LANE DROP STUDY
AT THE
DAVISON EXPRESSWAY

Report TSD-G-198-72

TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

I-75 (CHRYSLER FREEWAY) LANE DROP STUDY AT THE DAVISON EXPRESSWAY

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by

G. N. GRIMES

DEPARTMENT OF STATE HIGHWAYS
State Highways Building - P.O. Drawer K
Lansing, Michigan 48904

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ABSTRACT

An analysis of the northbound and southbound bottlenecks at the I-75 (Chrysler Freeway) - Davison Expressway interchange has revealed that the motorist is experiencing extensive delays as a result of the laneage reduction. This delay has, in turn, resulted in a higher than normal accident rate. Analysis of costs in delay and accidents indicated a yearly cost to the motoring public in excess of the estimated cost of eliminating the bottleneck.

This study has also indicated that lane drops should be used on a very selective basis. In general, the basic freeway laneage should be maintained through major interchanges to insure that the operational efficiency of the interchange is maintained.

INTRODUCTION

In recent years a number of major urban interchanges in Michigan have been designed on the premise that if a full lane of freeway traffic is projected to be exiting at the interchange, then a lane can be dropped beyond the exit point. The lane is added again beyond the merge of the entrance ramp to facilitate entering vehicles and the resulting increased volume. This leaves a short section of freeway that is one lane narrower than the basic laneage on either side of the interchange. At many of these locations we have not experienced the predicted exiting volumes while the through volumes have steadily increased. This being the case, some of these locations have become bottlenecks that create long backups of stop-and-go traffic during the peak hours. A considerable amount of public criticism has resulted, especially since the backups have developed relatively soon after opening the interchange to traffic.

Of particular concern is the I-75 (Chrysler Freeway) - Davison Expressway interchange in Detroit (Figure 1). The main line of I-75 at the interchange drops from four lanes to three lanes in each direction, causing backups of a mile or more upstream of the northbound and southbound lane drops (Figure 2).

The Detroit Expressway Technical Engineering Subcommittee recently discussed this problem and requested a traffic study to document the delay and its effect on traffic operations. A team was appointed to evaluate the problem and recommend solutions.

The study limits were set at Eight Mile Road to the north and at I-94 to the south. These points were chosen since I-75 is basically an eight-lane divided freeway which narrows to three lanes in each direction through the Eight Mile and I-94 interchanges. Any operational changes at Davison would affect the operation of the freeway at the Eight Mile Road and I-94 lane drops.

In addition to the traffic study, two methods of eliminating the bottlenecks were developed.

