

84-1281

TRIP GENERATION AT SPECIAL SITES

by

E. D. Arnold, Jr.
Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Seven-day volume counts were made at fast-food restaurants with drive-thru service, convenience markets, condominiums, drive-in banks, high-rise apartments, planned unit developments, mobile home parks, day-care centers, churches, suburban motels, and post offices throughout Virginia. Typical traffic patterns at the sites were determined from the count data. Based on available trip generation rates reported by the Institute of Transportation Engineers and an analysis of the count data, conclusions regarding valid vehicle trip rates for the above land uses were developed.

1234

7235

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INTRODUCTION

When land uses are proposed for development, transportation planners and traffic engineers require estimates of the anticipated traffic volumes attracted to or produced by the land uses. These estimates typically are needed to determine such items as the requirements of internal circulatory systems, parking requirements, the numbers and designs of entrances and exits, signal timing and phasing, and impacts on the surrounding network of roads.

Trip generation rates are generally used to calculate the estimated traffic volumes. A trip generation rate is developed by measuring the traffic volume at an existing similar land use and relating it to some easily measurable characteristic of that land use. For example, a rate of 10 trips per day per dwelling unit would be used to estimate the traffic to be generated by a proposed subdivision.

Many studies have been conducted in various parts of the country to determine the trip rates for land uses. The Institute of Transportation Engineers (ITE) has compiled and summarized the results of such studies into an information report entitled Trip Generation that is periodically updated.(1). An earlier report by the author concluded that the rates developed by the ITE are satisfactory for use in Virginia.(2) Another recent summary of trip generation rates is included in the National Cooperative Highway Research Program (NCHRP) Report 187 entitled Quick-Response Urban Travel Estimation Techniques and Transferable Parameters.(3) Unfortunately, information for many land uses is still lacking. This report describes a project initiated to develop trip rates for 11 of these uses.

PURPOSE

The primary purpose of the project was to develop trip generation rates for selected land uses for which such rates were either lacking or questionable due to being based on a small number of studies. Secondary purposes included the determination of which land uses lacking information are considered important by planners and traffic engineers in

1236

Virginia and an evaluation of traffic patterns for the selected land uses.

METHODOLOGY

The project was conducted through a series of tasks briefly outlined below.

Determination of Needed Land Uses

Based on a review of existing documents on trip generation, primarily the ITE's Trip Generation informational report, a list of land uses for which there were no trip rates was developed. The list was provided to 79 transportation planners and traffic engineers throughout the state with instructions to denote in priority order the 15 land uses for which they most often needed trip rates. A total of 12 land uses were selected by more than half of the 48 respondents for the top 15 needed land uses. These 12 land uses were then prioritized according to the average ranking given by the respondents as follows:

1. Fast-food with drive-thru
2. Convenience market
3. Condominium
4. Drive-in bank
5. High-rise apartment
6. Planned unit development
7. Mobile home park
8. Truck terminal
9. Day-care center
10. Church
11. Post office
12. Suburban motel

Selection of Sites

A total of 63 sites representing 11 of the above land uses were selected for study. The location and number of sites per land use are given in later sections of the report. As explained below, truck terminals were deleted from the project.

Since the project was designed for the exclusive use of automatic traffic recorders (ATRs), a primary consideration in selecting sites was the capability of obtaining accurate machine counts. Accordingly, all sites were isolated and had well-defined and relatively long entrances. The necessity of using ATRs also precluded the survey of truck terminals

1237

because the number of axles on vehicles entering the terminal varies. Accurate machine counts cannot be obtained in this case since the counters record traffic based on the assumption of a standard vehicle. In most applications it is assumed that the majority of vehicles have 2 axles.

It should be noted that site selection was not dependent on the need to place ATRs on public property. At most of the sites, permission was obtained from the owner/operator to locate the counters on private property in order to obtain the most accurate counts.

Collection of Data

Two types of data were collected at each site--background information and count data. Site information consisted of easily obtainable data which described the particular land use being surveyed. The data varied with the land use and are given in later sections of the report.

As mentioned previously, the count data for each site were obtained with ATRs having solid-state electronics and activated by electronic switches attached to rubber roadway hoses. The number of entering and exiting vehicles at all entrances to a site was counted for a minimum of 7 days. The paper tape recording mode was set to record the counts on a 15-minute basis so that peak-hour information could be accurately determined. The average weekday peak-hour traffic volume of the street adjacent to the site was needed for each of the periods 7:00 to 9:00 a.m. and 4:00 to 6:00 p.m. This information was obtained either from existing data sources or from field counting. In the latter case, the two-way vehicle count was recorded on a 15-minute basis for the five weekdays and used to determine the peak hours.

Data were collected between March and November of 1983. Counts taken on holidays were deleted from the calculations.

Analysis of Data

Computer programs for analyzing the data were developed for an earlier study by the author. Data from each site were analyzed to determine average weekday, Saturday, and Sunday trips. For each site, the number of trips by direction were determined during the morning and afternoon peak hours for the average weekday and during the daily peak hour for Saturday and Sunday. The number of trips by direction for the peak-hour traffic on adjacent streets in each of the periods 7 to 9 a.m. and 4 to 6 p.m. was also determined for the average weekday. Finally, miscellaneous statistics were developed from these basic analyses. An example of the computer printout summarizing the traffic analyses is shown in Figure 1.

1233

TRAFFIC INFORMATION FOR
DATA GATHERED DURING WEEK BEGINNING ON 11-07-79

SOURCE	DAY	START OF PEAK HOUR	TOTAL TRAFFIC	INCOMING TRAFFIC	OUTGOING TRAFFIC
GENERATOR	AVERAGE WEEKDAY MORNINGS	7:30	83	20	63
GENERATOR	AVERAGE WEEKDAY AFTERNOONS	17:00	132	71	60
GENERATOR	SATURDAYS	13:45	83	39	44
GENERATOR	SUNDAYS	12:30	109	56	53
ADJACENT STREET	AVERAGE WEEKDAY MORNINGS	7:30	83	20	63
ADJACENT STREET	AVERAGE WEEKDAY AFTERNOONS	16:45	129	69	60

AVERAGE WEEKDAY VEHICLE TRIP ENDS : 1118
 SATURDAY VEHICLE TRIP ENDS : 945
 SUNDAY VEHICLE TRIP ENDS : 839

MISCELLANEOUS STATISTICS

5 WEEKDAY TRIPS IN:

A.M. PEAK HOUR OF ADJACENT STREET 7.4
 P.M. PEAK HOUR OF ADJACENT STREET 11.5
 A.M. PEAK HOUR OF GENERATOR 7.4
 P.M. PEAK HOUR OF GENERATOR 11.8

RATES PER DWELLING UNIT

SOURCE	DAY	START OF PEAK HOUR	TOTAL TRAFFIC	INCOMING TRAFFIC	OUTGOING TRAFFIC
GENERATOR	AVERAGE WEEKDAY MORNINGS	7:30	.7	.2	.5
GENERATOR	AVERAGE WEEKDAY AFTERNOONS	17:00	1.1	.6	.5
GENERATOR	SATURDAYS	13:45	.7	.3	.4
GENERATOR	SUNDAYS	12:30	.9	.5	.5
ADJACENT STREET	AVERAGE WEEKDAY MORNINGS	7:30	.7	.2	.5
ADJACENT STREET	AVERAGE WEEKDAY AFTERNOONS	16:45	1.1	.6	.5

AVERAGE WEEKDAY VEHICLE TRIP ENDS : 9.7
 SATURDAY VEHICLE TRIP ENDS : 8.2
 SUNDAY VEHICLE TRIP ENDS : 7.3

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Figure 1. Example of key data printout.

