THE EFFECT OF ZONE SIZE ON TRAFFIC ASSIGNMENT

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

SUMMARY

The purpose of this study was to evaluate the effect of zone size on assigned link volumes. This was accomplished by comparing the volumes assigned to a common basic network using three different zone-size configurations. Assigned link volumes using medium and large zones (one square mile and half square mile zones, respectively) were compared with those using small (quarter square mile) zones.

The differences in assignments between the small-zone and the medium-zone systems were generally considerably less than those between the small-zone and the large-zone systems.

The average differences in assigned link volumes relative to the small-zone system was 5.8 percent for the medium-size zone system and 13.2 percent for large-zone system for assigned link volumes in excess of 25,000 vpd.

Of the links exceeding 100 vpd. in the small-zone system, approximately 45 percent had assignments that differed by more than 10 percent when compared to the medium-zone system. The corresponding value was 60 percent when comparing the large-zone system with the small-zone system.

Absolute differences in assigned link volumes were stratified into six volume groups. It was found that the medium-zone system consistently had assigned link volumes that were closer to that of the small-zone system than did the large-zone system for each volume group.

Compared with the small-zone system, there was a decrease of interzonal trips of 3.0 and 8.4 percent when going to medium-zone and large-zone systems, respectively.

It is concluded that zones as large as a half square mile can be used without serious or practical effect on the traffic assignment results. This conclusion is considered valid for medium size urban areas and for low density areas (such as single family residential) in any urban area.

CONCLUSIONS

The study of the effects of the size of traffic assignment zones on the assigned link volumes in the Waco study area revealed a number of differences between the volumes for the smallest zone size system when compared to the two larger zone size systems.

For the study area, significant relative and absolute "errors" in major street assignments occur when the zone size is larger than half square mile. Hence, it is consluded that zones of one half square mile are the maximum size that should be employed for study areas or portions of study areas of relatively low density (i.e. predominantly single family residential) development.

Conduct of the analysis suggested that the differences associated with describing the street network probably are more important than those associated with the size of the zone used.

INTRODUCTION

Traffic assignment is the process by which a set of trip desires (a matrix of zone to zone interchanges) is allocated to a representation of the transportation network in a rational and orderly way. Land areas are aggregated into zones and all trips are assumed to originate and terminate at the zone centroid. The aggregation into zones is necessary because:

1. It is not practical to describe the transportation network in enough spatial detail to "assign" a trip from its actual land parcel of origin to its parcel of destination.

2. The aggregation of trip ends for the purpose of sampling and trip end estimation techniques used in origin-destination surveys usually constitute zones which are considerably larger than the parcel, block or even larger areas.

3. When the study area is subdivided into small zones, the magnitude of the data handling problems increases since the size of the trip distribution table is a function of the square of the number of zones. Also, the number of trees required has a linear relationship to the number of zones used.

It is necessary to have each zone large enough so that the number of trip ends can be estimated with reasonable accuracy; yet, it must be small enough in relation to the network so as to obtain a realistic assignment of trips to the coded network. Further, the degree of network detail obviously must have a direct bearing on any assignment. General practice, of course, is not to include all the existing streets within the study area in the assignment network. Since, intrazonal trips can not be assigned, it is "hoped" that the degree-of-detail in the coded network is counterbalanced by this non-assignment of intrazonal trips - this may or may not be the actual situation.

As a result, zone size is a fundamental consideration in the delineation of traffic assignment zones. Questions that logically follow are:

1. What is the effect of zone size on the assigned volumes?

2. And, what is an "optimum" size zone?

OBJECTIVE AND PROCEDURES

This research was directed toward an evaluation of the effect of zone size on assigned link volumes. In designing the study it was decided that a relatively wide range in zone size should be considered in order to "bring out" any possible effects caused by changes in zone size. Yet, this range should represent the range that might be considered feasible for present techniques used in urban transportation planning. It was also believed that three different sizes would be adequate to identify any trends. These were:

small - quarter square mile
medium - half square mile
large - one square mile

The Waco Urban Area, (population 132,000) was selected for study as a typical medium sized urban area prior to the start of the origin-destination survey which was conducted in 1964. Each geographical area with public road or street access was assigned a unique number. These geographical areas (survey zones) ranged in size from a city block in the developed areas to about 1,000 acres in the undeveloped fringe. In the 248 square miles survey area, the number of such survey zones totaled more than 2,800.

Zone size could be varied only in that portion of the transportation study area where the O-D survey zones were the same size or smaller than the smallest traffic assignment zone (one-quarter square mile in area). This consisted of the developed area at the time of the origin-destination survey. Outside the developed area the same zones were used for all three zone size systems. Figure 1 shows the limits of the entire transportation study area and the area within which zone size was varied.

For this research a basic arterial street was defined; this network was then supplemented with additional links as required by the particular zone size being used. More links were of course necessary in order to provide connections between the centroids and the major street links when the zone size is relatively small.

Only those links that were common to all the coded networks were used in the analysis. Links at the fringe of the study area, where zone size was not varied, were also excluded from the analysis.

The survey zones were aggregated into traffic assignment zones by experienced personnel familiar with zoning philosophies and current practice. At the time this aggregation was done, a table of equals

1964 MAJOR STREET SYSTEM FOR WACO INDICATING THE AREA WITHIN WHICH THE ZONE SIZE WAS VARIED

FIGURE 1

indicating the correspondence between survey zones and each assignment zone was prepared for the three zone-size systems. The resulting number of assignment zones for each was:

1. quarter square mile system - 338 zones;

2. half square mile system - 152 zones;

3. one square mile system - 86 zones.

The configurations of zones used in the three systems are shown in Figures 2 through 4.

Insofar as was possible, the method illustrated in Figure 5 was used to supplement the basic arterial network and to connect the centroids to the coded network. Natural barriers and the absence of existing streets precluded the use of four ties to the zone centroid in several instances.

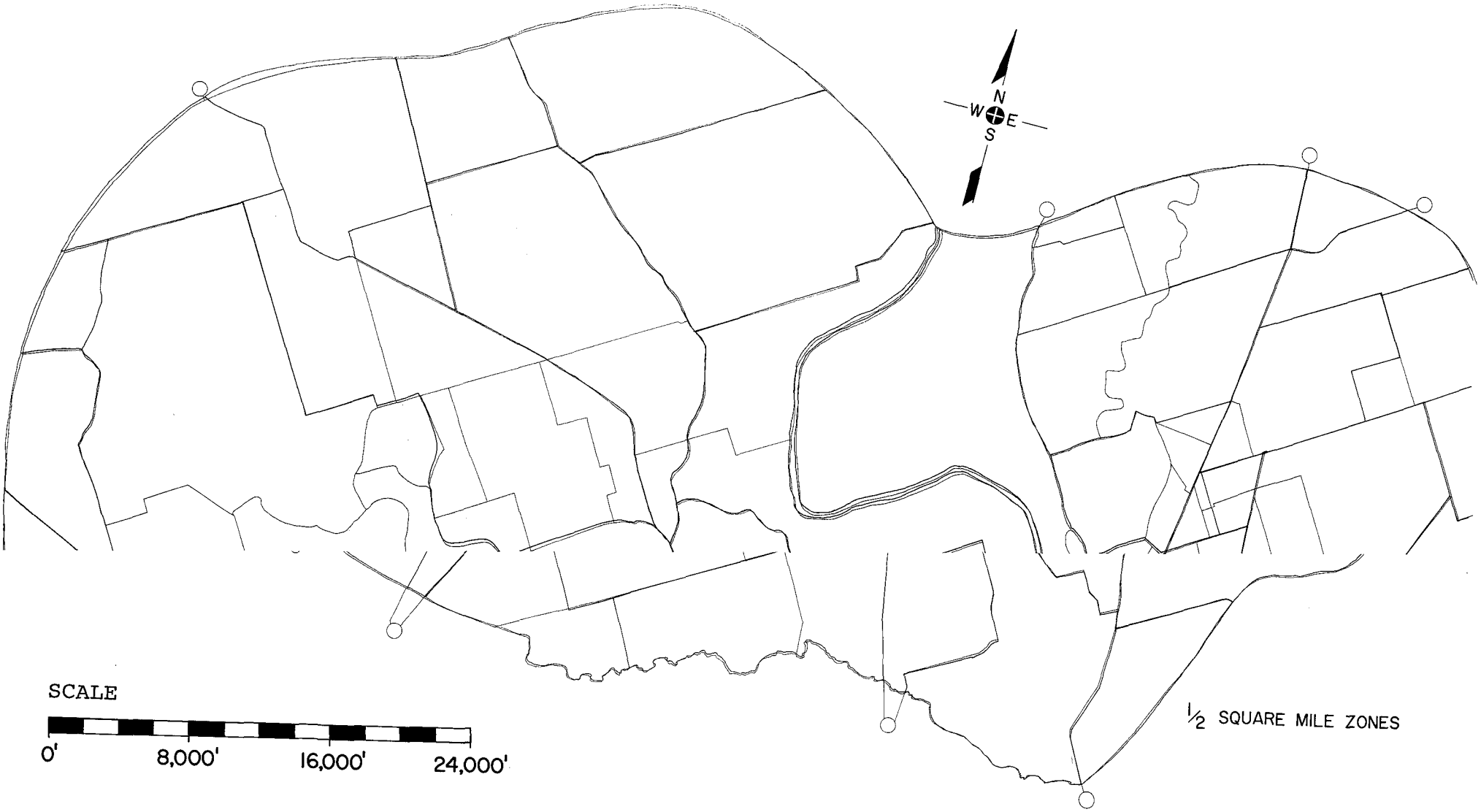
The level-of-service speed assigned to each link of the street network was selected after due consideration of the observed average speed, type of facility, the geometrics of the link, and traffic control. The link speeds used range from 15 m.p.h. on the local street links to 55 m.p.h. on some major arterial links. In general, multiples of 5 m.p.h. were used.