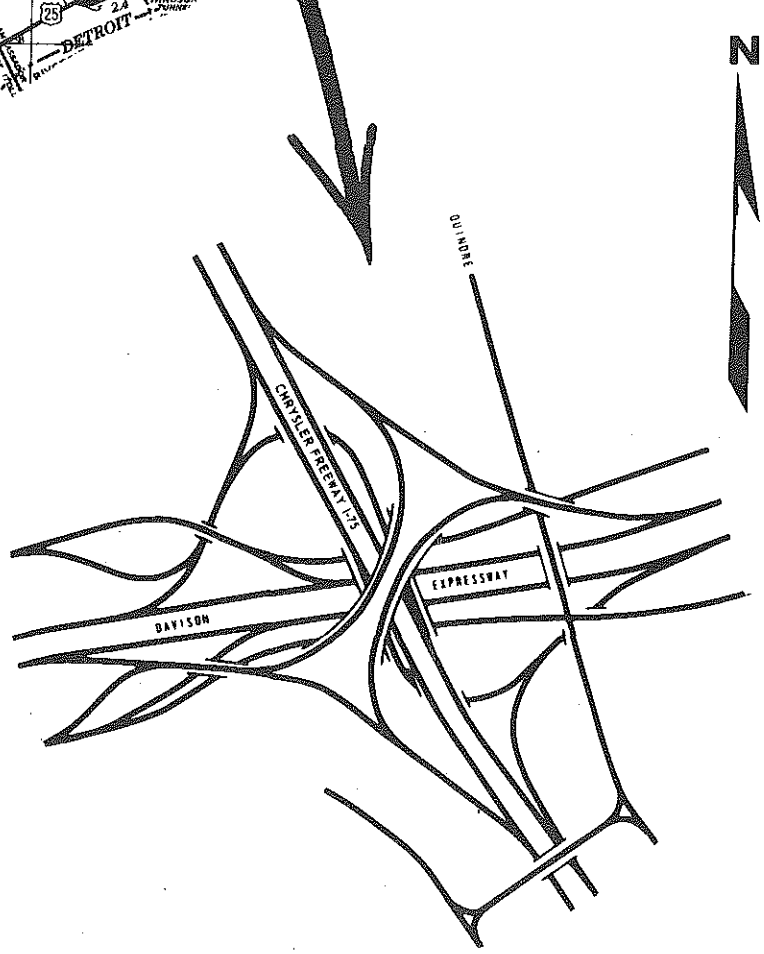


FIGURE 1. -- GENERAL AREA MAP

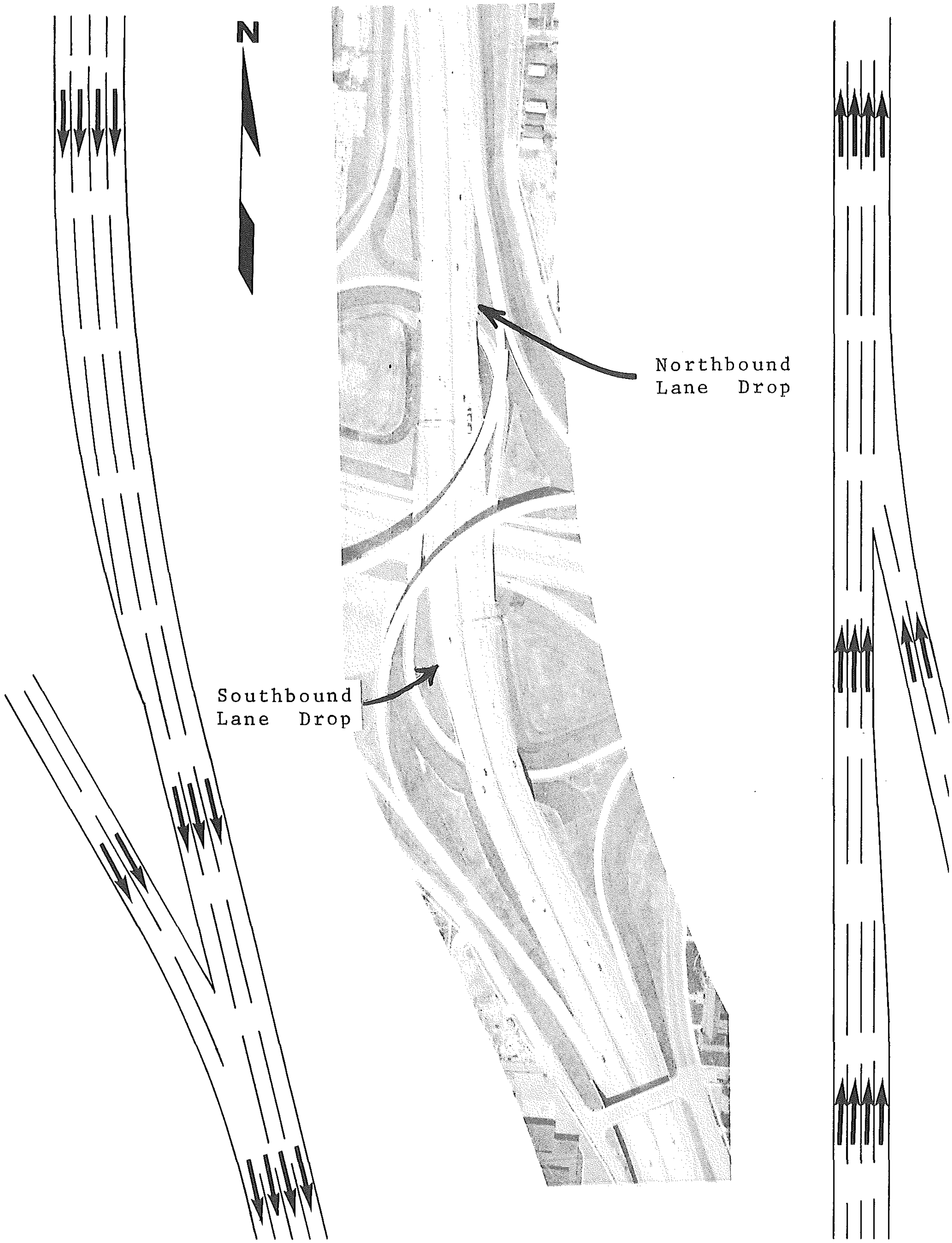


Figure 2.

CONCLUSION

Summary

The primary objective of this study was to determine the extent and cost of delay to the motoring public due to the bottlenecks at the I-75 - Davison Expressway interchange. The average delay during the peak period was determined to be 10 min. per vehicle northbound and 2.5 min. per vehicle southbound. This delay is estimated to cost the motorists an accumulated total of $2.27 million a year (page 29).

In order to evaluate the effect on the freeway if the bottlenecks at Davison were eliminated thus maintaining the basic four lanes, the expected delay due to the next downstream bottleneck was determined. The predicted average delay was determined to be 0 min. per vehicle and 1 min. per vehicle for northbound and southbound, respectively. By similar calculation this cost of delay to the motoring public is $91,322 each year (page 29). The difference of $2.18 million is the annual time savings to the motorist.

Cost to the motoring public would not be complete without adding the cost of accidents that are directly attributable to the reduction in laneage and the resultant stop-and-go operation. An analysis of all reported accidents occurring in 1970 shows that 17 accidents southbound and 37 accidents northbound can be attributed to the lane drops. The assumed savings from accident reduction resulting from reduced delay and congestion if the lane drops were eliminated is $85,085 per year (page 30).

The total savings in delay and accident costs to the motoring public is $2.27 million per year (page 30). This cost can be compared favorably to the construction estimate for eliminating the lane drops. This current estimate is $200,000.

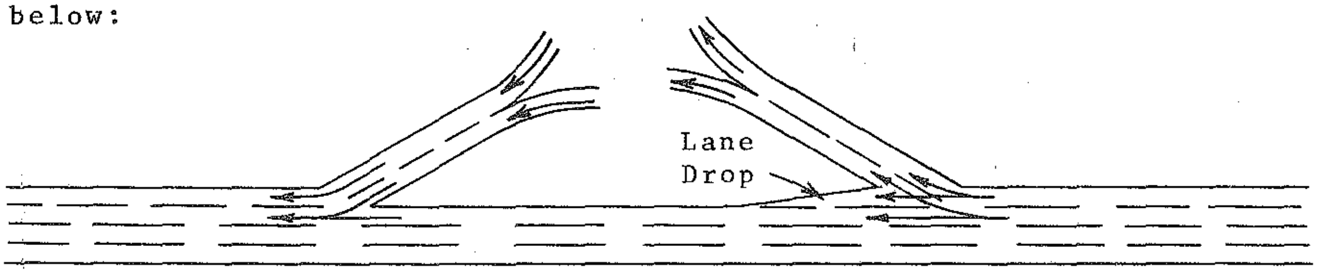
Recommendations

I-75 Lane Drops at Davison

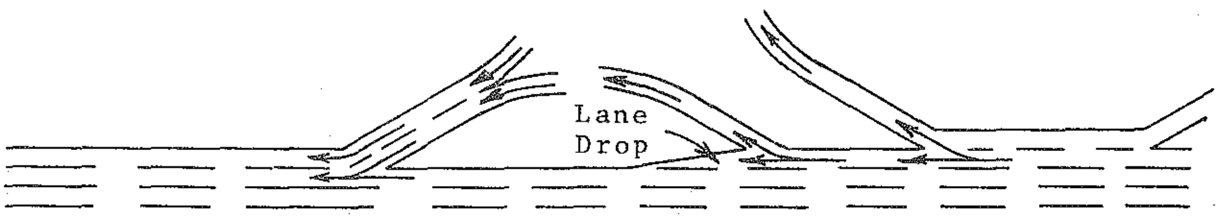
On the basis of reduced delay and increased safety to the motoring public, it is recommended that the I-75 laneage reduction be eliminated by new construction, in order to provide continuous basic freeway laneage through the interchange. This would require reduction to one lane of the two-lane entrance ramps, but current volume projections indicate this will not restrict the operation of the interchange.

Future Design Practice

This study has also shown that lane drops on freeways should be used on a very selective basis. During the design stage of this interchange we believed that enough traffic would exit and enter the I-75 Freeway at the Davison Expressway to allow the laneage reduction within the interchange. It theoretically facilitated exiting and entering volumes greater than could be handled on a single-lane ramp. A typical two-lane ramp configuration is shown below:



The Davison interchange is an interesting variation of the two-lane exit design as shown below. The directional exiting movements are separate and allow more efficient use of the ramps. There is considerable question as to the amount of traffic that the combined two-lane exits can handle safely and efficiently.

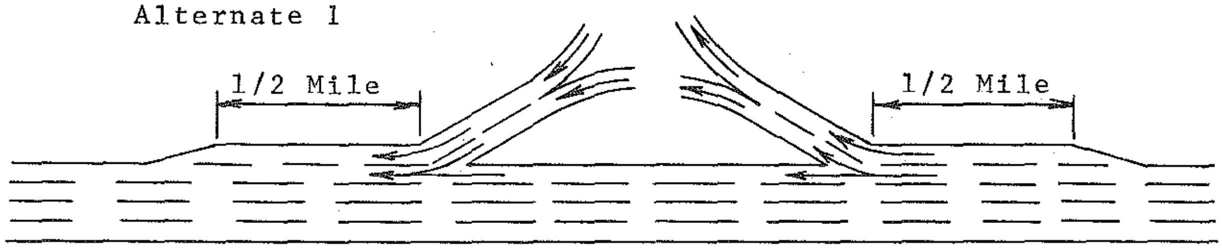


The fallacy in this case, in allowing a lane drop within a major interchange, is that the crossing freeway is not a completed facility. It therefore did not drain enough traffic off the mainline. The Davison Expressway is proposed to connect with I-96 to the west and I-94 to the east; however, these connections may be ten to fifteen years in the future.

