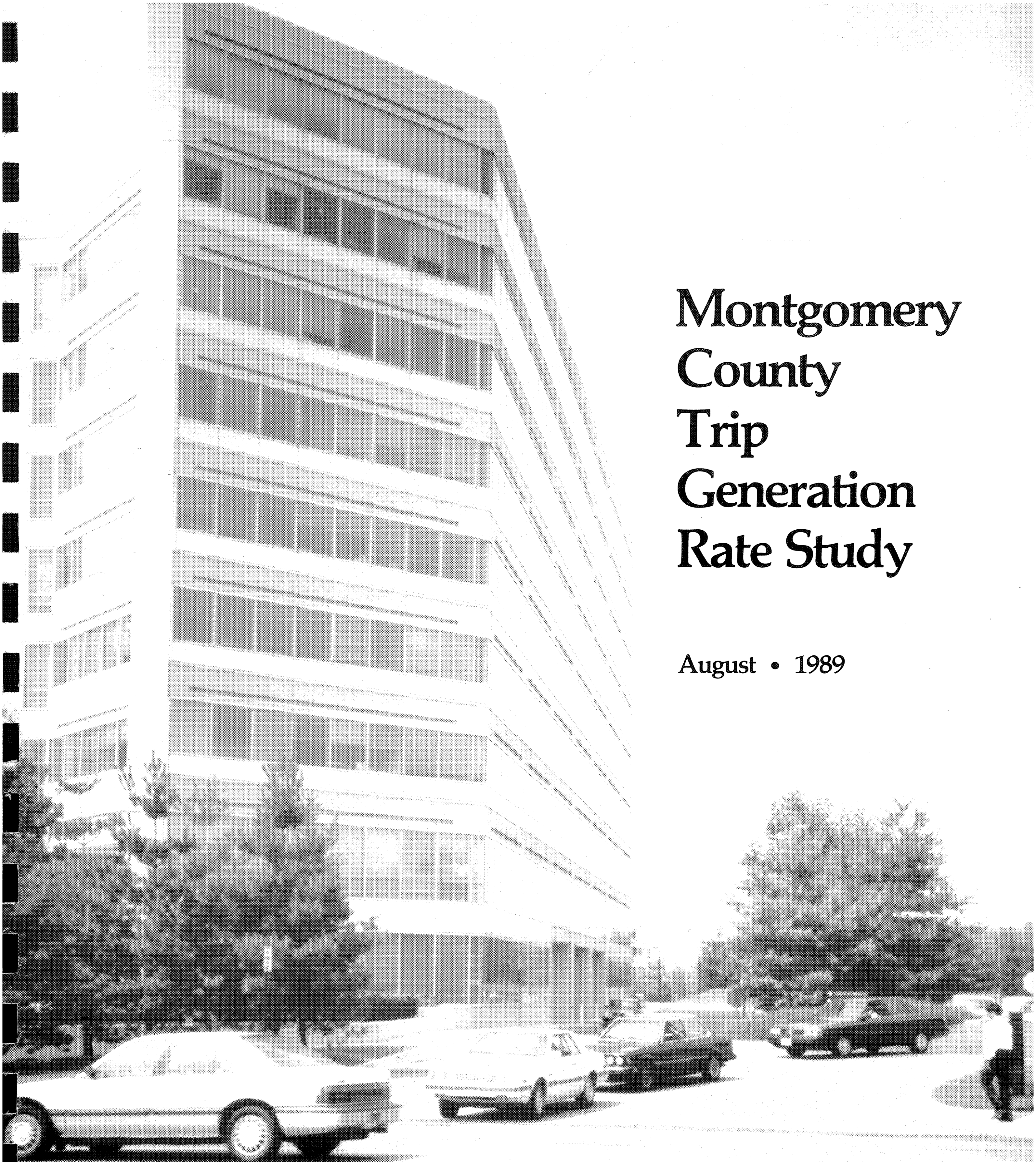


Montgomery County Trip Generation Rate Study

August • 1989

Prepared for:

Maryland-National Capital Park & Planning Commission

Prepared by:

Douglas & Douglas, Inc.

Memorandum

To: Rick Hawthorne
M-NCPPC

From: G. Bruce Douglas GBD
Douglas & Douglas, Inc.

Date: July 9, 1990

Subject: Revised Townhouse Data
Trip Generation Rate Study

We have processed the driveway count data you provided us through SPSS. For those sites with more than one set of counts we used the average values to avoid biased results.

The regression results are provided in Table 1. We have also included the full SPSS reports for your use. The "New Data" results include only data from the set provided by M-NCPPC. The "combined Data" results include DDI measurements for Burnt Mills Village, Survey 123 and Cherrywood, Survey 114.

Comparing results shows that the AM peak hour trip equations are quite similar to our earlier equation (4.35). Figure 1 shows the consistency in MC Data and the difference between MC and ITE trip estimates.

In the PM peak hour the new data indicate a larger number of trips (35/hour) than the previous equation. The increase falls almost completely in the constant term which means the impact on small developments is much greater than on large developments. For example, the new equation will estimate 70% more PM peak hour trips (83) for a development of 100 units than will the Low Rise apartment equation (Number 4.23) which estimates 48 trips. These same equations will give estimate which vary by only 16% (275 trips vs. 237 trips) for a development of 500 units. The shift in the PM peak hour curves is shown in Figure 2.

Comparing all the residential land uses in Figure 3, the new Townhouse curve is still parallel to the low-rise apartment curve but constantly above both the low-rise and previous townhouse curves. It would appear that the townhouse dweller's travel behavior is similar to single family trip making habits for the very small developments but more like apartment dweller behavior in the larger projects.

Conclusion:

The new data show a significant difference in estimates of PM peak hour trips made from the new equations and the Low Rise Apartment trip estimation equations, particularly for small townhouse developments. Because of these differences and the larger sized data base we suggest the use of a separate set of curves for townhouse developments which are based on townhouse data. The suggested equations are:

AM peak hour of Generator (4.35R)

T= 0.53(U) - 5 $\quad$ **$R^2 = 0.940$**

PM peak hour of Generator (4.19R)

T= 0.48 (U) + 35 $\quad$ **$R^2 = 0.916$**

The Difference in estimated trip ends from the Low Rise equations estimates will be as shown in Table 2.

Table 1

Regression equations for Total Trips Generated by Townhouse Development in Montgomery County

<u>AM Peak Hour of Generator</u>		
New Data	T=0.53U - 4.82	R^2=0.940
Combined Data	T=0.54U + 1.62	R^2=0.936
MC Mean(4.35)	T=0.56U - 16.34	R^2=0.249
Low Rise Apt (4.19)	T=0.40U + 3.26	R^2=0.798
<u>PM Peak Hour of Generator</u>		
New Data	T=0.48U + 34.78	R^2=0.916
Combined Data	T=0.46U + 40.89	R^2=0.902
MC Mean(4.39)	T=0.45U	
Low Rise Apt (4.23)	T=0.47U + 1.43	R^2=0.759

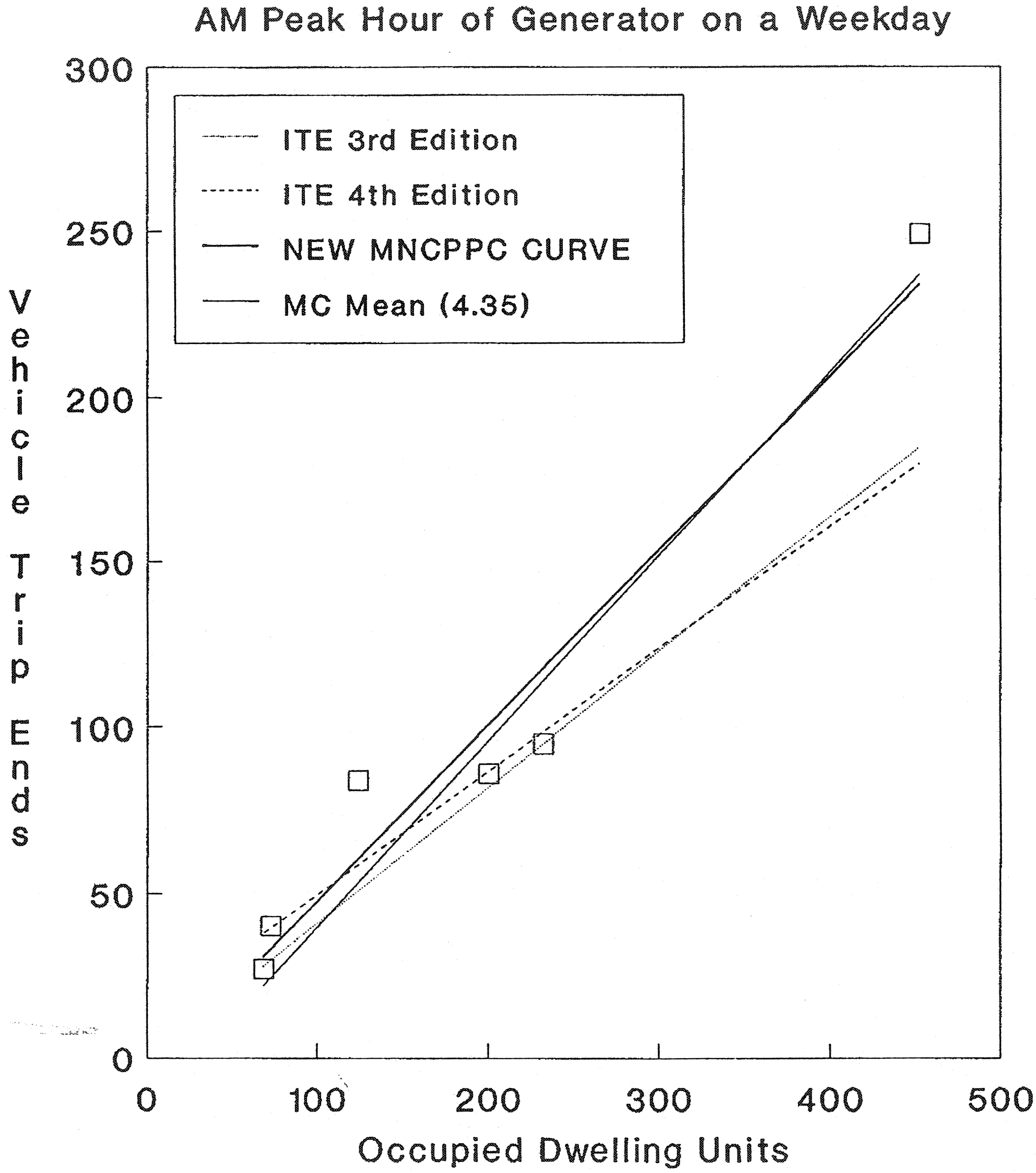
T = 2 way Trip Ends
U = Number of Occupied Dwelling Units