Since traffic count data were not available at the time, adjustments were not made in the link speed parameter in order to match ground counts.

The Revised Texas Traffic Assignment Package was used to assign the expanded 24-hour (directional) O-D survey trips to each of the three systems.

1964 MAJOR STREET SYSTEM FOR WACO SHOWING THE QUARTER SQUARE MILE ZONE DELINEATIONS

FIGURE 2

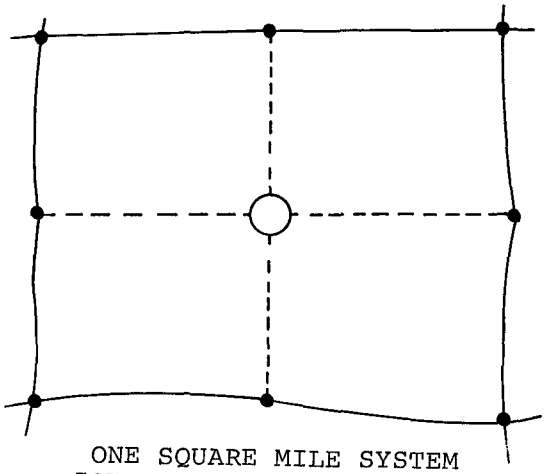


1964 MAJOR STREET SYSTEM FOR WACO SHOWING THE
HALF SQUARE MILE ZONE DELINEATIONS

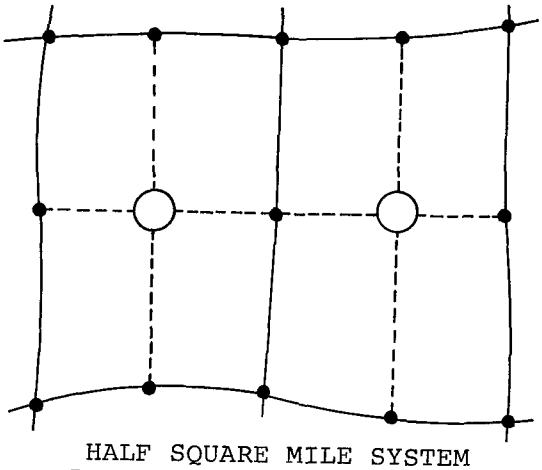
FIGURE 3

1964 MAJOR STREET SYSTEM FOR WACO SHOWING THE
ONE SQUARE MILE ZONE DELINEATIONS

FIGURE 4



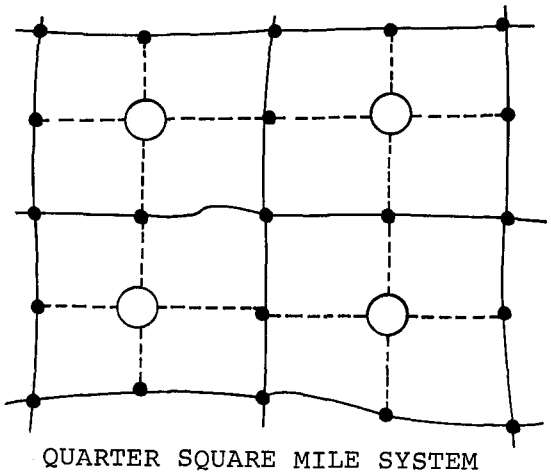
ONE SQUARE MILE SYSTEM
ZONE CENTROID CONNECTIONS



HALF SQUARE MILE SYSTEM
ZONE CENTROID CONNECTIONS

_____ Zone Boundary

---------- Centroid Connections



QUARTER SQUARE MILE SYSTEM
ZONE CENTROID CONNECTIONS

SCHEMATIC DRAWING INDICATING THE METHOD OF
AGGREGATING ZONES

FIGURE 5

ANALYSIS AND FINDINGS

For analysis purposes it was necessary to assume that differences in the assigned volumes on the 706 links were a function of zone size and not network description. It was also necessary to assume that the smallest of the zone systems was the most "accurate" system within the constraints of this study.

The effects due to variation of zone size were measured primarily in terms of the differences in the three assigned volumes on 706 links that were all within the area in which the zone size was varied (see Figure 1). Differences in assigned volumes for each of these links were measured in terms of the algebraic and relative (percentage) differences. The assigned volumes on the major links of the system were examined to determine the effects of zone size and links where the largest differences occurred were identified.

Differences In Assigned Link Volumes

Links for which the difference between the assigned volume with the small-zone system and that with either the medium-zone system or large-zone system exceeded 10,000 vehicles per day are listed in Figure 1. The data are arrayed from largest to smallest absolute value of the difference between the quarter square mile and one square mile zones. It should be noted that the differences recorded between the small-zone and medium-zone systems were generally much less than those observed between the small-zone and large-zone system.

Data for the 24 links with assigned volumes in excess of 25,000 vehicles per day are presented in Table 2. Only four of the links have absolute differences in excess of 10 percent when the medium-zone system is compared with the small-zone system. In this case, the average difference is 5.8 percent and the maximum percentage difference is 25.6 percent.

When the assigned volumes for the one square mile system were compared with those of the quarter square mile zone system, 16 of the 24 links recorded absolute differences in excess of 10 percent. Five of these differences exceeded 20 percent and the largest was almost 40 percent. The average absolute difference for the large-zone system was 13.2 percent. Volumes assigned for the large-zone system were consistently above those for the same links on the small-zone system.

Figure 6 shows the difference expressed as a percentage of the small-zone assignment for links with 100 or more assigned trips per day. Approximately 55 percent of the links had differences of 10 percent or less for the medium-zone system while only 40 percent of the links differed by 10 percent or less when the large-zone system

TABLE 1

LARGEST RECORDED DIFFERENCES IN ASSIGNED LINK VOLUME

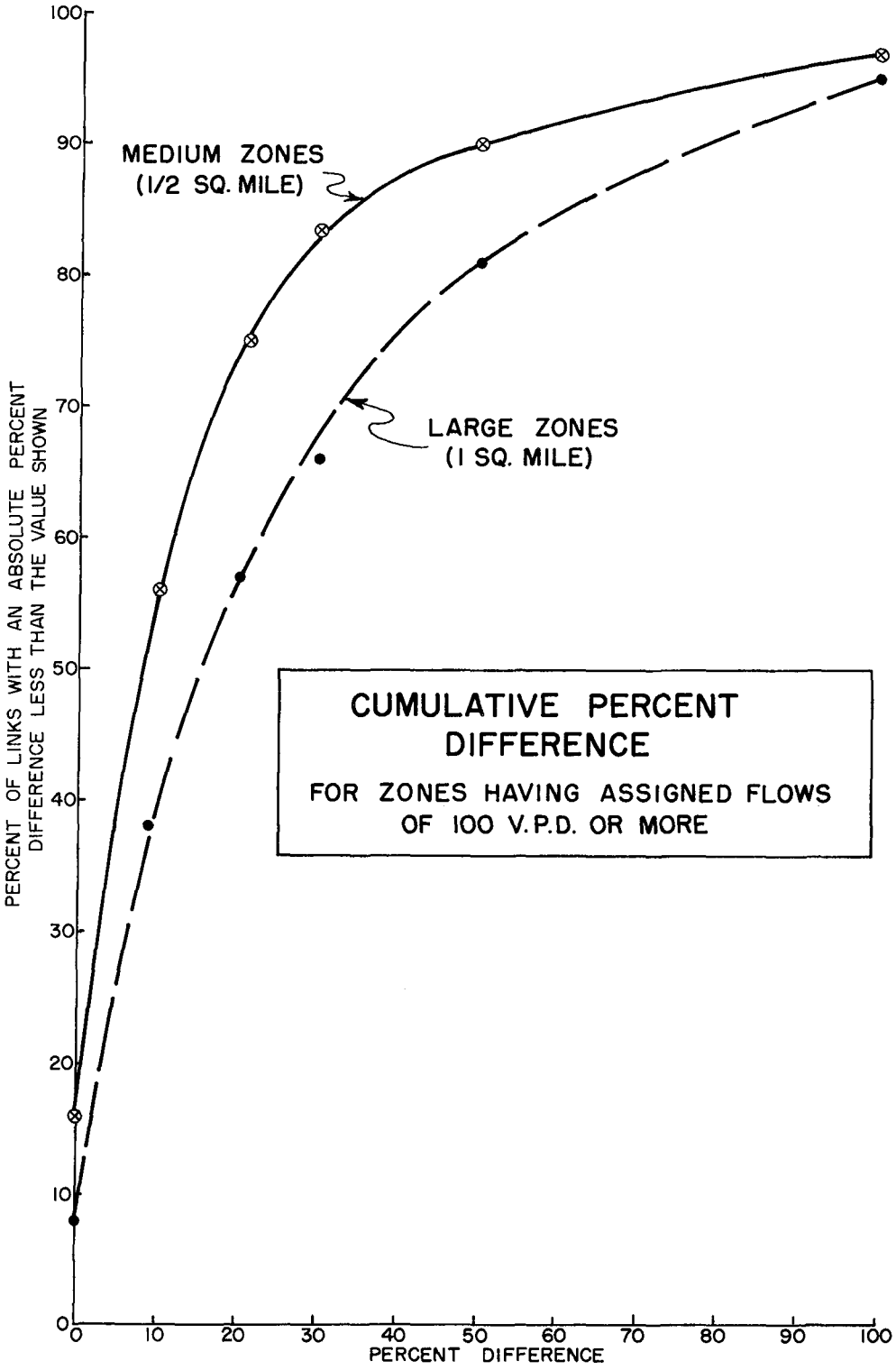
Assigned Volume			Differences	
1/4 Sq. Mile Zones	1/2 Sq. Mile Zones	1 Sq. Mile Zones	1/2 - 1/4	1 - 1/4
21,204	348	0	-20,856	-21,204
20,144	348	0	-19,796	-20,144
25,556	6,960	8,564	-18,596	-16,992
17,564	20,592	31,648	3,028	14,084
17,564	19,712	31,648	2,148	14,084
34,320	34,660	47,912	340	13,592
18,280	21,776	31,016	3,496	12,736
20,236	23,536	8,156	3,300	-12,080
19,896	22,180	8,156	2,284	-11,740
11,660	10,472	0	- 1,188	-11,660
11,528	348	0	-11,180	-11,528
19,284	23,536	8,156	4,252	-11,128
13,792	10,632	3,016	- 3,160	-10,776
13,792	10,632	3,016	- 3,160	-10,776
13,772	15,700	3,016	1,928	-10,756
19,124	6,960	8,564	-12,164	-10,560
6,168	8,672	16,572	2,504	10,404
13,960	16,580	24,172	2,620	10,212
13,244	11,932	3,180	- 1,312	-10,064