As a result most of the traffic stays on I-75 and easily exceeds the capacity of the three lanes at the bottleneck. When the Davison Expressway is a completed facility, enough traffic might exit to relieve the bottleneck; however, a very serious problem must be faced in the interim.

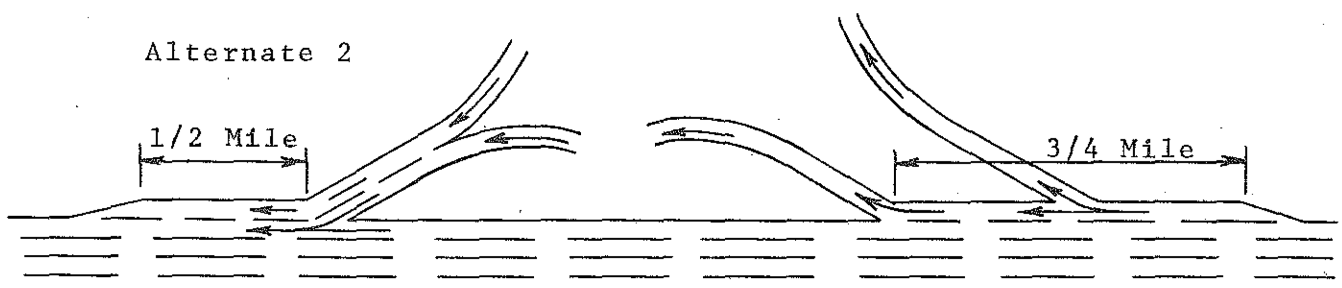
In order to alleviate this condition, the operational flexibility of major interchanges must be increased to allow for the safe and efficient use of the freeway both now and in the future. This flexibility can be provided by maintaining the basic freeway laneage through the interchange and providing long parallel deceleration and acceleration lanes as shown below:

Alternate 1



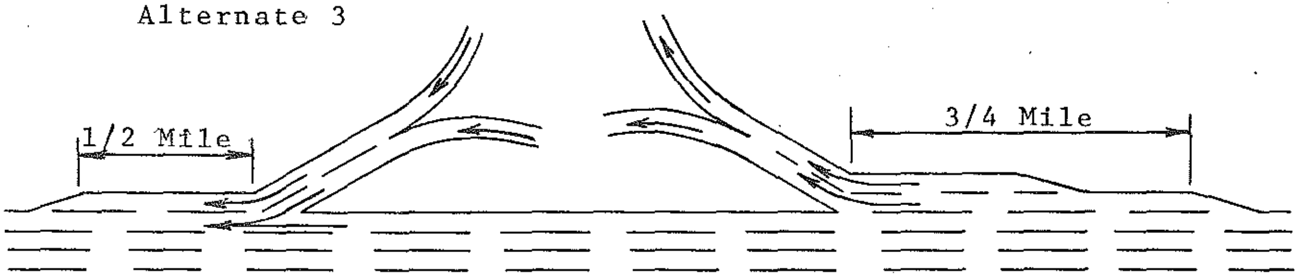
The second alternate separates the exit ramp movements. This would eliminate the dual-lane exit, with its inherent inefficiencies and potential for conflict.

Alternate 2



The third alternate should be utilized when the projected exiting volumes are very high (35% or greater). This design was included

Alternate 3



in a presentation prepared for the 1969 AASHO Operating Committee on Design meeting by Mr. A. C. Estep, Chief of Traffic and Engineering (former Engineer of Design), California Division of Highways. This alternate allows for advanced lane assignment signing while increasing the capacity of the diverge without overloading the right-hand through lane.

These alternates eliminate the lane drop and ensure the operational flexibility of the freeway. The freeway can now handle large through movements and the interchange can handle the predicted growth of exiting and entering traffic. Lane endings should only be introduced when the basic freeway laneage is to be discontinued permanently, and not within major interchanges.

Further Study

This study has taken a specific location and quantified the undesirable operation of the bottleneck. We feel that this method of analysis could be expanded to analyze other bottlenecks on the freeway system. As the Detroit Metropolitan Freeway System nears completion, traffic backups caused by geometric deficiencies should be evaluated and corrected to ensure that the system will operate at its maximum efficiency and safety.

METHOD OF STUDY

It was determined that sufficient traffic data should be collected to determine the extent of the existing congestion and delay to the motoring public and to predict any future operational difficulties within the study area if the lane drops at Davison are eliminated.

Volume Counts

We decided to take peak hour five-minute counts on the mainline and all exit and entrance ramps from I-94 to Eight Mile Road. The count stations and recorded volumes are shown on Figure 3. The morning peak period was found to occur in the southbound direction from 6:30 a.m. to 9:30 a.m. The evening peak period occurs in the northbound direction from 3:30 p.m. to 6:30 p.m. The northbound count was taken on August 9, 1971 and the southbound count was taken on August 10, 1971.

Speed-Delay Recorders

In conjunction with the counts, two cars were utilized to record vehicle speeds during the count period. Both cars contained Speed-Delay Recorders that provide a continuous vehicle speed tape as it is driven through the study area. One of the recorders failed, however, and a reduced number of recorded runs was made. The other car continued to make runs, during which average speeds between control points were recorded.

Accident Records

In order to develop a complete picture of operational aspects of the lane drops, all 1970 accidents reported to policing agencies were analyzed for the study section. There were 166 reports in the northbound direction and 125 in the southbound direction.

LANEAGE & PEAK HOUR VOLUMES
FIGURE 3

RESULTS

Delay to the Motoring Public

As stated previously, I-75 is a basic eight-lane divided freeway from I-94 to Eight Mile Road. The freeway narrows to a six-lane divided facility between the exit and entrance ramps of the Davison interchange.

Backups of a mile or more develop during the a.m. peak southbound and the p.m. peak northbound. This is primarily due to the excessive input of vehicles upstream, which easily exceeds the capacity of the three through lanes at the bottleneck.

Figures 4 and 5 show the volume input and resultant delay due to the northbound and southbound lane drops. The graphs were developed by accumulating the mainline and ramp counts to determine the demand of input at the bottleneck. The upper graphs show the volume demand into the lane drop indicating the period of time that it exceeds the capacity of the three lanes at the lane drop. The reader will note that the capacity northbound is 1550 veh/hr/lane while the rate southbound is 2200 veh/hr/lane. During the count period, backups began to develop at 3:20 p.m., with pressure intensifying upstream very rapidly. Southbound the demand developed gradually and therefore produced a relatively efficient operation at the bottleneck.