Source : M-NCPPC, JHK Assoc., Douglas & Douglas, Inc.

Table 2.
Comparative Estimate of Peak Hour Trips

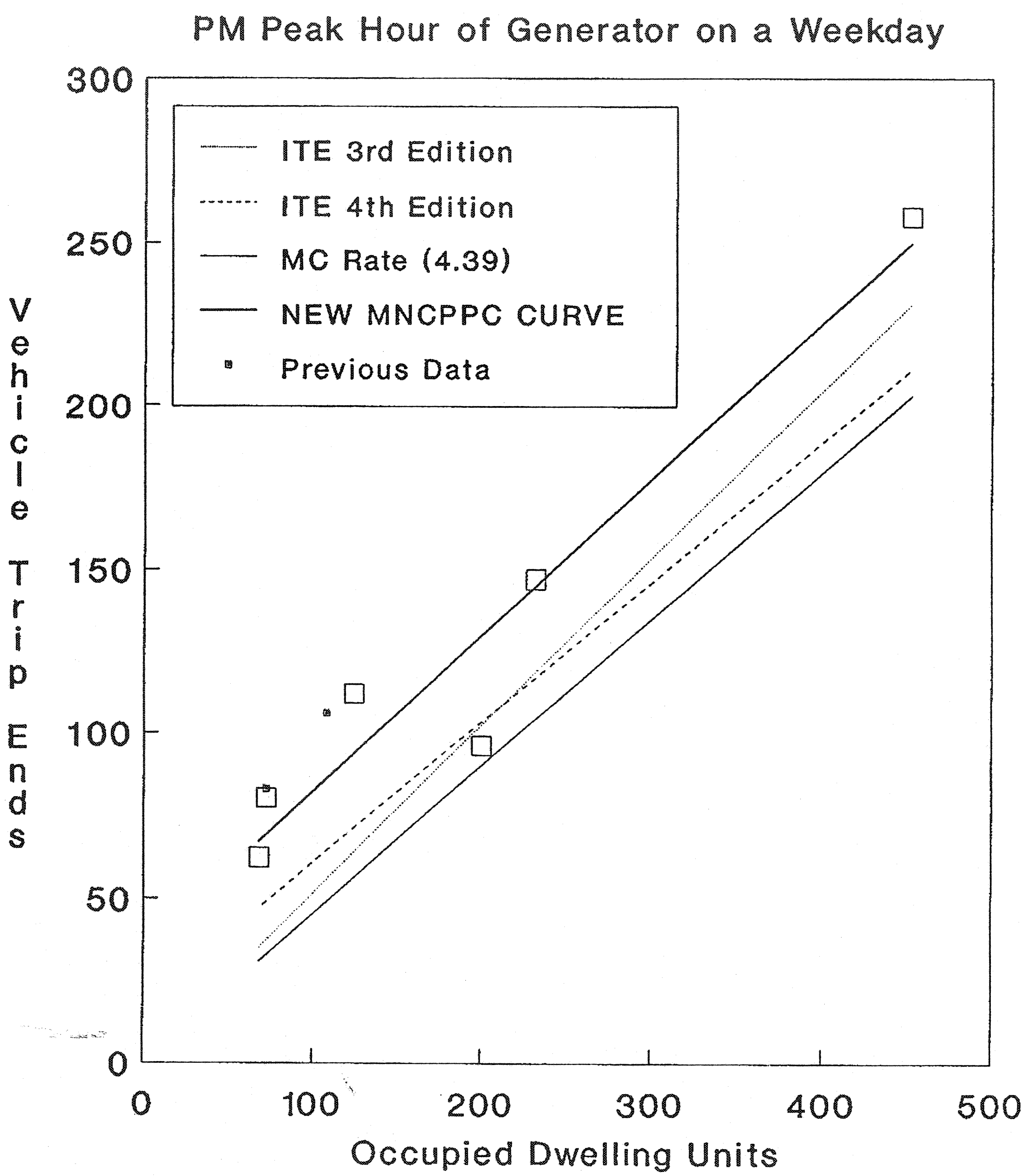
	AM Peak Hour		PM Peak Hour	
Development Units	**(4.35R)**	**(4.19)**	**(4.39R)**	**(4.23)**
50	22	23	59	25
100	48	43	83	48
400	207	163	227	189
	Diff	**%Diff**	**Diff**	**%Diff**
50-1	-4%	34	+136%	
100	5	+12%	35	+73%
400	44	+27%	38	+20%

Figure 1. Townhouses
Revised trip data (May 1990)
Average Vehicle Trip Ends



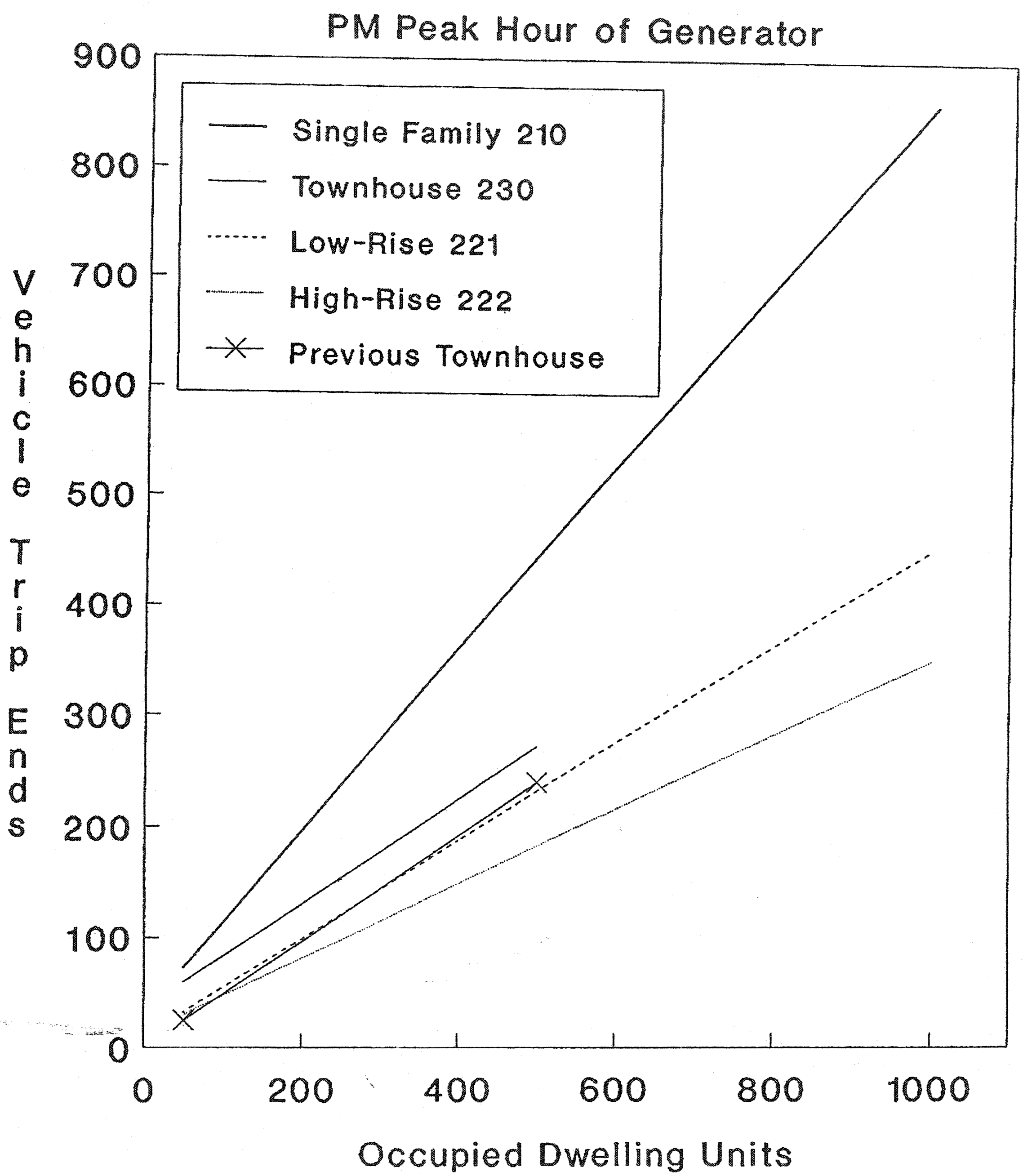
Source: M-NCPPC, JHK Assoc., D&D Inc.