Small Zone - One-Quarter Square Mile System
Medium Zone - One-Half Square Mile System
Large Zone - One Square Mile System

TABLE 2

DIFFERENCES FOR LINKS WITH LARGEST ASSIGNED VOLUMES

Assigned Volume			Percent Differences	
1/4 Sq. Mile Zones	1/2 Sq. Mile Zones	1 Sq. Mile Zones	1/2 - 1/4	1 - 1/4
38,160	39,072	41,920	+ 2.4	+ 9.9
38,160	40,880	41,920	+ 7.1	+ 9.9
38,080	40,708	38,728	+ 6.9	+ 1.7
38,076	40,880	41,920	+ 7.4	+10.1
37,716	38,564	41,920	+ 2.2	+11.1
35,548	36,384	39,728	+ 2.4	+11.8
35,340	34,660	39,728	- 1.9	+12.4
35,264	34,716	39,028	- 1.6	+10.7
34,320	34,660	47,912	- 1.0	+39.6
34,256	38,052	41,500	+11.1	+21.1
33,952	39,836	37,596	+17.3	+10.7
33,344	35,616	34,328	+ 6.8	+ 3.0
33,128	32,580	39,028	- 1.7	+17.8
33,092	29,740	37,180	-10.1	+12.4
32,940	32,644	34,352	- 0.9	+ 4.3
32,728	32,580	35,200	- 0.5	+ 7.6
31,612	33,760	28,308	+ 6.8	-10.5
29,604	32,176	33,412	+ 8.7	+12.9
29,448	28,024	37,004	- 4.8	+25.7
28,924	36,320	31,276	+25.6	+ 8.1
28,200	29,392	30,096	+ 4.2	+ 6.7
28,088	29,304	34,308	+ 4.3	+22.1
26,396	25,392	30,828	- 3.8	+16.8
25,556	25,404	30,780	- 0.6	+20.4



CUMULATIVE PERCENT DIFFERENCE IN ASSIGNED LINK VOLUMES
RELATIVE TO THE QUARTER SQUARE MILE ZONE SYSTEM

FIGURE 6

was compared to the assignment of the small-zone system. Eighty-five percent of the links in the medium-zone system had differences of less than 30 percent, while the 85th percentile difference for the large-zone system was nearly 60 percent.

The distribution of differences of the two comparisons of assigned link volumes is presented in Table 3. It is apparent from this table that large differences in the assigned volumes are far more frequent for the large-zone system, when compared to the small-zone system assigned volumes, than for the medium-zone size.

Figures 7 and 8 show the absolute differences in the assigned link volumes for the six volume groups used. The absolute differences for group 1A (0-1500 VPD) are very small. Further, it is believed that variations in the assigned volumes less than 1500 are of minor importance as the capacity of a two-lane, two-way roadway would be adequate for any volume of that magnitude. Therefore, the group 1A data were disregarded for the remainder of the analysis.

It is also apparent that the curves in Figures 7 and 8, that groups 3, 4, and 5 (10,000 VPD and more) describe similar absolute differences; thus, these three groups can be combined. Curves summarizing the absolute difference relationships for both zone size configurations are presented in Figure 9.

Curves displaying the percentage differences for the two comparisons (half vs. quarter square mile and one vs. quarter square mile zones) are presented in Figures 10 and 11. Group 1A was disregarded for the reasons stated above and the remaining curves reviewed for similarity. The curves for groups 1B, 2, and 3 all describe similar percentage differences and were combined into one curve representing the assigned volumes for flows between 1500 and 15,000 vehicles per day. The summary curves for the absolute percentage difference are presented in Figure 12.

The differences indicated in Figures 9 and 12 indicate that the assigned volumes for the half square mile system were consistently "better" than were those for the one square mile system (i.e., closer to the assigned volumes for the quarter square mile system). Table 4 contains the percentage of links in each volume group with a difference of 5000 VPD or more from the assigned volume in the quarter square mile system, and Table 5 contains the corresponding values for a difference of 30 percent.

Statistical evaluation of the difference between the assigned link volumes for the half and one square mile systems with the quarter square mile system is based on the "t" test, and thus, assumes that the difference is normally distributed. Transformation of the basic variable would be desirable if the data show a substantial degree

TABLE 3

DISTRIBUTION OF DIFFERENCES BETWEEN ASSIGNMENTS TO THE HALF SQUARE MILE SYSTEM AND THE ONE SQUARE MILE SYSTEM RELATIVE TO THE QUARTER SQUARE MILE SYSTEM

Half Square Mile System Vs Quarter Square Mile System

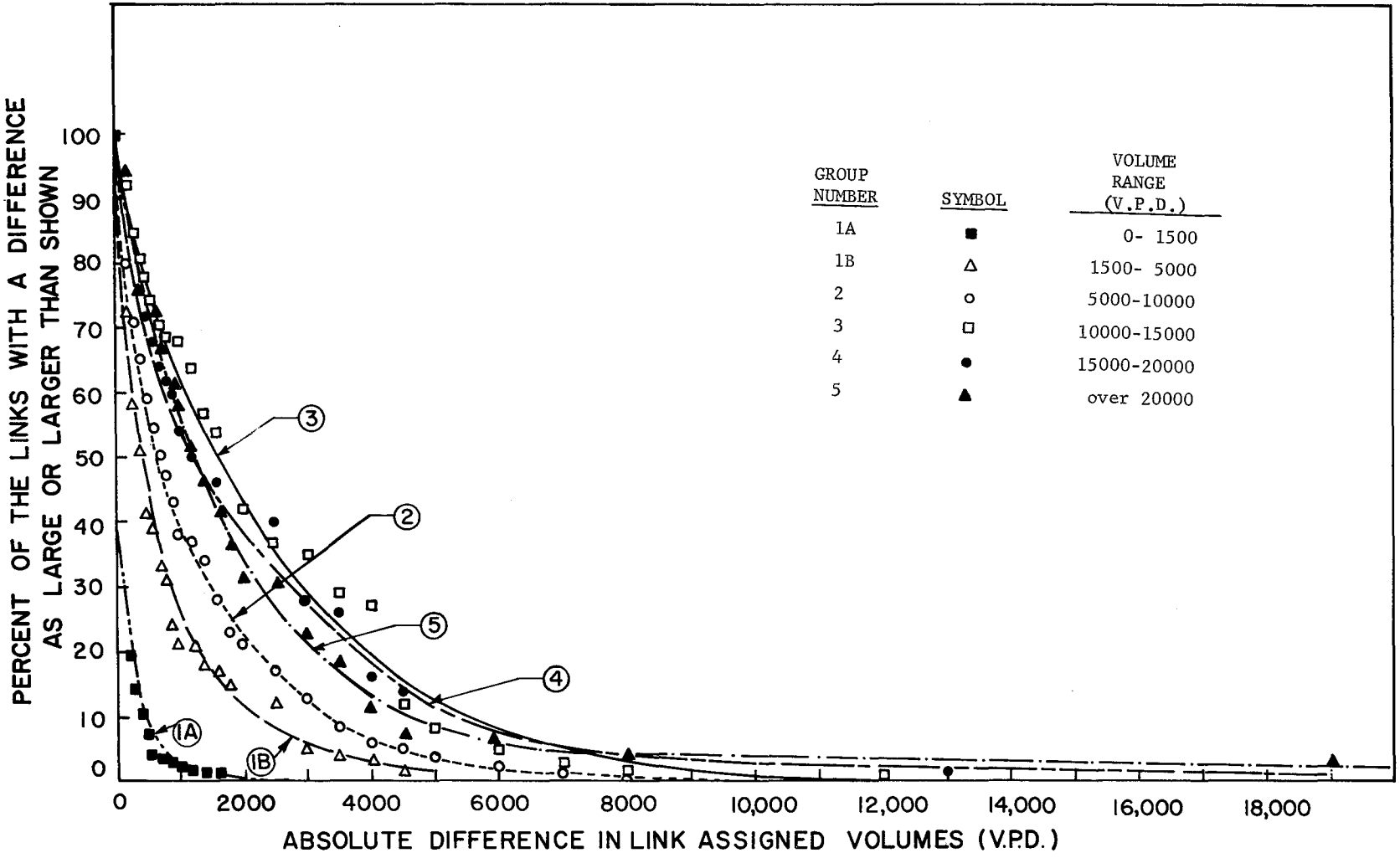
Range Of Assigned Volumes Of The Quarter Square Mile System