1232

After the traffic information was developed, the trips were divided by the pertinent land use characteristics of that site to develop the trip rates. Figure 1 also shows this calculation for the parameter dwelling units.

At a few of the sites, some of the count data for a week were missed because of an equipment malfunction in the field. Where feasible, the missing data were estimated based on data from a similar day at the same site. If significant amounts of data were missing, then either a recount was taken or the analysis was modified to reflect a limited data base.

For many of the land uses surveyed, it was assumed that daily totals of inbound and outbound trips would be reasonably close. In other words, the hours of operation at the commercial and service land uses, or a typical daily trip-making pattern at the residential land uses, suggest that all or at least a large majority of the trips at the site should occur during the course of a single day. Small differences could be explained by the error inherent in the counting equipment or by minor variations in the aforementioned trip-making pattern. Significant differences, however, were attributed to unanticipated traffic patterns that resulted in the improper crossing of the road tubes by vehicles entering and exiting the site. When this occurred, multiplicative factors were developed for each day to make the ins and outs equal. Depending on the geometrics of the site and the placement of the counters, these factors adjusted the ins to equal the outs, the outs to equal the ins, or both ins and outs to equal the previous total. These adjustment factors were then applied to the raw count data under the assumption that the directional errors were distributed equally throughout the day and at all entrances in the case of sites with more than one entrance.

While the adjustment procedure itself undoubtedly created errors in the data base, it was felt that the adjustment improved the accuracy of the counts at those sites where gross differences between ins and outs occurred.

FINDINGS

The findings of the project are presented in this section of the report. For each of the 11 selected land uses, information is presented on the number, location, characteristics, traffic patterns, and calculated trip rates of the sites studied.

Fast-Food Restaurants with Drive-Thru Service

A total of 8 fast-food restaurants having drive-thru service were surveyed. All restaurants are members of national chains; viz., Hardee's, McDonald's, Wendy's, and Roy Rogers. Information on the location, the number of seats, the number of employees, and the gross floor area of the sites is given in Table 1. Only 3 of the restaurants are open for breakfast. It is noted that only daily totals are known at 2 of the sites because of equipment failure.

Table 1

Site Description: Fast-Food Restaurants
with Drive-Thru Service

<u>Site No.</u>	<u>Location</u>	<u>No. Seats</u>	<u>No. Employees</u>	<u>GFA (1,000 sq.ft.)</u>	<u>Hours of Operation</u>
1	Charlottesville	96	30	2.6	S-Th: 7:00 a.m.-11:00 p.m. F-Sa: 7:00 a.m.-12:00 p.m.
2	Richmond	86	32	2.6	S-Th: 10:30 a.m.-1:00 a.m. F-Sa: 10:30 a.m.-2:00 a.m.
3	Charlottesville	100	35	2.3	S-Th: 10:00 a.m.-11:00 p.m. F-Sa: 10:00 a.m.-12:00 p.m.
4	Lynchburg	76	50	3.6	S-Sa: 24 hours/day
5	Richmond	76	30	2.4	S-Sa: 10:30 a.m.-4:00 a.m.
6	Lynchburg	83	40	3.6	S-Th: 6:00 a.m.-11:00 p.m. F-Sa: 6:00 a.m.-12:00 p.m.
7	Manassas	86	34	2.6	S-Th: 10:30 a.m.-10:00 p.m. F-Sa: 10:30 a.m.-12:00 p.m.
8	Centreville	80	45	2.7	S-Th: 10:00 a.m.-10:00 p.m. F-Sa: 10:00 a.m.-11:00 p.m.

Note: 1,000 sq. ft. = 93. sq. m.

Traffic Patterns

During the week, both morning and afternoon peak traffic flows at fast-food restaurants occur almost without exception during the lunch hours. This flow is very heavy, as approximately 16% of the daily trips occur during the p.m. peak hour, which occurs right after the noon hour. Traffic volumes increase around the supper hours; however, an average of only 5% of the daily trips occur during the peak hour on the adjacent street. Further, there is a tendency for the evening peak to occur after 6:00 p.m. The limited data for those restaurants open for breakfast indicate that the amount of traffic generated would have minimum impact on the local streets. Thus, the potential for negative impacts on local streets at fast-food restaurants is greatest during the lunch hours.

As discussed later, weekday volumes are generally maintained throughout the weekend. The peak hour for traffic flow again occurs around lunch on Saturday; however, the percentage of daily traffic occurring during the lunch hours is generally lower than that experienced on weekdays. Sunday's peak hour varies among the surveyed sites.

Trip Rates

Trip rates based on various parameters and for various times are provided in Table 2. Trip rates based on all three variables vary significantly among the surveyed sites; however, the trip rates per seat vary the least when the range of rates is considered. Both the seating capacity and gross floor area should be known for a proposed development and could be used in predicting travel.

Table 2

Trip Rates: Fast-Food Restaurants with Drive-Thru Service

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Seat</u>				
Average Weekday	8	8.9-35.8	22.2	23.0
P.M. Pk. Hr. Adjacent St.	6	0.4- 1.2	0.9	0.9
P.M. Pk. Hr. Generator	6	1.8- 4.8	2.9	2.9
Saturday	8	10.9-44.4	25.3	26.2
Sunday	8	7.4-32.3	19.3	20.0

1232

Table 2 (continued)

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Employee</u>				
Average Weekday	8	28.4- 90.6	51.2	52.4
P.M. Pk. Hr. Adjacent St.	6	1.3- 3.1	2.0	2.0
P.M. Pk. Hr. Generator	6	3.2- 12.9	6.7	7.1
Saturday	8	23.1-112.4	58.5	59.7
Sunday	8	23.6- 76.0	44.6	45.1
<u>Trips per 1,000 Sq. Ft. GFA</u>				
Average Weekday	8	327.7-1132.9	677.3	679.3
P.M. Pk. Hr. Adjacent St.	6	15.5- 38.2	27.9	28.5
P.M. Pk. Hr. Generator	6	44.6- 158.5	92.2	95.7
Saturday	8	384.8-1405.0	772.3	769.5
Sunday	8	272.7- 950.0	589.3	584.8

Note: 1,000 sq. ft. = 93 sq. m.

Based on the trip rates, the weekday trip attraction to fast-food restaurants with drive-thru service is generally maintained during the weekend. Specifically, the Saturday rate averages 14% higher and the Sunday rate 14% lower than the average weekday rate.

The ITE reports a daily trip rate of 553 trips per 1,000 sq. ft. (93 sq. m.) of gross floor area based on 6 sites for "drive-in restaurants." NCHRP Report 187 recommends a comparable rate of 533 for "fast-food restaurants." (3) If the higher rates observed in this study are attributed to the drive-thru service, then the rates in the literature are in reasonable agreement.

Convenience Markets

Only 3 convenience markets were located at which accurate machine counts could be obtained. Most of the sites inspected had very wide, curb-cut entrances or were built on a concrete pad. The characteristics of the 3 sites are given in Table 3. All stores were open 24 hours a day and did not have gas pumps.