Figure 2. Townhouses
Revised Trip Data (May 1990)
Average Vehicle Trip Ends



Source: M-NCPPC, JHK Assoc., D&D Inc.

Figure 3. Revised 7/9/90
Comparing Trips at Residential Land Uses
Predicted by Montgomery County Equations



Source: Douglas & Douglas, Inc.

Montgomery County Trip Generation Rate Study

Final Report

August • 1989

Prepared for:

Maryland-National Capital Park & Planning Commission
Transportation Planning Division
8787 Georgia Avenue
Silver Spring, Maryland 20910
(301) 495-4525

Prepared by:

Douglas & Douglas, Inc.
4400 East West Highway
Bethesda, Maryland 20814
(301) 654-3306

In Association with:

Gorove/Slade Associates, Inc.
Dynamic Concepts, Inc.

ACKNOWLEDGEMENTS

This project was performed for the:

Maryland-National Capital Park and Planning Commission

Montgomery County Planning Board

Gus Bauman	Chairman
Richmond M. Keeney	Vice Chairman
Nancy M. Floreen	Commissioner
Carol G. Henry	Commissioner
John P. Hewitt	Commissioner

Montgomery County Planning Commission

Richard E. Tustian	Director

Transportation Division

Dr. Robert M. Winick	Chief, Transportation Planning Division
Richard C. Hawthorne	Project Manager

This project was performed by the consulting firms of:

Douglas & Douglas, Inc.

Dr. G. Bruce Douglas	Project Manager
Penelope G. Douglas	Project Principal
Daniel Bernazzoli	Planning Technician
George B. Douglas	Computer Analyst
Kimberly Fisher	Planner
Andrew Jamieson	Planner
Dr. Charles D. Laidlaw	Statistician
Barry Zimmer	Planner

Gorove/Slade Associates, Inc.

Martin J. Wells	Project Manager
Louis B. Slade	Project Principal

Dynamic Concepts, Inc.

Pedro Alfonso	Project Principal

EXECUTIVE SUMMARY

MONTGOMERY COUNTY TRIP GENERATION RATE STUDY

Trip generation rates are fundamental building blocks in relating traffic volumes to land development. They allow us to project future travel needs of a development project once we have identified the proposed project's type and size. These traffic projections are then used to determine transportation facility requirements and to set the staging or timing of development as part of the local area review process. In Montgomery County, Maryland trip generation rates are also used in determining the schedule of impact fees.

Montgomery County, Maryland, located adjacent to Washington, D.C. with about 650,000 residents, is characterized by substantially higher than average income levels and by intensifying development in suburban centers. 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. 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. This report compares Montgomery County-derived trip generation rates with ITE rates collected nationwide.

Douglas & Douglas, Inc., assisted by Gorove/Slade Associates, Inc. and Dynamic Concepts for data collection, has performed a comprehensive study of vehicle trip generation for four important land uses, utilizing sites in Montgomery County, Maryland. For the study we surveyed the number of trips made to and from a total of 162 sites including 79 commercial office buildings, 59 residential sites, 15 shopping centers and 9 fast food restaurants. The major objectives of this study were to:

- Collect a reliable set of weekday peak hour data for office buildings, shopping centers, fast food restaurants, and residential land uses;

- Determine the variation in trip rates for developments which appear to be similar in size and type;

- Explain the sources of variation in trips; and

- Recommend a method for incorporating these new data in the methods used to estimate trips.

This report describes the data collected, examines reasons for variation in the number of trips from sites of similar land use and size and recommends a method for estimating the number of trips generated by proposed land use developments.

During the course of this study, the ITE released their 4th Edition of Trip Generation. 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 this study was expanded, therefore, to answer two questions: 1) how well do the 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? The following sections summarize our findings and answers to these questions.

GENERAL FINDINGS

The Montgomery County Trip Generation Rate Study has produced a trip generation data set based on a statistically reliable and randomly selected collection of development sites. In some cases the number of surveys we collected for a land use type in Montgomery County exceeds the size of the national data base used in the ITE manuals for that particular land use category. As a result, we are confident that the statistics developed from these data are the best available description of trip rates for Montgomery County land use in the four categories surveyed.

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 Exhibit 1. The degree of correspondence between the Montgomery County rates and other rates varies by land use. For example, the Montgomery County average trip rates for general offices were lower than 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 40% respectively.

In Exhibit 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 10% above or below the ITE rates. With respect to the remaining residential categories surveyed, we classified garden apartment and townhouse trip rates as being lower by 25% to 30% than the corresponding rates reported by the ITE.

A general finding of this study is 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.

A major objective of this study was to identify reasons for variation in trip rates among individual examples of a homogeneous land use. A number of these explanations for variation were identified and ultimately incorporated into our suggested methods for calculating trip rates:

Development Clusters - 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 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%. 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 suggests that the use of an average trip rate equation may be inappropriate for trip estimates for large, isolated development projects.

Exhibit 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	much lower
	PM	lower/same	much lower
Retail	PM	much higher	much higher
Fast Food Restaurant	AM	lower	N/A
	PM	same	same
Single Family Residences	AM	same	same
	PM	same	same
Garden Apts/Townhouses	AM	lower	lower
	PM	lower	lower
High Rise Apartments	AM	same	same
	PM	same/lower	same

Source: Douglas & Douglas, Inc.

Metrorail Station Walkshed Impact on Trip Rates - Analysis of trip rate data from a companion study of buildings located near Metrorail stations (this study did not survey buildings within 2500 feet of Metrorail stations), indicated that average vehicle trip rates during the morning peak hour are significantly lower for walkshed area office buildings than for the County average from this study. The PM peak hour statistics are less conclusive. For office buildings located near stations inside the Beltway, the average vehicle trip rates are almost identical with the County average. At Metrorail stations located outside the Beltway, there was a noticeable decrease in average trip rates for buildings located within 1000 feet of stations compared to the County average trip rate. The results of this analysis are included in the suggested technique for estimating office trips. Insufficient data were collected within the station areas to perform the same analysis for residential and retail sites.

Age of Building - Buildings of a similar size and seemingly similar use showed different trip rates for buildings of different ages. The variation was as high as one standard deviation from the average value for the County. This information further demonstrated the dynamic nature of trip generation which can vary not only from day to day but from year to year for the same building or group of buildings. No specific adjustments to the average trip generation rates at this time are suggested as a result of this analysis. Further monitoring of how trip rates at individual sites vary over time seems appropriate.

Supermarkets - The presence of a major chain food store or supermarket has a major impact on traffic at shopping centers with fewer than 200,000 square feet gross leasable area (SF GLA). For example a shopping center covering 100,000 SF GLA and containing a supermarket could be expected to have one-third more trips during the afternoon peak hour than a similarly-sized shopping center without a supermarket. The impact of supermarkets on retail centers is included as part of the suggested techniques for estimating trip ends for shopping centers.

Each of the above findings and sources of variation has been included in our recommended approach to computing vehicle trips for the four land uses covered by this report.

FINDINGS FOR EACH LAND USE TYPE

General Office Trip Rates

- Montgomery County office buildings with fewer than 300,000 SF generate fewer trips than estimated by the ITE 4th Edition equations. Larger buildings have trip rates roughly equal to the ITE 4th Edition estimates.

- For all sizes of buildings and at all times of day, office buildings in Montgomery County have average trip rates much lower than the ITE 3rd Edition average trip rates which are still being used in Montgomery County to estimate trips for new development projects.

- Commuters to Montgomery County offices generally travel alone - only 10% of the vehicles contain more than one person.

- As building size increases, average trip rates decrease.

Retail Center Trip Rates

- Large community shopping centers (more than 100,000 square feet store area) generate fewer trips per 1,000 square feet than do smaller neighborhood centers.

- Shopping centers containing a supermarket have higher average trip generation rates than shopping centers not containing a supermarket.

- About one-third of the trips to shopping centers may be pass-by trips - the shopper is just passing by the center between two other points and would have driven by even if not stopping to shop.