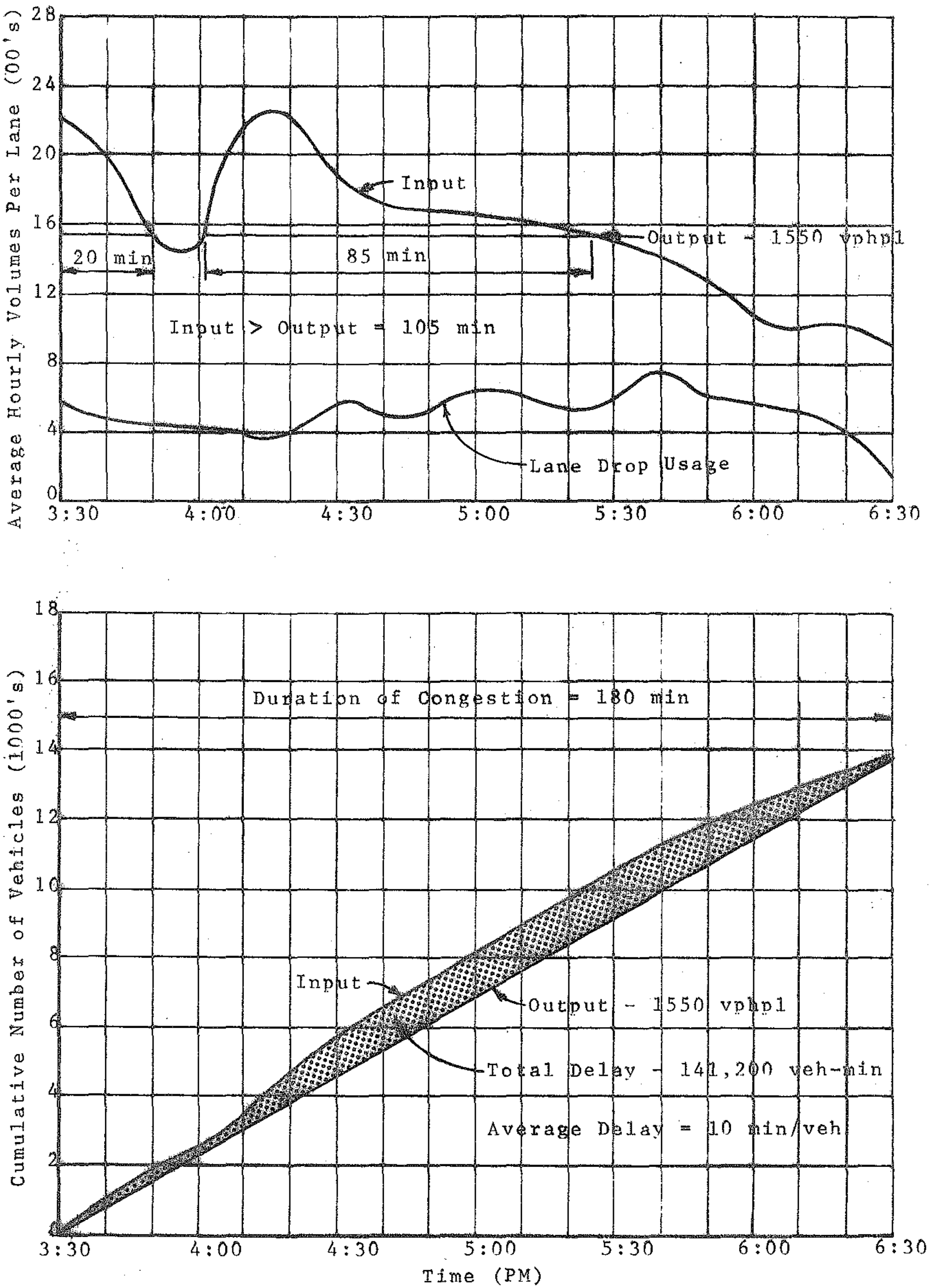


FIG. 4.-Northbound Bottleneck at Davison Expressway

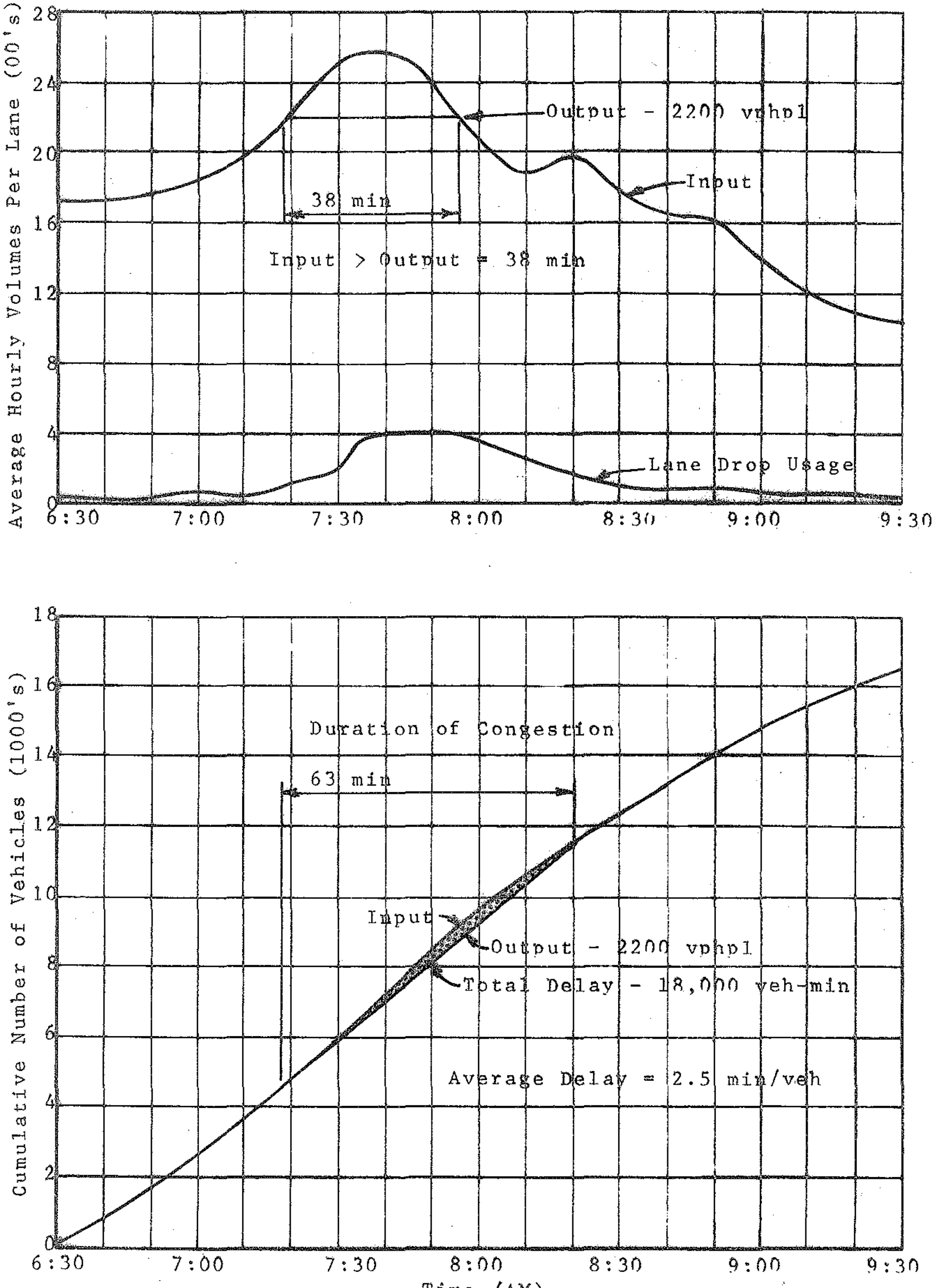


FIG. 5.-Southbound Bottleneck at Davison Expressway

The combination of high truck percentages in the outside lane and grades is another important factor. The northbound roadway approaches the lane drop at a +2.2% which flattens to +0.5% through the lane drop. The upgrade then increases to +1.5% extending to the Six Mile Road interchange. In addition, the freeway curves to the right which tends to hide the lane drop. During the count period, the outside lane at the lane drop contained 9% trucks. Observations have indicated that heavy trucks slowed by the grades are aggravating the operation of the lane drop because of their bulk and lack of maneuverability.