Table 3

Site Description: Convenience Markets

<u>Site No.</u>	<u>Location</u>	<u>GFA (1,000 Sq. Ft.)</u>	<u>No. Employees</u>	<u>Gas Pumps</u>	<u>Hours of Operation</u>
11	Roanoke	2.4	5	No	S-Sa: 24 hrs./day
12	Charlottesville	2.4	7	No	S-Sa: 24 hrs./day
13	Centreville	2.4	8	No	S-Sa: 24 hrs./day

Note: 1,000 sq. ft. = 93 sq. m.

Traffic Patterns

Traffic patterns at the 3 sites surveyed vary considerably; however, the data suggest that the traffic flow peaks at convenience markets during or on the fringes of the typical weekday rush hours. The morning peak volume is generally slightly higher than the afternoon peak flow. Saturday flows exhibit no patterns. On Sunday, traffic peaks in the early evening hours. Any weekday traffic occurring during the rush hours may result in negative impacts on the local street network.

Trip Rates

Trip rates for convenience markets are provided in Table 4. Based on the 3 sites surveyed, the trip-making characteristics at convenience markets vary considerably when rates are calculated on the basis of gross floor area or number of employees. All 3 stores are in a well-known chain of convenience stores and have the same basic design. If gross floor area is based on design standards, and not the amount of business, then it probably is not a valid predictor of travel. Likewise, the number of employees is likely dependent on the particular mix of full- and part-time employees and not necessarily on the amount of business at the store. These observations suggest that trip rates for convenience markets should not be based on gross floor area or the number of employees. Unfortunately, it was beyond the scope of this study, especially with data from only 3 sites, to pursue this problem further.

Based on the Saturday and Sunday rates, the number of daily trips experienced during the week is generally maintained through the weekend. This is as expected because of the "convenience" nature of the stores.

1232

Trip rates reported in the literature are generally lower than those determined in this study. For example, the ITE reports an average daily rate of 625.2 trips per 1,000 sq. ft. (93 sq. m.) of gross floor area based on 4 studies with rates ranging from 422.0 to 839.0, and the recent NCHRP report recommends a daily rate of 577 trips per 1,000 sq. ft. (93 sq. m.).

Table 4

Trip Rates: Convenience Markets

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per 1,000 sq. ft. GFA</u>				
Average Weekday	3	665.8-1198.3	876.2	876.2
A.M. Pk. Hr. Adjacent St.	3	59.7- 104.1	74.9	74.9
A.M. Pk. Hr. Generator	3	59.7- 116.3	79.2	79.2
P.M. Pk. Hr. Adjacent St.	3	48.6- 56.8	52.9	52.9
P.M. Pk. Hr. Generator	3	54.6- 65.9	61.4	61.4
Saturday	3	610.4-1355.8	903.5	903.5
Sunday	3	440.0-1180.9	751.0	751.0
<u>Trips per Employee:</u>				
Average Weekday	3	262.1- 359.5	315.4	313.7
A.M. Pk. Hr. Adjacent St.	3	20.9- 31.2	26.9	26.9
A.M. Pk. Hr. Generator	3	21.1- 34.9	28.5	28.2
P.M. Pk. Hr. Adjacent St.	3	14.6- 25.6	19.1	19.9
P.M. Pk. Hr. Generator	3	19.8- 26.2	22.1	22.6
Saturday	3	255.1- 406.8	325.3	318.3
Sunday	3	211.2- 354.0	270.4	260.7

Note: 1,000 sq. ft. = 93 sq. m.

Condominiums

A total of 11 condominium complexes were surveyed. The ITE's definition of condominium was used in the study -- viz., a single-family ownership unit that has at least one other single-family owned unit within the same building structure. For purposes of this study, the surveyed condominiums were classified according to unit and building structure. A townhouse is a residential unit in which the living space

is built on more than one level or floor. More than one unit exists in the building structure. An apartment has the living space on a single level or floor, with several units existing on a single level or floor of the building itself. Buildings have at least two levels. An apartment style is often further categorized into low-rise and high-rise condominiums, depending on an arbitrary selection of the number of levels in the building. All sites surveyed have at ~~less~~ three levels, and thus are high-rise if the ITE's definition for high-rise rental apartments is used. Information on the surveyed condominiums is given in Table 5. It is noted that site 30.1 has a branch bank, a beauty salon, and a general store located within the complex. These facilities are for the use of residents only.

Table 5

Site Description: Condominiums

<u>Site No.</u>	<u>Location</u>	<u>Structure Type</u>	<u>No. Dwelling Units</u>
21	Charlottesville	Townhouse	147
22	Roanoke	Townhouse	80
23	Charlottesville	Townhouse	85
24	Charlottesville	Townhouse	48
25	Lynchburg	Townhouse	111
26	Lynchburg	Townhouse	120
27	Lynchburg	Townhouse	108
28	Richmond	Apartment	336
29	Reston	Apartment	240
30	Fairfax Co.	Apartment	140
30.1	Alexandria	Apartment	1,456

Traffic Patterns

During the week and on the weekend, travel patterns at condominiums resemble those found at all residential developments. Peak traffic hours on weekdays fall consistently within the rush hours. On weekends, the times of the peak hours vary among the sites. As with all residential developments, condominiums have a potential for negative impacts on local adjacent streets.

1200

Trip Rates

Trip rates for condominiums are presented in Table 6. The number of dwelling units seems to be a valid parameter on which to develop trip rates as the observed rates are relatively close. When all the sites are considered, as in the first part of Table 6, the weighted average trip rate of 5.3 is approximately 50% of the rate for single-family detached housing. This rate also compares directly with the 5.2 rate reported by the ITE, which is based on 41 studies.

The data from this study suggest that trip rates for "townhouses" and "apartment" styles of condominiums may be different. This is shown in the rest of Table 6, as the average trip rates for the 7 townhouses are significantly different from the average rates of the 4 apartments. The ITE reports a range of rates from 0.6 to 11.8, which includes the high values observed at townhouses. It is also noted that the trip rates at high-rise rental apartments, discussed later, are very close to the high-rise condominium rates. However, the low rates observed at both the rental apartments and condominiums may be attributable to the availability of transit or, at one site, a significant elderly population.

Table 6

Trip Rates: Condominiums

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Dwelling Unit</u> (All Condos)				
Average Weekday	11	3.9-11.1	5.3	7.0
P.M. Pk. Hr. Adjacent St.	11	0.3- 1.0	0.5	0.7
P.M. Pk. Hr. Generator	11	0.4- 1.0	0.5	0.7
Saturday	11	4.1-11.4	5.4	7.0
Sunday	11	3.2- 8.6	4.3	5.8
<u>Trips per Dwelling Unit</u> (Townhouses Only)				
Average weekday	7	6.3-11.1	8.7	8.5
P.M. Pk. Hr. Adjacent St.	7	0.5- 1.0	0.8	0.8
P.M. Pk. Hr. Generator	7	0.7- 1.0	0.9	0.9
Saturday	7	6.8-11.4	8.7	8.4
Sunday	7	5.5- 8.6	7.2	7.0
<u>Trips per Dwelling Unit</u> (Apartments Only)				
Average Weekday	4	3.9- 4.9	4.2	4.5
P.M. Pk. Hr. Adjacent St.	4	0.3- 0.5	0.4	0.4
P.M. Pk. Hr. Generator	4	0.4- 0.5	0.4	0.5
Saturday	4	4.1- 5.3	4.3	4.6
Sunday	4	3.2- 4.2	3.4	3.7

Drive-In Banks

Seven drive-in banks were surveyed. The location, number of employees, and gross floor area of the banks are given in Table 7. It is noted that 3 of the banks were open for business on Saturday.

