SPECIAL 24-HOUR CLASSIFIED SPEED STUDY M-78 STATION 1, 2, 3, 4, and 5

ANALYSIS OF SPEED STUDY DATA

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Special 24-Hour Classified Speed Study
M-78 Station 1, 2, 3, 4 and 5

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Analysis of Speed Study Data

Speeds of all motor vehicles in both directions were observed at the following five locations in Ingham County, Michigan:

Station	Location
1	M-78, 200 feet east of Touraine Avenue
2	M-78, 200 feet east of Alton Road
3	M-78, Between Park Lake Road and end of 3-lane pavement
4	M-78, 1,000 feet northeast of Lake Lansing Road
5	M-43 (Michigan Avenue), near Olin Street

The general location of stations 1 thru 4 may be described as M-78 within a distance of 5 miles east of the intersection of US-16 and M-78. Station 5 was on Michigan Avenue approximately mid-way between Lansing and East Lansing.

The observations extended over the period of November 3, 1953 thru December 7, 1953.

Stations 1, 2, 3 and 5 operated a total of 24 hours with each hour of the day being represented. Station 4 operated for the equivalent of two 24-hour periods: One represented the 24 hours from 12 M., Tuesday thru 12 M., Wednesday and the other represented the 24 hours from 6 A.M., Sunday thru 6 A.M., Monday. The 24 hours during which observations were made did not consist of 24 continuous hours at all stations.

Since there were two 24-hour operations at station 4 each of these two, as well as each operation at stations 1, 2, 3 and 5, will frequently be referred to as a "station-operation" rather than as a "station". The operation at station 4 extending over Tuesday and Wednesday will be referred to as station or station-operation "4 (T-W)", and that extending over Sunday and Monday as "4 (S-M)".

At stations 1, 2 and 5 the traffic in the two directions was observed at different times. At station-operations 3, 4 (T-W) and 4 (S-M) the traffic was observed in both directions simultaneously.

The number of lanes and maximum legal speed at each location were as follows:

Station	Number of Lanes	Maximum Legal Speed
1	4	40
2	3	50
3	2	50
4	2	None
5	4D	45

The analysis of these data had three objectives as follows:

1. Determine the size of the sample of speed observations that should be taken.
2. Determine the best time of day to take speed observations.
3. Develop a method for determining when a speed limit should be imposed and what the limit should be.

Before proceeding to these specific objectives, a general analysis was made to determine the comparative behavior of drivers at the several station-operations under varying conditions of traffic volumes and time of day.

It should be clearly understood that the results of this analysis apply only to the locations at which the observations were made. They are not to be taken as representative of driver behavior on rural state trunklines in general. While it is true that each station represented a different combination of speed limit and number of lanes, there was only one location for each such combination and this could hardly be accepted as representative of such conditions statewide.

In Table I are shown a few basic statistics from the data. It is clear that station 5 is very different from the other 5 station-operations. It is fairly certain that the difference is not due to the station being located on a 4-lane divided roadway, but to its being in a suburban area and on the main street connecting two centers of population.

Travelling eastbound on M-78 from its intersection with US-16 one passes thru stations 1, 2, 3 and 4 in this order. Notice in Table I the increase in average speed and percentile speeds from stations 1 thru 4. There is a slight reduction in these speeds from station 2 where there are 3 lanes to station 3 where there are only 2 lanes. It was found that this reduction was due to eastbound passenger cars reducing their speed and not to westbound increasing theirs. Trucks and busses, however, travel faster on the average thru station 3 than thru station 2.

Attention is called to the fact that at station 1 the average speed of trucks and busses as well as passenger cars is more than the speed limit. This one statistic alone means that many vehicles must be travelling far above the speed limit.

Tests upon the 24-hour frequency distribution of the speeds of all vehicles at each station-operation show that no two are alike. These are tests for similarity of the ratios of the number of vehicles in each speed group at one station-operation to the number of vehicles in the same speed groups at another station-operation. Although the tests employ actual numbers of vehicles, similarities or dissimilarities are best shown by percentage distributions as in Table II. Stations 2 and 3 come the nearest to being alike, yet they are significantly different. To the extent that these data represent the total situation one can conclude that something is definitely influencing the drivers' speed differently at each of these station-operations.

