SUBURBAN TRIP GENERATION AND SOME NOTIONS ABOUT CHANGING TRAFFIC PATTERNS

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INTRODUCTION

Trip generation rates are estimates of the number of vehicles or persons entering or leaving a particular site during a specified time period, usually a peak hour or a whole day. In recent years trip generation rates have taken on new significance as they increasingly are used to produce estimates of the impact of new development projects on transportation infrastructure. With rapidly accelerating public concern about suburban congestion and intense development pressures, many jurisdictions are implementing impact fees and development caps, as well as, in the case of Montgomery County, Maryland, adequate public facilities ordinances. These policies impose controls on the timing of development and thus on the pace of demand for roads, schools, and sewers spawned by development. Trip generation rates are a cornerstone in such programs. Because of the stakes involved--the economic stimulation provided by new development balanced against increasing traffic congestion-- the validity of current trip generation rates has been attacked at various times by developers, planners, and neighborhood residents during the public review of proposed developments.

The Maryland-National Capital Park and Planning Commission (M-NCPPC) commissioned a comprehensive study of trip generation rates to improve the database for their development approval process. The results are documented in the recently released Montgomery County Trip Generation Rate Study (1) * prepared by Douglas & Douglas, Inc. In addition to measuring trip generation rates, the study examined a number of characteristics of suburban development related to traffic and travel behavior. This paper summarizes the study findings and draws inferences about suburban traffic patterns and the relationship of the transportation system and associated land uses.

Montgomery County, Maryland, located adjacent to Washington, D.C. with about 700,000 residents, is characterized by substantially higher than average income levels (1987 U.S. Census Bureau data rank it among the five wealthiest counties in the nation in per capita income) and by intensifying development in suburban centers. Evidence is increasing that in many locations in the U.S. the suburban transportation systems and the land use development pattern are not well synchronized either in time or in space. To address this issue, M-NCPPC has developed one of the nation's most sophisticated and comprehensive planning processes. Long term growth and infrastructure requirements are set through a comprehensive growth policy process. Annual growth policy reviews compare the development pipeline and the infrastructure pipeline to determine if adjustments must be made in the amount of development to be approved in the coming year.

Increasing complexity of the planning process and concerns expressed by developers, prompted M-NCPPC to implement a comprehensive survey of trips generated by four major land uses in Montgomery County. The purpose of this study was to determine if trip generation rates developed from analyses of Montgomery County development sites would produce vehicle trip estimates that fit Montgomery County conditions better than do nationally-derived rates.

The study surveyed the number of trips made to and from a total of 162 sites: 79 commercial office buildings, 59 residential sites, 15 shopping centers and 9 fast food restaurants. The specific major objectives of this study were to:

- o Collect a reliable set of weekday peak hour data for office buildings, shopping centers, fast food restaurants, and residential land uses;
- o Determine the variation in trip rates for developments which appear to be similar in size and type;
- o Explain the sources of variation in trips; and
- o Recommend a method for incorporating these new data in the methods used to estimate trips.

For many years the principal source of vehicle trip generation information nationally has been the Institute of Transportation Engineers' (ITE) report entitled Trip Generation. When this study began, the 3rd Edition of Trip Generation was in use in Montgomery County (2). During the course of the study, the ITE released their 4th Edition of Trip Generation (3). That publication changed the methods used to calculate trips; the new method uses regression equations to provide more accurate estimates of trip ends. The scope of the study was expanded, therefore, to answer two new questions: 1) how well do 4th Edition equations fit Montgomery County data, and 2) should the data and techniques in the 4th Edition be incorporated in the Montgomery County local area review process? This paper summarizes a number of the findings of this study and provides some tentative answers.

SUMMARY OF THE TRIP GENERATION RATE STUDY FINDINGS

The principal questions posed in the Montgomery County Trip Generation Rate study were: 1) should vehicle trip estimates for Montgomery County development projects be based on locally-collected data, and 2) which characteristics of proposed development should be used to estimate vehicle trips? This research clearly established that locally-derived trip estimates were preferable to those calculated from national data for estimating vehicle trips in Montgomery County. While the equations suggested for use by the study were based on traditional relationships between trips and development, several significant modifications to account for variations due to changes in type and location of development were also developed.

The results of the analysis were compared with the trip rates presented in the ITE 3rd and 4th Editions of Trip Generation. A summary of this comparison is shown in Table 1. The degree of correspondence between the Montgomery County rates and other rates varies by land use type. For example, the Montgomery County average trip rates for general offices were lower than those in the ITE 4th Edition and were much lower than the 3rd Edition rates. The shopping center statistics for Montgomery County, on the other hand, are much higher than those reported in the ITE reports. In this case, "much higher" and "much lower" refer to differences of plus or minus 35% to 45% respectively. The ranges shown reflect differences in AM and PM rates as well as differences for different size categories of building.

In Table 1 we classify single-family residential and high- rise apartment average trip rates as being about the same as the ITE rates. This means that they vary by less than 15% above or below the ITE rates. With respect to the remaining residential categories surveyed, garden apartment and townhouse trip rates were found to be lower by 25% to 30% than the corresponding rates reported by the ITE.

We concluded that the differences in rates between the Montgomery County and the ITE data were large enough to suggest that Montgomery County data be used to calculate trip volumes in the local area review process. The statistical analysis also shows a better fit of the data with regression lines derived in this study than with the ITE curves.

Another question with great interest to local governments is the extent of risk taken by approving sites using the selected trip generation rates or equations based on averages of many buildings. Historically, trip generation rates have been based on the average number of trips generated by the observed sample sites. According to the rules of statistics and as observed in practice, an estimate based on the average or mean value will estimate trip volumes lower than the actual observations in half the cases. The critical questions then are by how much will the actual traffic be underestimated and what will be the impact on the transportation system? In other words, what is the risk taken by the jurisdiction in using the average trip generation rates to estimate the size of transportation facilities needed for the future? The results of the analysis of the trip data collected at the selected sites in Montgomery County plus some tentative answers to the questions raised above are presented in the following sections.

SUBURBAN OFFICE TRIP GENERATION

Trips generated by office uses represent one of the most important components of peak hour and peak period traffic congestion. With the change in the traditional role of suburbs from bedroom community to major employment location, work trips to suburban offices have become an ever-larger component of the total peak period traffic. Driveways were surveyed at 79 office buildings of different sizes and at different locations within Montgomery County during the Fall of 1986 and the Spring of 1987. The distribution of the office sites was randomly selected from an inventory of more than 600 office buildings and is shown in

This study specifically excluded data collected at trip generators located within 2,500 feet of a Metrorail station, as sites within 2,500 feet were surveyed as part of a companion study (4). The most interesting contrast between the Montgomery County and ITE trip equations was that:

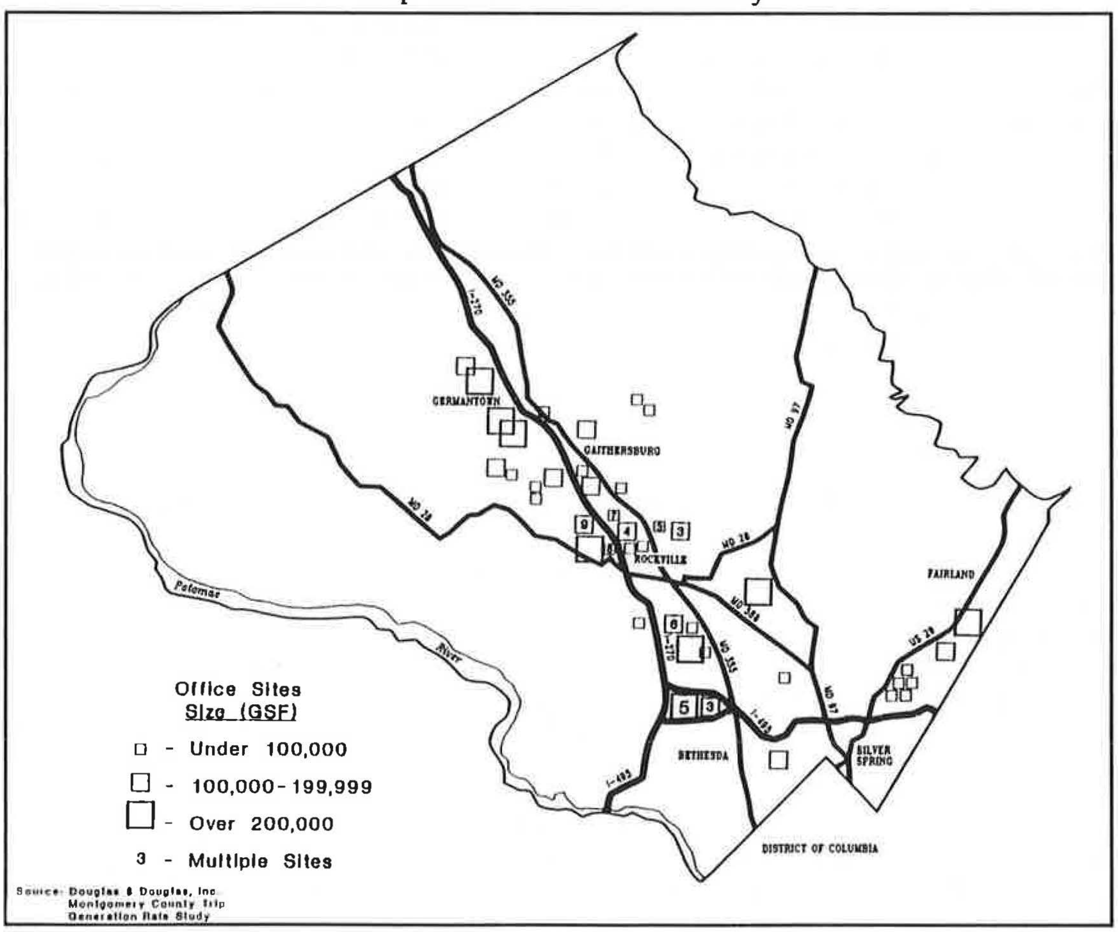
- o In every case, the trip rates in the ITE 3rd Edition were higher than the average trip rates found either in the 4th Edition or predicted by the Montgomery County equations;

- o As may be seen in Figure 2, the ITE 4th Edition equation and the Montgomery County equation for the mean value agreed rather closely for the PM generator peak hour. In the afternoon peak hour the curves crossed at points where the building size was rather large (575,000 square feet). Thus the ITE equations will estimate more trips in buildings below that size than will the Montgomery County equation. The ITE equations estimate far more trips during the adjacent street peak hour than do the Montgomery County equations;

- o Commuters to Montgomery County offices generally travelled alone - only 10% of the vehicles contained more than one person; and

- o As building size increased, the average number of trips per thousand square feet of gross floor area decreased.

Figure 1.
Office Building Sites Surveyed for
Trip Generation Rate Study



Source: Douglas & Douglas, Inc. Montgomery County Trip Generation Rate Study

Table 1

Comparison of Montgomery County Average Trip Generation Rates with ITE 3rd and 4th Edition Trip Rates

Land Use	Peak	Montgomery County Average versus ITE 4th Edition	Montgomery County Average versus ITE 3rd Edition
General Office	AM	lower/same (-30% to +14%)	much lower (-34% to -41%)
	PM	lower/same (-17% to +6%)	much lower (-37% to -97%)
Retail	PM	much higher (+22% to +46%)	much higher (+22% to +39%)
Fast Food Restaurant	AM	much lower (-45% to -55%)	N/A
	PM	same (0% to +20%)	same (-8%)
Single Family Residences	AM	same (+4% to -10%)	same (-7%)
	PM	same (-7% to -8%)	same (-12%)
Garden Apts/Townhouses	AM	lower (-23% to -28%)	lower (-26%)
	PM	lower (-29% to -31%)	lower (-28%)
High Rise Apartments	AM	same (+10% to -1%)	same (-7%)
	PM	same/lower (-10% to -16%)	same (-15%)

Source: Douglas & Douglas, Inc.

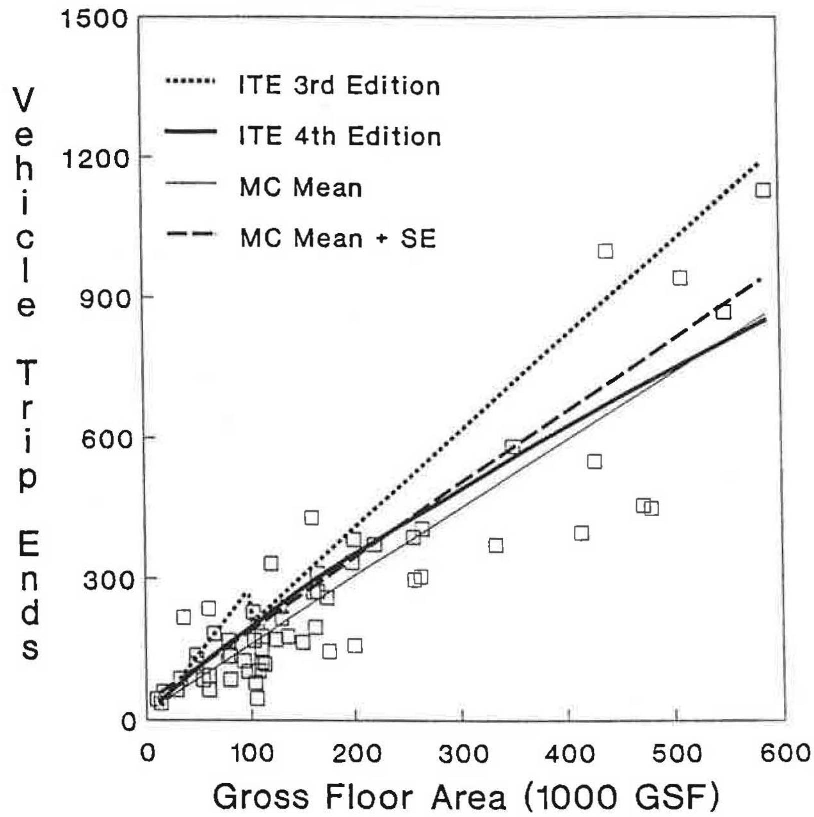
In addition to the central questions about which equations to use, the study also delved into important questions about suburban travel behavior. Because there were few organized carpool, vanpool or other transportation demand management actions taking place at the sites studied, the data may be used as a baseline for assessing the effectiveness of future actions. The trip generation rates observed in Montgomery County during this study reflect the results of limited transit accessibility, free parking with few if any restrictions on availability, and a gasoline price structure varying between 95 cents and $1.10 per gallon for regular unleaded gasoline (Fall of 1986 to Fall of 1987).