Table 7

Site Description: Drive-In Banks

<u>Site No.</u>	<u>Location</u>	<u>No. Employees</u>	<u>GFA (1,000 Sq. Ft.)</u>	<u>Sat. Hours</u>
31	Richmond	15	3.0	Yes
32	Lynchburg	7	2.0	No
33	Lynchburg	4	0.8	Yes
34	Lynchburg	9	4.0	Yes
35	Richmond	6	1.6	No
36	Richmond	9	3.2	No
37	Lynchburg	8	3.4	No

Note: 1,000 sq. ft. = 93 sq. m.

Traffic Patterns

During the week, traffic flows at drive-in banks most generally peak around the lunch hours; however, there is a significant amount of traffic during the afternoon rush hours. Further, a relatively large percentage of the daily traffic occurs during the peak hours. Thus, there is potential for negative impacts on the local street network. Banks are generally not open during morning rush hours, so there is no impact during that period.

Traffic volumes on Saturday are small compared to those on weekdays; however, the banks are not open all day. At 2 of the sites surveyed, the Saturday peak-hour volumes are higher than the average weekday peak-hour volume. Thus, there is potential for short-term congestion problems at banks around noon on Saturdays.

Trip Rates

Trip rates based on the number of employees and on gross floor area for selected times are presented in Table 8. There is a large amount of variation in the trip-making characteristics at the surveyed sites when based on the above variables. This fact suggests that other variables, or even combinations of variables, govern travel at banks. Because of the wide variety of activities at banks and possible factors that are related to those activities, however, it is felt that valid estimating techniques based on a comprehensive array of variables would not be practical in day-to-day planning activities.

- 7232

The ITE daily rates, which are based on data from 4 sites, of 192 trips per 1,000 sq. ft. (93 sq. m.) of gross floor area and 47.4 trips per employee are significantly lower than the comparable rates found in this study. The rates recommended in the NCHRP Report 187 of 388 trips per 1,000 sq. ft. (93 sq. m.) of gross floor area and 75 trips per employee are much more in line with the findings of this study.

Table 8

Trip Rates: Drive-In Banks

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Employee</u>				
Average Weekday	7	57.7- 272.3	122.7	132.5
P.M. Pk. Hr. Adjacent St.	7	5.3- 30.5	14.0	14.8
P.M. Pk. Hr. Generator	7	8.3- 45.0	17.4	19.0
Saturday	3	25.9- 63.8	38.6	46.1
Pk. Hr. Generator (Sat.)	3	7.9- 22.3	11.6	14.4
<u>Trips per 1,000 sq. ft. GFA</u>				
Average Weekday	7	202.0-1021.3	395.5	474.9
P.M. Pk. Hr. Adjacent St.	7	18.5- 114.5	45.1	53.9
P.M. Pk. Hr. Generator	7	26.3- 168.8	56.1	68.3
Saturday	3	109.5- 318.8	138.7	186.0
Pk. Hr. Generator (Sat.)	3	29.3- 111.3	41.7	60.1

Note: 1,000 sq. ft. = 93 sq. m.

High-Rise Apartments

Five high-rise apartment complexes in Northern Virginia were surveyed, and the number of units are given in Table 9. As noted in the table, the 3 largest complexes have on-site commercial services for the convenience of the tenants. Also, all the complexes are served directly by or are reasonably close to transit routes.

-1222

Table 9

Site Description: High-Rise Apartments

<u>Site No.</u>	<u>Location</u>	<u>Dwelling Units</u>	<u>On-Site Facilities</u>
41	Fairfax County	207	None
42	Fairfax County	279	Beauty Salon
43	Arlington County	362	Small Grocery Store
44	Alexandria	142	None
45	Alexandria	574	Convenience Store, Cleaners

Traffic Patterns

Traffic patterns at high-rise apartments parallel those at other residential complexes; that is, peak flows occur in the rush hours during the week and vary considerably among the sites surveyed on the weekend. Since home-based work trips are the cause of rush-hour congestion, trip generation at high-rise apartments obviously can have negative impacts on local streets.

Trip Rates

Information on the observed trip rates is given in Table 10 for selected times. As is the case for all residential developments, the use of trip rates based on the number of dwelling units appears to provide valid and accurate estimates of travel at high-rise apartments. Traffic generation at high-rise apartments is approximately 50% of the generation observed at single-family detached housing complexes.

Based on 4 sites, the ITE reports a daily rate of 4.0 trips per dwelling unit for high-rise apartments. This value is reasonably consistent with the findings of this study.

Table 10

Trip Rates: High-Rise Apartments

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Dwelling Unit</u>				
Average Weekday	5	3.7-5.4	4.7	4.6
P.M. Pk. Hr. Adjacent St.	5	0.3-0.5	0.4	0.4
P.M. Pk. Hr. Generator	5	0.3-0.5	0.4	0.4
Saturday	5	3.6-6.0	5.0	5.0
Sunday	5	2.8-4.2	3.6	3.6

Planned Unit Developments

A planned unit development (PUD) is defined as a development containing several types of residential units plus possibly some supporting retail and recreational facilities. The ITE classifies this as a residential PUD as differentiated from a commercial PUD, which is more business oriented. Four PUDs were surveyed in this study.

Site 51--Sugarland Run

Sugarland Run is a PUD located in the northeastern section of Loudoun County just west of Fairfax County in Northern Virginia. Two well-defined access roads serve the development. There are a total of 2,330 residential units consisting of 1,138 single-family detached units, 1,000 owned townhouses, and 192 garden-style rental units. Two elementary schools, one middle school, and a day-care center are located within the development. A building containing 9,000 sq. ft. (836 sq. m.) of retail floor space houses a convenience store, a beauty salon, a florist, a dry cleaners, a restaurant, and a bank. Also, a 6-pump, self-service gas station and a fire and rescue station are located within the development. Finally, the development has a community center with a swimming pool. It is noted that a large regional park located approximately 1 mile from Sugarland Run provides extensive recreational facilities, including a golf course, swimming pool, picnic areas, and boat ramps.

1202

Site 52--Circle Towers

Circle Towers is located in Fairfax County just northeast of Fairfax City in Northern Virginia. The development is served by two access points and contains 606 rental units, 555 of which are located in a high-rise, the remainder being multilevel townhouse units. There are approximately 64,000 sq. ft. (5,946 sq. m.) of retail area. Business establishments include a delicatessen, a commercial cleaning company office, two building contractor offices, a restaurant, a bank, a hospital consulting firm, a direct-mail advertising firm, a real estate firm, a management consulting firm, and a dentist. These types of businesses do more than "support" the residential units; therefore, Circle Towers should probably be categorized between ITE's residential and commercial PUDs.

Site 53--Becontree Lane

Becontree Lane provides a single access point to a small section of Reston that contains a mixture of residential land uses. Two apartment complexes having 453 garden-style rental units and three streets on which 90 owned townhouses are located are contained within the area surveyed. Also included in the area is an elementary school.

Site 54--Brandermill

Brandermill is a large, planned residential development located on the Swift Creek reservoir in Chesterfield County approximately 10 miles southwest of Richmond. Due to its configuration, the entire development could not be isolated or "cordoned off" with automatic traffic recorders. The key land use not included in the analysis is the commercial area.