Attention was given to the extent to which the speed limit was being exceeded at stations 1, 2, 3 and 5. Table III shows the percentage of vehicles in each hour exceeding the speed limit. Table IV shows the percentage of vehicles exceeding the speed limit by more than 5 miles per hour. Obviously the situation is most serious at station 1 where in every hour of the day and night more than 53 percent of the drivers were exceeding the speed limit, and where in one hour (6 A.M. to 7 A.M.) more than 83 percent exceeded the speed limit. In each hour more than 15 percent and in two hours more than 40 percent exceeded the speed limit by more than 5 miles per hour at station 1. The contrast between the percentages at station 1 and those at stations 2, 3 and 5 in Tables III and IV emphasizes the seriousness of the situation at station 1. It is clear that drivers in an area which is only slightly more densely populated than rural and surely less densely populated than suburban and on a 4-lane highway are not going to obey a 40 mile-an-hour speed limit without strict enforcement which is apparently lacking in the vicinity of station 1.

The relationship between volume of traffic and variation in speed was investigated and it was found that in general this variation decreases as traffic volume increases. Vehicles tend toward the same speed as more and more of them are crowded onto the road. Coefficients of variation in speed for all vehicles, vehicles travelling over 50 miles per hour and for vehicles travelling less than 50 miles per hour are shown in Table V. They are shown for each of the 6 station-operations and 4 hourly traffic volume groups.

The coefficient of variation, rather than the standard deviation, is used here because it is free of the unit of measure and therefore all the measures in Table V are directly comparable one with another.

There is a strong tendency for the coefficients of Table V to increase from station 1 thru stations 2, 3, 4 (T-W) and 5. This may be due to the percentage of the total volume that is trucks, or to the difference in number of lanes and posted speeds, or both. It is believed that this particular study does not contain sufficient data to warrant investigation of this increase.

Drivers' response to change in hourly traffic volumes and to changes in number of lanes and posted speeds represented by the several stations was studied by application of the methods of analysis of variance. Table VI shows the average speeds by these two criteria.

In evaluating these findings from analysis of the variance in average speeds it would be well to keep in mind that differences in average speed may also be influenced by such things as percentage of trucks in the traffic stream, roadside development, grade and alignment, etc. To isolate the effect of such factors upon average driver speed would require a well planned survey of much greater extent than this one.

Considering the speeds of all vehicles at all station-operations except 5 it was found that:

1. The average speeds among the several station-operations differed significantly. Number of lanes and posted speeds did affect average driver speed.
2. The average speeds among the several hourly traffic volume groups differed significantly. Size of hourly traffic volume did affect average speeds.
3. The effect of number of lanes and posted speeds is probably significantly greater than that of hourly traffic volumes.
4. There was significant interaction in the speeds between station-operation and hourly traffic volume group. Driver response to changes in hourly traffic volume was not the same at all station-operations. Or, what is the same thing, driver response to changes in number of lanes and posted speed (changes in station-operation) was not the same in different hourly traffic volume groups.
5. There is a definite trend toward reducing speed as hourly traffic volumes increase up to about 500 vehicles per hour. Beyond this there is no decrease shown.

Station 5 is obviously much different from the other 5 station-operations. It was treated separately because its inclusion with the other 5 station-operations would have unduly accentuated otherwise normal differences.

Considering only station-operations 4 (T-W) and 4 (S-M) it was found that the average speed of the former was significantly greater than that of the latter. This may be due to the fact that a greater percentage of the total vehicles are concentrated in the high traffic volume hours on Sunday than on weekdays. Driver response to change in hourly traffic volume was significantly different between 4 (T-W) and 4 (S-M).

Considering only station-operations 3 and 4 (T-W) affords an opportunity to compare two locations with the same number of lanes (2) but with different speed limit conditions. The speeds were significantly lower at station 3 with its 50 miles per hour speed limit than at station 4 (T-W) with no speed limit. The average driver's response to this change in speed limits was significantly greater than his response to change in hourly traffic volume. The drivers tended to change their speeds in the same manner at both these stations as hourly traffic volumes changed.