As is clear in Figure 2, the ITE 3rd Edition line has a much steeper slope than either the 4th Edition or the Montgomery County equation line. During the afternoon generator peak hour (i.e., the peak hour of the land use development under study) the Montgomery County data would estimate 25% fewer trips than the ITE 3rd Edition still used by many jurisdictions. For the adjacent street peak hours the 3rd Edition estimates were 44% higher than the Montgomery County data in the morning, and 60% higher in the afternoon.

Among the buildings larger than 300,000 gross square feet there was a wide variation in the number of trips for building sites of equivalent size. Note that for buildings of 400,000 gross square feet it is possible to have one site with twice as many PM peak hour trips as a site of similar size (See Figure 2).

The large sites with high trip rates (more than 400,000 gross square feet and more than 800 vehicle trip ends) were all occupied by single corporate tenants. The four sites between 400,000 and 500,000 gross square feet in size with trips below the average line were multi-tenant buildings.

Figure 2.
General Office (ITE 7-10)
Average Vehicle Trip Ends
Generator PM Peak Hour



SOURCES OF VARIATION IN OFFICE TRIP RATES

One of the most interesting aspects of the trip generation rate study was the analysis of variation in the number of trips generated by office sites of similar size and superficially similar characteristics. Characteristics which can be measured and/or controlled are of particular importance when jurisdictions make development control decisions. M-NCPPC was concerned about variations in trip rates due to location within the County, transit service availability, flexible uses, peak spreading, and changes in vehicle occupancy. The following sections summarize the research into these and related topics.

IMPACT OF MIXED USE LOCATIONS ON OFFICE TRIP RATES

The National Cooperative Highway Research Program (NCHRP) sponsored and has just published the results of a major study of trips generated at mixed-use developments performed by JHK & Associates (5). Figure 3 is a repeat of Figure 2 with the addition of PM peak hour trip data from Bellevue, Washington, one of the sites studied in the NCHRP project. While the results are not conclusive, the plot is intriguing. For buildings with fewer than 300,000 gross square feet, the buildings in the Bellevue, Washington mixed- used development appear to have trip rates quite similar to Montgomery County office buildings. There is no ready explanation for the behavior of the occupants of the four structures larger than 300,000 gross square feet although one of those buildings is occupied by a tenant who has implemented an aggressive ridesharing program. It will be remembered that the Montgomery County buildings in this study did not have significant ridesharing or other TDM activities in place during the survey. Although much of this is inferential, it does suggest that research is necessary to distinguish any change in office building vehicle trip generation rates due to being located in a mixed-used development from the change in trip generation rates due to changes in tenant behavior, transportation demand management programs and other activities which are independent from the location of a building and the composition of its neighbors.

TRIP RATES FOR OFFICES NEAR METRORAIL STATIONS

Transportation planners are often asked to project the impact of transit on the number of vehicle trips likely to result from proposed new buildings near transit facilities. One approach to this question is to analyze trip rate data for offices located within walking distance of Metrorail stations and compare them with trip rate data collected at offices located farther away. We had the opportunity to do this because data on trip rates for buildings situated within 2,500 feet of Metrorail stations had been collected by JHK & Associates in the Spring and Fall of 1986 for an M- NCPPC study entitled Post-Metrorail Transportation Characteristics Study (4), and we, in turn, collected data only for buildings located farther than 2,500 feet from Metrorail stations during this research.

The Post-Metrorail study measured trip rates at twenty buildings located within Metrorail walksheds in Montgomery County. Twelve sites were located in the walksheds of stations inside the Beltway (I-495)--Bethesda, Friendship Heights and Silver Spring. The remaining eight sites were located near three Metrorail stations located outside the Beltway--Twinbrook, White Flint and Rockville.

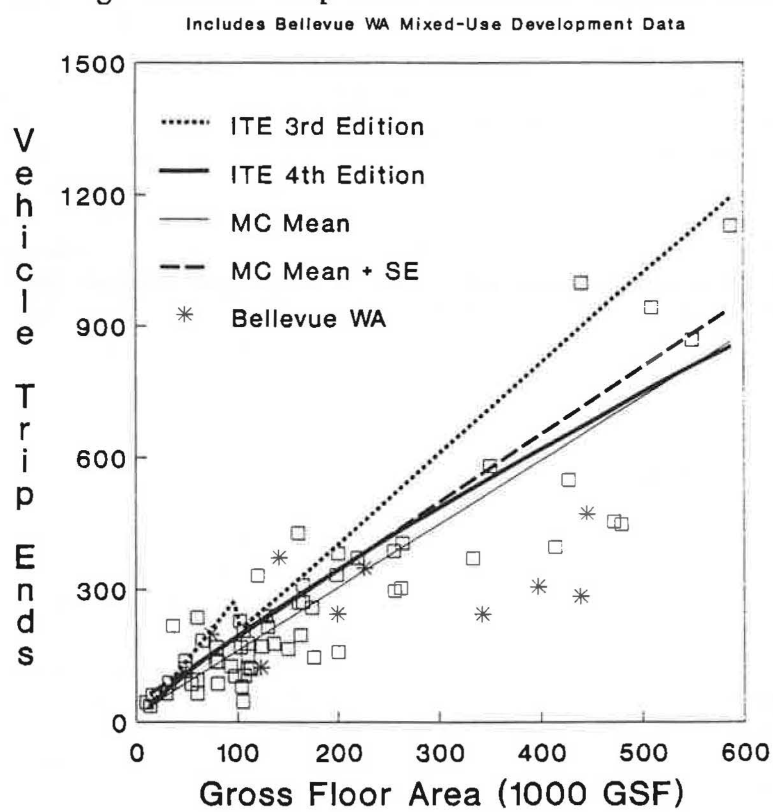
We constructed regression equations using the JHK data, and compared the results with our data. This analysis yielded some interesting findings:

- o During the PM peak hour, the average number of vehicle trips generated by office buildings located near Metrorail stations equaled the average number of trips generated by office buildings located throughout the rest of Montgomery County.

- o During the AM peak hour, the average number of vehicle trips generated by office buildings located near Metrorail stations was much lower (by approximately 50% to 60%) than the average number of trips generated by office buildings located throughout the rest of Montgomery County.

- o At stations located inside the Beltway, there appeared to be no strong or statistically significant relationship between the numbers of AM or PM peak hour vehicle trips generated by office buildings and their distances from Metrorail facilities.

Figure 3.
General Office (ITE 710)
Average Vehicle Trip Ends Generator PM Peak Hour



- At stations located <u>outside</u> the Beltway, the numbers of AM and PM peak hour trips generated by office buildings increased with distance from Metrorail facilities and in the PM peak hour exceeded the County-wide trip rates beyond a distance of 1,500- 1,600 feet from the station. (The precise distance varied according to building size since smaller buildings have slightly lower vehicular trip rates than do larger buildings.)