Within the survey area are a total of 1,624 residential units consisting of 1,462 single-family detached units and 162 single-family attached units. Recreational amenities include a country club with an 18-hole golf course, a clubhouse, a pro shop, a swimming pool, and tennis courts. Other amenities include two additional swimming pools, additional tennis courts, two boat launch and storage facilities, a teen center, a picnic area, a park with a ball field and basketball court, a playground, and an extensive network of bicycle/pedestrian trails. There are also a church, a large middle school, a day-care school, and a sit-down restaurant within the survey area. Finally, there are four small offices for contractors, sales, and administrative staff, and a maintenance facility for the public areas.

Traffic Patterns

Traffic flow characteristics at the PUDs reflect the predominant land use found within the bounds of the surveyed area; that is, residential. Weekday traffic peaks during the morning and afternoon rush hours; Saturday and Sunday peaks vary among the sites. Likewise, the percentages of daily traffic occurring during these peak hours are very similar to the percentages found at all residential developments. It is noted that the percentages for Circle Towers are less than those for the other sites, which suggests that there is relatively more traffic at Circle Towers during the day. This is as expected because of the large amount and type of commercial development which tends to draw from outside the development rather than just provide support inside the development.

Trip Rates

Trip rate information is summarized in Table 11. The rates vary considerably; however, the variation seems to follow a logical pattern if the type of development within each PUD is examined. Sugarland Run, which has both elementary and middle schools and more business providing support services than the other sites, has the lowest trip rates. Circle Towers, on the other hand, has no schools and a large number of businesses which tend to attract trips from outside the development. Consequently, it has the highest rates of those surveyed. Both Becontree Lane and the surveyed portion of Brandermill contain a school and a mixture of residential units. The trip rates at these PUDs fall between the rates at the aforementioned sites, and also between those observed at single-family detached and attached housing. Further, Brandermill rates are slightly higher than those at Becontree Lane, which can be explained by the extensive recreational facilities, especially the country club, which would attract trips from outside Brandermill.

Finally, the data at Brandermill were obtained over a period which included the last day of school before the summer break. Thus, trip rates which reflect the school being both in and out of session were developed. These rates are shown in Table 11, and it is noted that the school results in an approximately 13% increase in traffic.

A summary of data from 12 PUDs is reported by the ITE. The average daily rate is 7.8 trips per dwelling unit, with a range of rates from 5.8 to 14.4. The average number of units is 301, which is considerably smaller than the average of the sites surveyed in this study. NCHRP Report 187 recommends a daily rate of 7.9 trips per dwelling unit.

Table 11

Trip Rates: Planned Unit Developments

<u>Statistic</u>	<u>Sugarland Run</u>	<u>Circle Towers</u>	<u>Becontree Lane</u>	<u>Brandermill, School in</u>	<u>School out</u>	<u>Weighted Average¹</u>
<u>Trips per Dwelling Unit</u>						
Average weekday	6.0	11.2	7.9	9.1	8.0	7.8
P.M. Pk. Hr. Adjacent St.	0.6	0.9	0.7	0.8	0.8	0.7
P.M. Pk. Hr. Generator	0.6	0.9	0.7	0.8	0.8	0.7
Saturday	7.1	10.3	7.5	7.3	7.3	7.6
Sunday	4.2	7.8	6.3	5.8	5.8	5.4

¹Average includes Brandermill rates with school in session.

Mobile Home Parks

Six mobile home parks ranging in size from 45 units to 160 units were surveyed. The location and size of the individual sites are shown in Table 12.

Table 12

Site Description: Mobile Home Parks

<u>Site No.</u>	<u>Location</u>	<u>No. Units</u>
61	Lynchburg	121
62	Roanoke	152
63	Roanoke	160
64	Charlottesville	74
65	Charlottesville	80
66	Lynchburg	45

Traffic Patterns

Mobile home parks exhibit traffic patterns similar to those for all categories of residential development; that is, weekday peak traffic

flows occur during the traditional morning and afternoon rush hours. Also, the percentage of daily traffic occurring during these peak hours is very similar to the percentages found at other residential developments. Thus, traffic flows at mobile home parks can have significant impacts on local streets. The times of the Saturday and Sunday peak hours vary among the sites.

Trip Rates

A summary of the trip rates for pertinent time periods is given in Table 13. Trip production and attraction at mobile home parks is significantly less than those observed at single-family detached housing developments and at subdivisions. In fact, trip rates at the surveyed parks are very similar to those found at apartments. A further similarity with most residential land uses is the fact that Saturday trip rates are slightly higher than and Sunday rates are slightly lower than the average weekday trip rates.

The recent edition of ITE's manual reports an average daily trip rate of 4.8 trips per occupied unit based on 29 sites having an average size of 208 units. The weighted average trip rate, which is comparable to the ITE's trip rate, developed in this study is 42% higher than the ITE's rate. The parks in this study contain an average of 105 units.

Table 13

Trip Rates: Mobile Home Parks

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Unit:</u>				
Average Weekday	6	5.3-10.4	6.8	7.2
P.M. Pk. Hr. Adjacent St.	6	0.5- 1.0	0.6	0.7
P.M. Pk. Hr. Generator	6	0.5- 1.1	0.7	0.7
Saturday	6	4.8-10.9	7.0	7.5
Sunday	6	4.9- 9.0	6.0	6.3

Day-Care Centers

Five day-care centers were surveyed, with the average attendance, the number of employees, and the gross floor area of the facility being obtained as descriptive parameters. This information, along with the location of the center, is given in Table 14. The centers did not operate on the weekend.

-1208

Table 14

Site Description: Day-Care Centers

<u>Site No.</u>	<u>Location</u>	<u>Average Attendance</u>	<u>No. Employees</u>	<u>GFA (1,000 sq. ft.)</u>
71	Richmond	80	12	6.0
72	Charlottesville	68	12	3.4
73	Richmond	100	16	6.0
74	Richmond	50	7	2.8
75	Reston	75	9	5.3

Note: 1,000 sq. ft. = 93 sq. m.

Traffic Patterns

The traffic pattern occurs as predicted, given the operational characteristics of day-care centers; that is, children are dropped off and picked up in conjunction with the morning and afternoon work trips. Accordingly, peak hours of traffic flow fall within the traditional rush hours and generally coincide with or fall close to the times of the peak hours on the adjacent street. Further, a relatively large percentage of the trips at day-care centers occur during this period. Thus, day-care centers can cause a significant impact on the local street.

Trip Rates

The trip rates for selected time periods for the various descriptive parameters are presented in Table 15. The variable that appears to best explain the trip making is average student attendance. The weekday average of 5.0 also seems logical as 4 trip ends are required for a child to be dropped off in the morning and picked up in the afternoon. The 1.0 additional trip end can then account for employee arrival and departure, for transporting some of the children to local elementary schools, and for other miscellaneous trips. Since proposed day-care centers would most likely have an associated anticipated enrollment or maximum enrollment based on facility design, it appears that a forecast of trips based on the number of students would provide the best results.

A review of available literature uncovered no other estimates of trip rates at day-care centers.