Analyzing stations 2 and 3 affords an opportunity to test the effect of number of lanes (3 at station 2 and 2 at station 3) when the speed limit is constant at 50 miles per hour at both stations. The average speed at station 2 was significantly greater than that at station 3. This is an indication that number of lanes does affect average speed. Driver response to change in hourly traffic volumes was the same at both stations and not significantly large.

The variance between the average speeds at stations 2 and 3, both of which have 50 miles per hour speed limits, is not nearly as great as the variance between the average speeds at stations 3 and 4 (T-W) of which station 4 (T-W) has no speed limit. This would seem to show the greater effect of a speed limit over that of a difference in number of lanes. However, with so few stations possessing these various characteristics available, the evidence is not conclusive. The two variances were not statistically significantly different.

At station 5, analyzed separately from the other 5 station-operations, the driver response to change in hourly traffic volume was highly significant. Drivers tended to drive slower as hourly traffic volume increased up to 500 vehicles per hour. Beyond this volume the average speed increased slightly.

Using only those drivers driving over 50 miles per hour the same analysis of variance tests were made for the same groups of station-operations as for all drivers. Generally speaking, these faster drivers made the same types of response to changes in speed limits, number of lanes and hourly traffic volume as all drivers, but their responses were less pronounced. Also, they showed more nearly the same degree of response to changes in speed limits, number of lanes and hourly traffic volumes than did all drivers. In other words, the faster driver changed his speed less frequently and by a lesser amount due to speed zones, number of lanes of roadway and hourly traffic volumes than did the slower driver. Average speeds of these vehicles travelling over 50 miles per hour are also shown in Table VI.

Analysis of variance techniques were next applied to the data divided into several times of day and night periods for each of the 6 station-operations individually. The purpose of this was to determine whether or not the average speed of all vehicles was significantly higher at night than during the day. It was found that this depends upon what is considered as "day" and "night".

The periods 6 A.M. to 6 P.M. and 6 P.M. to 6 A.M. were first considered as day and night respectively. The average speed at station 1 was significantly higher at night than during the day; at station 5 exactly the reverse was true. At station-operations 2, 3, 4 (T-W) and 4 (S-M) there was no significant difference between the average day and night speeds.

When the periods 6 A.M. to 12 P.M. and 12 P.M. to 6 A.M. were considered as day and night, respectively, the situation was entirely different. At stations 1 and 2 there was no significant difference between the average day and night speeds; at station-operations 3, 4 (T-W), 4 (S-M) and 5 the average speed at night is significantly greater than during the day.

In general, the night speeds are not less than the day speeds. They are either greater than or no different from the day speeds.

Although the complete analysis was not carried out in detail there is no doubt that the variance of the average speeds among station-operations is far greater than that of the average speeds among the time periods. And therefore the data indicate that speed is influenced more by number of lanes and speed limits than by time of day or night.

There is also strong indication, although again the analysis was not carried out in detail, that the variance of the average speeds among hourly traffic volume groups is greater than that among time periods of the day and night, but is less than that among station-operations.

It is important to note the conclusion to be drawn from this analysis of variance: The physical characteristics of the highway have the greatest influence on the average driver's speed. The traffic volume is next in importance as an influence on speed and time of day or night is least of the three. The driver has no control over the first two but he could reduce his speed at night if he chose to do so. Many do not so choose.

Determination of the size of sample presents a problem to which there is no one answer because several factors are involved. First, there is the amount of variation existing in the population to be sampled. Second, there is the amount of error that will be tolerated in the estimate of the average speed from the sample data. Third, there is the probability level for which the sample size is to be estimated. This is a measure of the assurance that the average speed computed from the sample will differ from the average speed of the total population by no more than the amount of error that will be tolerated. Fourth, if the population being sampled is relatively small, a smaller sample than that required from an infinite population may suffice for a given error tolerance and level of probability.