Possible explanations for these surprising findings include: a more efficient use of floor space at offices close to Metrorail facilities (which may result from higher rent structures typical near the stations); differences in tenant mix between offices which lead to higher employee densities and/or more visitors at office buildings near rail facilities; and differences in work hours with offices near Metrorail starting later, perhaps after the end of the survey time. The presence of a Metrorail station has a significant influence on vehicle trip rates, but this influence varied with the location of the station, the distance to the station, and the size of the office building. The interplay of these variables is seen in Figures 4 and 5. For stations located inside the Beltway Figure 4, only one curve is shown; the number of vehicle trips varied by the size of the building but not by distance from the station. In Figure 5, the range of vehicle trip estimates as a function of distance from the Metrorail station is shown by the shaded area. For any given building size, the number of trips generated by a site located at the station is estimated by the lower edge of the shaded area. For a building located 2,500 feet from a station, the number of trips is given by the upper edge of the shaded area. The trip estimates for buildings located 1,250 feet from the station are indicated by a dashed (---) line.

The data for the morning peak hour indicate clearly that buildings in station walksheds generated fewer trips than those outside the walkshed. Offices located within the station walkshed generated fewer AM peak hour trips than did non-station walkshed offices for all station locations, all distances and all building sizes.

The pattern of trips generated by offices within the Metrorail walkshed during the PM peak hour resembled that at offices throughout the County. At stations located inside the Beltway (See Figure 4) the number of vehicle trips generated was almost identical to those estimated by the general equation (1.7) for buildings located in other parts of the county. For stations outside the Beltway (See Figure 5) buildings located fewer than 1,500 to 1,600 feet from the station generated fewer trips than the County average. However, buildings located beyond that distance generated more trips than the general equation (1.7) would estimate. From the data presented above, we concluded that for offices located near Metrorail stations outside the Beltway, the vehicular trip rate estimate should reflect the distance of the office from the station. For offices located at stations inside the Beltway, a reduction in trip estimates is given for the morning peak hour but no reduction in vehicle trip estimates for the PM peak period hour. In both cases, the change in trip estimates is independent of the distance from the station.

Although there are no data to provide evidence, it does seem possible that the impact of the Metrorail stations on locations inside the Beltway was less related to distance from the station because of the greater "pedestrianization" of development around those stations. Silver Spring, Bethesda and Friendship Heights are all inner suburbs with CBD's approximating those of small cities. Sidewalks are ubiquitous and numerous traffic signals provide for pedestrian crossings. Offices located in the newer suburbs at stations located outside the Beltway have a less-friendly pedestrian environment with narrow sidewalks (in some cases no sidewalks), higher vehicular speeds on the adjacent streets, and limited crossing locations.

THE IMPACT OF AGE AND TIME ON TRIP RATES

Any person preparing forecasts of traffic is interested in whether trip rates are constant over the life of a building. To attack this problem, one can do a time-series analysis or a cross-sectional analysis. The cross-sectional analysis is not a substitute for the time-series analysis, but the benefit is that data are available at one time. The time- series analysis is limited by a number of factors including availability of data, consistency of analysis and data collection techniques, and availability of descriptive data from the past. In this study, both approaches were used as described below.

There were some time-series data available to examine trends in trip rates generated by office buildings within the County. Prior-year data had been collected for three sites in 1976 by the Maryland State Highway Administration (SHA) and for five sites in 1981 for M-NCPPC. Average trip rates were calculated from these counts collected by other consulting firms. There was a long list of caveats, however, in using and interpreting these data. Principal problems revolved around differences in data collection techniques used by a variety of earlier consultants and a lack of reporting of some data such as building occupancy rates and occupied gross floor areas.

TEN-YEAR TREND

The statistics for the three buildings surveyed in 1976 and 1986/7 showed a significant (-23% to -60%) decrease in generator peak hour rates during the intervening 10 years. In general, the decline was greater when we compared adjacent street peak hour data (-36% to -87%) rather than generator peak hour data. Additional confounding factors included low employment densities at two of the sites, one of which was emptying-out prior to being sold soon after the data were collected.

FIVE-YEAR TREND

Changes in the trip rates measured at five sites in 1981 and again in 1986/7 showed an almost entirely different pattern from the three 1976 to 1986 surveys. The peak hour trip rates in 1986/7 were usually larger than for the same building in 1981, sometimes by wide margins (i.e. 50%-95% or more). We had no information regarding site characteristics to explain this phenomenon. The 1986/7 rate for one of the buildings represented the average for three surveys over a two month period covering different days of the week. The range of rates over the two months for that building were anywhere from +/- 5% to +/-19% depending on the peak hour in question. This range was insignificant compared with the 50% to 90% increases in average values since 1981. Thus, it is difficult to imagine that the differences are the result of daily or seasonal changes in travel behavior. A more likely explanation is that the tenant population had changed significantly and/or space utilization had increased as firms matured. Unfortunately, data from earlier surveys which could be used to test these possibilities were not available.

Figure 4
General Office (ITE 710)
Average Vehicle Trip Ends at Buildings

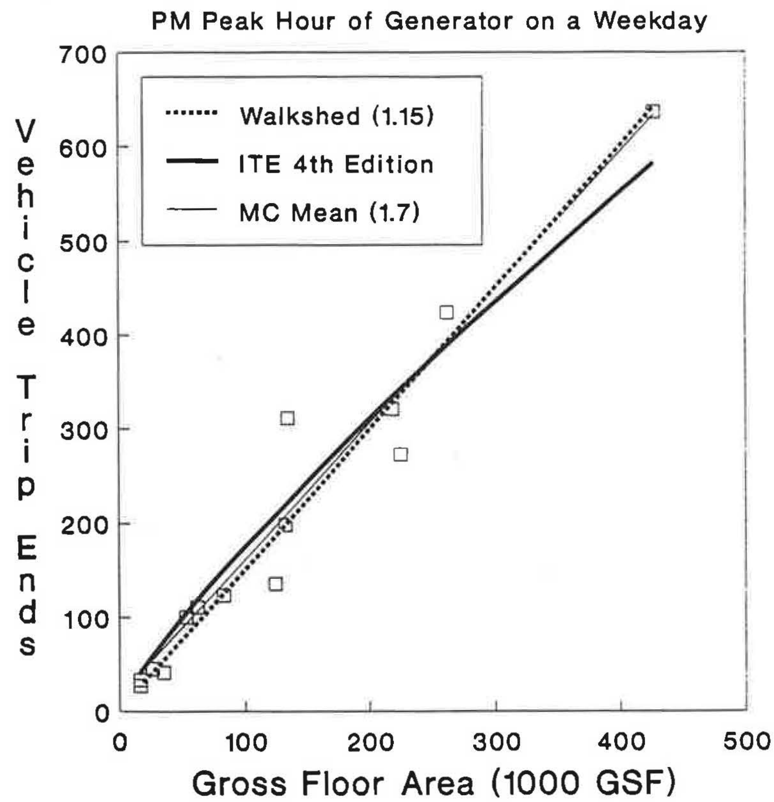
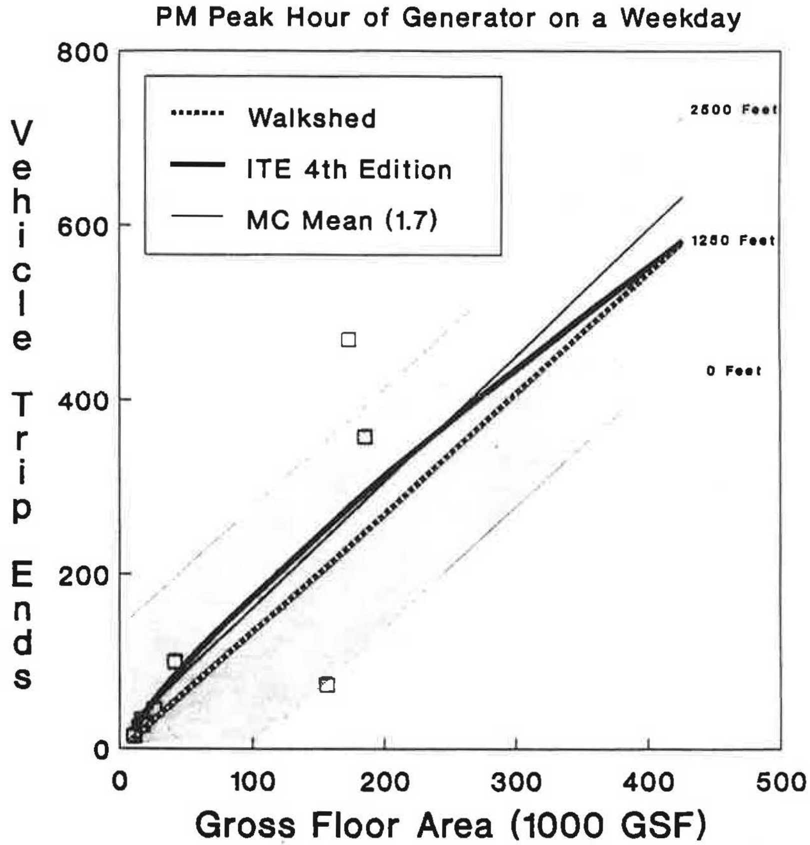