Fast Food Restaurants

- Average afternoon peak hour trip rates for fast food restaurants in Montgomery County are the same as ITE nationwide rates.

- The average trip rate appears to be most affected by the volume of traffic on the street passing by the store rather than by the type or size of restaurant.

Residential Trip Rates

- Single-family homes generate more trips on the average than do multi-family homes.

- Garden apartments and townhouses have the same average trip rates.

- Average trip rates for Montgomery County single-family homes are similar to ITE trip rates for single-family homes.

- Average trip rates for Montgomery County multi-family residences tend to be lower than the ITE trip rates.

SUGGESTED TECHNIQUE FOR CALCULATING TRIPS FOR MONTGOMERY COUNTY DEVELOPMENT

This study has considered a number of ways to use the newly-collected data as part of a method for calculating trip rates. These methods ranged from continuation of the use of current practice to more complex and more conservative methods for protecting the public interest. Objectives we used to select procedures included: ensuring that there was a solid data base on which to build; minimizing the risk of underestimation for individual developments; attaining equity between developments; and ensuring clarity of understanding for all potential users of the procedures.

Each possible methodology or set of techniques for estimating trips involves some trade-offs among objectives. In our consideration of the various techniques available, we placed somewhat greater emphasis on mitigating the risk of underestimating the need for public facilities. We propose a technique designed to reduce the probability that during the review process there will be a serious underestimation of the traffic impacts of proposed development. Of necessity this will tend to complicate the procedures slightly, but not so much as to make them unworkable.

We recommend the following as general guidelines for local area review trip generation (with details presented in Chapter 8):

1. Use procedures based on Montgomery County data for the land uses surveyed in this study: general offices, shopping centers (at or less than 200,000 SF GFA), fast food restaurants, and residential sites. Continue to focus on the peak hour of the site (generator), and add this to the peak hour of the adjacent street as a conservative approach. Generally, use the average rate as presented through the equations in Chapter 8, except as discussed in the following paragraphs.

2. For the larger general office sites which are not part of a development cluster, use a second assessment which tests the site-generated traffic impacts by applying a rate that reflects the 84th percentile value. This minimizes the chance of serious underestimation of the trips from these sites. Require travel demand management of these and other sites to decrease risk.

3. For retail, use the basic equations and adjust for supermarkets and pass-by trips as appropriate. The pass-by percentage should be considered on a case-by-case basis due to the large variation among sites.

4. Treat offices within Metrorail walksheds in much the same way as those outside, with the following exceptions:

    - For buildings located within Metrorail walksheds outside the Beltway, the morning peak hour rate should be reduced;

    - For central business district or other Metrorail walksheds where there is strong transit encouragement (such as Silver Spring CBD or Bethesda CBD), use locally established trip rates from the appropriate sector plans.

5. For fast food restaurants of 3,500 SF or less, use a flat rate reflecting the most successful of these establishments. For sites larger than this, use an increasing rate roughly parallel to the rate for this land use as presented in ITE's 4th Edition.

6. For land uses not addressed in the Montgomery County study, use the procedures contained in the ITE 4th Edition report to be consistent with the procedures outlined above.

ORGANIZATION OF THE REPORT

This report describes the methods, results and recommendations of the study:

- Chapter 1 presents the study objectives and the background to the research.

- Chapter 2 discusses the trip generation rate concept and briefly describes the process of data collection and analysis.

- Chapters 3 through 6 describe details of the data collection process and the results for the four major land use categories surveyed as part of the research: general offices (Chapter 3); retail centers (Chapter 4); fast food restaurants (Chapter 5); and residential units (Chapter 6).

- Chapter 7 contains a comparison of Montgomery County trip rates with those in the 3rd and 4th editions of ITE's Trip Generation report. It also includes a discussion of variation in trip rates due to differences in location and the types of tenants present (where applicable). The concept of utilizing the 84th percentile as a trip rate standard is presented here.

- Chapter 8 presents the conclusions of the research and recommends trip rates and specific trip estimation procedures for use in Montgomery County.

- A Glossary defines technical terms used in this report.

- Appendix A contains detailed trip data by collection site.

- Appendix B describes the details of the data collection methods utilized during the course of the research.

- Details of each site are contained in a separate Technical Appendix available from the Maryland-National Capital Park and Planning Commission.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

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 increasing 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, 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 that is 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 often been attacked at various times by developers, planners, and neighborhood residents during the public review of proposed developments.

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. Trip generation rates are applied at two distinctly different planning levels by planners and traffic engineers:

a) At the more localized micro-scale planning level of building site plan approval, trip generation rates represent the initial step in the process of translating new development into traffic requirements. For short-range planning and the assessment of development impacts, trip rates usually are expressed in terms of vehicle trips per hour or per day. They are also related to measurable site characteristics such as square feet of space, number of dwelling units, or number of employees. The vehicle trip rate is the trip generation measure used in this study.

b) At the overall macro-scale planning level, they are used for city, county and regional long range planning and transportation facility planning. The number of person trips per day or per hour is the measure typically used in long range planning.

Used in long range planning, person trip rates are normally derived from interviews or home interview surveys. The resulting trip estimates then form the basis of the traditional four-step transportation planning process:

1) Trip generation - the number of trips associated with peoples' activities at various land uses;

2) Trip distribution - where trips will come from and go to;

3) Modal choice - the selected mode of travel such as walking, taking transit buses or Metrorail, or using one's own vehicle; and

4) Trip Assignment - the path of the trip.

For many years, the attention of planners focused on producing more sophisticated models for modal choice and trip assignment. Recent renewed interest in trip generation rates and trip distribution has arisen following dramatic changes in life style and, consequently, in travel habits.

Vehicle trip rates are based on observation of the actual numbers of vehicles entering and leaving a particular type and size of land use (a 200,000 square foot shopping center, for instance) during a particular time period. The number of trips is then expressed in terms of some characteristic of the land use. Thus we find trip levels measured per thousand square feet of occupied floor area, per dwelling unit, or per acre. The resulting projection of traffic based on the trip generation rate is compared with current roadway capacities. If projections suggest that new traffic will outstrip current capacities, it is prudent (and, in many jurisdictions today, legally required) to make adjustments either to the timing of the project or to the various roadways around it.

1.2 SOURCES OF TRIP GENERATION RATES

The prime source of trip generation rates has traditionally been the Institute of Transportation Engineers' (ITE) trip generation rate reports. The 3rd Edition, entitled Trip Generation, An Informational Report [1], was published in 1983 and was in use when this study began. In the Fall of 1987 when we had almost finished this study, the 4th Edition, entitled simply Trip Generation [4], was published. With publication of a new edition, the work program was amended to allow a comparison of ITE 3rd and 4th Edition rates with those derived from Montgomery County data. The results of this comparison are the subject of Chapters 7 and 8.

In 1985 the Federal Highway Administration (FHWA) produced Development and Application of Trip Generation Rates [2]. In this document the ITE 3rd Edition rates were combined with additional data to update the information and attempt to measure the impact of the 1973 fuel crisis. The report included a bibliography with almost 100 citations of trip generation rate studies performed by various states, cities and local agencies. In all three of these references, trip generation rates are averaged from studies done around the country.

In addition to these national average trip generation rates, locally-derived rates have been published. Many of these data are not used by planners and traffic engineers, however, because documentation on the sites which form the basis of the rates is lacking. Therefore, it is often unclear whether they can be applied successfully elsewhere in the country. In addition, the presence of bias is often suspected since many trip generation studies have been done to support a particular action, and the sites surveyed are therefore sometimes selected with an eye to the desired results rather than at random. The FHWA report was based primarily on ITE data. Consequently in most cases where important decisions are being made the ITE data have been used because they are the most commonly accepted rates and hence the easiest to defend.

Trip generation rates used in development impact assessments have been criticized by those most affected by them: developers, neighborhood groups opposing aspects of new development projects, and planning officials trying to decide what is in everyone's best interest. Criticism and questioning understandably have been greatest in high growth areas, such as Montgomery County in the Maryland suburbs of Washington, DC. In such high growth areas, confrontation between developers and neighborhoods is frequent. Indeed, trip generation rates have often become the focal point of conflicts between developers and neighborhood groups where the adequate public facilities requirements are perceived as all that stand in the way of development projects. In this study, therefore, we aimed to collect data that represent current Montgomery County conditions and that are pertinent to current development issues.

1.3 PURPOSE AND SCOPE OF THE STUDY

Prompted by the notion that national trip generation rates produced in the late 1960's and early 1970's might not be representative of current rates in Montgomery County, the Maryland-National Capital Park and Planning Commission (M-NCPPC) commissioned this study to perform a comprehensive survey of land use types in Montgomery County and located outside Metrorail station walksheds. The technical scope and focus of the study were developed by M-NCPPC transportation planning staff. These were modified following recommendations from the Project Advisory Committee and suggestions from Focus Group meetings.

The resulting four principal study objectives were to:

- Produce a consistent set of trip generation rate data based on a uniform method of collection;
- Explain the variation in rates among sites;
- Evaluate different approaches to analyzing the trip rate data; and
- Recommend a set of trip rates for use in evaluating development proposals and for application in short-range planning.

