Enough already has been developed to show beyond doubt that data collected in good origin and destination studies are necessary not only in locating and designing new facilities properly, but also in providing more efficient use of present street and parking facilities. The information also is important in broad planning for future urban development, because of the close relationship between transportation in the city and its housing, schools, stores and other facilities.

During the coming months, more information will be developed from the cities in which surveys have been conducted, and in others not yet started. Refinements in survey techniques and additional uses for the data can be expected, so that this first report of the committee is a report of progress to date.

Members of the committee are:

LLOYD M. BRAFF	HARRY W. LOCHNER
JAMES S. BURCH	LADISLAS SEGOE
NATHAN CHERNIACK	I. S. SHATTUCK
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ORIGIN AND DESTINATION SURVEYS IN URBAN AREAS

PREPARED BY JOHN T. LYNCH
Senior Highway Economist, Public Roads Administration

SYNOPSIS

Origin and destination surveys have been made for many years in connection with studies for river crossings and city bypasses and the techniques for such surveys of comparatively limited scope are well developed. Generally, automobile drivers are interviewed at roadside stations and the results correlated with traffic counts.

The finding that all but a small percentage of the traffic approaching any of the larger cities is destined for the city itself shows that the greatest need is for adequate highways leading into the city rather than for bypasses. Because of the complexity of urban traffic, brought about by the influence of the street grid on the large traffic volumes, origin and destination surveys are especially needed, yet difficult to make by methods previously used.

The need for new techniques has become apparent, and in recent years a number of methods have been tried in different cities. Study of this experience leads to the conclusion that the method promising to give the most valuable information at the least cost is one based on interviews made in a representative sample of the dwelling units in the area, in which information is obtained concerning all of the travel for a day by all residents of the dwelling units, supplemented by information concerning trips by non-residents obtained at a cordon of stations at the outer limits of the area.

The home-interview method is especially adapted to studies under abnormal traffic conditions, because it provides the means for adjusting for the abnormalities. Studies of this type are now under way in 24 cities, and in a number of these, the work has progressed to the analysis stage. First results are confirming the value and the practicability of the method.

For many years, origin and destination surveys have been made at river crossings in connection with specific problems, such as the selection of the proper location for a new facility, the estimation of the traffic volumes which should be assumed in the design, and the

determination of the economic practicability of toll crossings. For example, the New York Port Authority has collected and used many data concerning the origins and destinations of the trans-Hudson vehicular traffic.[1]

Another important use for surveys of this character has been in the investigation of proposed bypasses around cities. Origin and destination data obtained at stations located on highways where they enter the urban areas have been employed in estimating the number of vehicles which would use a bypass, if constructed, the location which would be of most service to traffic, and the benefits which would accrue to the users. While such surveys have shown the need for bypasses in some cases, they have generally indicated that most of the approaching traffic is destined for the city itself, rather than beyond it, and would be served best by a highway that would permit free and uninterrupted travel to or near the heart of the city. This finding has led to the realization that the principal need in most large urban areas is for express facilities into and through the city. As such facilities would be used by intracity traffic to an even greater extent than by through traffic, the need has developed for origin and destination studies including within their scope travel with origin and destination both within the city, as well as that extending on to the rural highways.

The techniques for the surveys at river crossings, and at the outer fringes of urban areas have been well developed and are comparatively simple. For a representative period of time, all vehicles are counted and classified as to type, and the drivers of all, or a representative portion, are stopped and asked the origin and destination of the trip and the location and purpose of any intermediate stops. If only a portion is interviewed, percentages calculated from the origin and destination questionnaires are applied to the total traffic observed.

The determination of the origin and destination of the intracity traffic is much more difficult, because of the larger traffic volumes and the many alternate routes of travel afforded by the street grid. These same factors make it impossible to estimate accurately the benefits which would accrue from any improvement, or the location which would best serve traffic, from an observation of traffic counts and turning movements alone. Traffic in an urban area is fluid in nature; it may shift from one route to another to avoid congestion and delay, or to take advantage of especially attractive facilities. It is only through a knowledge of origins and destinations, therefore, that a determination of needed traffic routes can be made.

[1] "Geographic Distribution of Trans-Hudson Vehicular Traffic in 1935," WPA Project No 665-97-3-13.

METHODS PREVIOUSLY USED

For the past several years realization has been growing that new techniques would have to be developed for urban origin and destination surveys; in fact, procedures somewhat experimental in nature have been devised and used in a number of cities. In some cases as, for example, in Columbia, South Carolina, the conventional methods of the external surveys have been employed within cities and traffic has been stopped and interviewed at points of traffic concentration. Such methods, however, are applicable only to problems of limited scope or to those of a more general nature in small or medium-sized cities in which most of the traffic funnels through a few bottlenecks. In any case, the large traffic volumes which occur within urban areas make roadside interviewing extremely difficult.

In Chicago, a comprehensive survey was made, in which routes of travel were traced for a day by the observation of tag numbers as the vehicles passed stations which encircled numerous zones throughout the city. Boy scouts were used as recorders and the supervising personnel was supplied by the States, municipalities, counties, and other jurisdictions which participated in the survey. The voluminous data obtained were analyzed by punch-card methods. The survey was successfully carried out and proved to be of great value in the planning of highway facilities.[2] Surveys much more limited in scope have been made by similar methods in Texas and elsewhere.[3] Such surveys are quickly organized

[2] "A Traffic Survey of the Chicago District," by the Cook County Highway Department, April 1943.

[3] "Preliminary Report on an Expressway Through and Between the Cities of Dallas and Fort Worth for the Texas Highway Department," by Parsons, Brinckerhoff, Hogan, and MacDonald, October 1944.

and analyzed and give invaluable assistance in the solution of definite urban problems where time is a vital factor.

In Cleveland, questionnaires were distributed to workers through their employers to determine the daily movements to and from work. The returns were expanded on the basis of total employment by zones or census tracts. This information was used in the location and design of expressways. Similar surveys have been made in Schenectady and other cities.

In Detroit origins of workers in all major industrial plants were obtained by analysis of a "swap-ride" questionnaire which was distributed by the local office of War Transportation. To these were added the origins of downtown employees, obtained by the Street Railway Department through a questionnaire distributed in cooperation with the building managers.

The industrial sample was divided into ten industrial areas and adjusted for 100 per cent employment within each area. All of the workers were distributed to census tracts of residence in the same ratio as found in the original sample.

Census tracts were used as the basis for the origin of all employees and "industrial areas" as the destination. Maps were made showing the daily movements between home and industrial area with straight-line flow bands, the width of which indicated the number of persons. One flow map was made for each industrial area and a composite (Fig. 1) was made from that. Included in the composite, however, in addition to the downtown employees are shoppers distributed throughout the city according to population in census tracts and department store sales by census tracts.