The first factor, amount of variation in the population, is generally the most difficult to determine. However, with the data from these 6 station-operations available, the variation can be computed fairly close. Three sets of coefficients of variation, each by a different set of criteria, were computed from these data. A large proportion of them lay between 0.14 and 0.18. Therefore, a conservative figure of 0.20 for coefficient of variation would be satisfactory for estimating size of sample. There seems little reason to expect the coefficient of variation to change much from one part of the state to another. Generally it is a rather stable statistic.

The second and third factors, error tolerance and level of probability, must be determined on the basis of judgement, past experience or perhaps cost of obtaining the sample. These may also depend upon the use to be made of the sample data.

Where speed observations are to be made the fourth factor, size of population to be sampled, i.e. traffic volume, will generally be known with sufficient accuracy for estimating size of sample. If the traffic volume is not known and cannot be readily or easily determined the sample size can be determined on the basis of an infinite population. Such an estimate may be larger than necessary but the error is on the safe side.

In most cases the problem will be to secure a sufficiently representative sample rather than a sufficiently large one. Segments of the population whose representation in the sample may be desirable are the two directions of travel, type of vehicle, hour of day, day of week and season of year. It may also be desirable to have various weather and surface conditions represented, especially if the sample is to be used to estimate average year around conditions. To have all these various conditions represented several sub-samples would be necessary and the resulting total sample may turn out to be much more than adequate. For a spot check of the average speed at a single location it is quite possible that a 4- to 6-hour observation would suffice. To obtain the average speed or a sufficiently accurate frequency distribution of the speeds along a route, in a large area or on a state-wide basis, it may be more important to have various surface types, surface widths, numbers of lanes, types of terrain and traffic volumes represented than to have the various days of the week or seasons represented.

Clearly the problem of sample size is a complex one. In addition to the purely statistical factors there is the kind of use to be made of the sample data and the area to be represented. Each sample size problem will generally have to be considered on its own merits. As a general guide to sample size for spot checks of speed and perhaps to size of sub-samples of a larger total sample Table VII shows some sample sizes for estimating average speed. These are shown for various traffic volumes flowing during the time the sample is to represent. These traffic volumes are not necessarily the volumes flowing only while the sample is actually being observed. The sample sizes are shown for three different tolerable errors, 1%, 2.5% and 5%, at each of two probability levels, 95% and 99%. The entire table is based on a coefficient of variation of 0.2.

The "required size of sample" values shown in Table VII are computed on the assumption that the observations will be taken at random from the "traffic volume to be represented". From an operational standpoint it would not be feasible to attempt to secure a purely random sample of vehicles for speed measurement. An alternative method, very widely used, is systematic sampling. By this method every n-th vehicle is selected and its speed measured. The value of n is determined by computing the ratio of the estimated total traffic volume that will pass while the sample is being taken to the number of vehicles to be included in the sample. In applying this method the observer must be extremely careful to count the vehicles correctly and measure the speed of every n-th vehicle and not the n-th minus 1 or n-th plus 1 vehicle.

In cases where it is desired to know the average speed during each hour over a period of time it may be necessary to observe every second, third or fourth vehicle in order to secure a sufficiently large sample for each hour. To meet these conditions with radar equipment it has been found feasible to let the equipment register the speed of every vehicle on the tape and then later in the office read from the tape only every second, third or fourth vehicle as required for analysis purposes. This results in a substantial reduction of the amount of office work required.

In cases where it is desired to know the average speed over a comparatively long period of time, it may suffice to record the speed of only every 10th, 15th or 20th vehicle. To meet these conditions it has been found feasible to turn on the radar equipment for only each n-th vehicle required. Here again the office work is greatly reduced.

As a general guide to sample size for estimating frequency distributions of speeds Table VIII contains some sample sizes for this purpose. Again these are shown for various traffic volumes flowing during the time the sample is to represent. These traffic volumes are not necessarily the volumes flowing only while the sample is actually being observed. The sample sizes are shown for four different tolerable errors, 5%, 2.5%, 1% and 0.5%, at each of two probability levels, 95% and 99%.

Table VIII is made on the assumption that in such frequency distributions the modal class, i.e. the speed group in which the largest number of vehicles appear, may contain as many as 50% or more of the vehicles. If it is known that no class will contain as many as 50% of the vehicles (none do in Table II), then the sample sizes in Table VIII are slightly larger than necessary for estimating frequency distribution.