Figure 5.
General Office (ITE 710)
Average Vehicle Trip Ends at Buildings
In Metrorail Walkshed (Outside Beltway)



TRIP RATES AS A FUNCTION OF OFFICE BUILDING AGE

Unlike the time-series analysis from the preceding section, the following is a cross-sectional analysis of trip rates among buildings of different ages during the same year -- 1986/7. The data collected in 1986/7 could be used effectively as the baseline for future time-series analysis; five years from now M-NCPPC could collect data at the same building sites to determine how trip rates have changed through the buildings' life cycles. The results of the analysis are shown in Figures 6 and 7. Figure 6 covers buildings under 100,000 gross square feet in size, and Figure 7 covers buildings over 100,000 gross square feet. Buildings under 100,000 gross square feet showed a much higher utilization in the 11th through the 21st year than the buildings which were less than 10 years old. Buildings which were under 10 years old had trip rates at or below the average (about 1.8 trips per thousand gross square feet). Buildings that were between 10 and 21+ years of age had trip generation rates considerably higher than the average (mean) but not as high as one standard deviation above the mean, which is approximately 3.2 trips per thousand square feet. For the office buildings between 100,000 and 200,000 gross square feet, the buildings that were 3 to 5 years old had higher trip rates than buildings in other age categories.

While not conclusive, the variations in trips as a function of building age and the trends in office trip rates in the time-series data do indicate that buildings of a similar size and seemingly similar use can produce different trip rates. The variation was as high as one standard deviation from the average value for the County. This information further demonstrates the dynamic nature of trip generation which cannot only vary from day to day but from year to year for the same building or group of buildings. Further research as to how trip rates and individual sites vary over time seems appropriate.

PEAK SPREADING

Evidence for peak spreading is available if we compare the percentage of trips to and from sites during the two-hour peak period that occurred during the adjacent street's peak hour with the percentage of trips that occurred during the site's (generator's) own peak hour. These percentages are presented in Table 2. The consistently higher percentages for the generator peak hour tell us that while the generator peak and the adjacent street peak might overlap, they did not correspond exactly. This perhaps indicates that, in many cases, individual driver's decisions or office policies are working to distribute trips away from the adjacent street peak hour to just slightly before or after it. We can expect that if traffic congestion were to increase further, the percentages for the generator peak hour would also decrease towards 50%. An important consequence of this peak spreading phenomenon is the limited capacity for furtherreduction in peak hour congestion without measures which increase vehicle occupancy (e.g., carpools, vanpools, bus use, etc.).

AUTO OCCUPANCY

From the auto occupancy rates collected in the surveys, it appears that neither traffic congestion nor parking problems have a major impact on commuters' desire to carpool to Montgomery County offices. A 1984 Trip Generation Study for Prince George's County (a county adjacent to Montgomery County) reported that 60% of the buildings surveyed had auto occupancy rates over 1.2 persons per vehicle and one building had an auto occupancy rate of 1.3 (6). In the study reported in this paper (1), auto occupancy averaged only 1.1 persons per vehicle. In the Montgomery County AM peak hour, more than 65% of all sites had auto occupancy rates at or below 1.1, and only 3.3% had an occupancy rate greater than 1.2. At many sites, 90% or more of the vehicles had the driver as the sole occupant. The high average income levels in Montgomery County relative to neighboring Prince George's County may account for some of this difference insofar as more Montgomery County households own a car for each worker. Lower auto occupancy may also reflect the high levels of employment in service industries in Montgomery County: many employees drive company-provided cars, and so travel alone since the office is just one stop on a tour of service calls made during the day. (A sizable number of the buildings surveyed were occupied by computer-related service companies.) More research is needed to probe this possibility further.

THE IMPACT OF LOCATION IN DEVELOPMENT CLUSTERS ON TRIP RATES

A question central to the local area review process is whether the total trips generated by a group of buildings located in the same area will approach the total expected number of trips based on the average rates for each building.

In other words, will there be a number of buildings with lower than average trip rates to offset those which have higher than average trip rates? This notion was examined for three groups of buildings located in the I-270 development corridor in North Bethesda and Gaithersburg. The results of the analysis indicated that indeed the equation for average trip rates developed from the Montgomery County data gave a good estimate of the total trips from all buildings in the cluster. The trip estimates for individual buildings within the clusters varied from an underestimation of 55% to an overestimation of 100%. But the number of trips estimated for each of the three building complexes varied from the observed number of trips by less than 20%. These findings indicate that the use of an average trip rate equation is appropriate for buildings which are built in clusters. However, the same analysis suggested that the use of an average trip rate equation may be inappropriate for trip estimates for large, isolated, single-tenant development projects, at least in Montgomery County.