Southbound the grades are all negative which allowed trucks to move with traffic even though the outside lane contained 15% trucks.

It should also be noted that the northbound count was taken in the afternoon on a hot sunny day. It is estimated that the temperature on the depressed freeway was 100°. The heat resulted in a number of breakdowns, and this greatly reduced the efficiency of the freeway. The southbound count was taken in the early morning, so that heat was not a factor. Additionally, 2nd and 3rd Streets in Highland Park were converted to two-way operation the previous Saturday. Since Woodward Avenue is congested, it can be assumed that some of the traffic formerly using 2nd and 3rd Streets switched to I-75 on the days that we took the counts.

Also shown on the upper graphs (Figures 4 and 5) are the number of vehicles actually using the lane drops. The pressure on the northbound bottleneck is shown by the fact that the lane drop is used by an average of 509 veh/hour throughout the three hours, whereas southbound the average is only 132 veh/hour.

The lower graphs (Figures 4 and 5) also show a large variation in the average and total delays experienced by the motorist. In the northbound direction the average delay was ten minutes for each vehicle with the backups continuing for the full three-hour period. Southbound the delay was only 2.5 minutes per vehicle with the backups lasting only one hour. The efficiency of the southbound operation is evidenced by the fact that approximately 17,000 vehicles passed through the bottleneck while only 14,000 vehicles were facilitated at the northbound bottleneck for the same period of time. These differences can be attributed to the factors discussed previously. The "shock wave" effect of the bottleneck is evidenced by the fact that northbound traffic exceeded the flow rate of the bottleneck for 105 minutes ending at approximately 5:20 p.m. while the delay did not clear up until 6:30 p.m.

Operating Speed

An additional indicator of the operational efficiency of the freeway is average vehicle speed throughout the study section. Figure 6 is developed from the Speed-Delay tapes and graphically shows the

SPEED CONTOURS
FIGURE 6

effect of the bottlenecks. Again, the northbound lane operated so inefficiently that a very wide band of 30 mph speeds and below were developed. The efficiency of the southbound bottleneck is indicated by the fact that vehicle speeds at the end of the lane drop had already increased to 40 mph, whereas at the end of the northbound lane drop speeds were only 10 to 15 mph.

Levels of Service are also shown on Figure 6 as developed in the 1965 Highway Capacity Manual. Operating speed is directly related to the concept of levels of service, as shown. The six levels of service ranging from A to F were developed for application in identifying the conditions under which a highway is operating for various speeds and volumes. Levels A, B and C represent stable-flow conditions whereas D, E and F are unstable or forced-flow conditions. Under Level of Service F the speeds are very low with numerous stoppages. Needless to say, this type of operation is very frustrating to the driver who is already tired from a full day at work as is the case on northbound I-75. Level of Service F must be tolerated by the public for several miles upstream from the Davison interchange and for a large portion of the peak period.

Accidents

All 1970 accident reports for this section of freeway were analyzed to determine if there may be some correlation to the laneage reduction and the resultant stop-and-go operation of the freeway upstream

1970 ACCIDENTS
FIGURE 7

of the lane drop. Figure 7 shows the location of all reported accidents occurring in 1970. Those accidents which occurred during the peak hours (3:00 p.m. to 7:00 p.m. northbound and 6:00 a.m. to 10:00 a.m. southbound) are shown separately from the off-peak accidents.

One hundred sixty-six accidents occurred in the northbound direction. Of the 49 accidents which occurred between I-94 and Davison during the peak hours, 37 or 76% could be attributed to the lane drop and the resultant stop-and-go operation. These 37 accidents are 22% of the total northbound accidents.

While the accident picture southbound is not as severe, the same general conclusions can be drawn as for northbound. One hundred twenty-five accidents occurred southbound. Of the 25 accidents which occurred between Eight Mile and Davison during the peak hour, 17 or 68% could be attributed to the lane drop and the resultant stop-and-go operation. These 17 accidents are 16% of the total southbound accidents.

Figures 8 and 9 illustrate the effect of peak hour traffic on the accident picture. Twenty-four hour volumes are plotted against time. The total accidents and those attributable to the laneage reduction and stop-and-go operation are also plotted. In general, the two curves correspond very well. Both volume and accidents