The origin and destination chart was used to determine where people want to go in their daily travels, regardless of existing street facilities. From the original chart, the flow bands were bent and consolidated until they formed the network shown by Figure 2. From a study of this chart, in conjunction with maps showing existing streets and cultural and topographic features, the network of expressways shown in Figure 3 was selected.

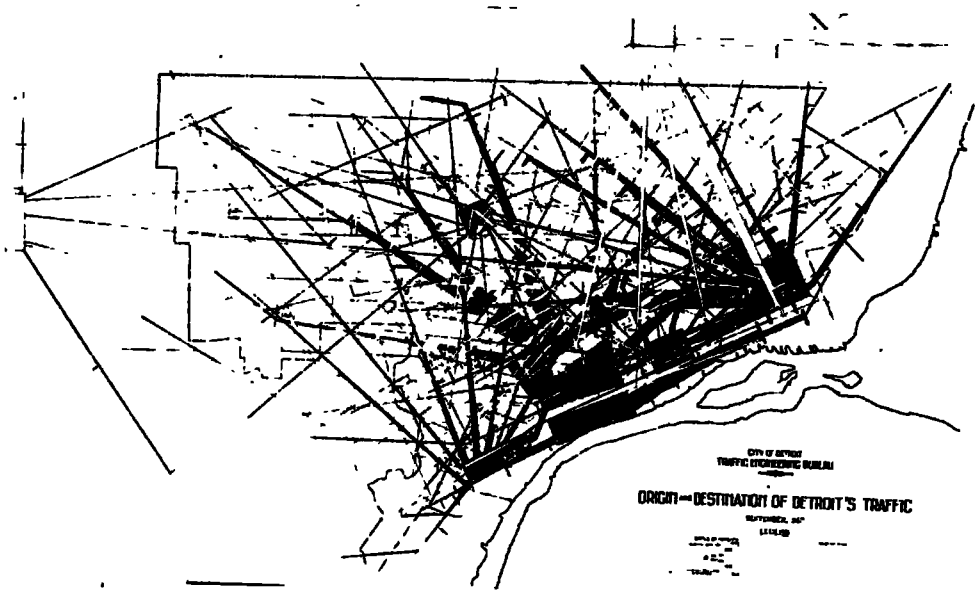


Figure 1

Based on the previous experience in Cleveland, the Ohio Department of Highways decided that better results could be obtained by questioning workers in their homes, rather than at their place of work, and in a similar origin and destination survey in Toledo the census tract of residence was used as the basis

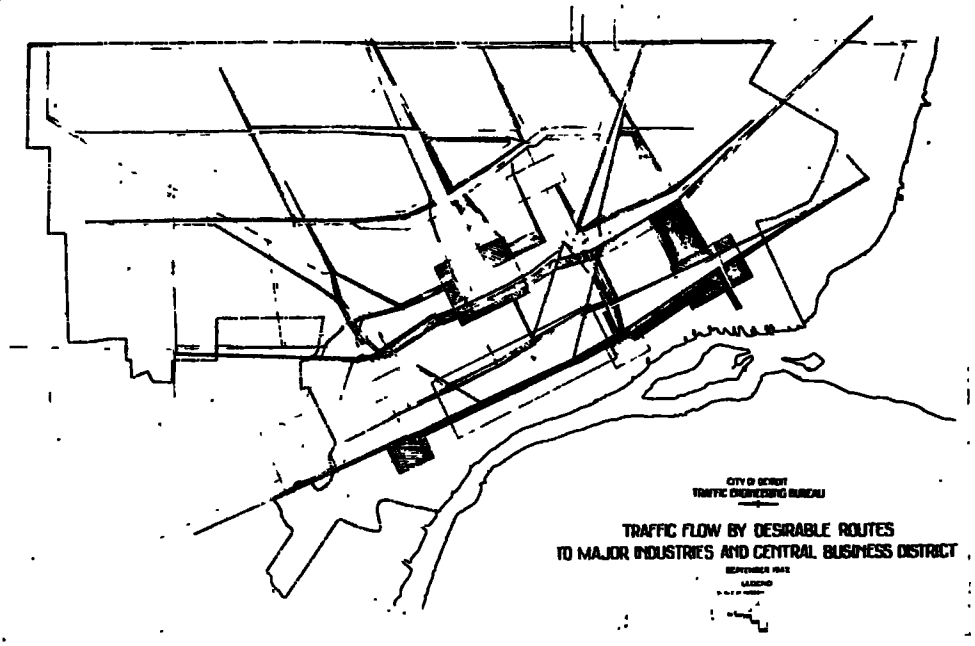


Figure 2

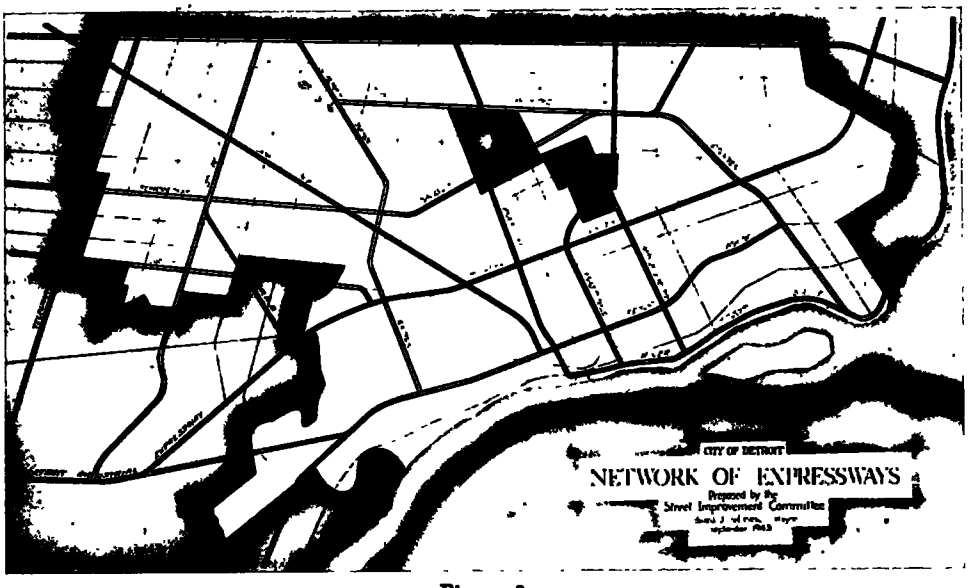


Figure 3

of sampling.[4] Through the cooperation of the public and parochial school authorities pupils obtained information on the means, route, and time of travel to and from work on a specified day by all workers in their families. Expansion was made on the basis of the number of gainfully employed persons residing in each

[4] "Toledo, Ohio, Regional Traffic Study, 1943," Ohio Department of Highways, Toledo Traffic Commission.

tract as shown by the census. The data were correlated with ground counts and the origins and destinations of peak-hour travel, which is composed mainly of travel to and from work, were thus determined.