At the beginning of the research, about forty representatives invited from Montgomery County Government agencies, the local development community, and citizens organizations attended Focus Group meetings. Focus Group members identified issues that needed to be addressed by the study. Selected members of the Focus Groups also became members of the Project Advisory Committee which reviewed the work scope and the interim report and made recommendations on the direction of the technical work. Based on suggestions from the Focus Groups and the Advisory Committee, we made some changes to the original work scope.

Douglas & Douglas, Inc. led the consultant team and was responsible for project management and analysis. Gorove/Slade Associates, Inc. assisted with the development of data collection techniques and with the data analysis, and was responsible for the field data collection. Dynamic Concepts, Inc. supplied the field crews used in data collection.

Data collection took place in the Fall of 1986 and the Spring of 1987. While vehicle trip rates have been compiled for a wide range of land uses from institutions to parks and military bases (ITE lists over 300 land use categories), this research focused on just four: general offices, residences (apartments, townhouses and single-family detached homes), shopping centers, and fast food restaurants. These land uses were selected because they represent: 1) those land use categories for which the largest number of development approval applications are received in Montgomery County, and/or 2) those land uses expected to generate either most of the increase in travel in the future or most of the controversy.

The original work scope for the project included hotels and elderly housing. These were eliminated following discussions with the Focus Group and the Advisory Committee. This decision was further justified during preliminary screening when it became clear that, in Montgomery County, most hotels were located in Metrorail station walksheds and that housing for the elderly appeared to be a very low traffic generator. (Confirming this latter impression, an apartment building we surveyed which seemed to have extremely low trip generation rates turned out to be almost entirely inhabited by the elderly.)

All sites in the County falling within one of the four land use categories being considered were candidates for trip generation surveys except those lying within 2500 feet of Metrorail stations (an area defined as the Metrorail walkshed). A separate study, prepared for the Maryland-National Capital Park and Planning Commission in July, 1987 by JHK & Associates and entitled Post-Metrorail Transportation Characteristics Study, surveyed sites in Metrorail walksheds.

At each site, surveyors counted the number of vehicles entering and leaving the site during the morning and afternoon peak periods. Manual counts included auto occupancy rates. At retail and fast food restaurant sites, interviewers asked patrons if their trip represented a primary trip with that stop as its sole purpose or one diverted or captured from pass-by traffic. In office buildings, the survey staff interviewed tenants to determine the number of employees, the type of employees (management, clerical staff, sales people, technicians, etc.), the existence of programs for ride-sharing, the number of parking spaces, the hours of work, and any special circumstances affecting the number of employees on site the day of the survey.

To meet the study objective of developing a consistent set of trip generation rates, the study team: used a uniform data collection method; trained, tested and used the same field crew members for the entire project to reduce errors; selected sites to be surveyed using stratified random sampling techniques to eliminate bias; and tested and revised our interview instruments for determining pass-by trips to remove ambiguities.

In accord with another study objective, we organized the analysis phase of the study to identify sources of variation in rates. Typical questions being raised were: how much do office rates vary depending upon the type of office use and location within the County, and how are residential trip rates related to housing prices? Ideally, trip generation rates should be stable, measurable, and predictable. In addition, the number of trips must be related to variables which can be controlled by the planning and zoning process if they are to be useful. For example, although trip rates from residential units have been shown to have a higher correlation with automobile ownership than with the number of dwelling units, trips per dwelling unit is a more usable statistic because the number of automobiles per household is neither regulated by the zoning process nor available for each site at the time development plans are appraised.

The remainder of this report describes the methods, results and recommendations of the study. Chapter 2 discusses trip generation rates and briefly describes the data collection and analysis process. Chapters 3 through 6 describe the results for the four major land use categories surveyed in the study: general offices, retail centers, fast food restaurants, and residential units. Chapter 7 contains a comparison of Montgomery County trip rates with those in the 3rd and 4th editions of ITE's trip generation manuals. They also include discussions of variation in trip rates due to differences in location and type of tenants. Chapter 8 presents the conclusions of the research and recommends trip rates and trip estimation procedures for use in Montgomery County.

CHAPTER 2

EXPLANATION OF TRIP GENERATION RATES

2.1 BASIC DEFINITION OF TRIP GENERATION RATES

Most suburban Americans find it necessary to travel from one place to another several times daily. These trips might be from home to work or vice versa, or from home or work to stores, libraries, schools, and friends. In this way people generate trips. In suburban areas, these are usually automobile trips, but walking, bus transit, and rail transit trips also occur.

By observation we know that the number of people making trips to and from a particular site is a function of the activity going on there. Transportation planners and engineers usually describe the trips as if they were generated by a site rather than by people. For instance, when planners state that the Luxury Arms Apartments generated 300 vehicular trips in the PM peak hour, they mean that 300 vehicles entered or left the apartment building site during that hour of the afternoon or evening when traffic was heaviest. When we express the number of trips in terms of the number of apartment units, we are then talking about a trip generation rate. For example, if there were 600 units in the Luxury Arms Apartments, the PM peak hour trip generation rate would be 0.5 trips per dwelling unit.

Trip generation rates are one of the basic building blocks of all transportation planning. Traffic engineers and planners developed trip generation rates (or trip rates) because they needed to estimate: 1) the amount of traffic that results from developing particular sites, and 2) area-wide traffic levels generated by all activities in a given geographical area. Trip generation rates must relate the number of trips to the type of land use. But clearly, knowing only the type of proposed development--a hospital, for instance--is not enough to estimate the number of trips it will generate; the planner must also estimate the intensity of use based on measurable characteristics of the proposed development. In the case of the hospital, the number of beds or employees might be used as indices of the intensity of use.

It is important to recognize what trip generation rates are and what they are not. By knowing their strengths and weaknesses we can determine suitable applications. This chapter examines trip generation rates and their statistical basis, and gives a brief review of the process used for estimating them in this study. A detailed description of study methods used to select samples and to collect and analyze data is given in Appendix B.

2.1.1. *Types of Trips*

Planners and traffic engineers distinguish between two types of trips:

1. Vehicle trips

2. Person trips

For this study, we were primarily interested in collecting vehicle trip data, but person trip data were also collected at most sites since auto access was the only transport mode used and we counted vehicle occupants.

A vehicle trip is a journey between two sites by a motorized vehicle (in most cases an automobile) and its occupants, regardless of their number. In most cases, vehicle trips are counted at the driveway of the site under consideration. However, in those instances where there is significant off-site parking for trips destined for a particular site, other procedures must be used to obtain an accurate estimate of the number of trips being generated by an activity. Vehicle trip rates are measures of the number of vehicle trips per unit of land use and are expressed in terms of:

- Development site size (trips per 1,000 square feet);

- Intensity of use (trips per employee); and

- Land use type (for example, trips per 1,000 square feet of shopping center, discount store, or hardware/paint store).

ITE uses 94 major categories (300 total including subcategories) of land use types for vehicle trips. These categories represent far more differentiation of types than for person trips which are distinguished by a small number of broad activity categories such as households, office employment, industrial employment, and retail employment.

A person trip is simply a journey between two points by a single individual. Each individual traveler is counted whether walking, driving, riding in a private or public vehicle, or traveling by any other conveyance. We count person trips at the entrances to buildings and/or driveways, or by conducting interviews at homes, offices, shopping centers or other land uses. Person trip data are relatively expensive to collect and provide only a limited picture of trip rate variations at nonresidential sites. The number of person trips generated is usually expressed in terms of population (trips per person), number of employees (trips per employee), or number of households (trips per household). At any given site there are always at least as many person trips as vehicle trips. Usually there are more person trips than vehicle trips because autos may contain two or more occupants, and transit riders and pedestrians add to the total. For this study we counted the number of occupants in each vehicle entering and leaving sites surveyed.

2.1.2. *Applications of Trip Rates*

Because of their differences, vehicle trip rates and person trip rates are appropriate for different tasks. Vehicle trip rates are appropriate for estimating short run traffic from a specific site with a defined land use. Traditionally, vehicle trip rates have been used to estimate the expected near-term traffic impact caused by developing a particular site. Today, they additionally are used to determine:

- If there are adequate public transportation facilities;
- The nature and extent of on-site and off-site transportation facilities required to accommodate expected traffic; and
- The land developer's potential share of the cost of transportation infrastructure improvements (e.g., impact fees).

Vehicle trip rates also form the basis of programs designed to reduce traffic volumes such as Transportation Demand Management Programs (TDM's) and serve as an index of the effectiveness of transportation management organizations, associations, or districts.

Person trip rates are generally used for long range planning or for short range planning where non-auto trips are important (e.g., transit, walking). They are more appropriate for longer-term travel demand analysis where land use is only indicated in broad categories. After estimating person trip rates generated in an area, a planner must then prepare estimates of auto occupancy levels and transit use. When we wish to look farther into the future and to change assumptions about travel patterns, gas prices and shortages, or carpool programs, we must use person trips as the starting point. Person trip rates and vehicle trip rates, therefore, give alternative perspectives on the same phenomenon and thus serve different purposes.