Figure 6.
PM Peak Hour Trip Rates vs. Building Age
General Offices - Under 100,000 GSF

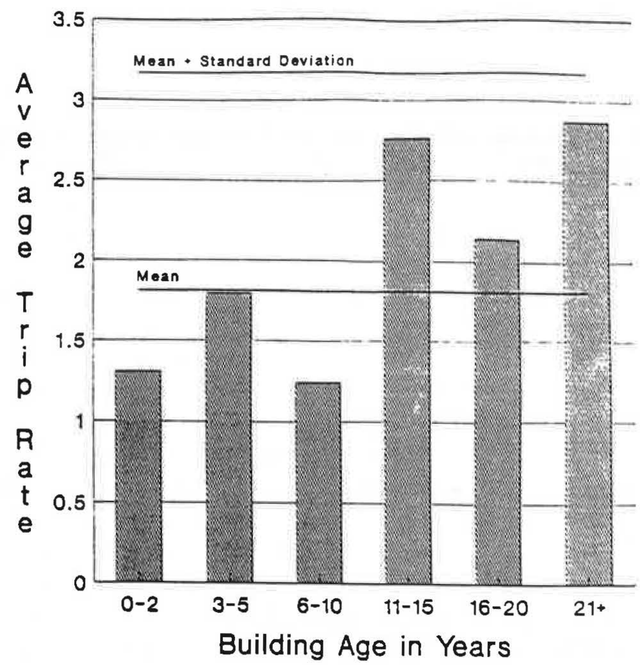
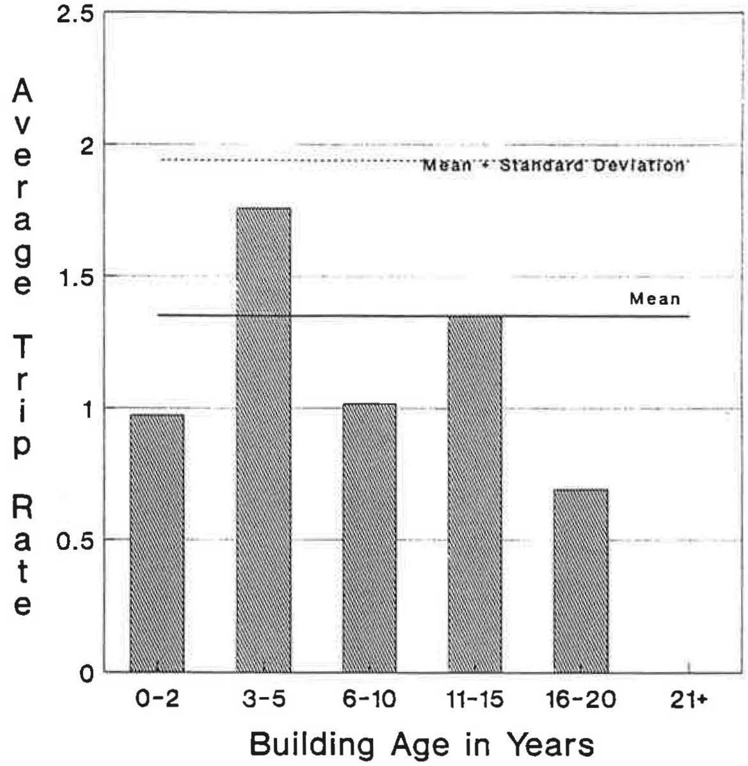


Figure 7.
PM Peak Hour Trip Rates vs. Building Age
Offices - 100,000-199,999 GSF



TRIPS GENERATED BY SHOPPING CENTERS

Trips generated by shopping centers with fewer than 200,000 gross square feet--termed neighborhood or subregional centers--gave surprising results when compared with ITE data as shown in Figure 8. The regression line for the Montgomery County data predicts considerably higher numbers of trips than the older 3rd Edition equations and even a greater increase (as much as 80% higher) compared to the 4th Edition equations. In Montgomery County this may result from the relatively high disposable incomes which may engender more shopping trips than typical of the country as a whole.

These results suggest that afternoon peak hour traffic congestion may be in part the result of an increase in non- work trips. These data tend to agree with research by Gordon et al. (7) which suggests that non-work trips are becoming an increasingly large share of total traffic. This has serious implications on the possible success of HOV lanes, carpools and other traffic management devices which are aimed primarily at the commuter commutation trip. More success in trip reduction can be achieved by changing the clustering of land uses.

TABLE 2

PEAK SPREADING

Percentage of Peak Period Trips (2-Hour)
Occurring in the Peak Hour

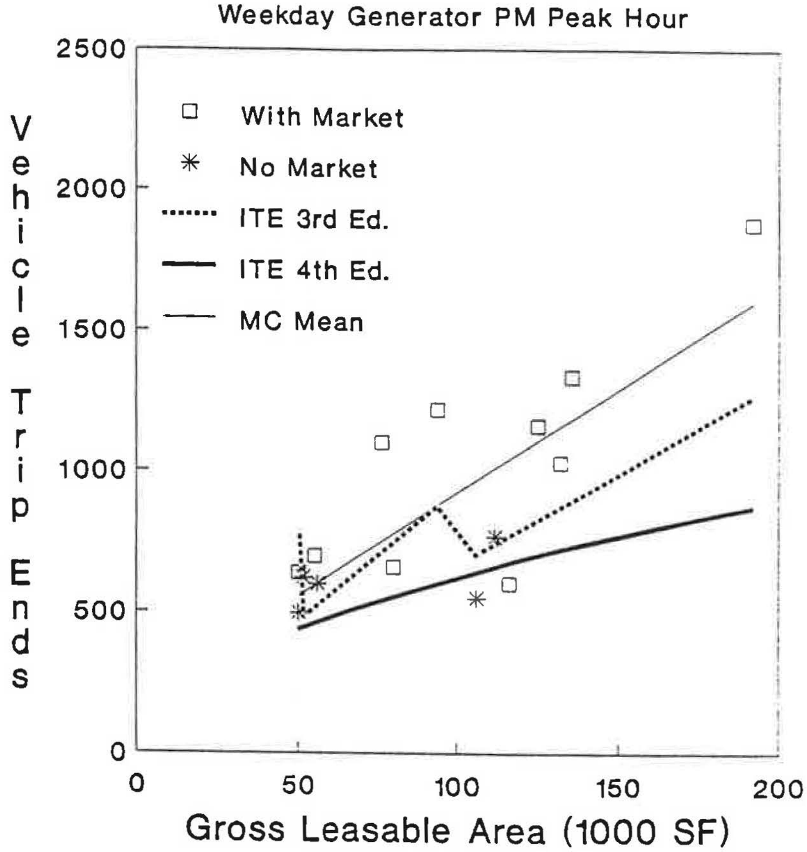
BUILDING SIZE (GSF)	ADJACENT STREET PEAK HOUR	
	AM	PM
BELOW 100,000 GSF	57.3%	52.5%
100,000 - 199,999 GSF	53.7%	54.0%
200,000 GSF AND OVER	49.9%	47.3%
	GENERATOR PEAK HOUR	
BELOW 100,000 GSF	69.7%	64.1%
100,000 - 199,999 GSF	64.5%	64.9%
200,000 GSF AND OVER	65.6%	63.7%

SOURCE: Douglas & Douglas, Inc.

SUMMARY OF SOURCES OF VARIATIONS IN OFFICE TRIP RATES

Our comparison of simultaneously-measured trip rates among buildings with similar characteristics coupled with an examination of time-series data lead logically to several notions about trip rates in general. It appears that changes in the utilization of interior spaces which are not apparent to the observer looking at the exterior of the building can have an impact on trip rates. Firms expand and contract their staffs to meet changing business conditions; this will, in its turn, alter trip rates. Changes in the mix of tenants will also be reflected in the trip rates. Increases in office rents may mean an increased number of trips as employment densities are increased to contain overhead costs. Finally it appears that, all other things being equal, peak hour trip rates for an individual building will vary inversely with local traffic congestion; as congestion increases, trip rates will decrease through peak spreading, increased auto occupancy and, where available, increased transit use.