In several urban areas, including the Ansonia-Derby-Shelton area in Connecticut,[5] Albuquerque, New Mexico, and Louisville, Kentucky,[6] the origins and destinations of traffic counted on the streets, especially at bridges and other points of concentration, were assumed to be distributed to various zones in accordance with the estimated relative importance of each zone as a source or objective of traffic. The estimates were based on data obtained at external stations, on census data relative to each zone, and on factors developed in more elaborate surveys in other cities. As more data become available from surveys now under way, it should be possible to establish relationships which will aid greatly in future estimates of this kind.

NEW TECHNIQUE DEVELOPED

Proposals for large Federal appropriations for post-war highway construction, including, for the first time, substantial sums for the relief of city congestion, made it highly important to develop and perfect techniques of general applicability which would give a basis for the determination of traffic needs in urban areas. After a thorough examination of the procedures which had been used, including those previously described, and conferences with those who used them, the conclusion was reached that interviews made at a cordon of external stations surrounding the urban area and in a representative sample of the homes within the area would give the information of greatest value for the least expenditure of manpower and funds. These interviews would be so conducted as to develop information concerning all of the travel within the area on a typical weekday.

The procedure already perfected in the bypass studies, with some relatively minor modifications, was suitable for the interviewing at the cordon of external stations. For the home interviews, however, an entirely new technique had to be developed, because the determination of a day's travel by questioning residents in their homes had never been attempted before, except as regards travel to and from work as described in the Toledo survey.

In other fields, however, the science of sampling through home interviews was well developed. The Bureau of the Census, in particular, had used this method extensively to determine trends between census years as well as to obtain special information for numerous governmental agencies. For example, a consumer requirements survey was conducted in 1943 for the Office of Civilian Requirements by the Bureau of the Census, assisted by an advisory board composed of most of the nationally known public opinion sampling experts. In this survey it was established beyond question that a sample carefully distributed as regards place of residence would be representative in all other respects. The 4,935 households in which interviews were conducted for this Nation-wide survey were selected solely on the basis of geographical location, yet the distribution as regards race, size of family, occupation, etc., was very nearly the same as in the 1940 census.

In order to take advantage of their extensive experience in sampling and interviewing, the Bureau of the Census was asked to assist in the development of procedures and numerous conferences were held between representatives of that Bureau and those of the Public Roads Administration. In addition, at the request of the State Highway Department of Georgia, employees of the Bureau of the Census later assisted in the field work in Savannah.

Following conferences among the officials of the State highway departments, cities, and the Public Roads Administration, in which definite procedures were agreed upon, work was started during March, April, May, and June 1944, in Tulsa, New Orleans, Little Rock, Kansas City (Kansas), Kansas City (Missouri), Memphis, Savannah, Oklahoma City, and Lincoln (Nebraska) in the order named. Based on experience gained in these cities, a manual was prepared and distributed to district engineers by the Public Roads Administration on July 17, 1944. Subsequently, work has been started in Nashville, Shreveport, Denver, Omaha, Greenville (South Carolina), Fort Wayne, Council Bluffs, Milwaukee, Atlanta, Cincinnati, Covington-New-

[5] Highway Research Board, *Proceedings*, Vol. 23 p. 363 (1943).

[6] "Traffic Analysis and Expressway Plan for the City of Louisville, Kentucky," by H. W. Lochner and Company, September 1944.

port (Kentucky), Spartanburg (South Carolina), Richmond (Virginia), Providence (Rhode Island), and Charlotte (North Carolina). Thus, surveys similar to those described in the manual are now being made in 24 cities, or city groups, comprising 21 metropolitan areas. In all cases the surveys are being made by State highway departments in cooperation with the Public Roads Administration and with city officials. The metropolitan areas of Kansas City, Omaha, and Cincinnati lie in two States and, in each case, both states have adopted identical procedures and are working in close cooperation.

The proportion of dwelling units to be included in the sample was fixed at 10 per cent for cities of medium size such as Savannah, Tulsa, and Little Rock. This percentage was somewhat arbitrary and was based largely on the experience of the Bureau of the Census. For metropolitan areas of larger size such as Kansas City and Milwaukee it was decided that 5 per cent would be sufficient. The results of tests made in Tulsa, Kansas City, and Savannah indicate that samples based on these proportions have been amply large.

In Tulsa interviews were made in all of the dwelling units in one zone and Figure 4 shows how the results compare with those obtained

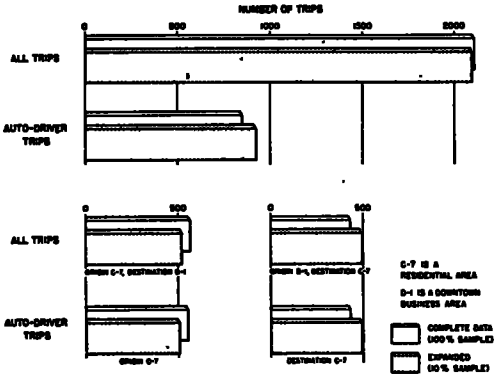


Figure 4. Comparison of data expanded from a ten per cent sample with complete data obtained in zone C-7, Tulsa, Oklahoma

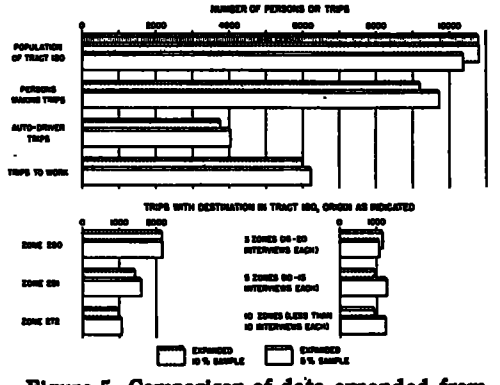


Figure 5. Comparison of data expanded from five and ten per cent samples, tract 180, Kansas City, Kansas

PROCEDURES

For the internal survey the method is to select a uniform proportion of the dwelling units throughout all sections of the metropolitan area and to obtain from all of the residents of the selected dwelling units a complete record of all trips made by automobile, bus, or street car on the last weekday preceding the interview. Expansion is made separately for each census tract or zone, using as a factor the figure obtained by dividing the total number of dwelling units in the zone by the number of dwelling units for which trip information was obtained. For trucks and taxis the basis of sampling is the registration list and a complete record of a day's travel is obtained from the driver.

by expanding the ten-per cent sample. Bearing in mind the fact that the results are for a typical day, and that the two samples do not cover exactly the same period of time, the agreement is remarkably close. The same can be said for the comparison of an expanded 5-per cent sample and an expanded 10-per cent sample for a zone of residence in Kansas City, Kansas, shown in Figure 5.