2.2 TRIP RATE VARIATIONS

Trip rates for a particular land use, or even a particular site, are not fixed quantities but can vary significantly over time, and not always in a predictable manner. Variation can be on a daily basis or from one site to another, ostensibly similar, site, or can occur across decades or regions. When we measure vehicle trip rates--typically by having someone actually count the number of vehicles entering and leaving a building site--we are getting a sample or snapshot of the number of trips for one short time period. Actually the number of trips is varying all the time. Thus, trip rates are statistical in nature: they represent a sample in time of a phenomenon which derives from an ever-changing aspect of human behavior.

2.2.1 *The Statistical Nature of Trip Variation*

Because trip rates vary from site to site and time to time, statistics can be of use in understanding their level and variability. Some basic statistics used in traffic engineering include the:

- Mean or average - the total trips from all sites divided by the number of sites or by the total size of all the sites (as measured by such variables as the number of dwelling units or the occupied gross square footage, for example). This, a measure of central tendency and the statistic most frequently used by the ITE, is an indicator of the level of traffic generated by a land use. It is clear that the procedures used to calculate it ensure that the largest sites generating the most traffic have the strongest influence on the value of the mean. Thus, the statistic is properly called a "weighted" mean.

- Median - the middle measurement, if there is one, after the trip rates for all the sites surveyed have been arranged in order of magnitude. To obtain the "weighted" median, all sites are arranged in ascending order of trip rate. When the cumulative size of the sites (floor area in square feet) has reached 50% of the total size of all sites, that building's trip rate becomes the "weighted" median trip rate.

- Range - the difference between the largest and smallest trip rate measured. The range describes the extent of variation about the mean, and tends to increase as the sample size increases.

- Standard Deviation - this statistic summarizes the extent of variation about the mean in a set of observations. It is conceptually similar (though not equal) to the average deviation of (in this case) a set of trip rates about their mean. In the case of what is known as a "Normal Distribution," roughly 68% of all observations lie within one standard deviation of the mean and about 95% within two standard deviations.

- Percentile - another useful statistic, the "N"th highest percentile indicates the trip rate that equals or exceeds that of "N" percent of the land use. A "weighted" percentile is computed in a manner similar to the "weighted" median discussed above (in fact the median is the 50th percentile). The sites are arranged in ascending order of trip rates and the cumulative size (where size is measured by number of dwellings or occupied gross square footage) is calculated for each site as a percentage of the total size for all sites. The trip rate associated with the site covering a cumulative "N" percent of the total size of all sites is the "N"th percentile. For example, the 84th percentile represents the trip rate at which 84% of the floor space measured falls below the given rate. Put another way, one would expect only 16% of the floor area of all buildings in the sample to have a trip rate higher than the 84th percentile.

These statistics tell us about different aspects of trip rates. Before we consider a real life example drawn from ITE data, let us examine how these statistics are related theoretically.

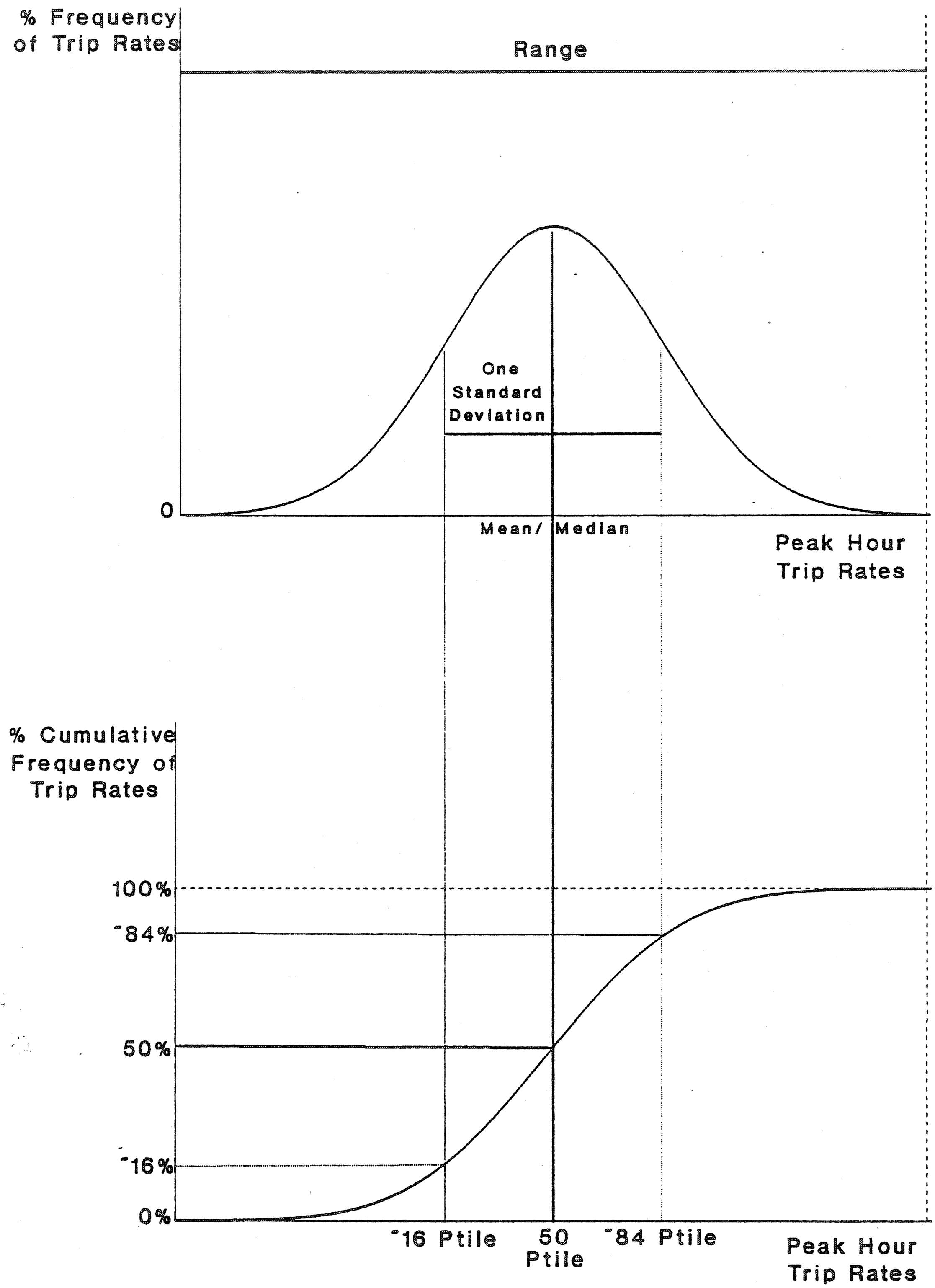
Imagine that we have measured the PM peak hour trip rates (or volumes) for every site occupied by a particular land use of particular size (that is, the total population of sites in that land use category). Suppose now that we group sites (according to the level of their trip rates) into a very large number of categories and calculate a frequency distribution of sites across these categories. Performing this operation for a whole series of land use types, we would "typically" derive the bell-shaped frequency distribution illustrated in Figure 2.1 This is referred to as a "normal" distribution. Its perfectly symmetrical shape indicates that the point about which it is symmetrical is both the mean and the median. Further, its bell-shape ensures that this point also represents the trip rate which occurs most frequently across the population of sites. Many naturally occurring phenomena, such as shoe sizes or peoples' heights, are normally distributed, as are many behavioral phenomena.

If asked to summarize these trip rates with some statistical measure, it is evident that the use of the mean or median would give us some idea of their level, but none whatsoever of their distribution. We might compute the range of the trip rates (the maximum and minimum rates are clearly visible at the extreme ends of each "tail" of the distribution). But the range is of limited value because it does not reflect the pronounced "bunching" of trip rates about their mean/median. This is where the standard deviation and various percentiles become useful. The greater the bunching around the mean, the lower the standard deviation. In a normal distribution, 68.26% of all observations lie within one standard deviation of their mean; thus, 15.87% are less than one standard deviation below the mean, and 84.13% are less than one standard deviation above the mean. Looked at another way, the 16th percentile is roughly one standard deviation below the mean, and the 84th percentile is roughly one standard deviation above it. The relationships among all these statistics are indicated in Figure 2.1.

Up till now, we have been assuming that our frequency distribution describes trip rates at a large number of sites at one point in time. Let us now consider that it can also describe trip rates observed at a large number of time points, but at a single site. We commented earlier that counting peak hour traffic at a site at one point in time gives us only a snapshot of a variable that is constantly changing. It is easy to imagine, however, that if we collected PM peak hour trip rate data for the same site for a large number of afternoons, the distribution of rates would also approximate a normal distribution. What is more, the mathematical structure of this distribution should be identical to that of the distribution of PM peak hour trip rates across sites at a point in time. (This of course makes the not unreasonable assumption that the one site surveyed over time is very similar to each of the large number of sites surveyed at one point in time.)