To determine the best time of day to make speed observations a search was made for those time periods during which the frequency distribution of speeds differed insignificantly from the distribution for 24-hours. The chi-square test was used to determine significance or insignificance of differences between distributions. Each station-operation was tested separately.

Detailed results of these tests will not be given. The following table gives the hour periods found to be most satisfactory:

Number of Hours in Period	All Station-Operations Except Sta. 5	Station 5
9	-	9 A.M.-6 P.M.
9	-	12 M. -9 P.M.
6	9 A.M.- 3 P.M.	-
4	7 A.M.-11 A.M.	1 P.M.-5 P.M.
4	4 P.M.- 8 P.M.	2 P.M.-6 P.M.
4	5 P.M.- 9 P.M.	3 P.M.-7 P.M.
4	7 P.M.-11 P.M.	-
4	8 P.M.-12 P.M.	-

Regarding the third objective, to develop a method for determining when a speed limit should be imposed and what the limit should be, no method was found from the data available. An attempt at a solution to this problem was made by computing certain statistics relating to the number of passing maneuvers that would take place in an hour at the observed distributions of speed if passing opportunities were always available when desired. Graphs of these statistics gave no clues to the solution of the problem.

It is believed that no amount of speed data alone will solve these problems regarding speed limits. At the present time speed limits are determined more or less arbitrarily and often imposed only after considerable public clamor is raised. The reasons for speed limits may occasionally be economic, but they are usually imposed for the purpose of reducing or preventing accidents.* It would seem, therefore, that the determination of whether or not to impose a speed limit should include an examination of the accident record, or an evaluation of the accident potential, or both.

Admittedly there is evidence both pro and con to the question of speed limits reducing accidents. Nevertheless, if it were not for the ever present possibility of an accident, most driving would be at greater speeds than at present.

On modern turnpikes where roadside friction is nearly zero, speed limits are set as high as 70 miles per hour. Few drivers would consider this limit too high. Many drivers exceed it. But where roadside friction is high, as it is on many free roads and streets, there are few who would condone a speed limit as high as 70 miles per hour.

The point is that a connection between high speed and accidents is clearly recognized and whether or not to establish a speed limit should rest on the accident record and the accident potential due to roadside friction. The question cannot be answered from speed data alone.

* Except in the case of local and National cemeteries where a speed limit is imposed to compel respect for the dead rather than to protect the living.

It should be recognized also that a speed limit has little value if it is not enforced.

Table I

Number of Vehicles, Percentage Trucks and Busses, Average Speeds and Percentiles by Station-Operation

Item	Station-Operation 1	2	3	4(T-W)	4(S-M)	5
Total Vehicles Observed	9,673	8,553	6,969	6,094	5,882	13,312
Percentage Trucks and Busses	14.9	16.5	17.3	19.8	5.9	10.8
Average Speed (Mis./Hr.):						
All Vehicles	42.11	44.96	44.25	46.22	44.96	36.68
Passenger Cars	42.39	45.43	44.40	46.72	45.04	36.73
Trucks and Busses	40.48	42.55	43.56	44.20	43.80	36.27
Percentile Speed (All Vehicles):						
75	45.26	49.42	49.22	51.83	49.51	40.20
80	46.65	50.65	50.47	53.01	50.86	41.57
85	48.04	52.24	51.97	54.19	52.64	42.93
90	49.44	53.83	53.47	56.20	54.43	44.30

Table II

Percentage Distribution of Speeds at the 6 Station-Operations

Speed Group (Miles per Hour)	Percentage in Each Speed Group					
	Station 1	Station 2	Station 3	Station 4(T-W)	Station 4(S-M)	Station 5
1 - 25	0.20	0.30	0.62	0.66	0.26	1.85
25 - 30	1.06	1.44	1.86	1.43	1.67	9.84
30 - 35	6.47	6.00	7.38	6.07	5.13	26.35
35 - 40	26.92	12.09	13.49	10.85	18.05	36.25
40 - 45	39.41	32.60	33.46	27.65	25.81	18.26
45 - 50	17.97	25.53	21.61	20.58	26.69	5.91
50 - 55	6.37	15.73	16.69	21.20	13.99	1.18
55 - 60	1.19	4.19	3.43	6.55	5.71	0.27
60 - 65	0.34	1.67	1.32	3.85	1.99	0.06
65 - 70	0.06	0.31	0.10	0.85	0.44	0.02
70 & up	0.01	0.14	0.04	0.31	0.26	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table III