From the Savannah data a more elaborate and somewhat more significant test was made. The entire sample of automobile trips recorded in interviews in 10 per cent of the dwelling units of the metropolitan area was tested to determine the extent to which the results obobtained by expanding the 10-per cent sample and by expanding 5-per cent and 2½-per cent samples, similarly selected, would be expected

to deviate from the results which would be obtained if interviews were made in all of the dwelling units of the area. The measure of the deviation is the "standard error," which is the percentage within which the expanded data from the sample will agree with the complete data from all dwelling units in two cases out of three, and is one-half the percentage within which the data from the sample will agree with the data from all dwelling units in 99 cases out of 100.

Table 1 gives estimates of the standard errors, for samples of 10 per cent, 5 per cent, and 2½ per cent, in the expanded number of trips with destination in specified census tracts. The tracts are arranged according to the number of trips terminating in each, the one with the largest number of trips being first, and the others following in descending order. According to the expanded 10-per cent sample, 2,710 automobile trips ended in tract No. 3, and the chances are two out of three that this figure does not differ more than 7.7 per cent from the figure which would have been obtained if interviews had been conducted in all dwelling units in the area. If only a 5-per cent sample had been obtained, the corresponding figure would have been 10.9 per cent, and for a 2½-per cent sample, it would have been 15.4 per cent. For tract No. 4, which was the destination for a slightly smaller number of trips, the standard error is slightly larger. When the number of trips drops to 1,263 (tract No. 29), the standard error goes up to 11.2 per cent for the 10-per cent sample, to 15.9 per cent for the 5-per cent sample, and to 22.5 per cent for the 2½-per cent sample.

TABLE 1

STANDARD ERROR OF ESTIMATES FOR NUMBER OF AUTOMOBILE-DRIVER TRIPS DESTINED TO DIFFERENT CENSUS TRACTS FROM INTERVIEWS AT 10, 5, AND 2½ PER CENT OF THE TOTAL NUMBER OF DWELLING UNITS IN SAVANNAH, GEORGIA

Census tract of destination	Estimated number of trips	Standard error		
		10-per cent sample	5-per cent sample	2½-per cent sample
		per cent	*per cent*	*per cent*
3	2710	7.7	10.9	15.4
4	2482	7.8	11.0	15.6
29	1263	11.2	15.9	22.5
27	929	12.1	17.1	24.1
24	895	13.2	18.6	26.4
30	854	14.8	20.9	29.5
22	822	8.8	12.5	17.6
21	819	12.2	17.2	24.3
9	806	15.8	22.3	31.6
26	785	13.7	19.4	27.4
37	773	9.7	13.7	19.3
7	731	15.2	21.4	30.3
19	730	17.7	25.0	35.3
8	696	18.5	26.2	37.1
25	584	15.6	22.1	31.2
11	560	15.1	21.4	30.3
13	557	16.7	23.7	33.5
18	556	23.2	32.8	46.4
6	552	18.2	25.7	36.3
15	546	19.6	27.7	39.2

In view of the fact that accurate estimates are needed principally for the larger traffic movements (say, upwards of 2,000 vehicles a day), the 10-per cent sample appears to be amply large for Savannah. A 5-per cent sample appears to be somewhat too small in this case, but the figures suggest that a sample of this percentage, or even a smaller one, might be ample for a larger city in which the principal interest is in traffic movements greater than any shown in the table. A test of the data relative to internal auto-driver trips crossing the Bay Street Viaduct, shown by the expanded sample to be 4,092 per day, indicates a standard error of 5.4 per cent for the 10-per cent sample and 7.7 per cent for a 5-per cent sample.

As results of the various surveys now under way are received, further analyses will be made to determine the proper size of samples for different conditions. It must be borne in mind that the limiting of the interviews to a percentage of the dwelling units is not the only, nor necessarily the principal, source of error in the data. Even a 100-per cent sample might be in error because of failure to report all trips.

The best basis for sample selection has been found to be the Sanborn maps, where they are available and up to date, as they usually are for the more populous portions of a city. If the sample is 10 per cent, the person making the selection starts counting at one corner of a block and counts around the block, indicating every tenth dwelling for inclusion in the sample. After the last dwelling unit in a block is designated, the counting proceeds on to the end of that block and continues up to ten in the next block for the designation of the next unit.

Where there are two or more dwelling units in one building, each designated by a separate house number, this is indicated on the map and each house number is considered as a separate unit. In the case of an apartment house, the

map does not show the number of apartments and this information must be obtained from a city directory or through a telephone call or ground inspection. After the number is ascertained, each apartment is treated as though it were a one-family dwelling and the counting proceeds right through the apartment house, every tenth apartment being designated for inclusion in the sample. Residents over stores and permanent residents of hotels and institutions are separately sampled, but transients are excluded. In areas for which no Sanborn maps are available, such use as is possible is made of city directories and existing maps, but generally some field listing has to be done.

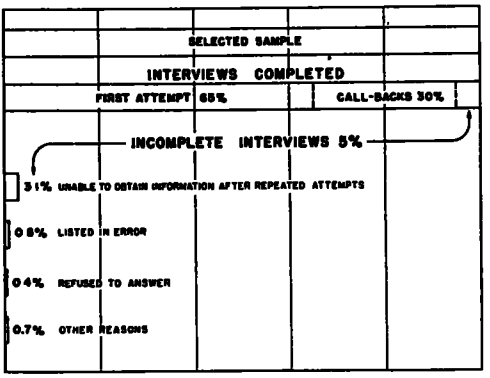


Figure 6. Proportion of sample selected for which interviews were completed in first attempt, and in call-backs, in three cities

Once the sample is selected, it is rigidly adhered to, and no substitution is allowed. If a dwelling unit in the sample is vacant, that fact is the answer wanted, because no travel was performed by persons residing in it. Every effort is made to obtain complete information concerning all of the travel by all residents in a selected dwelling unit and as many calls are made as are required to do this. It has been found that favorable publicity in the newspapers and by radio, explaining the purposes and methods of the survey before the interviewing is started, has helped to obtain the cooperation of the public, principally by removing any suspicion that the questions have anything to do with gasoline rationing. In most cases, additional advance information concerning the survey is given on post cards sent to the householder in each selected dwelling unit just a few days before the call is to be made. With such aids the public reception of the survey has been excellent and full information has been freely given. Figure 6, which gives combined data from Tulsa, Nashville, and Savannah, shows that the number of persons refusing to answer has been negligible, amounting to only four-tenths of one per cent. It shows further that in 65 per cent of the cases, only one call was required, and that in 30 per cent complete information was obtained after one or more repeat calls.

The information obtained concerning all trips was the occupation and industry of the person making it, the time and place of starting and ending the trip, and the purpose. Street car and bus passengers were asked, in addition, whether they would have driven a car if it had not been for wartime restrictions. For automobile drivers additional questions were asked concerning the number of passengers, route of travel, intermediate stops, and place of parking. A typical form to be filled out for each dwelling unit is shown in Figure 7 and a typical trip form is shown in Figure 8. Much of the latter form can be completed by simply circling numbers.