Table 15

Trip Rates: Day-Care Centers

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Average Attendance:</u>				
Average Weekday	5	4.1- 7.1	5.0	5.2
P.M. Pk. Hr. Adjacent St.	5	0.6- 1.7	0.9	1.0
P.M. Pk. Hr. Generator	5	0.8- 1.7	1.0	1.0
<u>Trips per Employee:</u>				
Average Weekday	5	25.6- 50.4	33.2	35.9
P.M. Pk. Hr. Adjacent St.	5	4.1- 12.3	6.0	6.8
P.M. Pk. Hr. Generator	5	4.6- 12.3	6.6	7.3
<u>Trips per 1,000 Sq. ft. GFA:</u>				
Average Weekday	5	57.2-126.1	79.1	85.3
P.M. Pk. Hr. Adjacent St.	5	8.1- 30.7	14.4	16.3
P.M. Pk. Hr. Generator	5	11.0- 30.7	15.7	17.3

Note: 1,000 sq. ft. = 93 sq. m.

Churches

Four churches, ranging in size from 500 members to 1,700 members, were surveyed. Along with church membership, estimates of the number of families and the gross floor area of the facility were obtained as descriptive parameters. The land use characteristics are given in Table 16. It is noted that 3 of the churches provide nursery or day-care service during all or some of the weekday mornings.

12001

Table 16

Site Description: Churches

<u>Site No.</u>	<u>Location</u>	<u>No. Members</u>	<u>No. Families</u>	<u>GFA (1,000 Sq. Ft.)</u>	<u>Nursery School</u>
81	Lynchburg	500	200	20.4	Yes
82	Richmond	1,350	550	49.2	Yes
83	Richmond	1,200	250	19.6	No
84	Richmond	1,700	600	14.4	Yes

Note: 1,000 sq. ft. = 93 sq. m.

Traffic Patterns

As expected, traffic flows at churches peak around a few major events; e.g., Sunday services, a weeknight service, and the nursery or day-care school. Generally, a very large percentage of the trips occur during the a.m. and p.m. peak hours at a site. Further, peak traffic flow at churches does not fall within the traditional rush hours; in fact, a very small percentage of church traffic occurs in the 7 to 9 a.m. and 4 to 6 p.m. periods. Thus, based on the sites surveyed, traffic attracted to churches probably results in very few negative impacts. Possible exceptions are short-term periods occurring around a major event at the church, in particular, Sunday morning services.

Trip Rates

The trip rates based on the various descriptive parameters and for selected key time periods are given in Table 17. As expected, the trip rates for all parameters are larger on Sunday than on any other days. Also, trip making is concentrated on Sunday morning, as evidenced by the relatively high trip rates during Sunday's peak hour.

Based on the sites surveyed, considerable variability occurs in the trip-making characteristics at churches for all land use characteristics. An investigation of the literature uncovered an estimate of 30 trips per 1,000 sq. ft. (93 sq. m.) per weekday and 90/1,000 sq. ft. (93 sq. m.) on Sundays or days of assembly. These statistics are not supported by the findings of this study.

Table 17

Trip Rates: Churches

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per 100 Members:</u>				
Average Weekday	4	7.3- 40.6	16.7	20.6
P.M. Pk. Hr. Adjacent St.	4	0.2- 1.5	0.7	0.8
P.M. Pk. Hr. Generator	4	1.4- 5.6	2.4	2.9
Sunday	4	41.3-117.8	68.2	75.5
Pk. Hr. Generator (Sun.)	4	10.7- 34.4	18.1	20.6
<u>Trips per Family:</u>				
Average Weekday	4	0.3- 1.0	0.5	0.6
P.M. Pk. Hr. Adjacent St.	4	0.0- 0.0	0	0
P.M. Pk. Hr. Generator	4	0.1- 0.1	0.1	0.1
Sunday	4	1.8- 2.9	2.0	2.2
Pk. Hr. Generator (Sun.)	4	0.4- 0.9	0.5	0.6
<u>Trips per 1,000 sq. ft. GFA:</u>				
Average Weekday	4	4.4- 12.8	7.7	8.4
P.M. Pk. Hr. Adjacent St.	4	0.2- 0.4	0.3	0.3
P.M. Pk. Hr. Generator	4	0.8- 2.1	1.1	1.3
Sunday	4	21.6- 75.7	31.3	37.9
Pk. Hr. Generator (Sun.)	4	6.0- 18.5	8.3	9.9

Note: 1,000 sq. ft. = 93 sq. m.

Suburban Motels

Five suburban motels were surveyed. Information on the location, number of employees, number of rooms, and number of occupied rooms, where available, is given in Table 18. All the motels are members of national chains and have restaurants, bars, and convention/banquet facilities.

Table 18

Site Description: Suburban Motels

Site No.	Location	No. Employees	No. Rooms	Occupied Rooms		
				Weekday	Sat.	Sun.
91	Lynchburg	87	124	71	48	33
92	Lynchburg	100	260	--	N/A	--
93	Roanoke	135	149	140	77	47
94	Charlottesville	60	100	--	N/A	--
95	Salem	80	120	107	58	47

Traffic Patterns

Weekday traffic generally follows the work trip pattern; that is, peak hours in the morning and afternoon fall within the traditional rush hour times. Peak-hour volumes, however, represent a relatively small percentage of the daily volumes, which tends to lessen the potential negative impact on local streets. Saturday and Sunday peak-hour times vary widely among the surveyed sites.

Trip Rates

Trip rate information is given in Table 19. Rates based on the number of employees decrease slightly on Saturday and significantly on Sunday. Since the number of employees, the divisor, is assumed constant, then these changes in rates are also representative of the changes in traffic flow. On the other hand, because of a significant reduction in occupancy on the weekends, trip rates based on the number of occupied rooms increase for both Saturday and Sunday. These facts suggest an influx of local traffic to the motels on the weekend, most likely occasioned by persons patronizing the restaurant and bar facilities. Thus, if 100% occupancy occurred on the weekends, especially Saturday, peak traffic at motels could occur on the weekends.

The motels surveyed in this study more closely fit the ITE's definition of a hotel in that "sleeping accommodations, restaurants, cocktail lounges, meeting and banquet rooms or convention facilities" are provided. A motel is defined by the ITE as offering only sleeping accommodations and possibly a restaurant. The daily rates for hotels reported by the ITE of 11.3 per employee and 10.5 per occupied room are reasonably close to the rates observed in this study. It is noted that

the weekend volumes and rates described above do not agree with the ITE data.

Table 19

Trip Rates: Suburban Motels

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Employee</u>				
Average weekday	5	8.9-24.5	14.4	14.1
P.M. Pk. Hr. Adjacent St.	5	0.5- 1.7	0.9	0.9
P.M. Pk. Hr. Generator	5	0.7- 1.8	1.2	1.2
Saturday	5	8.6-17.2	12.2	12.6
Sunday	5	5.2-11.4	7.5	7.6
<u>Trips per Occupied Room</u>				
Average weekday	3	10.1-15.4	11.5	12.0
P.M. Pk. Hr. Adjacent St.	3	0.6- 0.9	0.7	0.7
P.M. Pk. Hr. Generator	3	0.8- 1.6	1.0	1.1
Saturday	3	13.1-23.7	16.7	17.3
Sunday	3	13.5-15.1	14.5	14.5

Post Offices

Five post offices were surveyed, three of them branch offices. Information concerning gross floor area, number of employees, and the number of mailboxes at each post office was obtained and is given in Table 20. Each of the post offices had two basic types of entrance, one for customers and one for employees and mail delivery operations. Counts were not taken at the employee entrance at site no. 104 because its design did not enable the use of automatic traffic recorders.