Difference (V.P.D)	1 to 1499	1500 to 4999	5000 to 9999	10,000 to 14,999	15,000 to 19,999	20,000 or more
0-499	188	81	55	18	15	23
500-999	7	33	25	7	10	21
1,000-1,999	4	12	29	24	5	21
2,000-2,999	0	13	14	7	7	9
3,000-4,999	1	7	9	20	12	11
5,000-9,999	1	1	4	4	0	3
10,000-14,999	0	0	0	1	1	0
15,000 or more	0	0	0	0	0	3

One Square Mile System Vs Quarter Square Mile System

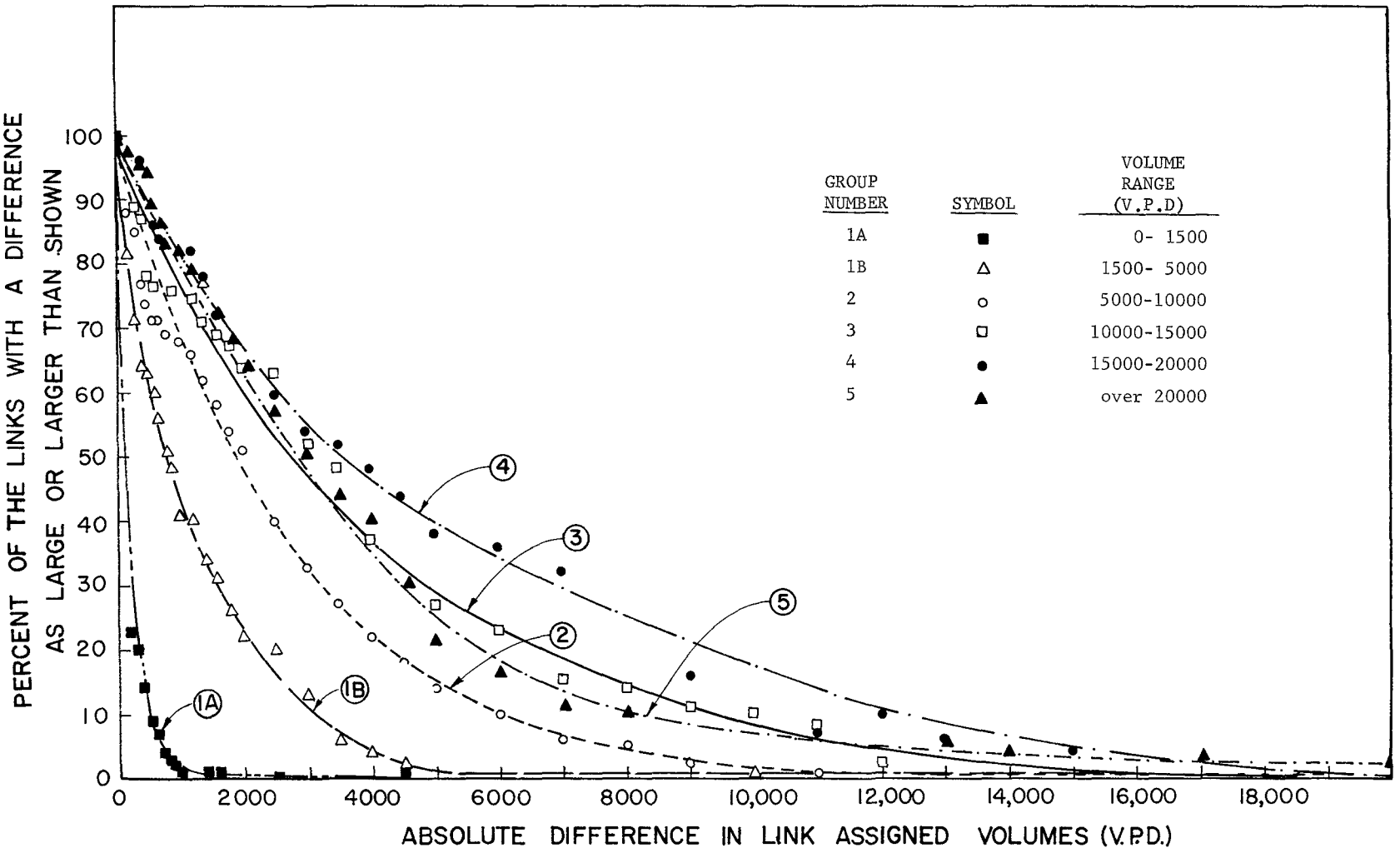
Range Of Assigned Volumes Of The Quarter Square Mile System

Difference (V.P.D.)	1 to 1499	1500 to 4999	5000 to 9999	10,000 to 14,999	15,000 to 19,999	20,000 or more
0-499	182	58	41	15	6	10
500-999	11	37	8	2	5	9
1,000-1,999	2	25	31	10	11	20
2,000-2,999	1	15	21	15	4	12
3,000-4,999	1	10	20	21	8	26
5,000-9,999	0	1	14	13	12	10
10,000-14,999	0	0	1	7	6	2
15,000 or more	0	0	0	0	0	3



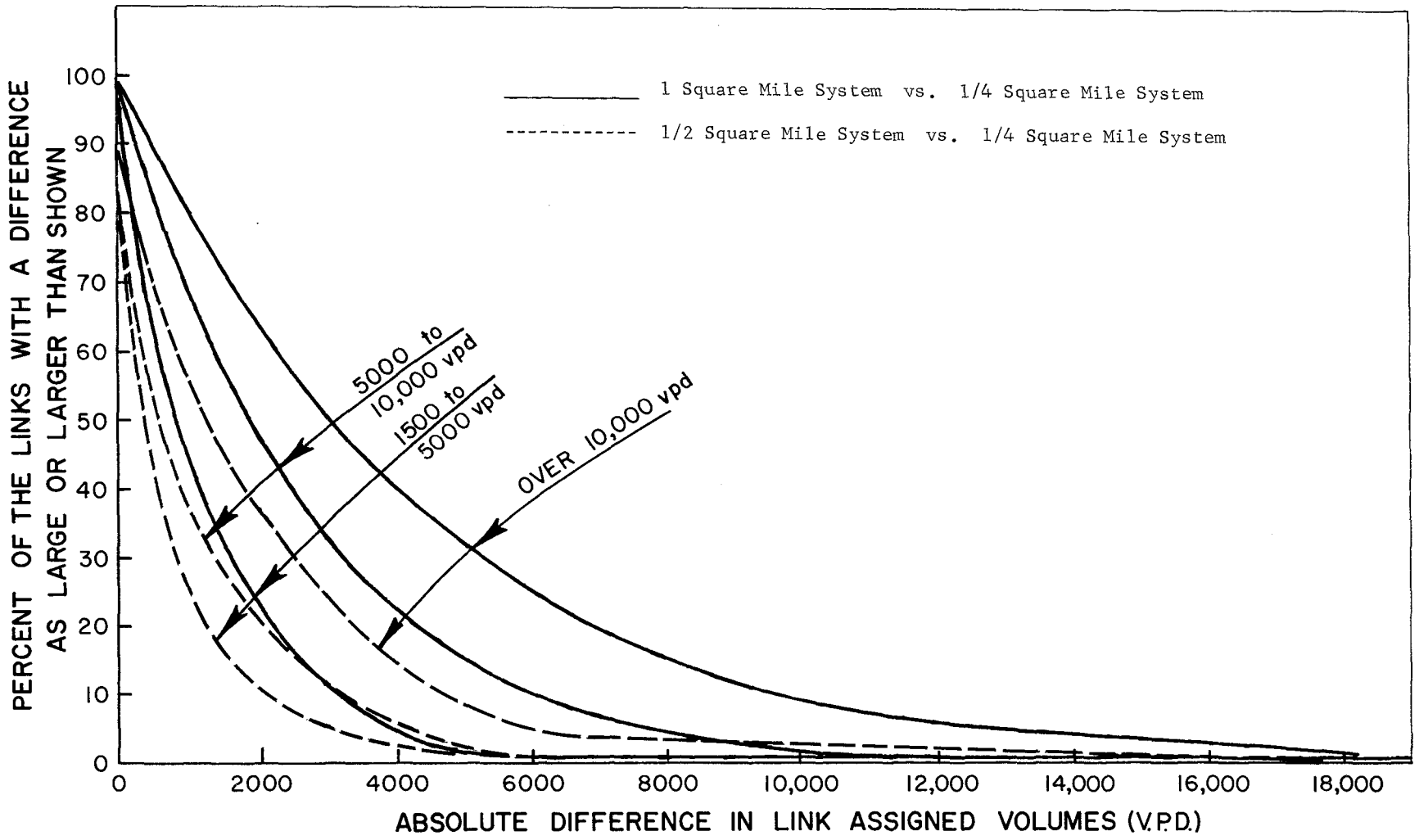
ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES BY VOLUME GROUPS
HALF SQUARE MILE SYSTEM VS. QUARTER SQUARE MILE SYSTEM