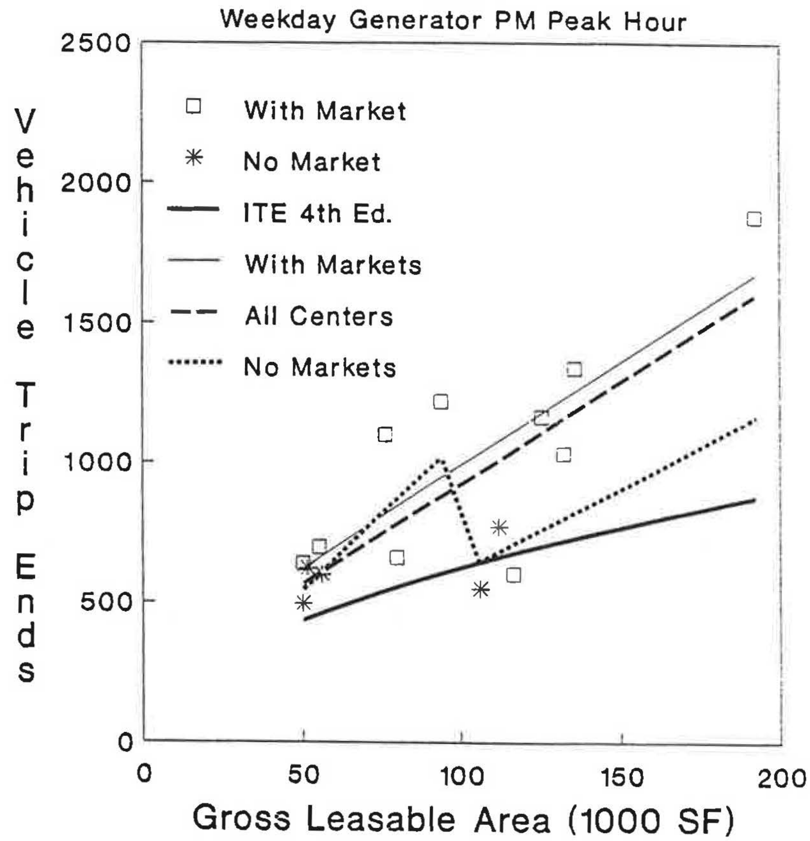
Figure 8.
Average Vehicle Trip Ends
for All Shopping Centers (ITE 820)
(Combined Sample)



IMPACT OF SUPERMARKETS ON RETAIL RATES

The Montgomery County research revealed that shopping centers with supermarkets generate considerably more trips than those without. As may be seen in Figure 9, the shopping centers without supermarkets generated some 30% fewer trips than those which had supermarkets. Not only do shopping centers with supermarkets generate more trips, but they also attract more primary trips. The percentage of pass-by trips (see next section) for shopping centers without supermarkets was found to be 40% while for shopping centers with supermarkets only 25%. This means then that effectively a shopping center with a supermarket has 60% more trips in the afternoon peak hour than a shopping center of equivalent size but without a supermarket.

Figure 9.
Average Vehicle Trip Ends
for Shopping Centers With and Without Supermarkets



PASS-BY TRIPS

Traffic engineers are interested in whether a trip end at a proposed development would represent a new vehicle on the highway system or just one stop in a longer tour such that the absence of the development would make no difference to the volume of traffic on the road system. In trip generation rate literature, trips are described as falling into the following three categories:

- Primary Trip - a trip made for a specific purpose in which the vehicle will return directly to the point of origin. An example is a shopping trip from home to store to home.

- Pass-by or Captured Trip - a trip made by a vehicle destined for some other location than the current stop on a tour which would have taken the vehicle past the site in question even if the stop were eliminated from the tour.

- Diverted Trip - a trip which is part of a sequence of stops or a tour but in which the vehicle was diverted from the path it would have followed had the site in question been eliminated from the tour.

An earlier study by Slade and Gorove (8) estimated shopping center primary trips as 35% of all traffic, pass-by trips at 25%, and diverted trips at 40% of the total traffic. This pass-by traffic percentage is roughly in agreement with our findings from a survey of shoppers at two small centers (50,000 gross leasable square feet or less) which contain supermarkets and at community centers (100,000 gross leasable square feet or more) without a supermarket. At the other shopping centers, we observed a range of capture rates from 15% to 65%, (more than twice that reported by Slade and Gorove). The most striking difference between their data and our observations was the percentage of trips diverted from another route--our average observed value of 19% is only one-half that reported by the earlier study.

The question of the rate of pass-by and diverted trips has taken on new relevance with the onset of development impact fees. Some argue that trips captured as pass-by traffic should not be assessed in the impact fee determination on the same basis as primary or diverted trips. There are others who argue that even diverted trips which are "already on the network" should be eliminated from impact fee assessment. The percentage of PM peak hour traffic captured from pass-by trips varies widely, even within one size category. In Montgomery County, the average pass-by trip rates for neighborhood shopping centers is roughly twice the pass-by trip rate for community centers.

The impact of the presence of a supermarket on pass-by trips is an intriguing phenomenon, particularly when combined with the supermarket influence on shopping center trip rates. Centers without supermarkets exhibited a higher percentage of pass-by trips than did centers of equivalent size which contained supermarkets. The effect was more pronounced for neighborhood centers (fewer than 100,000 square feet gross leasable area) because the supermarket represents a higher proportion of the total square footage. For these smaller centers, as many as 60% of the PM peak hour trips were pass- by trips if there was no supermarket. In the larger community centers, pass-by trips accounted for between 20% (with supermarket) and 27% (no supermarket), a significant but much smaller percentage.

On the presumption that primary trips and diverted trips represent "new" trips on the road or street adjacent to the shopping center, we examined their variation across the different sized centers. The proportion of these "new" trips, that was primary, as opposed to diverted, was fairly stable at 75% for centers with supermarkets and 63% for centers without. This suggests that trips to supermarkets are more likely to be primary trips and less likely to be diverted trips, a finding that agrees with our own sense of shopping patterns.

TRIPS GENERATED AT RESIDENTIAL SITES

Residential land uses fall into different categories; the principal division is between single-family detached housing and multi-family housing. Multi-family housing may further be subdivided into garden apartments, townhouses, low-rise apartments and high-rise apartments.

The trip generation equations derived from the Montgomery County data estimate trip volumes quite similar to those reported in the ITE 4th Edition for single-family detached housing. This is true for all time periods and for all sizes of developments up to 500 units. Among all the land uses surveyed in the Montgomery County Trip Generation Rate Study, the single-family detached housing category was the only one in which the ITE 3rd Edition and 4th Edition trip generation rates were almost identical.

It perhaps is not surprising that the single-family detached housing trip equations were similar to those developed on a nationwide basis by the ITE. It may be that single-family detached home dwellers across the country and through the last twenty years or so have had similar trip patterns because they have had analogous lifestyles (young suburban families raising children may be fairly similar across the country in terms of much of their travel behavior). Shrinkages in family size have probably been offset by increases in the number of workers per household. Consequently, the number of trips in the peak periods, which includes both work trips and non-work trips, appears to be similar in scale in Montgomery County and in the country as a whole.