Percentage of Each Hour's Traffic Volume Exceeding
the Speed Limit at 4 Stations

Hour of Day	Percentage Exceeding			
	Station 1	Station 2	Station 3	Station 5
12 P.M. - 1 A.M.	58.8	17.7	31.6	10.6
1 A.M. - 2 A.M.	61.1	28.0	22.5	20.3
2 A.M. - 3 A.M.	62.4	28.6	23.3	28.9
3 A.M. - 4 A.M.	56.6	30.4	35.7	20.8
4 A.M. - 5 A.M.	56.1	25.2	26.0	25.1
5 A.M. - 6 A.M.	71.4	21.3	22.1	13.6
6 A.M. - 7 A.M.	83.8	23.1	22.2	12.0
7 A.M. - 8 A.M.	79.9	21.6	19.2	6.7
8 A.M. - 9 A.M.	58.0	23.5	19.0	6.6
9 A.M. - 10 A.M.	63.8	27.2	28.4	8.5
10 A.M. - 11 A.M.	56.5	28.6	29.5	4.6
11 A.M. - 12 M.	53.9	23.8	34.7	9.0
12 M. - 1 P.M.	60.0	19.7	17.9	11.9
1 P.M. - 2 P.M.	65.5	15.5	18.7	8.6
2 P.M. - 3 P.M.	60.5	21.0	16.1	6.8
3 P.M. - 4 P.M.	61.7	18.2	18.8	6.2
4 P.M. - 5 P.M.	66.9	22.0	21.0	6.2
5 P.M. - 6 P.M.	58.3	17.3	17.8	6.8
6 P.M. - 7 P.M.	72.9	24.9	23.1	5.7
7 P.M. - 8 P.M.	69.8	25.8	25.0	5.0
8 P.M. - 9 P.M.	66.1	19.2	11.4	4.1
9 P.M. - 10 P.M.	69.2	26.8	20.0	6.8
10 P.M. - 11 P.M.	70.1	18.3	20.7	7.0
11 P.M. - 12 P.M.	70.7	23.3	18.3	8.0
Total	100.0	100.0	100.0	100.0

Speed Limits:
Station 1 - 40 mis./hr.
Station 2 - 50 mis./hr.
Station 3 - 50 mis./hr.
Station 5 - 45 mis./hr.

Table IV

Percentage of Each Hour's Traffic Volume Exceeding the Speed Limit by More Than 5 Miles per Hour at 4 Stations

Hour of Day	Percentage Exceeding Station 1	Station 2	Station 3	Station 5
12 P.M. - 1 A.M.	35.0	3.9	9.7	4.1
1 A.M. - 2 A.M.	28.4	10.0	10.0	6.7
2 A.M. - 3 A.M.	33.8	9.2	4.2	11.9
3 A.M. - 4 A.M.	15.7	7.2	-0-	11.4
4 A.M. - 5 A.M.	26.8	5.5	6.0	7.2
5 A.M. - 6 A.M.	40.5	5.1	2.0	4.5
6 A.M. - 7 A.M.	43.2	5.0	5.7	1.7
7 A.M. - 8 A.M.	33.5	5.1	3.4	0.9
8 A.M. - 9 A.M.	23.0	6.3	4.2	0.3
9 A.M. - 10 A.M.	27.0	8.4	8.7	1.4
10 A.M. - 11 A.M.	21.9	8.5	9.0	0.9
11 A.M. - 12 M.	20.8	8.3	11.2	1.3
12 M. - 1 P.M.	21.1	5.0	3.9	2.8
1 P.M. - 2 P.M.	24.7	3.7	3.2	1.8
2 P.M. - 3 P.M.	22.0	6.7	2.6	1.3
3 P.M. - 4 P.M.	15.6	4.5	2.0	0.9
4 P.M. - 5 P.M.	20.3	6.5	2.2	1.3
5 P.M. - 6 P.M.	22.9	4.1	3.8	1.0
6 P.M. - 7 P.M.	30.2	10.0	6.7	1.1
7 P.M. - 8 P.M.	30.2	8.0	7.1	0.8
8 P.M. - 9 P.M.	26.9	5.8	4.0	1.0
9 P.M. - 10 P.M.	29.5	7.2	4.2	1.0
10 P.M. - 11 P.M.	27.2	5.4	5.4	2.7
11 P.M. - 12 P.M.	29.4	10.1	3.6	2.5
Total	100.0	100.0	100.0	100.0