The questions concerning occupation and industry and trip purpose were asked because they have a definite bearing on probably postwar changes. Travel by persons in different occupations and industries and for different purposes might be expected to change at different rates. At the present time most of the travel is to and from work, as can be seen from Figure 9 which shows the distribution by trip purpose for Tulsa. For travel not extending beyond the limits of the city and its suburbs 66 per cent of the trips were to and from work, 12 per cent were to and from shopping, and 22 per cent were for social, recreational, and other purposes. We might reasonably expect a relatively large increase in travel in the latter category after the war. For travel extending out into rural areas, 31 per cent were for work, 3 per cent for shopping, and 66 per cent for other purposes. Figure 10 gives similar information for internal traffic in Kansas City, Kansas. It will be noted that the percentages are almost the same as for Tulsa.

GROUND COUNT CHECKS

In order to test the completeness of the data being obtained, certain well-known points,

STATE OF_____

STUDY OF TRAVEL IN THE_____METROPOLITAN AREA

I. Dwelling Unit Summary

Tract No._____ Block No._____ Schedule No._____

Address: _____ (Apt. No.) _____ (House No.) _____ (Street)

A. Date of travel_____, 1944

B. How many passenger cars are owned by persons living at this address?_____

C. How many of these are not in service? _____

D. How many persons live here? _____

E. How many of these are 5 years old or older? _____

(1) How many made no trips on date specified in A? _____

(2) How many made one or more reported trips on that date? _____

(3) For how many was it impossible to obtain trip information?_____

(a) Reason_____

Note: (1) plus (2) plus (3) should equal E.

F. What is the total number of trips reported for persons shown in E(2)? _____

G. If questions B, C, D, or E are not answered what is the reason? _____

H. Date interview completed:_____,1944

Signature of interviewer:_____

Note: Fill a separate trip report (reverse side of this sheet) for each trip made by each person, even though two or more of them may have traveled together. The total number of trip reports for the address should equal the number entered in F above. Two trip reports should be completed for each round trip -- one for trip away and one for the return trip.

P-1498

Factor_____

Figure 7. Typical Dwelling Unit Summary Form

Person No. _____ Schedule No._____
Person's Trip No. _____ Tract No._____ Block No._____

1. M; 2. F. 1 - 2 - 3

II. Trip Report (applicable to all)

A. Person's occupation and industry:_____

B. How did you make this trip? (If more than one mode of travel, circle each one used):
1. Auto driver 2. Auto passenger 3. Streetcar or bus 4. Taxi

C. Where and when did you start this trip?
a. Place:_____ b. Time:_____a.m. p.m.
(Number & street, or "Home" or name of place if well known)

D. Where and when did the trip end?
a. Place:_____ b. Time:_____a.m. p.m.

E. What was the purpose of the trip?

	2. To	3. From	4. During
a.			
b.	1 Work	4. School	8. Shopping, important
	2. Business	5. Social, cultural	9. Shopping, incidental
	3. Doctor, dentist	6. Recreational	0. For rider
		7. Eating	

F. If there were no wartime shortages or restrictions, would you have made this trip as an auto driver? 1. Yes 2. No

III. Supplemental Trip Report (applicable to auto drivers only)

G. How many passengers made this trip, yourself included? . . . . . _____

H. How many intermediate stops for your own purposes or for your passengers did you make during this trip? . . . . . _____

I. (If any intermediate stops were made) Where were these stops? What was the purpose? What kind of parking did you use? (Make entries for each stop):

Place	Purpose (Enter code No. from Eb)	Parking (Enter code No. from N)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

J. What were the principal streets used on the trip?_____

K. Which of these structures or places did you pass through? (Circle each one used)
1. _____ 2. _____ 3._____ 0. None

L. Did you park the car or cruise at the end of the trip?
1. Parked car 2. Cruised 3. Did not park or cruise

IV. Parking Report

M. Where and for how long did you park the car?
a. Place:_____ b._____hrs. _____mins.
(Number & Street, or "Home" or name of parking lot or garage)

N. What kind of parking space did you use?
1. Curb, unrestricted 4. Residence property 7. Service or repair
2. Curb, restricted 5. Parking lot, free 8. Garage storage, free
3. Curb, metered 6. Parking lot, pay 9. Garage storage, pay

O. (If charged for parking--3, 6, or 9 in N) What was the parking charge?
$_____per: 1. Hour 2. Day 3. Overnight 4. 24-hour day 5. Week 6. Month

P. a. How long did it take you to go from where you parked to your destination?_____min.
b. How far was it from where you parked to your destination?____blocks or__hundred ft.
c. How did you travel from the parking place to your destination?
1. Walked 2. Auto 3. Streetcar or bus 4. Taxi

Q. How many times a month do you park in this manner? . . . . . _____

R. Why did you use this parking space?_____

S. Factor_____

P-1000

Figure 8. Typical Trip Report Form

preferably bridges, underpasses, or other constrictions through which large volumes of traffic funnel, were designated as control points and the traffic passing them was counted and classified. From the combined external and internal interview data, either on the basis of the answers to a specific question, or on the basis of the route of travel and origin and destination information, the passenger cars passing these points were calculated. Figure

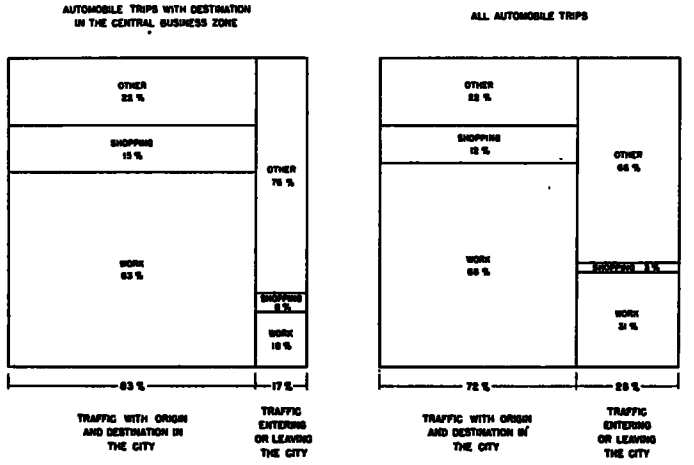


Figure 9. Trip Purposes of Automobile Traffic in Tulsa, Oklahoma

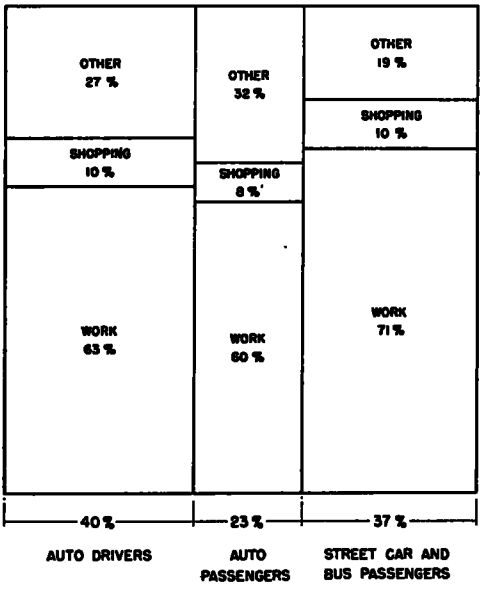


Figure 10. Purposes of Travel originating and terminating within the Metropolitan area of Kansas City, Kansas, for each means of travel.