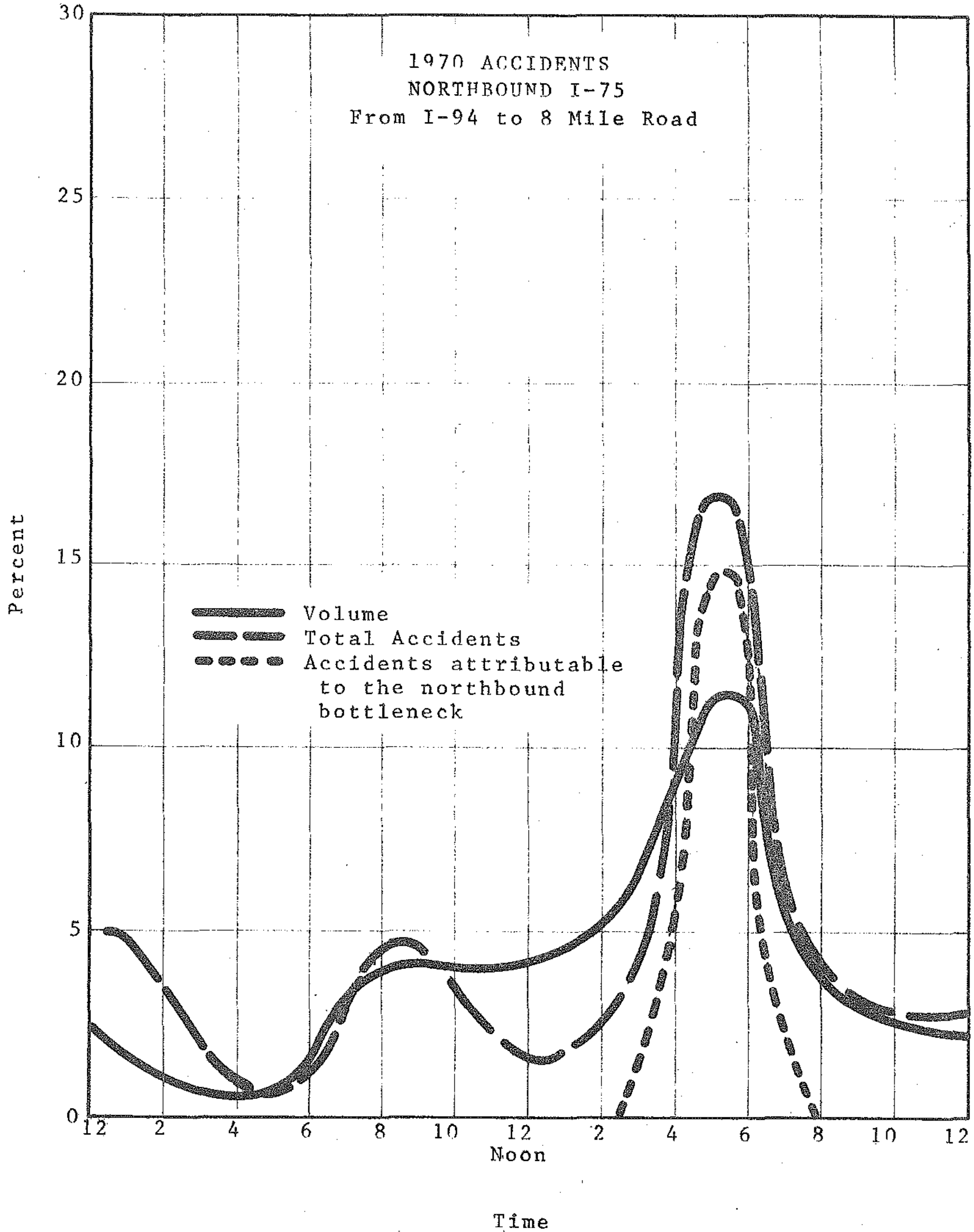


FIGURE 8 - NORTHBOUND I-75; ACCIDENT, VOLUME COMPARISON

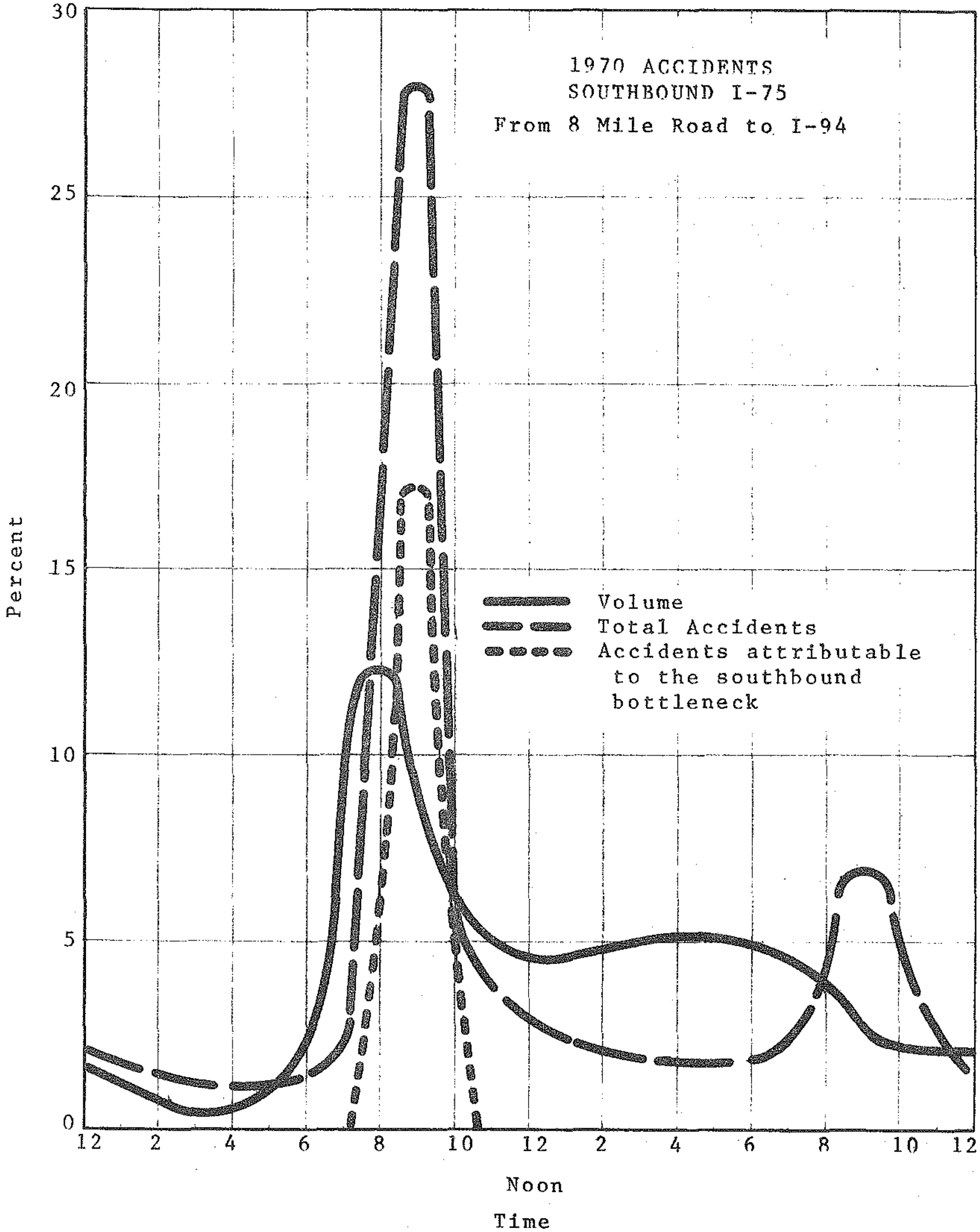


FIGURE 9 - SOUTHBOUND I-75; ACCIDENT, VOLUME COMPARISON

peak at the same time period, indicating the direct relationship of volume to accidents.

