	0.00	2.80	0.90	1	3	45		2	2	1	1	90	2	0	6	0
25072023R	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.33	1.53	1	4	40		2	2	1	1	60	3	0	1	0
25081001R	0.00	0.00	0.00	0.00	1.13	0.00	0.57	0.57	0.00	1.13	2.82	1	4	35		2	2	0	0	90	4	0	0	2
25081005R	0.00	0.00	0.00	0.00	0.75	0.75	0.75	0.75	0.00	1.50	1.11	1	4	30		2	2	1	1	90	3	0	0	1
* 00000015R	0.00	0.00	0.00	4.20	2.10	2.10	4.20	4.20	0.00	8.41	3.33	0	4	50	45	2	2	1	1		3	0	2	1
* 00000016R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0	4	55	45	2	2	0	1	90	4	0	0	0
* 00000017R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41	0	4	50	40	2	2	0	1	75	4	0	0	0
* 00000018R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0	4	55	40	2	2	0	1	45	4	0	0	0
* 00000019R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08		4	45	45	2	2	1	1	30	3	0	0	0
* 00000020R	0.00	0.00	0.00	4.23	0.00	0.00	0.00	4.23	0.00	4.23	3.33	0	4	45	45	2	2	1	1	90	3	0	3	0
* 00000021R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0	4	55	35	2	2	0	1	30	4	0	0	0

APPENDIX B

Volume of Traffic on Major and Minor

Street Approaches by Time of Day

	INTERSECTION I.D. NUMBER	MAJOR STREET NIGHT VOLUME	MAJOR STREET DAY VOLUME	MINOR STREET NIGHT VOLUME	MINOR STREET DAY VOLUME
1	00000001F	1772	8802	170	696
2	00000002F	2083	11794	255	3718
3	00000003F	1313	11298	608	5882
4	00000004F	248	9871	188	7460
5	00000005F	7794	21680	247	10618
6	00000006F	207	6887	196	3564
7	00000007F	207	6887	652	5626
8	00000008F	9081	9970	572	1323
9	00000009F	2063	8511	165	962
10	00000010F	2548	20130	85	1471
11	00000011F	1656	5986	98	1353
12	00000012F	421	11821	196	8790
13	00000013F	1758	8790	1200	4222
14	00000014F	652	5626	140	4031
15	09031001F	807	10842	23	638
16	09031002F	777	11022	238	3083
17	09031003F	980	14170	85	2626
18	09032001F	1030	17570	184	3219
19	09032003F	1163	26836	500	13370
20	09032005F	527	16872	297	8681
21	09032007F	1204	26595	591	17558
22	09032008F	644	16755	354	10060
23	09032009F	1240	26960	166	5310
24	09032014F	1796	20553	37	1511
25	09042010F	575	18924	187	7184
26	09042011F	572	18927	223	7114
27	09042028F	1749	16950	427	6319
28	09042029F	1531	18068	482	5921
29	09071001F	576	6223	445	8087
30	09071003F	346	6453	251	5316
31	25051017F	1249	14400	274	3560
32	25052028F	833	24166	276	11420
33	25052030F	1066	16783	516	11036

	INTERSECTION I.D. NUMBER	MAJOR STREET NIGHT VOLUME	MAJOR STREET DAY VOLUME	MINOR STREET NIGHT VOLUME	MINOR STREET DAY VOLUME
34	25072019F	2023	18976	548	7761
35	25072020F	1344	10605	574	7924
36	25072027F	3866	17633	350	2481
37	25072035F	588	13011	103	3630
38	25072036F	1010	17014	146	3253
39	33011003F	4754	26495	3390	36198
40	33032008F	1648	29551	291	4089
41	33032012F	1270	22880	487	11360
42	33032016F	2346	21653	272	5033
43	33034009F	2301	24198	142	2476
44	33042005F	2670	24980	282	5223
45	33042013F	2253	22946	256	4201
46	33043004F	2138	17611	265	4169
47	33043010F	2476	30448	61	1773
48	33061001F	1867	14308	1303	7900
49	33061002F	1690	15134	260	3507
50	33061023F	2198	18351	446	7589
51	33061034F	1572	14727	511	3273
52	33062003F	2341	22858	234	3480
53	33081010F	438	10712	97	2467
54	33082003F	1390	36409	194	10355
55	33082004F	1146	32403	301	16270
56	33082005F	662	4937	310	2752
57	33082011F	322	21027	50	5717
58	33082016F	1356	11994	344	4296
59	33082029F	1840	14184	84	1031
60	37011004F	519	15480	82	3955
61	37011007F	371	10128	130	3511
62	37011010F	520	13380	114	5355
63	37012001F	873	20845	221	8251
64	37012002F	494	14655	104	5768
65	37012003F	435	11415	286	8452
66	37012007F	464	14685	14	1292