11 shows the comparison with ground counts for a control point in Tulsa and for one in the Kansas City area. It will be noted that from 85 to 90 per cent of the total passenger automobile travel crossing these structures were accounted for by the expanded interview data. Included in the 10 to 15 per cent not accounted for is travel by transients, as well as any unreported trips. Considering the broad ranges in traffic volumes which are used as a basis for design standards and considering the uncertainties with regard to future fluctuations in traffic, these are considered to be very satisfactory checks. Adjustments can be made for the small amount of traffic not accounted for by the interveiws.

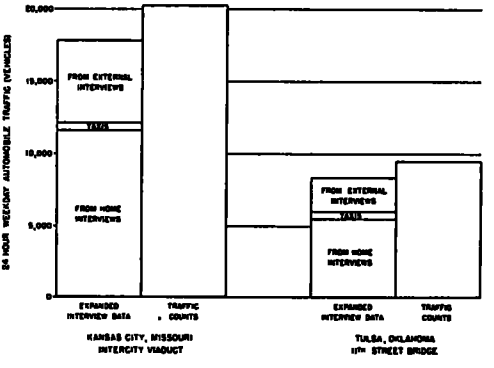


Figure 11. Typical trip data expanded from interviews compared with actual traffic counts.

The control points shown in Figure 11 were selected because they are well-known structures of considerable size through which large volumes of traffic funnel. In these cases it can be determined with reasonable accuracy, from origin and destination information alone, what trips went through the control points. Some of the other control points in Kansas City could be bypassed on parallel streets close by and it was necessary to rely on the statement of the person being interviewed as to whether or not the point was passed. In these cases, a much smaller portion of the counted traffic was accounted for by the expanded interviews, probably indicating that a number of persons who passed the point did not remember having done so. In order to eliminate this element of uncertainty, it has been decided that, in future surveys, where conditions are favorable to such a procedure, a "screen," or line of control points dividing the city, will be used so that a definite comparison can be made between the expanded origin and destination data and the total counts for the screen.

Preliminary results from one city, indicate that only about 61 per cent of the traffic crossing a large and well-known viaduct was accounted for by expanded interview data. This was not due to the sample size, because the standard error for the sample, in this case, is estimated to be less than 6 per cent. When the comparison is made by hours, it is found that the check for the peak hour is 88 per cent, and, as the peak-hour traffic is used as the basis for design, the most important part of the information has an accuracy within allowable limits.

The reason for the lack of uniformity in the completeness of the data for different hours may be the fact that the travel to and from work, which makes up most of the peak-hour travel, was rather fully reported, while much of the travel for other purposes was not reported. This emphasizes the need for extreme care in instructing the interviewers so that they will elicit full information from the person being interviewed, and will refuse to accept as final second-hand information which may be incomplete. It may also indicate the need for better publicity to remove the fear of reporting non-essential driving. It will probably be easier to obtain full information concerning trips for all purposes after gasoline restrictions are lifted.

TIME AND COST OF THE SURVEY

The time required to make the survey naturally varies with the availability of personnel, especially supervisory personnel. If the work is to be pushed, a survey director and two or more assistants with considerable previous experience in the supervision of traffic surveys are needed. In addition, for each ten interviewers to be used in the internal survey, there should be a capable supervisor who need not, however, have had previous experience in traffic studies. From three to five days are required to organize and train each group of ten interviewers.

In the surveys so far made the maximum number of persons used at one time in making home interviews has been between 20 and 40, except in one city where 77 were used. The number of persons per dwelling unit averages about 3.3 and the interviewers have completed about one dwelling unit per hour, on the average. In a city of 200,000 population, therefore, the man-hours of interviewing for a 10-per cent sample are approximately 200,000 divided by 3.3, divided by 10, or 6,060. For a crew of 30 interviewers the time required is 202 hours, or about 25 days.

The sample selection is usually started about a week before the interview parties are organized, two or three men being used. Truck and taxi interviews are generally made by men especially qualified for this work, while the home interviewing is being done.

The external survey party for interviewing traffic in both directions generally requires a chief, a man to classify traffic (the counts are made with automatic recorders), two police officers, and from three to eight interviewers, depending on the traffic volume. Such a party can complete the external survey while the internal survey is being made.

Average unit time and cost figures, reported by the cities making surveys, are given in Table 2.

The elapsed time, from the beginning of the sample selection through the completion of all interviewing, has generally ranged from six to eight weeks. In some cases the office work has been delayed, or done on a very small scale, while field surveys were being made in other cities. Where it was carried out expeditiously to the point of completion of all of the tables and analyzing one or more proposed routes, it has taken about the same length of time as the

field work. There is no reason, however, why the office and field work cannot be overlapped in such a manner as to greatly reduce the over-all time.

As regards over-all costs, the office work has been completed, or nearly so, for only a few cities, all of which are under 250,000 population, and had a 10-per cent sample. For these, the average over-all cost is remarkably close to ten cents per person; in other words, $10,000 for a city of 100,000 population, and $22,000 for a city of 220,000 population. For larger cities where a 5-per cent sample is used, the cost per person should be lower; however, higher wages paid in such cities sometimes tend to compensate for the smaller sample. Based on the experience so far, it seems probable that costs will average about eight cents per person in the larger cities where a 5-per cent sample is used, and may drop as low as five cents per person in a very large city in which a 2½-per cent sample is sufficient. These figures are for completing all field work and tabulations and making some preliminary route analyses. The data will undoubtedly be used in the analysis of various proposals over a protracted period of time and the costs of such work are chargeable to the projects being considered, rather than to the general survey.

TABLE 2

Item	Unit	Units per man-hour	Cost per unit (dollars)
Sample selection	dwelling unit	6.6	0.20
Sample selection	truck or taxi	7.1	0.19
Interviewing	dwelling unit	1.0	1.07
Interviewing	truck or taxi	1.0	1.25
Interviewing (external)	trip	5.7	0.26
Coding	dwelling unit	4.2	0.25
Coding (external)	trip	17.8	0.06

USE OF THE DATA

For Tulsa an interesting analysis was made of the answers to the question asked of passengers in busses, street cars, and automobiles as to whether they would have driven a car on the trip if it were not for wartime restrictions. It seemed obvious that if the answer were "yes," such a trip would not always have been made as an automobile trip because the car would have been out of repair or left for others to drive part of the time. It was assumed that 70 per cent of the trips for which the answer was "yes" would have been automobile trips if it were not for restrictions and the resulting shifts in passengers carried by streetcars and busses and in car occupancy were calculated. These shifts were then compared with the shifts from automobile to streetcar and bus, which were estimated by officials of the streetcar and bus companies to have taken place during the war, with changes in car occupancy observed on the streets and with changes in automobile traffic volumes. The calculations showed that the pre-war relationships would be very closely restored if 70 per cent of the trips for which the answers were "yes" were considered to be automobile trips.