Clearly, how the distribution of trip rates about their mean is viewed affects how the various statistics which describe it are to be interpreted. If we regard the distribution as a description of one site over time, the mean/median becomes the peak hour trip rate on a typical afternoon rather than the trip rate at a typical site. And instead of representing the trip rate which exceeds those of 84% of the total population of sites, the 84th percentile gives us that PM peak hour trip rate which is not exceeded 84% of the time. These distinctions are of some conceptual importance since the trip rate data collected during surveys normally come from a crosssection of sites,

Figure 2.1
Theoretical Distribution of Trip Rates



while trip generation rates themselves are applied to specific sites as part of the development review process. Further, trip rates will tend, on any given day, to either overestimate or underestimate the amount of traffic at a specific site.

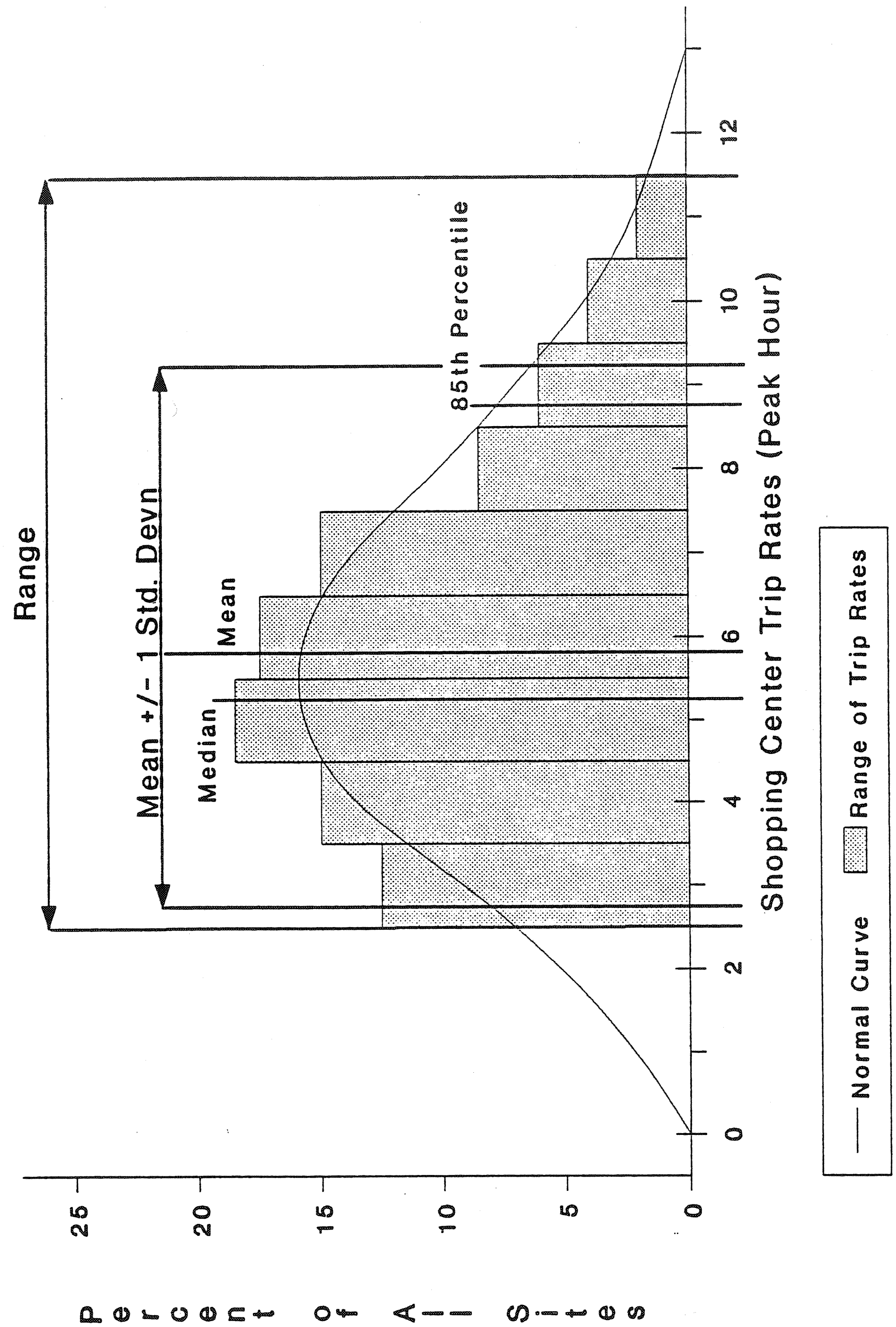
One final comment before we move on to a real-life example of trip rates; it is clear that there are significant time and resource constraints to surveying a whole population of sites in order to derive trip generation rates. For this reason, random samples of the sites in a particular land use and size category are normally taken and subjected to detailed investigation. The distribution of sample data will tend to approximate the distribution of data for the whole population (though this is rarely, if ever, known) but is unlikely to correspond with it exactly. However, with a good sample size (usually above 25 for a single population of sites), the statistics computed for the sample should be reasonably close to the parameters for the total population that they are supposed to be estimating.

Let us move on now to consider the distribution of trip rates for a set of real sites as presented by the ITE. Figure 2.2 shows the relationship among the statistics for a set of 100 shopping centers. The mean and the range are taken from ITE's 3rd Edition. Each bar shows the percentage of sites with a particular trip rate; the curve indicates the theoretical (normal) distribution of trip rates for the total population. Notice that the rates are not uniformly distributed; instead they tend to cluster between the average value and one standard deviation above or below it. In fact, more than 50% of all sites have rates below the average. In this example the median does not coincide with the mean but is to its left, demonstrating that these data do not form a perfectly normal distribution. The impression is further confirmed by the fact that the trip rates for sites with rates greater than the average extend much farther to the right than those for sites with below-average rates extend to the left. This has the implication that, if we assume all sites to be "average," we can underestimate the total number of trips for a particular site by a much bigger margin than we can overestimate them.

This bias toward the high side has important regulatory ramifications. The choice of a statistic to be used for setting standards and regulations is not intuitively obvious. While average values have a certain appeal when looking at all the sites of a particular type in the County, the consequences of using average values for specific developments can possibly lead to traffic disasters. For a single large development site, using the average value may result in a serious underestimate of traffic by as much as 100%.

We can illustrate the problem concerning the choice of a trip rate with an example and by referring to Figure 2.2 which indicates an average trip rate of 5.9 vehicles (per thousand square feet of floor area). A plan for a proposed new shopping center with 100,000 square feet (SF) of gross leasable area (GLA) thus estimates that, during the afternoon hour in which the highest traffic volumes are measured on the nearest major street, the average trip generation rate will be 5.9 vehicle trips for each 1,000 SF GLA for a total of 590 trips (5.9 x 100), both in and out. This estimate assumes that the proposed shopping center is fully leased and that it fits the definition of "average" when compared to other centers studied and reported in ITE's 3rd Edition.

Figure 2.2
Typical Trip Generation Rate Statistics



Source: Douglas & Douglas, Inc.

It could be that the stores prove to be extremely popular in which case 1,100 vehicles (the ITE maximum rate) could be going in and out of the driveway entrances during the adjacent street peak hour, or, conversely, that the location proves unattractive and as few as 310 vehicles (the ITE minimum rate) might go in and out. The types and number of stores, the inclusion of a supermarket in the center, and the general economic conditions of the surrounding area will all affect the number of trips to and from the center. Potentially, there is a wide variation in the number of trips we could observe at this new shopping center, and our estimates of traffic using a trip generation rate of 5.9 per thousand square feet GLA could be in error by almost 100%. Overestimating traffic has a less serious impact on the road network than does underestimating traffic.

We also need to recognize that if we were to measure the PM peak hour traffic flows at the same location repeatedly, we would get different results according to the day of the week and the season of the year. Some land uses vary more than others. For example, Saturday traffic at shopping centers generally exceeds weekday traffic, and all of us are familiar with the Christmas rush! On the other hand, office building trip rates vary much less over a year (but tend to get lower during holiday and summer periods).