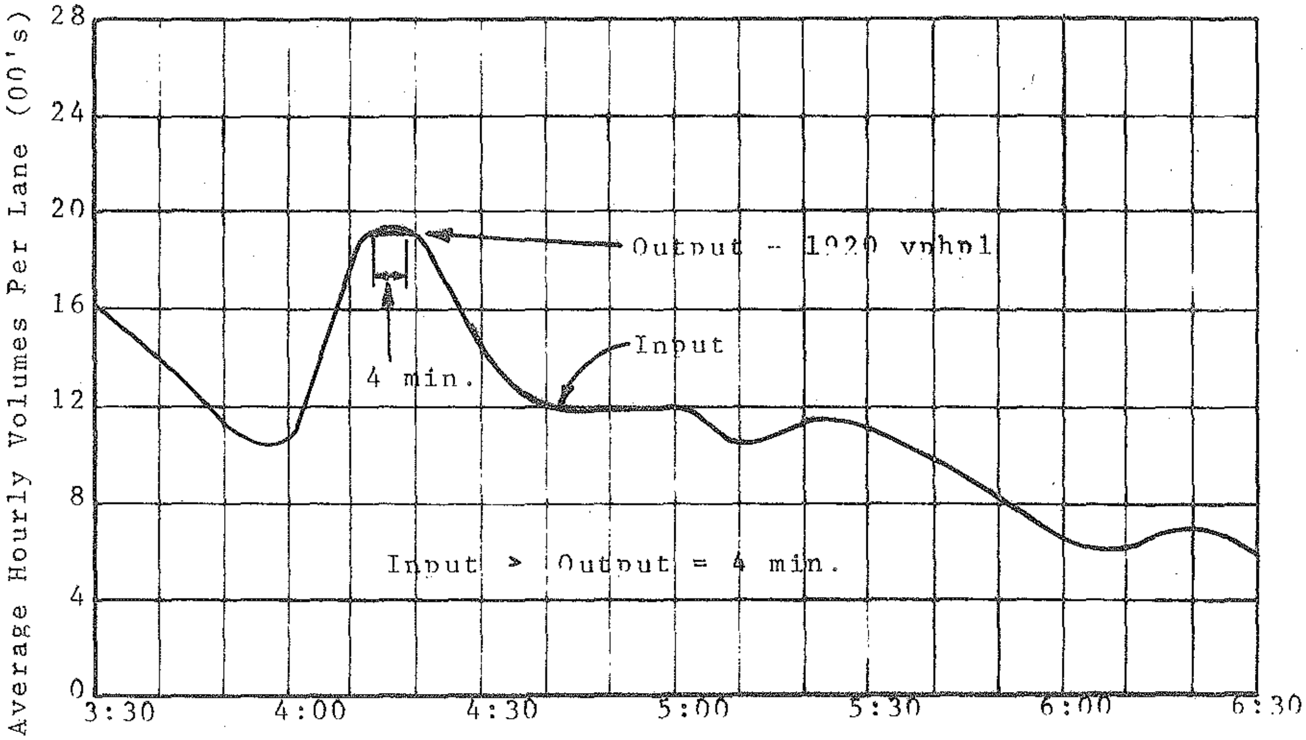
No attempt has been made to analyze the accident data statistically because only one year was utilized. This being the case, only general conclusions can be drawn from the graphs presented here. However, it is evident that the motoring public is subject to not only a heavily congested freeway but also the greater probability of being involved in an accident because of the congestion.

ANALYSIS OF RESULTS

Reduction in Delay

As discussed previously, there is considerable delay to the motorist due to the existing bottlenecks at Davison. Given the assumption that the lane drops are eliminated by construction of additional laneage, it is then necessary to determine what delay will be experienced at the Eight Mile northbound and I-94 southbound bottlenecks since traffic will no longer be restricted at Davison.

A prediction of the potential delay was made by determining the input into the Eight Mile lane drop and the I-94 lane drop as shown on Figures 10 and 11. Of course, an assumption must be made as to the output of these lane drops as they are not presently operating at capacity. We have assumed that the maximum output through the bottleneck is 1920 veh/hr/lane. While southbound I-75 did carry 2200 veh/hr/lane through the Davison bottleneck, it is felt that this volume is extremely high. An output of 1920 veh/hr/lane northbound at Eight Mile will not cause any delay while southbound will experience 6400 veh/min delay at I-94. Northbound, the average delay is reduced from 10 minutes to 0 delay (see Figure 4). This 100% reduction can only be achieved because 32% of the freeway traffic approaching Eight Mile exits at this point. Southbound, the average delay per car is one minute as compared to the present 2.5 min delay (see Figure 5).