Speed Limit:
- Station 1 - 40 mis./hr.
- Station 2 - 50 mis./hr.
- Station 3 - 50 mis./hr.
- Station 5 - 45 mis./hr.

Table V

Coefficient of Variation of Speeds of Vehicles by Station-Operation and Hourly Traffic Volume Groups

All Vehicles

Hourly Traffic Volume Group	Coefficient of Variation Station 1	Station 2	Station 3	Station 4(T-W)	Station 4(S-M)	Station 5
0 - 199	0.146	0.157	0.169	0.181	0.182	0.212
200 - 399	0.146	0.167	0.163	0.178	0.160	0.178
400 - 499	0.135	0.155	0.165	0.169	0.168	0.170
500 or more	0.125	0.144	0.147	0.168	0.146	0.158
	Vehicles Travelling Over 50 Miles Per Hour					
0 - 199	0.067	0.081	0.066	0.089	0.088	0.106
200 - 399	0.069	0.073	0.057	0.081	0.075	0.057
400 - 499	0.053	0.068	0.070	0.073	0.068	0.044
500 or more	0.041	0.061	0.040	0.071	0.066	0.049
	Vehicles Travelling Less Than 50 Miles per Hour					
0 - 199	0.117	0.111	0.134	0.132	0.126	0.174
200 - 399	0.116	0.128	0.128	0.129	0.121	0.163
400 - 499	0.111	0.120	0.127	0.124	0.136	0.153
500 or more	0.108	0.112	0.122	0.126	0.106	0.150

Table VI

Average Speeds of Vehicles by Station-Operation and Hourly Traffic Volume Group

Hourly Traffic Volume Group	Station 1	Station 2	Station 3	Station 4(T-W)	Station 4(S-M)	Total	Station 5
	All Vehicles						
0 - 199	41.82	45.29	44.22	46.79	46.50	45.43	39.16
200 - 399	42.68	44.86	44.35	46.30	45.07	44.83	37.61
400 - 499	42.30	45.01	44.11	45.72	43.45	43.66	36.19
500 or more	41.75	44.88	44.15	45.76	45.16	43.65	36.60
Total	42.11	44.96	44.25	46.22	44.96	44.29	36.68
	Vehicles Travelling over 50 Miles per Hour						
0 - 199	54.17	54.97	54.15	55.57	56.38	55.34	56.40
200 - 399	54.38	54.77	54.20	55.33	55.05	54.84	55.19
400 - 499	53.76	54.49	54.38	54.87	54.60	54.40	54.32
500 or more	53.45	54.19	53.30	55.04	54.53	54.12	53.62
Total	53.82	54.57	54.02	55.28	55.22	54.68	54.10

Table VII

Required Size of Sample from Various Traffic Volumes for Estimating Average Speed
(Based on Coefficient of Variation of 0.2)