	INTERSECTION I.D. NUMBER	MAJOR STREET NIGHT VOLUME	MAJOR STREET DAY VOLUME	MINOR STREET NIGHT VOLUME	MINOR STREET DAY VOLUME
67	37021001F	197	9502	82	3019
68	37021004F	298	9401	31	1795
69	38072005F	2046	18703	145	2979
70	38083011F	1596	17453	240	3944
71	39041004F	503	13271	339	13027
72	39042002F	1466	32383	746	18099
73	39042013F	977	19622	410	12751
74	39051002F	1196	31708	770	23262
75	39081004F	2307	23617	391	7150
76	39081008F	1794	24130	315	4942
77	41012025F	3165	26060	442	4550
78	41043002F	1142	9007	185	2050
79	41043007F	461	6038	88	2012
80	41051001F	1040	15010	302	5247
81	41051005F	1022	18852	323	7910
82	41051013F	2534	17340	524	7026
83	41061002F	380	18020	148	9620
84	41062001F	826	33800	103	9100
85	41062003F	338	12036	80	2518
86	41062004F	1034	37490	206	12050
87	41062005F	960	40040	106	10694
88	41062006F	665	28209	69	3499
89	41063001F	1095	41654	177	9021
90	41063002F	1112	37888	517	16606
91	41063004F	838	33911	91	11316
92	41131025F	1183	45316	505	16153
93	54012001F	731	18830	154	5725
94	61022001F	393	20906	126	7008
95	61073002F	319	4730	105	1577
96	61151002F	864	27885	124	6079
97	61151004F	746	19903	217	6663
98	61151005F	841	22158	666	13119
99	63091016F	877	15272	131	2038

	INTERSECTION I.D. NUMBER	MAJOR STREET NIGHT VOLUME	MAJOR STREET DAY VOLUME	MINOR STREET NIGHT VOLUME	MINOR STREET DAY VOLUME
1	00000015R	649	10361	703	11802
2	00000016R	792	15328	539	11650
3	00000017R	2095	37496	303	10112
4	00000018R	1022	19472	172	6870
5	00000019R	395	9647	184	5280
6	00000020R	1734	11643	454	3618
7	00000021R	1093	19224	802	12709
8	09032002R	744	17855	662	14444
9	25051005R	1446	23803	705	16122
10	25052021R	1562	24587	386	8995
11	25072002R	1166	16933	1516	27761
12	25072003R	2207	26667	530	6450
13	25072004R	2065	31259	1349	17478
14	25072005R	3246	35803	497	6596
15	25072006R	3018	33731	437	8988
16	25072007R	3163	34586	461	12408
17	25072008R	3292	34457	1028	14493
18	25072018R	2681	21818	416	4762
19	25072022R	3278	32471	26	2113
20	25072023R	2742	27007	832	10827
21	25081001R	1171	13828	1246	16816
22	25081005R	991	17508	839	8312
23	33011002R	1953	23046	487	13665
24	33032007R	1114	26535	620	15188
25	33033001R	1148	16300	676	16218
26	33033002R	1541	15908	1026	21580
27	33033007R	967	15532	446	8331
28	33034001R	1569	28397	873	15256
29	33034002R	1633	17766	811	13943
30	33034005R	1638	18236	685	11538
31	33034008R	1466	17509	1016	21066
32	33034016R	1193	20184	963	18828
33	33040004R	1116	27983	73	3017
34	33042001R	1274	24925	651	15840
35	33042008R	1239	22510	1124	25209

	INTERSECTION I.D. NUMBER	MAJOR STREET NIGHT VOLUME	MAJOR STREET DAY VOLUME	MINOR STREET NIGHT VOLUME	MINOR STREET DAY VOLUME
36	33042012R	1537	25612	311	9345
37	33043001R	1002	14452	367	10545
38	33061020R	1111	18288	1045	16020
39	33061024R	979	20346	313	5378
40	33062001R	825	21949	596	15490
41	33082001R	1539	37260	225	9401
42	33171003R	1212	25537	245	6481
43	38072002R	294	12880	589	16170
44	38072003R	420	14904	314	10124
45	38072004R	511	15988	302	9124
46	38072008R	1573	17551	562	5750
47	39041001R	810	23589	292	11761
48	39051001R	700	20220	350	10925
49	39051003R	1169	34356	713	20836
50	41014001R	1007	15943	561	11789
51	41014013R	530	11219	734	20466
52	41051004R	995	21354	368	10731
53	41061001R	237	7862	315	11562
54	41062002R	1100	43300	156	13926
55	61151001R	897	27852	997	20522
56	63021007R	431	14918	301	13351
57	63021012R	510	20279	167	6080
58	63031003R	2601	53273	272	14275
59	63031005R	2282	35817	654	18403
60	63031006R	3103	46596	274	10632
61	63041002R	1552	24697	1339	19223
62	63041005R	1586	30013	546	7879
63	63041007R	1757	35892	484	11348
64	63043011R	363	7011	564	10805
65	63091010R	900	19600	1435	11673
66	63131008R	1395	20354	758	13575
67	63132003R	714	16810	351	7521
68	63151016R	1504	20246	767	7561
69	63151020R	2435	31597	1045	13993
70	81081018R	1449	29875	68	3878

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