Table 20

Site Description: Post Offices

<u>Site No.</u>	<u>Location</u>	<u>GFA (1,000 sq. ft.)</u>	<u>No. Employees</u>	<u>No. Boxes</u>	<u>Classification</u>
101	Lynchburg	113.0	278	793	Main
102	Charlottesville	84.6	303	1,349	Main
103	Richmond	9.5	34	622	Branch
104	Richmond	14.0	86	1,825	Branch
105	Richmond	9.5	48	533	Branch

Note: 1,000 sq. ft. = 93 sq. m.

Traffic Patterns

Peak traffic flow varied considerably at the post offices surveyed; however, several general observations can be made. The beginning of the weekday morning peak hour occurs within the 7 to 9 a.m. period at 3 of the 5 sites, whereas the beginning of the afternoon peak hour occurs within the 4 to 6 p.m. period at 4 of the 5 sites. The volumes during the morning and afternoon peak hours average 9% and 10%, respectively, of the sites' daily traffic. Thus, post offices do have a significant impact on the adjacent street network. Weekend volumes are considerably less than weekday volumes.

In the majority of instances, peak hours on Saturday and Sunday occur around noon, with peak-hour volumes generally being lower than the weekday peak-hour volumes.

Trip Rates

Trip rate information is presented in Table 21. The trip rates are based on total traffic at the post office, with the rates at site no. 104 being estimated based on a comparison of traffic volumes at the employee/delivery and customer entrances at sites 103 and 105. At branch post offices, an average of 87% of the daily trips are by customers. For the one main office where customer trips and employee/delivery trips can be separated, 78% of the daily trips are by customers. During periods of peak traffic flow at both classifications of post office, the percentage of customer trips is generally larger than the daily percentages cited above.

70

The best descriptive parameter is the number of individual postal boxes at the post office, as trip rates for all 5 sites are reasonably close. Trip rates based on the number of employees and the gross floor area vary considerably among the facilities. Due to operational characteristics, the number of employees and the gross floor area at main post offices are considerably higher than at branch post offices. This fact results in trip rates that also differ significantly. Thus, there is less variability in trip rates based on these parameters when main and branch post offices are separated. This categorization is shown in Table 21.

The most current edition of ITE's manual provides trip rate data for 1 post office in the San Francisco Bay Area. For this facility, which has 200 employees and a gross floor area of 36,000 sq. ft. (3,344 sq. m.), reported trip rates are 139.7 and 11.36 trips per 1,000 sq. ft. (93 sq. m.) of gross floor area for the average day and p.m. peak hour, respectively. Comparable trip rates per employee are 25.1 and 2.04. While these rates fall within the ranges observed at all 5 sites surveyed in this study, they fall between the ranges observed when the sites are separated into main and branch post offices.

Table 21

Trip Rates: Post Offices

<u>Statistic</u>	<u>Sample Size</u>	<u>Range</u>	<u>Weighted Average</u>	<u>Arithmetic Average</u>
<u>Trips per Post Office</u>				
<u>Lockbox:</u>				
Average Weekday	5	2.3- 6.3	3.8	4.6
P.M. Pk. Hr. Adjacent St.	5	0.1- 0.7	0.3	0.4
P.M. Pk. Hr. Generator	5	0.2- 0.7	0.4	0.5
<u>Trips per Employee</u>				
<u>(Main):</u>				
Average Weekday	2	13.3- 14.5	13.9	13.9
P.M. Pk. Hr. Adjacent St.	2	0.9- 1.3	1.1	1.1
P.M. Pk. Hr. Generator	2	1.0- 1.5	1.2	1.2
<u>Trips per Employee</u>				
<u>(Branch):</u>				
Average Weekday	3	49.0-111.5	67.6	76.8
P.M. Pk. Hr. Adjacent St.	3	2.9- 12.2	5.0	6.2
P.M. Pk. Hr. Generator	3	4.9- 12.7	7.2	8.3
<u>Trips per 1000 sq. ft. GFA</u>				
<u>(Main):</u>				
Average Weekday	2	35.6- 47.7	40.8	41.7
P.M. Pk. Hr. Adjacent St.	2	3.2- 3.3	3.3	3.2
P.M. Pk. Hr. Generator	2	3.5- 3.8	3.7	3.7
<u>Trips per 1000 sq. ft. GFA</u>				
<u>(Branch):</u>				
Average Weekday	3	301.0-399.1	344.0	350.8
P.M. Pk. Hr. Adjacent St.	3	18.3- 43.6	25.8	26.9
P.M. Pk. Hr. Generator	3	30.6- 45.4	36.7	37.6

Note: 1,000 sq. ft. = 93 sq. m.

SUMMARY AND CONCLUSIONS

This section of the report highlights the findings and presents conclusions regarding trip rates at the surveyed land uses. The trip rates for the average weekday, for the p.m. peak hour of the site, and for the adjacent street peak hour between 4 and 6 p.m. for all surveyed land uses are given in Table 22. The ITE reports weighted averages;

therefore, unless otherwise noted, weighted averages are also used in this section.

Table 22

Summary of Trip Rates

Weekday Vehicle Trip Ends

<u>Land Use</u>	<u>Average Weekday</u>	<u>P.M. Peak Hour Generator</u>	<u>P.M. Peak Hour Adjacent St.</u>
Fast-Food Restaurant with Drive-Thru Service	22/seat 51/employee 680/1,000 sq. ft. GFA	2.9/seat 6.7/employee 92/1,000 sq. ft. GFA	0.9/seat 2.0/employee 28/1,000 sq. ft. GFA
Convenience Market ^{1,2}	730/1,000 sq. ft. GFA	53/1,000 sq. ft. GFA	50/1,000 sq. ft. GFA
Condominium (all types) ¹	5.2/d.u.	0.5/d.u.	0.5/d.u.
Condominium (townhouse style with minimum or no transit service)	8.7/d.u.	0.9/d.u.	0.8/d.u.
Condominium (apartment style in high rise with good transit service)	4.2/d.u.	0.4/d.u.	0.4/d.u.
Drive-In Bank ¹	80/employee 290/1,000 sq. ft. GFA	12/employee 43/1,000 sq. ft. GFA	8.1/employee 31/1,000 sq. ft. GFA
High-Rise Apartment ¹	4.3/d.u.	0.4/d.u.	0.4/d.u.
PUD ¹	7.8/d.u.	0.7/d.u.	0.7/d.u.
Mobile Home Park ¹	5.0/d.u.	0.6/d.u.	0.6/d.u.

Table 22 (continued)

<u>Land Use</u>	<u>Average Weekday</u>	<u>P.M. Peak Hour Generator</u>	<u>P.M. Peak Hour Adjacent St.</u>
Day-Care Center	5.0/student ³ 33/employee 79/1,000 sq. ft. GFA	1.0/student ³ 6.6/employee 16/1,000 sq. ft. GFA	0.9/student ³ 6.0/employee 14/1,000 sq. ft. GFA
Church ⁴	17/100 members 0.5/family 7.7/1,000 sq. ft. GFA	2.4/100 members 0.1/family 1.1/1,000 sq. ft. GFA	0.7/100 members 0.0/family 0.3/1,000 sq. ft. GFA
Suburban Motel ^{1,5} ("hotel" by ITE definition)	13/employee 11/occupied rm.	0.9/employee 0.9/occupied rm.	0.6/employee 0.7/occupied rm.
Post Office Post Office (Main) ⁶	3.8/p.o. lockbox 14/employee 41/1,000 sq. ft. GFA	0.4/p.o. lockbox 1.2/employee 3.7/1,000 sq. ft. GFA	0.3/p.o. lockbox 1.1/employee 3.3/1,000 sq. ft. GFA
Post Office (Branch) ⁶	68/employee 340/1,000 sq. ft. GFA	7.2/employee 37/1,000 sq. ft. GFA	5.0/employee 26/1,000 sq. ft. GFA

1. Rates are combination of rates reported by the ITE and those found in this study.
2. A.M. peak hour rates are 65 and 63 per 1,000 sq. ft. GFA for generator and adjacent street, respectively.
3. Average number of students attending.
4. Sunday trip rates are 68/100 members, 2.0/family, and 31/1,000 sq. ft. GFA; Sunday's peak-hour trip rates are 18/100 members, 0.5/family, and 8.3/1,000 sq. ft. GFA.
5. Limited data suggest a Saturday rate of 17/occupied room.
6. Based on limited data.