FIGURE 7



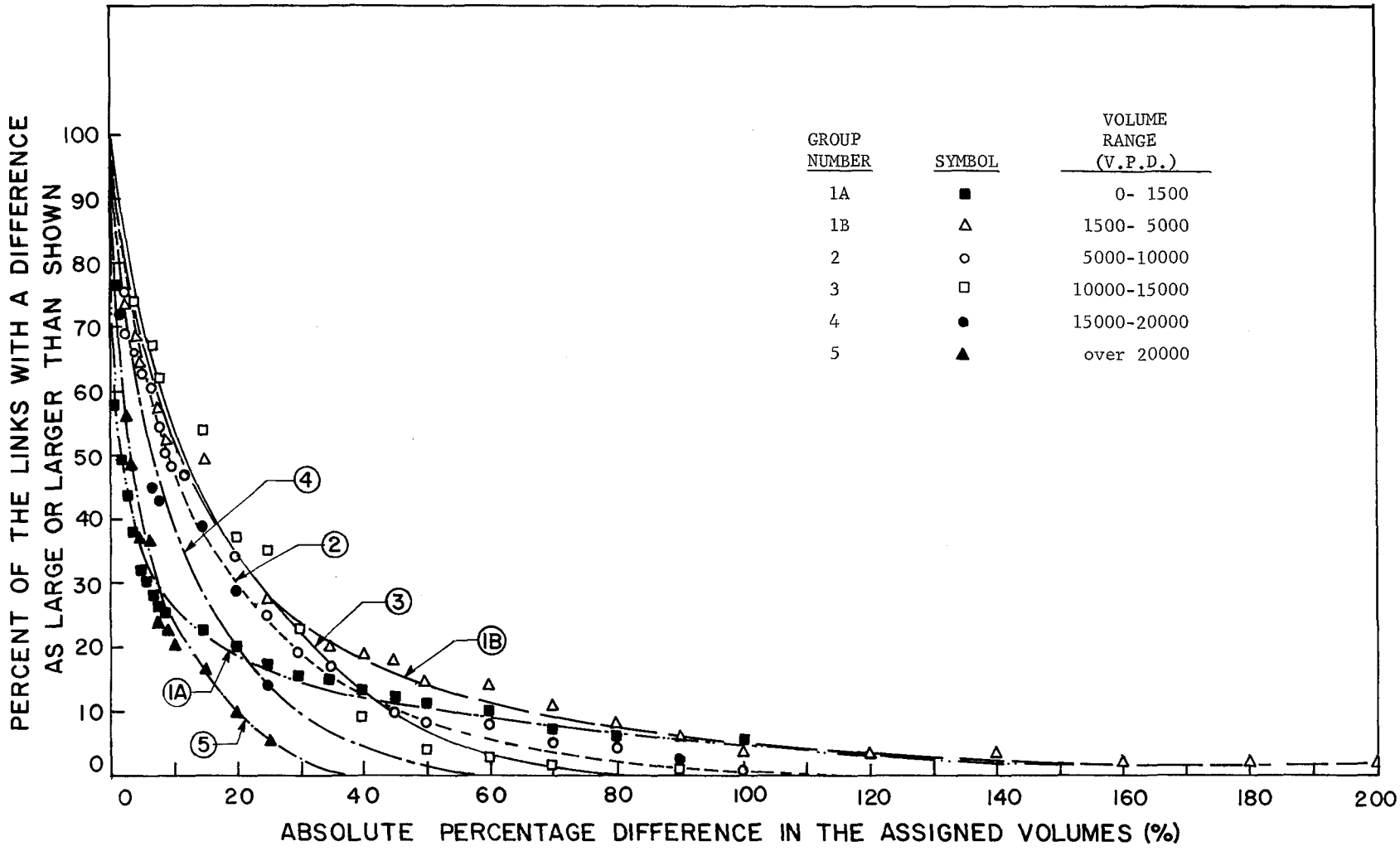
ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES BY VOLUME GROUPS
ONE SQUARE MILE SYSTEM VS. QUARTER SQUARE MILE SYSTEM

FIGURE 8



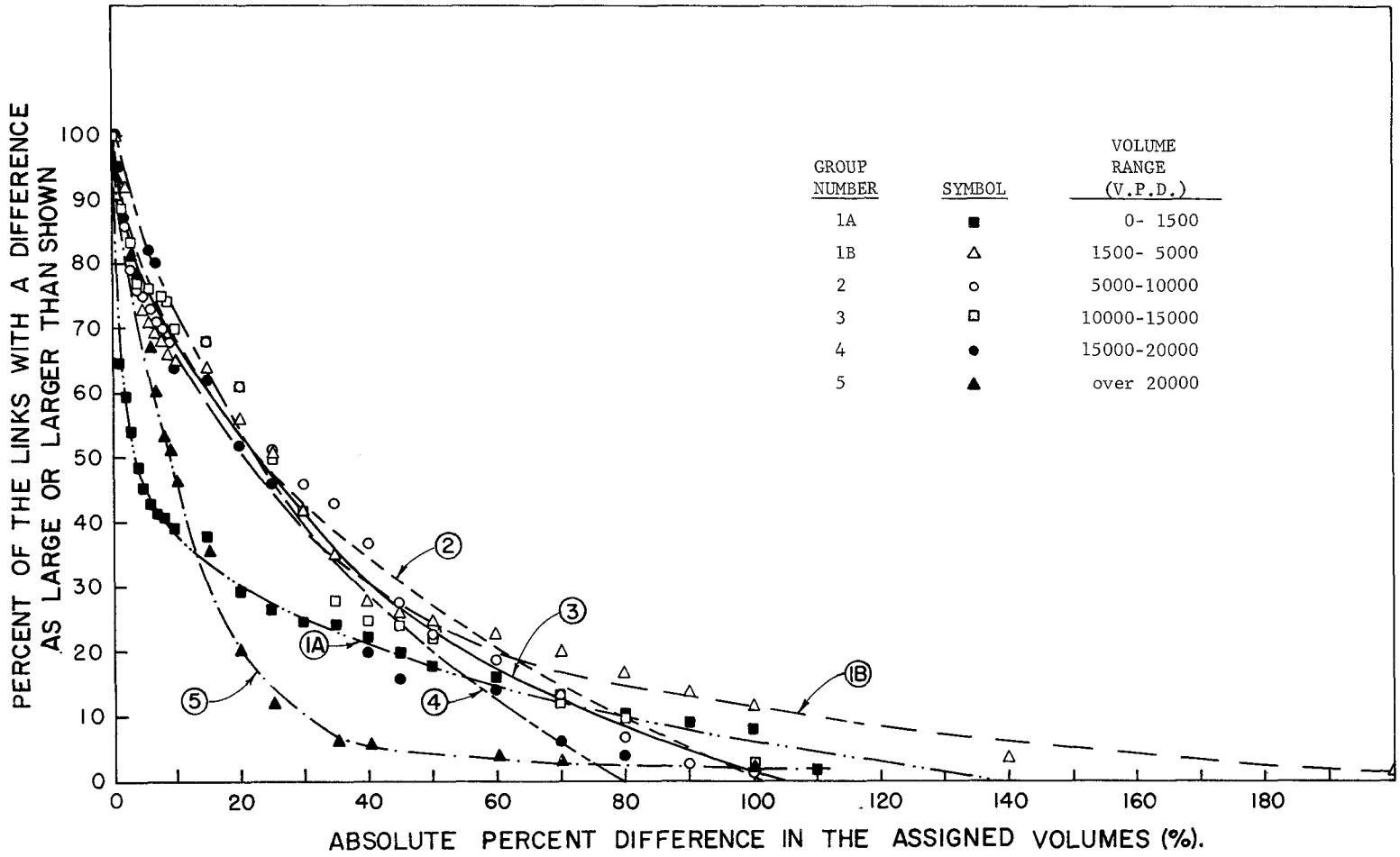
ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES FOR COMBINED VOLUME GROUPS