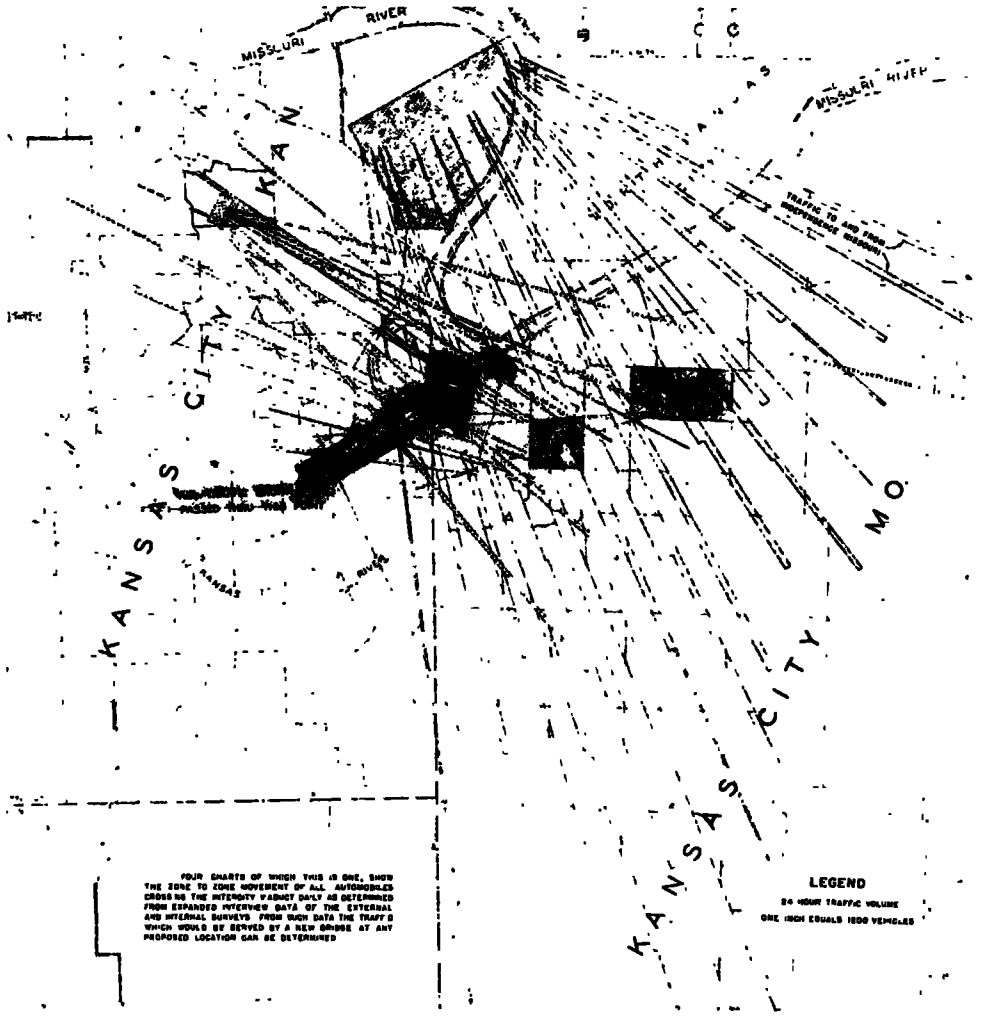
The tabulations resulting from the surveys which will be of greatest use are those showing the daily interchange of traffic from one zone to another. This information is shown separately for automobile drivers, automobile passengers, and streetcar and bus passengers, and for different travel purposes. Passengers who say they would have driven if it were not for restrictions are separately tabulated. The zones used are census tracts, or subdivisions or combinations of these, for cities in which such tracts have been established; and otherwise are zones determined on the basis of desirable size and land-use characteristics. They are small enough to permit a reasonably accurate analysis of the desired path for the traffic movement and the actual city blocks in which the origins and destinations occurred were recorded and punched on the cards so that the zones may be subdivided in any manner desired to assist in the solution of any specific problem.

Figure 12 shows how this zone to zone information can be made to assist in the determination of a bridge location. The zone to zone interchange of all traffic crossing the Intercity Viaduct in Kansas City is shown in four charts similar to this one. An analysis of the data depicted in the four charts will permit the determination of the proper location for a new bridge, from the point of view of traffic service, and the estimation of the traffic which would probably use it.

Figure 13 shows the daily interchange of automobile traffic between the downtown business area in Tulsa and the other zones throughout the city. The trips shown here constitute almost 40 per cent of all automobile trips made daily in the area. A study is being made of the number of daily trips to the downtown area

per 100 residents in relation to the economic characteristics of the zone of origin as determined from census data, and after this has been done for a large number of cities, it should be possible to develop factors which can be used in estimating this important traffic movement in different cities under present and assumed future conditions.

It will be noted from the chart that the bulk of the traffic comes into the downtown business area from the east. From other charts it is seen that there is an important east-west movement of traffic to and from industrial plants and of traffic coming in from outside the city. An east-west expressway is indicated and an analysis was made to determine how much traffic such an expressway would carry, on the assumption that no other major



KANSAS CITY METROPOLITAN AREA SURVEY CONDUCTED JOINTLY BY THE STATE HIGHWAY DEPARTMENTS OF KANSAS AND MISSOURI

Figure 12

changes in the street system would be made. Figure 14 shows the results of this analysis.[7]

The assumed expressway was divided into sections not more than about a mile long, each section terminating at an important cross street. From the zone to zone traffic flow tables, traffic was assigned to different sections of the expressway, if time would be saved by using the facility. In making the calculations, shown separately by the band with coarse cross hatching just below the centerline so that the extent to which the usage of any portion of the proposed facility would be affected by closing the plants or greatly curtailing production could be determined. It will be noted that the war plant traffic is large near the east city limit, but relatively small through the downtown area.