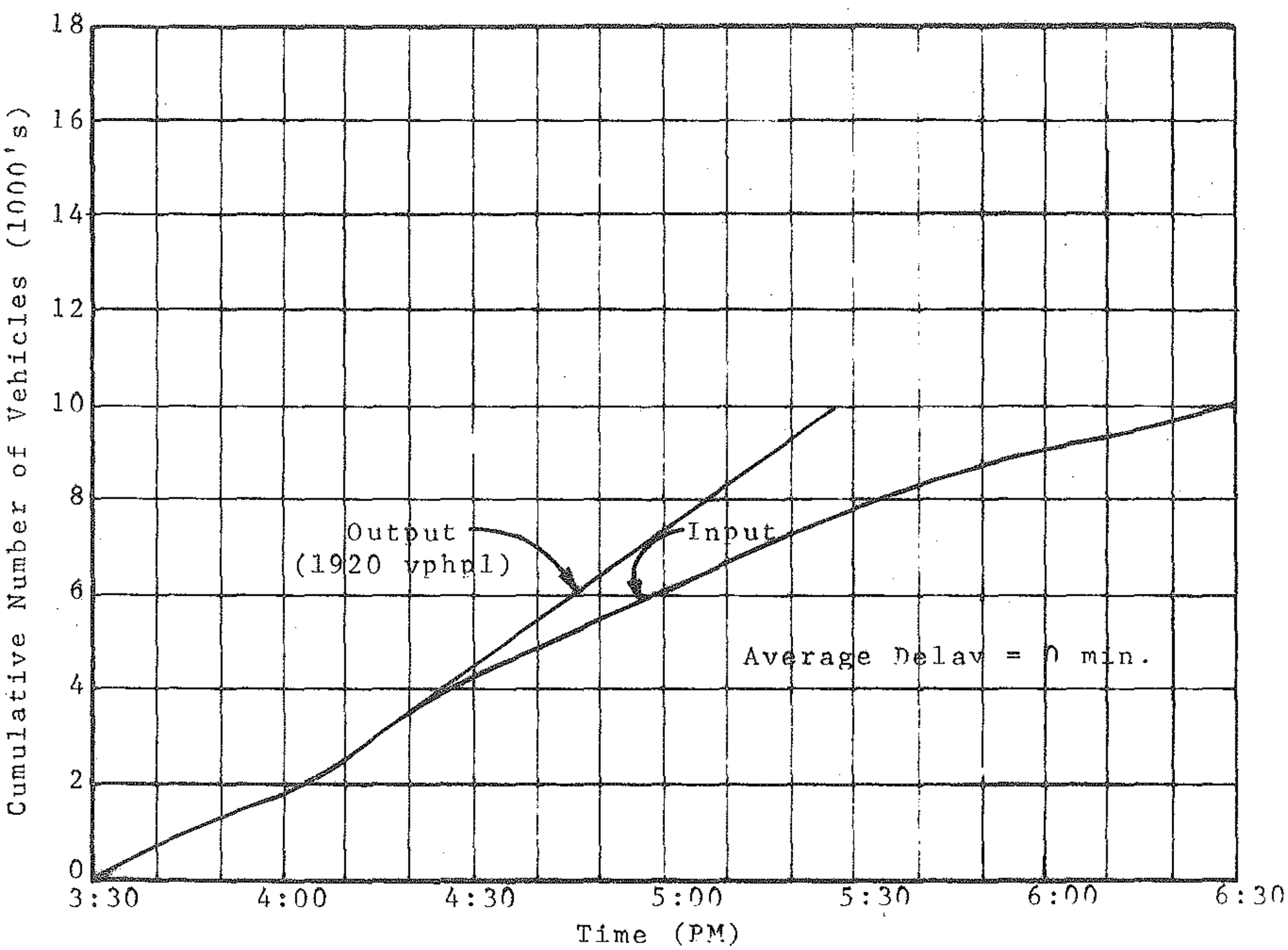


FIG. 10.-Northbound Bottleneck at 8 Mile Road

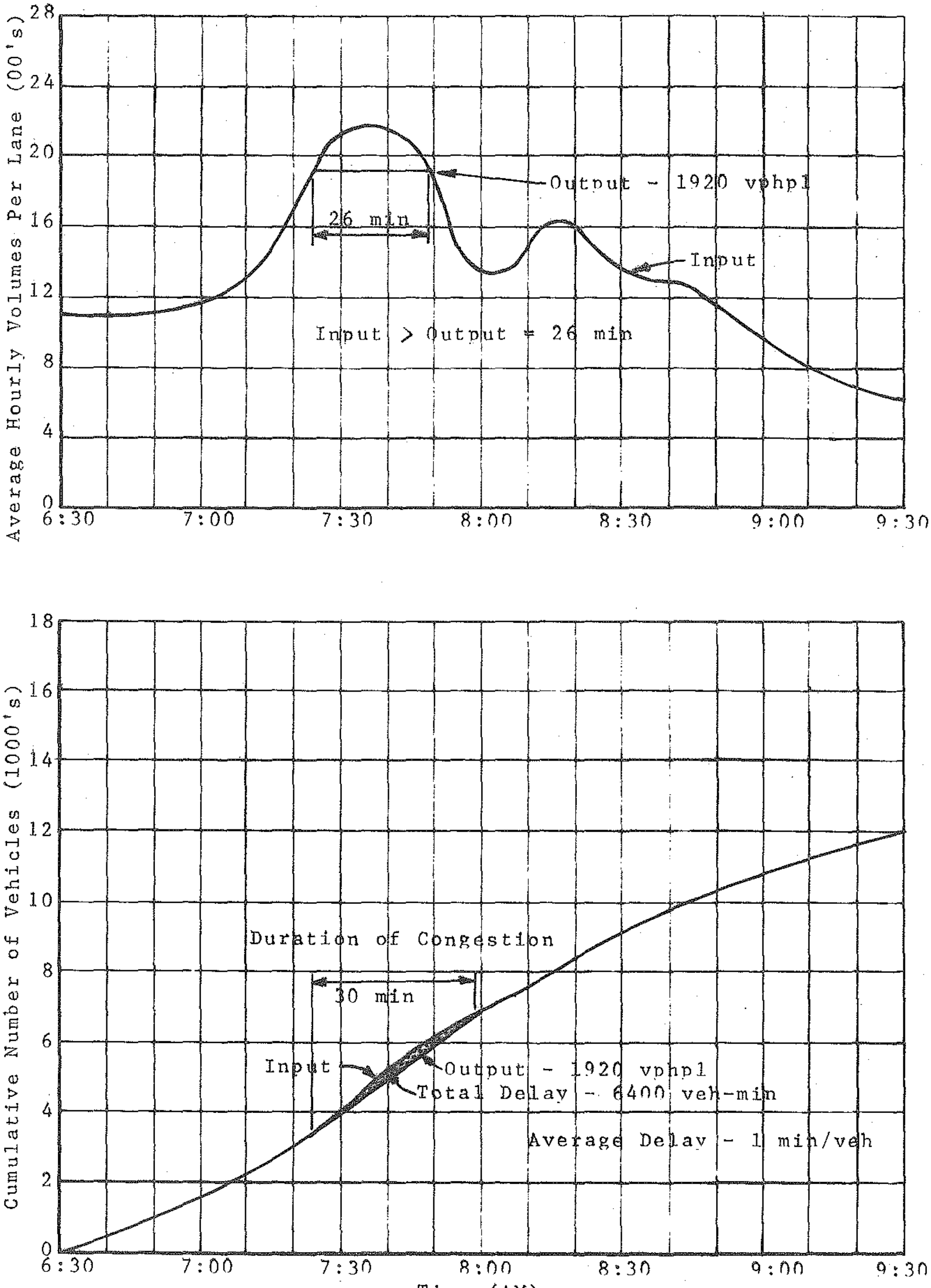


FIG. 11.-Southbound Bottleneck at I-94 Freeway

Cost to the Motoring Public

Value of Time

The Stanford Research Institute has done extensive research into the value of travel-time savings for commuting motorists. The study recommends the use of $2.82 per person per hour as the value of travel-time savings for commuter trips of more than ten minutes and more than five miles in length. As the trips on I-75 during the peak hours are generally commuting trips, we have utilized the estimate of $2.82. Assuming 1.2 persons per car and 253 working days per year, the yearly cost of delay to the motoring public can be calculated. The 1.2 persons per vehicle is taken from the 1969 Detroit Regional Transportation and Land Use Study (TALUS).

Northbound Delay Due to the Davison Bottleneck:

(141,200 veh-min/day) x (1.2 persons/veh.) x
($2.82 person/hour/60) x (253 working days/year) = $2,014,783/year

Southbound Delay Due to the Davison Bottleneck:

(18,000 veh-min/day) x (1.2 persons/veh.) x
($2.82/person/hour/60) x (253 working days/year) = $ 256,852/year

Total Delay at the Davison Bottlenecks $2,271,635/year

As previously discussed, if the Davison bottleneck is eliminated, the predicted delays at Eight Mile for northbound traffic and I-94 for southbound traffic will be 0 veh-min and 6400 veh-min, respectively.

Total Cost of Delay if the Bottlenecks at Davison are eliminated:

(6400 veh-min/day) x (1.2 persons/veh.) x
($2.82 person/hour/60) x (253 working days/year) = $91,322/year

The total savings in reduced delay to the motoring public then is:

$2,271,635/year

$ - 91,322/year

$2,180,313/year

Accident Costs

As previously discussed, 16 accidents southbound and 37 accidents northbound can be attributed to the lane drops and the resultant stop-and-go operation. Utilizing National Safety Council cost figures for 1970, the costs to the motoring public can be determined.

Northbound:

1970 Costs

PD	13 x $ 400	=	$ 5,200
INJ	24 x $ 2,700	=	$65,100
FATAL	0 x $45,000	=	$ 0
	Total		$70,300/year

Since there will be no delay at Eight Mile Road, the accident cost savings can be assumed to be $70,300 or 100% per year.

Southbound

1970 Costs

PD	10 x $ 400	=	$ 4,000
INJ	7 x $ 2,700	=	$18,900
FATAL	0 x $45,000	=	$ 0
	Total		$22,900/year

Since the southbound delay will be reduced by 65%, we have assumed that the accident costs will be reduced proportionately. This would result in an accident cost savings of $14,785 per year. Total savings for northbound and southbound is $85,085.

Operating Costs

We have not included operating costs as the only available cost data is based on vehicle miles which will be the same with or without the lane drops at Davison.

Total Savings

Total savings to the motoring public are as follows:

Value of Time	=	$2,180,313/year
Accident Costs	=	$ 85,085/year
Total Cost Savings	=	$2,265,398/year

Of course, these user costs are based on a one-day sampling of traffic and various assumptions; however, we are of the opinion that the results give a clear indication of the magnitude of the problem at this location.