FIGURE 9



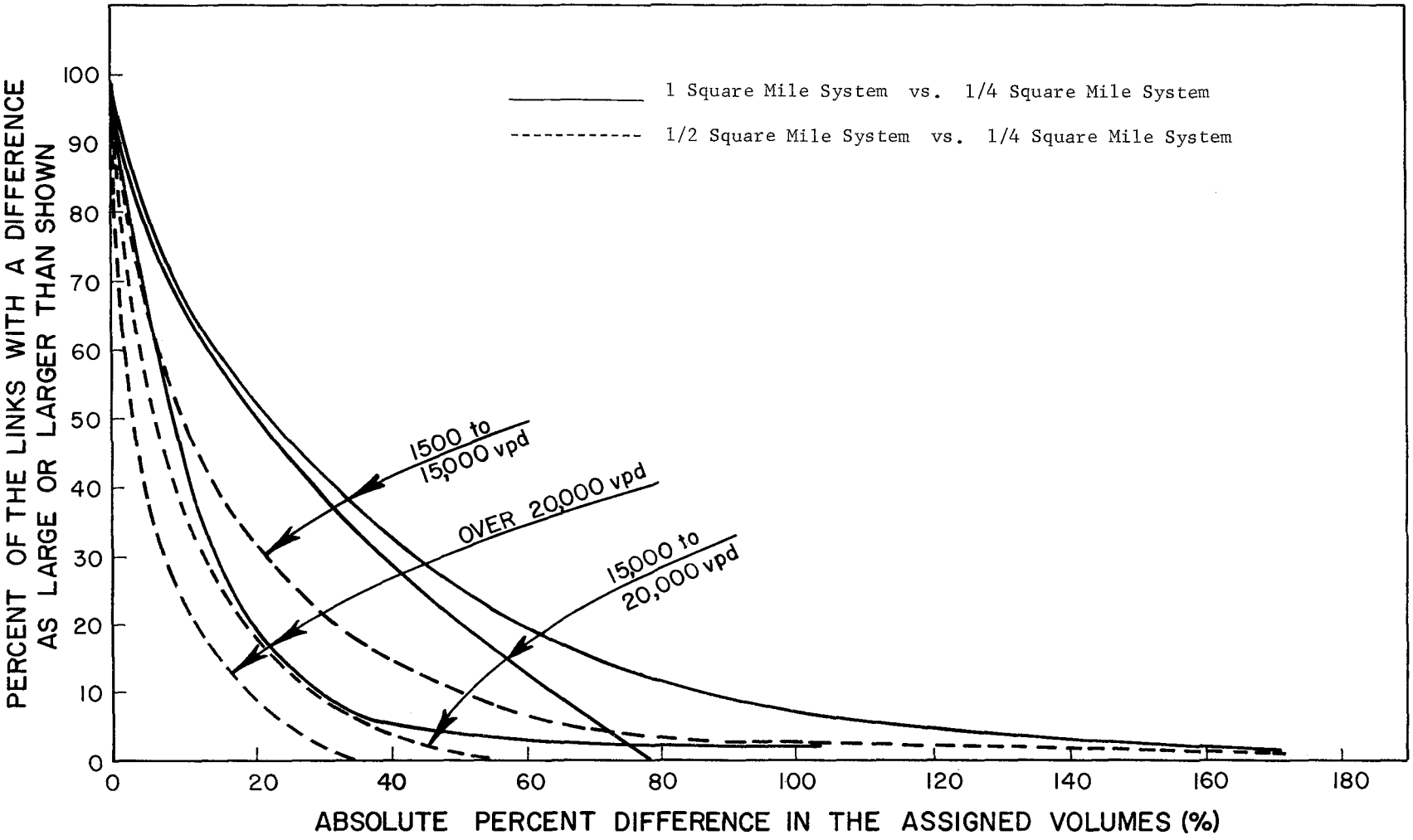
ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES FOR SEVERAL VOLUME GROUPS
HALF SQUARE MILE SYSTEM VS. QUARTER SQUARE MILE SYSTEM

FIGURE 10



ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES FOR SEVERAL VOLUME GROUPS
HALF SQUARE MILE SYSTEM VS. QUARTER SQUARE MILE SYSTEM

FIGURE 11



ABSOLUTE DIFFERENCES IN ASSIGNED LINK VOLUMES
FOR SEVERAL VOLUME GROUPS

FIGURE 12

TABLE 4

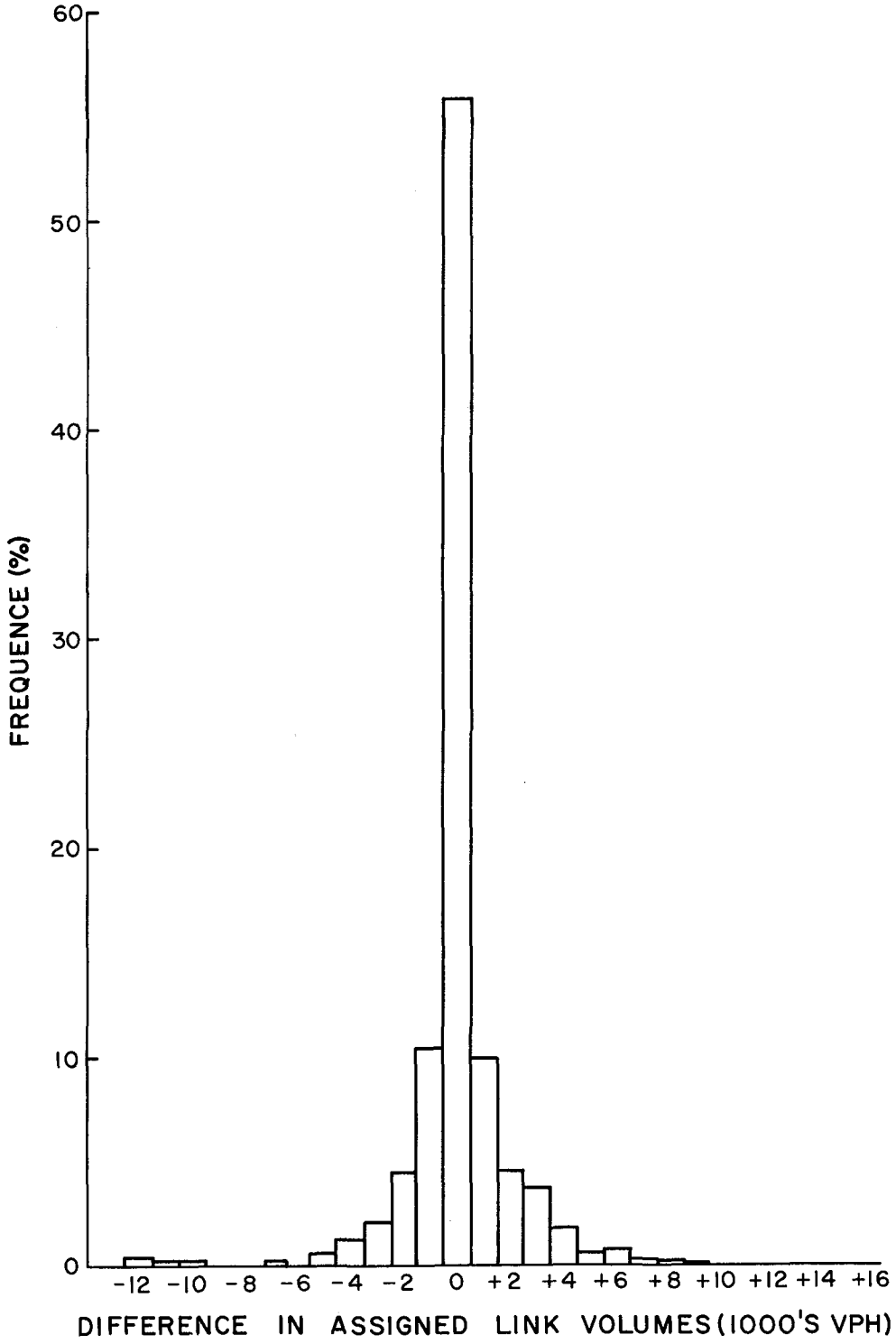
PERCENT OF LINKS HAVING ABSOLUTE DIFFERENCE EQUAL TO OR GREATER THAN 5000 VPD WHEN COMPARED TO THE QUARTER SQUARE MILE SYSTEM ASSIGNED VOLUMES

Volume Group	Percent of Links: Half Square Mile System	Percent of Links: One Square Mile System
1500 - 5,000	1 1/2	1
500 - 10,000	4	15
over - 10,000	12	31