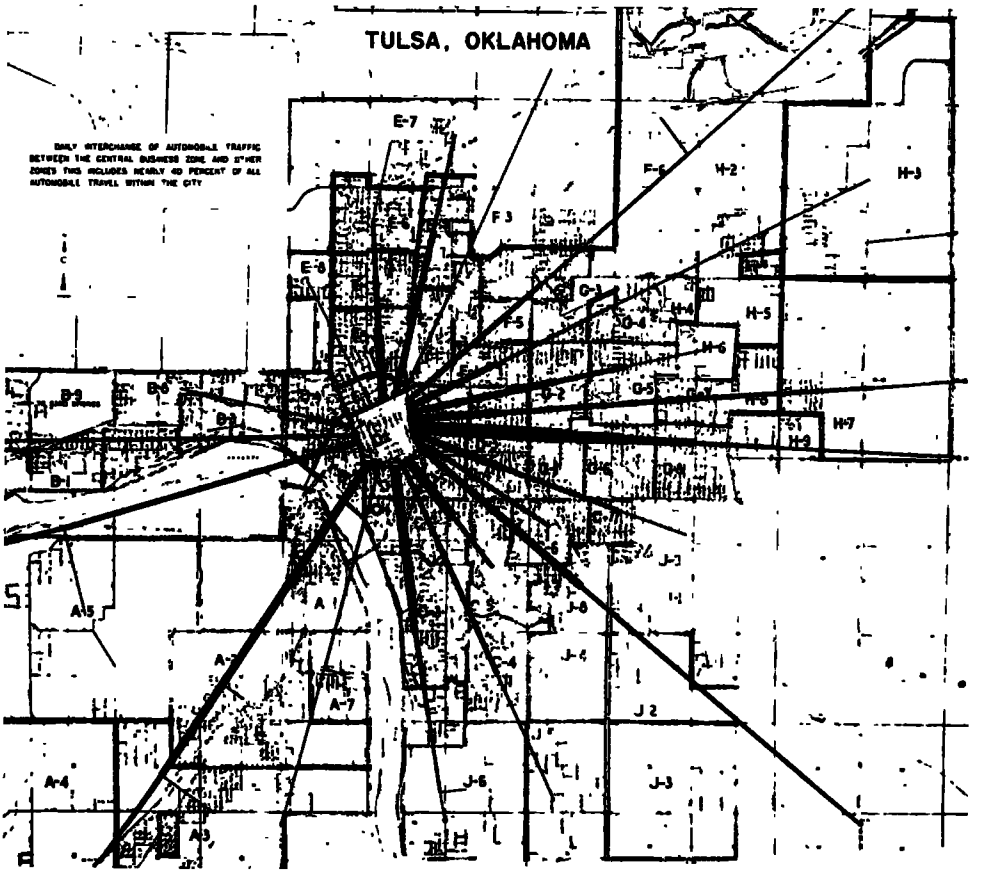


Figure 13

speeds on the expressway were assumed to be three times as great as those on existing streets in the congested area and twice as great in outlying areas.

Existing automobile traffic going to and from war plants with an uncertain future is

All other existing automobile traffic which would use each section of the facility is shown by the similarly marked band just above the centerline. This traffic is relatively small near the city limits and reaches a maximum near the center of the city. It is much more stable in character than that to the war plants.

The band at the bottom shows potential automobile traffic to and from the war plants due to driving by persons now traveling as

[7] See report of the Oklahoma State-wide Highway Planning Survey, State Highway Commission, entitled "Tulsa Metropolitan Traffic Survey, 1944."

passengers in busses, streetcars, or automobiles, in case the plants should remain in full production and restrictions on automobiles, parts, and fuel should be lifted. The band at the top shows similarly all other potential automobile traffic from such shifts. As previously explained, this was calculated on the assumption that an automobile trip would result in 70 per cent of the cases where a passenger said he would have driven if it had not been for the restrictions.

If further study indicates that other major improvements should be included in the plan, a reanalysis of the east-west route will have to be made, because it is probable that such improvements would materially effect the usage of the route. Future traffic growth, over a period of 20 years or more, remains to be estimated. Also, it would be desirable to have an analysis of traffic in different seasons and on Saturdays and Sundays, as well as on weekdays. During the war it was not thought practicable to obtain this information because the flattening of the traffic pattern makes it less important than normally, and the shortage of manpower makes it necessary to reduce the work to a minimum. After the war, however, there should be interviews in each season and information concerning week end traffic should be included.

Much remains to be done to perfect and refine the procedures which have been described. However, there is reason to believe that a method is being developed which is entirely practicable, and which will give information of a completeness and reliability not hitherto attainable in urban traffic studies.

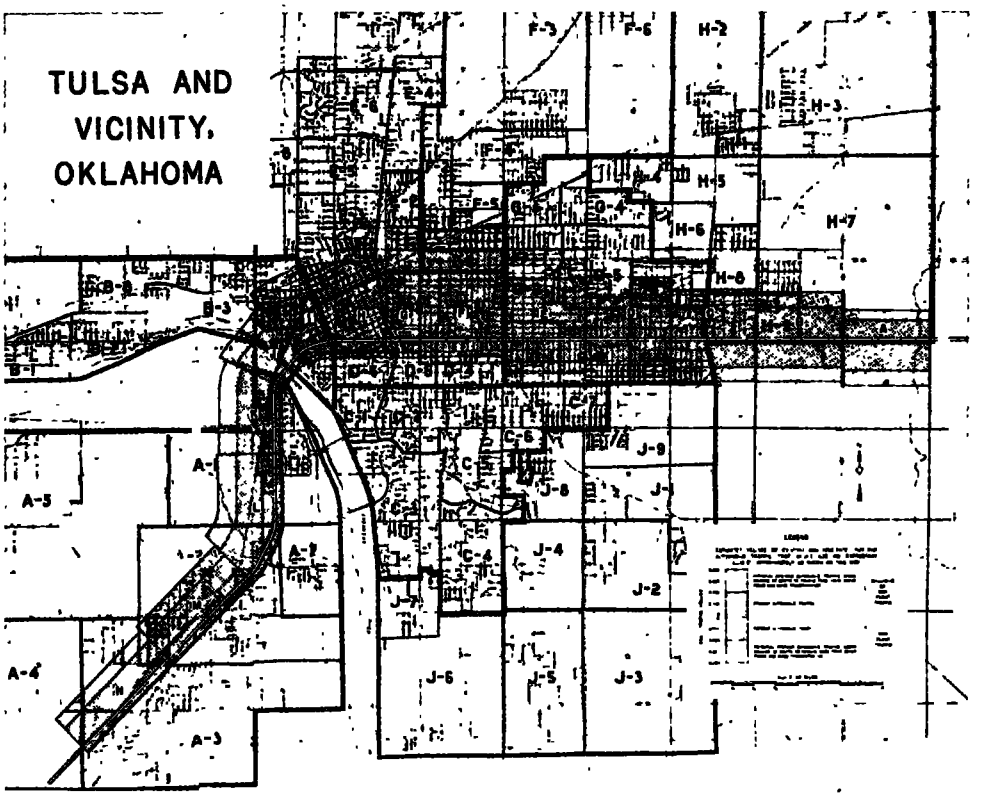


Figure 14. Estimated Immediate Post-war traffic on an expressway if constructed near present location of U. S. 66 through Tulsa, Oklahoma