Traffic Volume to be Represented	Probability Level of 95%			Probability Level of 99%		
	Tolerable Error			Tolerable Error		
	5%	2.5%	1%	5%	2.5%	1%
25	18	23	25	20	24	25
50	28	42	48	34	45	49
75	34	58	72	44	64	73
100	39	71	94	52	81	96
150	44	94	137	63	111	142
200	48	111	177	70	136	186
250	50	124	215	75	158	229
300	52	136	251	79	176	270
400	54	153	318	85	206	348
500	56	165	377	88	230	421
750	58	186	504	94	272	585
1,000	59	198	606	97	299	727
1,500	60	212	760	100	332	959
2,000	61	220	870	102	351	1,141
2,500	61	225	952	103	364	1,288
3,000	61	228	1,017	103	373	1,409
3,500	61	231	1,069	104	380	1,510
4,000	62	233	1,111	104	385	1,596
5,000	62	235	1,176	105	392	1,734
6,000	62	237	1,224	105	397	1,841
8,000	62	240	1,290	106	404	1,994
10,000	62	241	1,333	106	408	2,098
15,000	62	243	1,395	106	414	2,256
20,000	62	244	1,428	107	417	2,344
25,000	62	244	1,449	107	419	2,400
50,000	62	246	1,492	107	422	2,521
75,000	62	246	1,507	107	423	2,564
100,000	62	246	1,514	107	424	2,586
200,000	62	247	1,526	107	425	2,620
300,000	62	247	1,530	107	425	2,632
400,000	62	247	1,532	107	425	2,637
500,000	62	247	1,533	107	425	2,641
750,000	62	247	1,535	107	425	2,646
1,000,000	62	247	1,535	107	425	2,648
Infinite	63	247	1,538	108	426	2,655

Table VIII

Required Maximum Size of Sample from Various Traffic Volumes for Estimating Frequency Distribution of Speeds
(Modal class containing as much as 50% or more of the vehicles)

Traffic Volume To be Represented	Probability Level of 95%				Probability Level of 99%			
	Tolerable Error				Tolerable Error			
	5%	2.5%	1%	0.5%	5%	2.5%	1%	0.5%
25	23	25	25	25	24	25	25	25
50	44	48	50	50	46	49	50	50
75	63	72	74	75	67	73	75	75
100	79	94	99	100	87	96	99	100
150	108	137	148	149	122	142	149	150
200	132	177	196	199	154	186	198	199
250	151	215	244	248	182	228	246	249
300	168	251	291	298	207	270	295	299
400	196	317	384	396	250	348	391	398
500	217	377	475	494	285	421	485	496
750	254	504	696	736	352	585	718	742
1,000	278	606	906	975	399	726	943	985
1,500	306	759	1,297	1,444	460	958	1,376	1,467
2,000	322	869	1,655	1,901	498	1,141	1,785	1,941
2,500	333	952	1,984	2,347	524	1,287	2,173	2,409
3,000	341	1,016	2,286	2,783	543	1,408	2,541	2,870
3,500	346	1,068	2,565	3,208	558	1,509	2,890	3,325
4,000	350	1,110	2,824	3,623	569	1,595	3,223	3,773
5,000	357	1,175	3,288	4,424	585	1,734	3,842	4,650
6,000	361	1,223	3,693	5,189	597	1,840	4,406	5,502
8,000	367	1,289	4,364	6,621	613	1,993	5,397	7,139
10,000	370	1,332	4,899	7,934	622	2,097	6,239	8,690
15,000	375	1,394	5,855	10,788	635	2,255	7,877	12,234
20,000	377	1,427	6,488	13,152	642	2,343	9,067	15,368
25,000	378	1,448	6,938	15,144	646	2,399	9,971	18,158
50,000	381	1,491	8,056	21,724	655	2,520	12,455	28,513
75,000	382	1,506	8,513	25,403	658	2,563	13,583	35,205
100,000	383	1,513	8,762	27,753	659	2,585	14,227	39,885
200,000	383	1,525	9,164	32,225	661	2,619	15,317	49,821
300,000	384	1,529	9,306	34,054	662	2,631	15,718	54,333
400,000	384	1,531	9,378	35,048	662	2,636	15,927	56,909
500,000	384	1,532	9,423	35,674	663	2,640	16,055	58,576
750,000	384	1,533	9,482	36,543	663	2,645	16,228	60,957
1,000,000	384	1,534	9,512	36,993	663	2,647	16,317	62,221
Infinite	384	1,537	9,604	38,414	663	2,654	16,587	66,349