TABLE 5

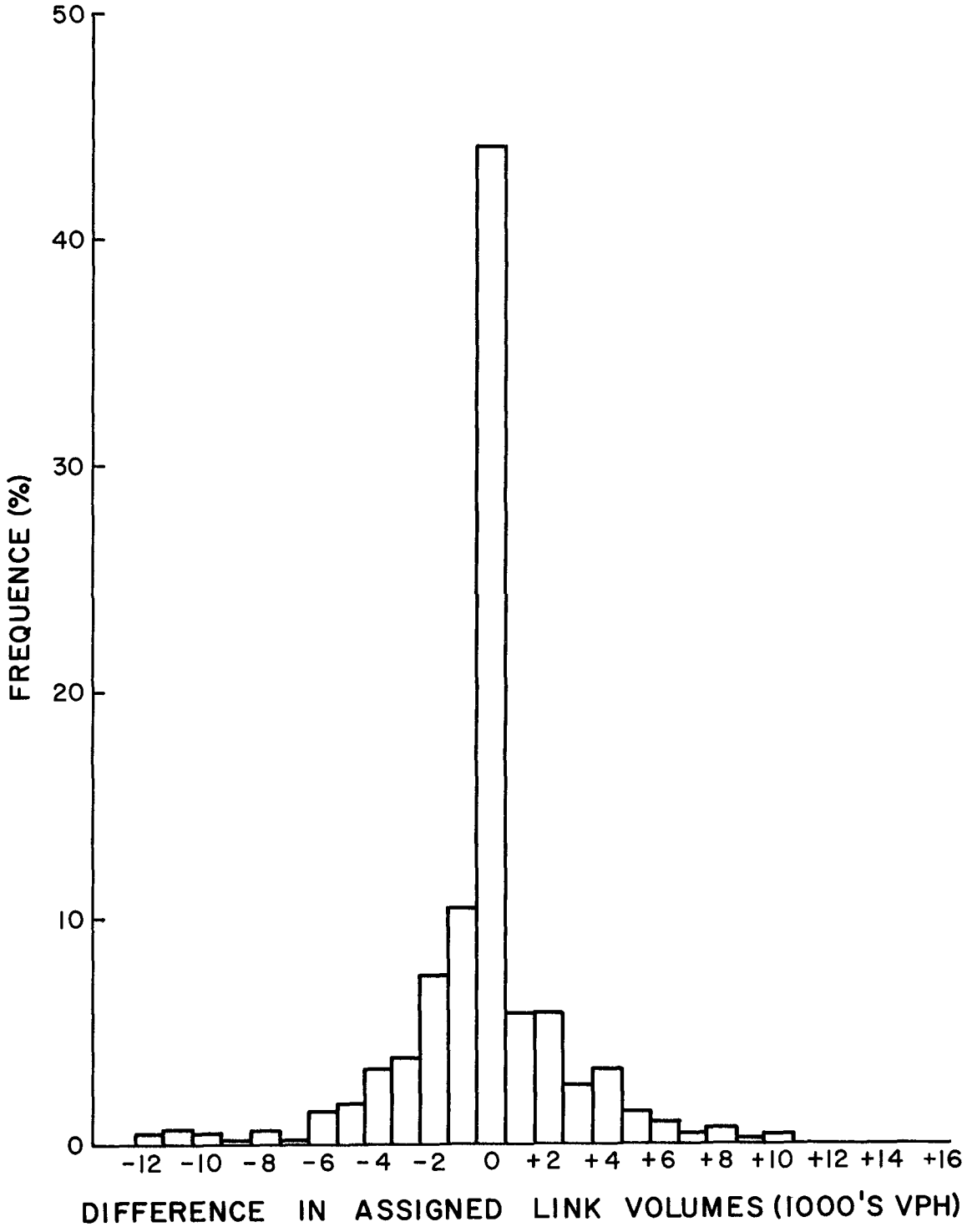
PERCENT OF LINKS HAVING AN ABSOLUTE PERCENTAGE DIFFERENCE OF 30 PERCENT OR MORE WHEN COMPARED TO THE QUARTER SQUARE MILE SYSTEM ASSIGNED VOLUMES

Volume Group	Percent of Links: Half Square Mile System	Percent of Links: One Square Mile System
1,500 - 15,000	22	43
15,000 - 20,000	10	40
over - 20,000	2	10



DISTRIBUTION OF DIFFERENCES IN ASSIGNED LINK VOLUMES BETWEEN THE HALF SQUARE MILE SYSTEM AND THE QUARTER SQUARE MILE SYSTEM

FIGURE 13



DISTRIBUTION OF DIFFERENCES IN THE ASSIGNED LINK VOLUMES
BETWEEN THE ONE SQUARE MILE SYSTEM AND
THE QUARTER SQUARE MILE SYSTEM

FIGURE 14

of skewness. Referring to Figures 13 and 14, there is no noticeable degree of skewness in the differences; therefore, the assumption appears to be valid and variable transformation was deemed not to be necessary.

Difference In Volumes Assigned To Major Corridors

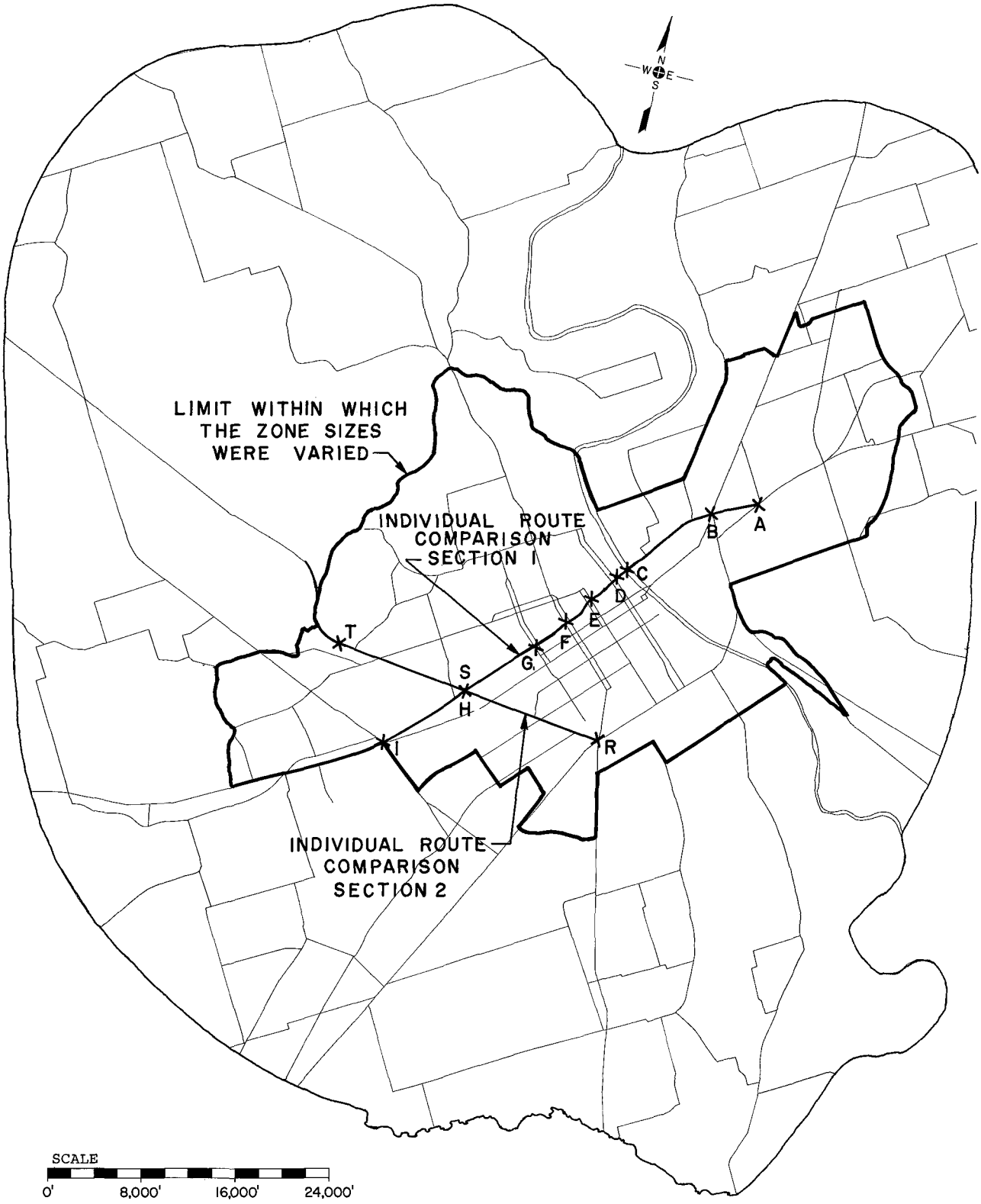
The effect of varying the size of traffic assignment zones on the volumes assigned to the links of two major street corridors was also studied. Two corridors that have substantially different characteristics were selected; the locations of these two routes are shown in Figure 15. Study section number one is the Waco Drive corridor which has several parallel facilities represented by one route (Waco Drive) in the traffic assignment network. The second study section is the Valley Mills Drive corridor which has no parallel facility of any significance throughout its length.

The volumes assigned throughout the length of the study sections are shown in Figure 16 and 17. In Figure 16, it is apparent that the quarter square mile system and the half square mile system yield essentially the same assigned volumes. The one square mile system resulted in somewhat higher corridor volumes than did the others.

Assigned volumes for the Valley Mills Drive corridor as shown in Figure 17, are essentially the same for all three zone size configurations.