Note: 1,000 sq. ft. = 93 sq. m.

Fast-Food Restaurants with Drive-Thru Service

Weekday peak traffic flow occurs during the lunch hours, with a relatively large percentage of the daily traffic being in the p.m. peak hour, which occurs right after the noon hour. Traffic increases around the supper hours; however, the evening peak tends to be on the fringe of the rush period; i.e., after 6:00 p.m. Compared to the weekday, weekend traffic is slightly higher on Saturday and slightly lower on Sunday, with a tendency on both days for the peak-hour traffic volume to be a smaller percentage of the daily volume.

Trip rates calculated on the basis of the seating capacity, number of employees, and gross floor area vary among the sites; however, rounded average rates are listed in Table 22. These rates seem consistent with findings in the literature; that is, the lower rates reported by the ITE are not identified specifically with restaurants having the drive-thru service.

Convenience Markets

Weekday peak traffic flows at convenience markets generally coincide with the morning and afternoon rush hours, with the a.m. volume being slightly higher than the p.m. volume. Daily traffic volumes are generally maintained throughout the weekend.

Trip rates based on gross floor area and the number of employees vary considerably, and there is reason to believe that neither is a particularly accurate predictor of travel. The trip rates reported by the ITE have been combined with the results of this study to develop the rates shown in Table 22. Thus, the rates are an average of 7 sites. A footnote to the table gives the rates for the morning peak hours which are higher than the afternoon rates. The ITE does not report rates based on the number of employees; therefore, Table 22 does not report these rates due to the limited sample size and aforementioned inaccuracy.

Condominiums

Traffic patterns at condominiums resemble those found at all residential developments. Trip rates, however, differ considerably. Based on all 11 sites surveyed, trip rates are approximately 50% of those found at subdivisions, and the rates compare very favorably with the weighted averages reported by the ITE. The weighted average is influenced by the low trip rates found at 4 of the sites, which contain

76% of the total number of dwelling units. These 4 sites contain apartment style units -- i.e., the living space is on a single level -- which are located in multilevel structures. Further, 3 of the 4 sites are located in a transit-oriented area and are served by transit. On the other hand, the other 7 sites contain townhouse style units -- i.e., the living space is on several levels -- located in buildings containing from 2 to 6 units. None of the sites are located within transit-oriented areas and receive minimum, if any, transit service. Thus, although the data are limited, it appears that condominiums exhibiting the above characteristics should be distinguished from condominiums in general. This has been done in Table 22, and it can be seen that the trip rates are significantly different.

Drive-In Banks

Weekday peak traffic at drive-in banks generally occurs around lunch; however, there is significant traffic during the afternoon rush hours. Saturday traffic is less than weekday traffic due to shorter hours of opening; however, peak-hour traffic tends to be higher than that on weekdays.

Trip rates calculated on the basis of gross floor area and the number of employees exhibit a wide range of variability. Weighted average trip rates found in this study are significantly higher than those reported by the ITE. Compared to the average floor area and number of employees of the 4 banks on which the ITE rates are based, the sites surveyed in this study are all smaller. Thus, in order to increase the validity of the data base, the information from the ITE and this study have been combined and reported in Table 22.

High-Rise Apartments

Traffic flows at high-rise apartments also parallel those at other residential developments. Trip rates are similar to those at high-rise condominiums and are approximately 50% those of single-family detached complexes. Trip rates in this study are reasonably close to those reported by the ITE, and they have been combined in Table 22 to improve the data base.

Planned Unit Developments

Traffic patterns at PUDs are governed by the predominant land use, viz., residential, and are similar to those found at all residential developments. Trip rates seem to vary depending on the mix of land uses within the PUD; however, the weighted average rates found in this study

are essentially the same as those reported by the ITE. In order to improve the data base, the 2 sets of information were combined to produce the rates in Table 22. If information on the land use mix is known, consideration should be given to modifying the average rates in the table based on the rates found in this study and reported earlier.

Mobile Home Parks

Traffic patterns at mobile home parks are similar to those found at all residential developments, but trip rates are significantly less than those found at subdivisions. The rates in this study are significantly higher than those reported by the ITE; however, the sites in this study contain an average of 105 units, as compared to the ITE's average site size of 208 units. In order to provide the best data base, therefore, data were combined to develop the rates shown in Table 22.

Day-Care Centers

Weekday traffic at day-care centers is heaviest during both the morning and afternoon rush hours, with the a.m. and p.m. peak hour each having approximately the same percentage of the daily traffic. Traffic in the two peak hours combined account for approximately 40% of the daily volume.

Average trip rates based on average attendance, number of employees, and gross floor area are given in Table 22. The average number of students attending seems to provide the best prediction of travel, as the trip rates based on the gross floor area and number of employees are more variable.

Churches

Traffic flow at churches peaks during the scheduled events occurring throughout the week. During the week, traffic flow is highest around the hours of a nursery or day-care operation or a weekday service. There is very little traffic during the weekday rush hours. Peak traffic occurs on Sunday during the morning services.

Trip rates based on membership and gross floor area vary considerably, and the averages are given in Table 22. Weekday travel is approximately 25% of Sunday travel, with volumes in the peak hour on Sunday averaging approximately the same or slightly more than the average weekday volumes. Trip rates for Sunday are included in a footnote to Table 22.

1220

Suburban Motels

During the week, peak traffic flows generally occur during the rush hours. Compared to the average weekday volume, the Saturday volume is down slightly while the Sunday volume is down by approximately 50%.

Trip rates calculated on the basis of the number of occupied rooms and the number of employees are presented in Table 22. The rates were developed by combining data from this study and the ITE. The data suggest that if room occupancy is high on the weekend, especially Saturday, then traffic volumes may be higher on the weekend than during the week. A Saturday rate based on 3 sites is provided in a footnote to Table 22.

Post Offices

Weekday travel at post offices tend to peak during the rush hours, and weekend volumes drop significantly.

Trip rates based on the number of postal boxes seem to provide the most consistent estimate of travel at all post offices. Rates based on gross floor area or the number of employees vary considerably; in fact, the differences are so great that it is advantageous to group post offices into branch offices and main offices. When post offices are thus categorized, the range of trip rates for a given period in each group is reduced and is considerably different from the range in the other group. Even though the data base is very limited, categorization seems to be logical and warranted, and thus is shown in Table 22.

RECOMMENDATION

While it is recognized that engineering judgment must be used in forecasting traffic at proposed land developments, it is recommended that engineers within the Department generally use the vehicle trip rates developed in this report to forecast travel at the listed land uses.

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1234

720

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1234