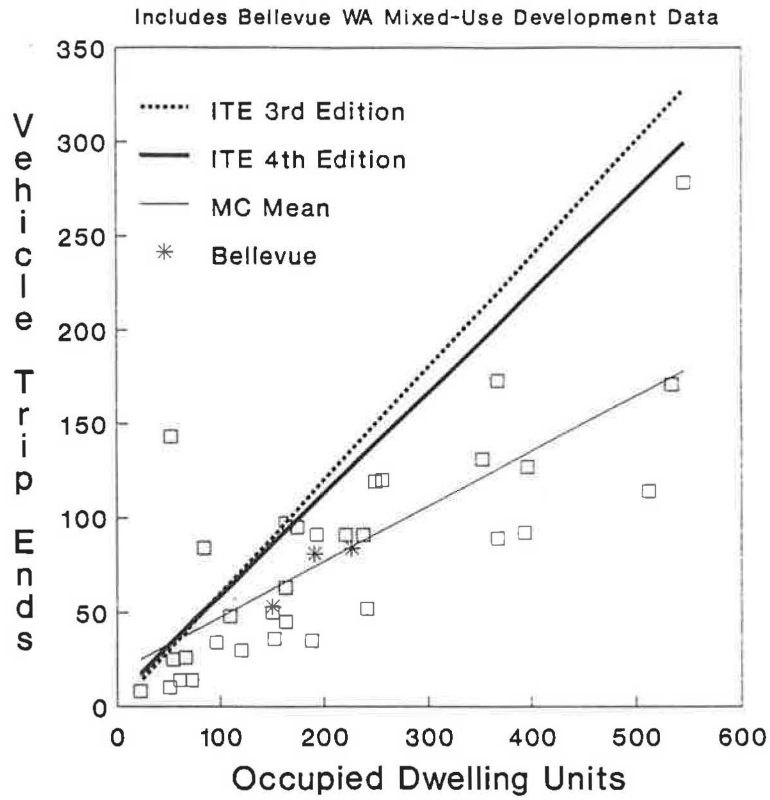
For multi-family dwelling units, mostly apartments in the Montgomery County sample, trip rates were 43% lower than the ITE 4th Edition rates as may be seen in Figure 10. The most intriguing question raised by the graph is whether residential dwelling units in a mixed use development have different characteristics from those in Montgomery County. In Figure 10, three points from Bellevue, Washington used in the NCHRP study (5) are superimposed on the Montgomery County data. The rates fall almost on the Montgomery County curve. This suggests that there may be more similarity between Bellevue, Washington and Montgomery County, Maryland and perhaps other suburban development areas than between these locations and the data in the ITE database. Possibly the difference could be explained by the age of the ITE data or because Bellevue, Washington and Montgomery County, Maryland have similar development characteristics. Comparison of the PM peak hour data gave similar results.

FAST FOOD RESTAURANT TRIP GENERATION

A survey of nine Montgomery County fast food restaurants produced some surprising results. The data collected suggest that customers have relatively little loyalty to particular restaurant chains, seem not to care whether there is a drive-through available, and are not attracted by the number of seats or parking spaces available. The same firm owned the restaurants with both the highest number of trip ends and the lowest number of trip ends in the peak hour. What appeared to affect trip rates at any one restaurant was the volume of traffic on nearby arterials and the density of urban development in the immediate area. Heavier traffic and denser development lead to higher peak hour trip rates.

One of the most intriguing statistics discovered in the research was the correlation between restaurant traffic and vehicular traffic on adjacent streets.

Figure 10.
Apartment Trip Ends
Includes Low-and High-Rise Buildings
AM peak Hour Trips vs Dwelling Units



Based on roadside volumes, the fast food restaurant peak hour traffic was found to be equivalent to 1.25% of the peak hour traffic on the adjacent roadway. The correlation had an r_2 of 0.75. One could speculate that if we wished to reduce traffic at fast food restaurants, we should insist they be located on roads and streets with low traffic volumes.

The presence or absence of a drive-through seemed to be of very little importance. It may be that drive-through windows have little impact on peak hour traffic because the service times are long (60 to 90 seconds). Consequently, the drive-through can only handle a small proportion of peak hour traffic. Drive-through facilities may be more important in the late evening or early morning when patrons are less willing to leave their cars.

STUDY SUMMARY

A major implication of the data and research in the Montgomery County Trip Generation Rate Study is that suburban travel patterns are changing. This certainly is proving true in Montgomery County and may be broadly applicable to growing, affluent suburban areas nationwide. In particular there appears to be more retail travel during the peak hours, particularly the afternoon peak period. One thousand feet of retail space generates six times as many trips as a thousand feet of office space. Even allowing for 1/3 or 32% pass-by trips, one thousand feet of retail space generates 3 1/2 times as much traffic (primary trips) as does office space.

In Montgomery County About 51% of the office trips made during the peak two-hour period occurred during the peak hour. This means that the peak period is relatively flat, and raises interesting questions about the possible effectiveness of transportation demand management actions. The peak spreading measured during the Trip Generation Rate Study at sites surveyed was essentially voluntary. Some employers offered flex-time and one employer had scheduled departure times but only because of parking lot and driveway problems. The data also suggested that given a choice, many employees chose to leave their work site on the shoulder rather than the center of the peak hour of the adjacent street traffic.

Locating offices near rail transit stations has a beneficial impact on overall transportation system performance. As many as 24% of the employees used transit for commuting to work. Thus, development at rail transit stations can accommodate significantly more employees for the same number of vehicle trips. Offsetting these gains in transportation system efficiency, however, was the finding that during the afternoon peak hour, vehicle trip rates were the same for buildings located at Metrorail stations as for those located beyond any available high speed transit service. It appears that employment densities increase at offices near transit stations, possibly because of higher rents.

The similarity of results from Bellevue, Washington and Montgomery County, Maryland raises questions about the need for additional research on the impact of clustering buildings with different uses in the same activity center. Such research should be focused on differentiating between the effects of the mixed-use development and possible changes through time since ITE data were collected. It further suggests the need for base-line data from land uses homogeneous as to age and type. Finally, it is quite possible that the primary benefits of mixed-use land developments will be to reduce total trips rather than through any significant change in peak hour travel. As a result there may be an overall reduction in daily vehicle miles of travel although it may not affect the peak hour traffic to any great extent.

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SUBURBAN TRAFFIC CONGESTION LAND USE AND TRANSPORTATION PLANNING ISSUES: PUBLIC POLICY OPTIONS

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INTRODUCTION

Traffic congestion has reemerged in the 1980's as a leading public concern. In metropolitan areas throughout the United States, reports about mounting traffic levels and daily tie-ups appear on a regular basis. Highway agencies and transit operators are castigated for failing to provide the facilities and services needed to assure a convenient commute. The agencies, in turn, point to funding cutbacks and escalating costs as barriers to action. Urbanists and demographers note that long-term trends toward decentralized development and increased participation in the work force have both contributed to congestion. Increasingly, angry citizens are blaming new development for the traffic problems and are pressuring local officials to either slow growth or find some other way to relieve the traffic loads.

Congestion problems are not, of course, a new phenomenon. For many decades, heavy traffic has been a fact of life in central business districts and on routes leading downtown. Today, however, in an increasing number of communities, the rush hour has become a two or three hour peak period, and congestion recurs mornings, midday, midevening, and on weekends as well. Heavy congestion is occurring in the suburbs as well as the city, both on local streets and on the circumferential highways that a decade ago provided for high speed travel.

The development of congestion in once-untroubled suburban locations has helped