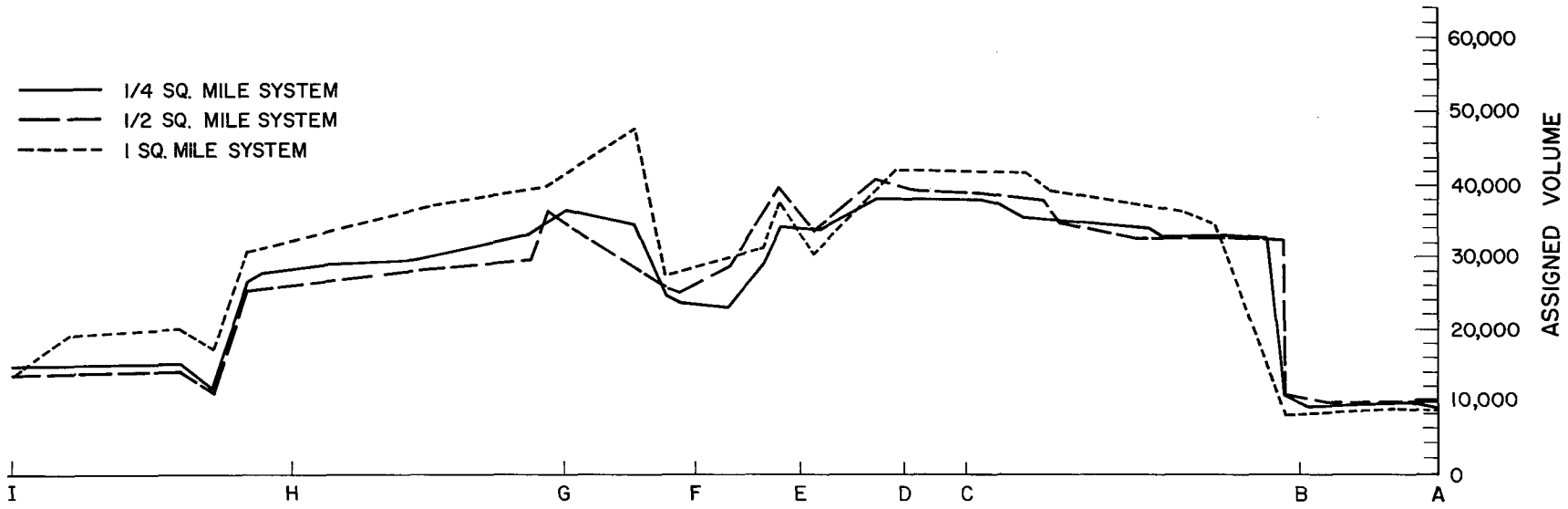
Interzonal And Intrazonal Trips

Increasing the number of zones increases the number of interzonal trips which are assigned to the representation of the street network, and this fact could have an effect on the differences compared above. Interzonal trips were decreased by 3.0 percent in going from the quarter to the half square mile zone system; a decrease of 8.4 percent resulted in aggregations to the one square mile zone system. On the basic network, both the quarter and the half square mile systems had average assigned link volumes of 8,100 vehicles per day; the average for the one square mile system was 7,760 vehicles per day. This is a difference of about four percent.



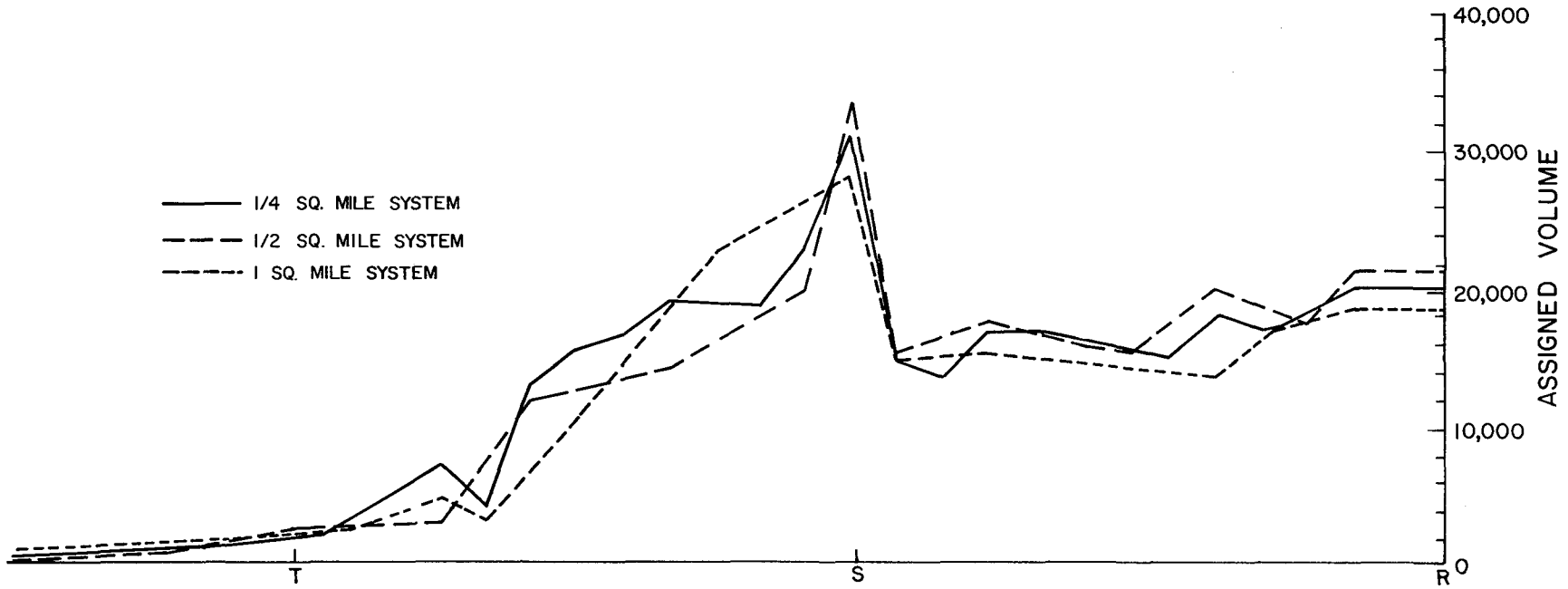
1964 MAJOR STREET SYSTEM FOR WACO INDICATING THE LOCATION OF THE INDIVIDUAL ROUTE COMPARISON STUDY SECTIONS

FIGURE 15



EFFECTS OF ZONE SIZE ON THE WACO DRIVE
CORRIDOR ASSIGNED VOLUMES

FIGURE 16



EFFECTS OF ZONE SIZE ON THE VALLEY MILLS DRIVE
CORRIDOR ASSIGNED VOLUMES

FIGURE 17

APPENDIX

The technique of paired comparisons was utilized to aid in the analysis of differences in the assigned link volumes. The assigned volume for the medium (half sq. mile) and large (one sq. mile) zone systems was paired with the assigned volume of the small (quarter sq. mile) zone system. The difference in the assigned volume was analyzed as the measured variable.

Variable

$$D_i = V_{i,j} - V_{i,\ 1/4}$$

where:

D_i = Difference in assigned volumes for link i

$V_{i,j}$ = Assigned volume for link using the jth zone system ($j = 1/2,\ 1$)

$V_{i,1/4}$ = Assigned volume for link i using the quarter square mile system

Expected mean value of Measured Variable D_i

$$E(\bar{D}_i) = 0$$

Confidence interval for mean value of D_i

$$C.I._{.j-1/4} = \bar{D}_i \pm t_{n-1,\ \alpha}\left(\frac{S_i}{\sqrt{N}}\right)$$

where:

$\bar{D}_i$ = Mean value of D_i

$t_{n-1,\alpha}$ = Students "t" value for n-1 d.f. degrees of freedom and α % significance level

S_D = Standard deviation of the differences D_i

N = Sample size

Hypothesis

The hypothesis is that there is no significant difference between the assigned link volumes for the one quarter, half and one square

mile systems; the null hypothesis is then:

$$H_o : D_i = 0$$

$$H_{alt} : D_i \neq 0$$

Confidence Limits

Since the alternate hypothesis is that the measured variable is not equal to zero (i.e. it can be positive or negative) a two-tailed test is appropriate. For n-1 = 700 degrees of freedom and α = 0.10 (0.05 in each tail), the tabled value of $t_{n-1,\alpha}$ is 1.645.

The 90% confidence interval for the difference in the quarter and half square mile systems is:

$$C.I._{1/2 - 1/4} = D_{1/2} \pm 1.645\ S_{D1/2}$$

$$= 29.52 \pm 1.645\ (76.911)$$

$$-97.16 \text{ to } 156.19$$

Since the confidence interval includes the expected value of $\bar{D}$ (zero), it is concluded that no significant difference exists between the half square mile system assignment and the quarter square mile system assignments.

The 90% confidence interval for the difference in the 1/4 and 1 square mile systems is:

$$C.I._{1/2 - 1/4} = \bar{D}_1 \pm 1.645\ S_{D1}$$

$$= -328.66 \pm 1.645\ (114,281)$$

$$= -516.88 \text{ to } -140.43$$

Since the interval does not contain the expected value of $\bar{D}$ the hypothesis is rejected, and it is concluded a significant difference in the link assigned volumes between the one square mile system and the one quarter square mile system exists.