2.2.2 *Types of Trip Volume Variation*

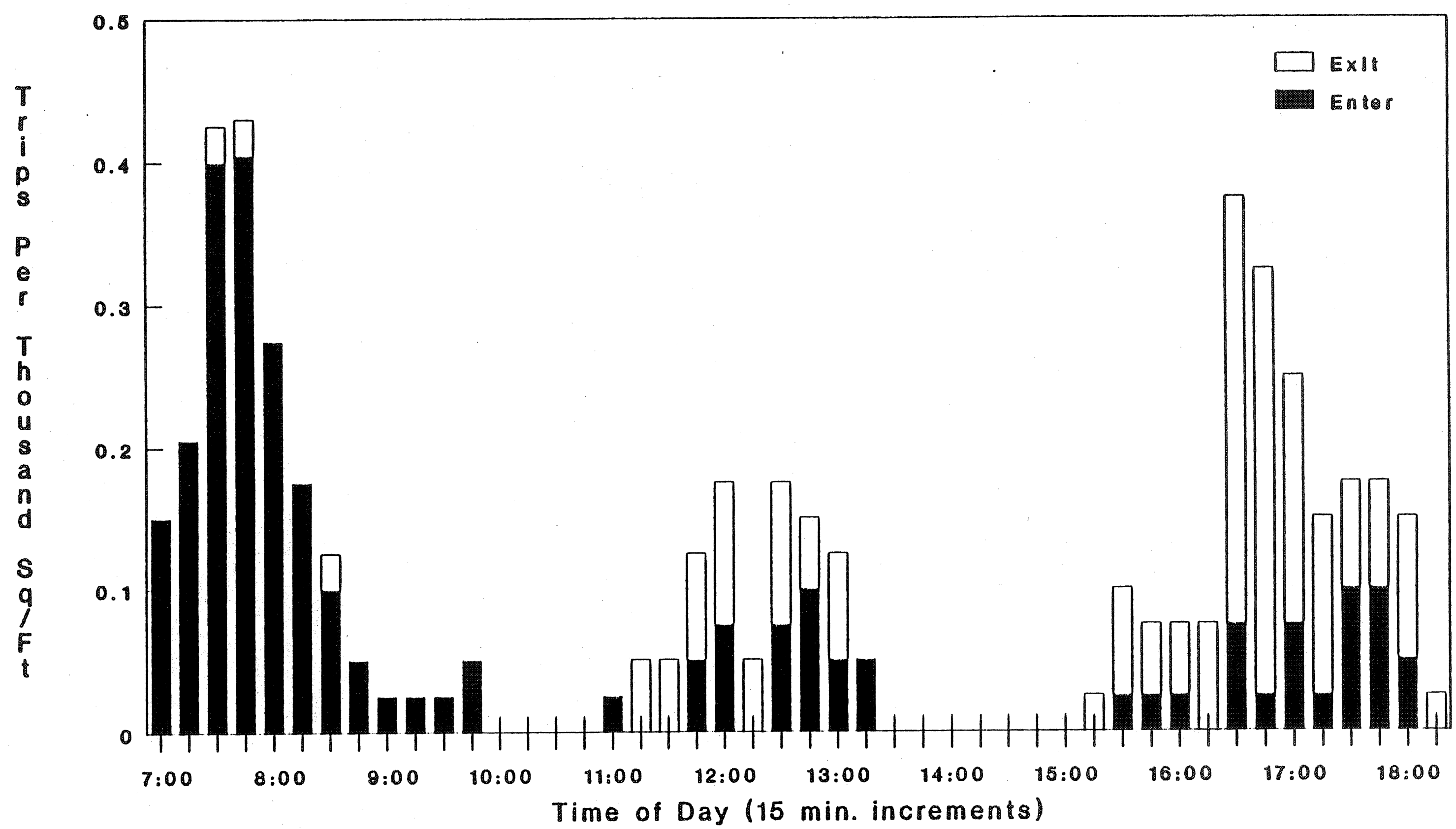
So far we have concentrated on traffic during the PM peak hour. At offices, homes and, in fact, for all land uses, vehicle trips vary throughout the day. A typical daily traffic pattern for an office building resembles that shown in Figure 2.3. The height of the bars represents the total number of vehicles per thousand square feet (or total trip rate) entering or leaving the site during a fifteen-minute period. The peaks of activity during morning and afternoon rush hours and the lunch traffic show up clearly. The shaded portion of the bars indicates the number of vehicles <u>entering</u> the site per thousand square feet of space during successive fifteen-minute time intervals with the unshaded portion indicating the number of vehicles <u>exiting</u> the site during these periods.

Repeated surveys have shown that the pattern shown in Figure 2.3 is not uniform for all buildings, even those which look alike on the outside. For example, morning traffic patterns at two similar buildings that we surveyed took the form illustrated in Figure 2.4.

The reasons for the variations include differences in the numbers of firms in the buildings, the numbers of employees in each 1,000 SF of office space, the hours of work, and the transportation options such as transit, car pools, and travel demand management programs that are available.

We have seen that trip rates vary over the course of a day and among different land uses. These observations lead naturally to questions about trip rate variation during the life of a single building and the impacts of being located near a Metrorail station or in a mixed-use development. Some of these questions will be addressed in this research.

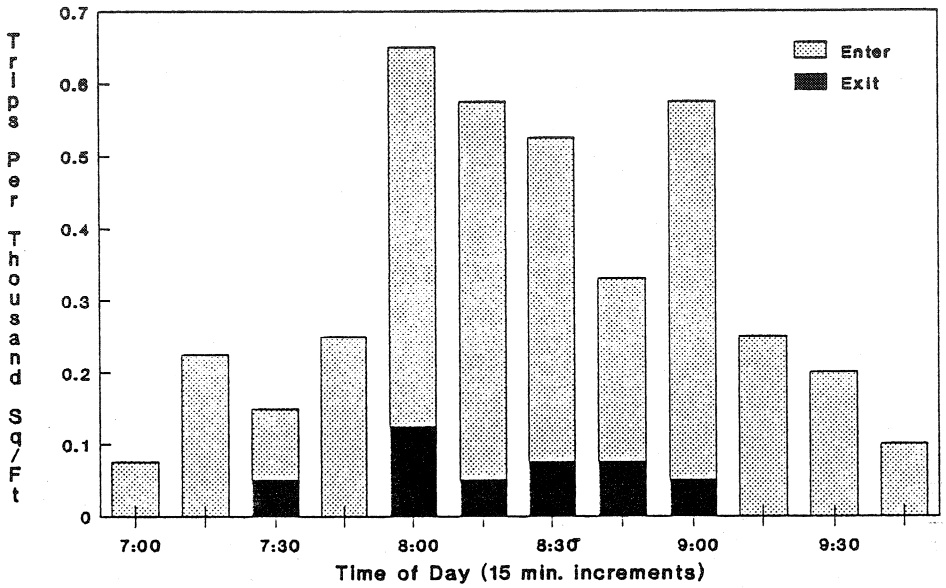
Figure 2.3
One Day's Trips at an Office Building



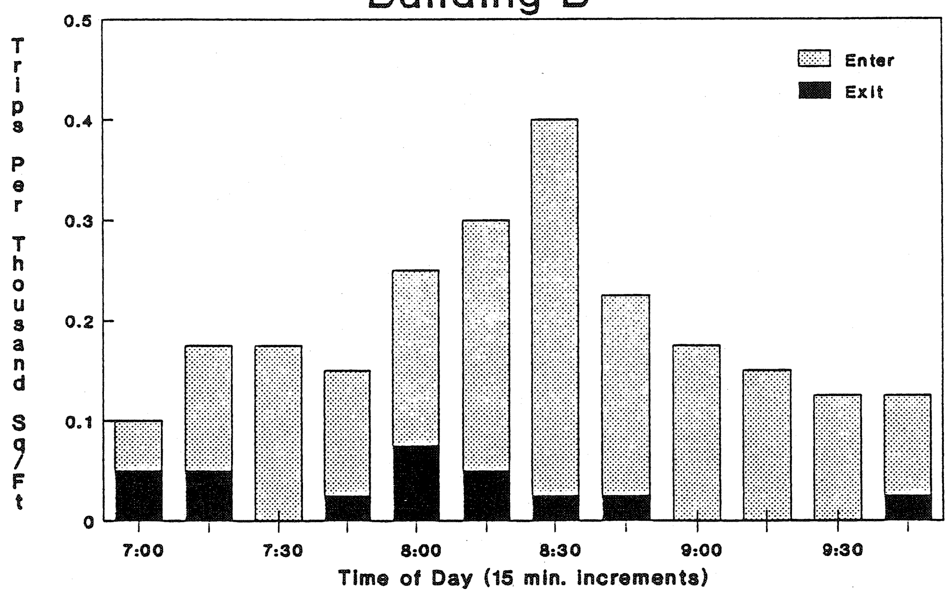
Source: Douglas & Douglas, Inc.

Figure 2.4. Comparing AM Peak Trip Rates at Two Office Buildings

Building A



Building B



Source: Douglas & Douglas, Inc.

2.3 TRIP GENERATION RATE STUDY PROCESS

The technical methods used in the trip generation rate study were designed to respond to questions and criticisms currently being directed at trip generation rates in Montgomery County. The viewpoints of neighborhood groups, commercial developers and the providers of transportation facilities all constitute important perspectives on the subject. Consequently, every effort was made to incorporate concerns expressed by these groups into the framework of the research and analysis.

Briefly, the steps in the process were as follows:

1. Focus Group Meetings - Representatives from all stakeholder groups were invited to attend a series of meetings to discuss issues of credibility, development impacts, and applications. These meetings resulted in revisions to the original work plan which increased the value of the research. Several members of the focus groups were then incorporated into a Study Advisory Committee to assist M-NCPPC in reviewing the results.

2. Fall, 1986: Initial Data Collection - Complete inventories of candidate sites containing general offices, shopping centers, fast food restaurants or residential units were compiled. Stratified samples were then drawn to obtain the required number of sites for field data collection. The field data collected included driveway counts of vehicles leaving and entering a site and the number of occupants in each vehicle. The type of business plus the number and type of employees was ascertained for each office tenant through a questionnaire administered to tenants. The number of parking spaces on site was counted. At shopping centers and fast food restaurants, trip origins were determined through a short interview of patrons. (In this way, the number of pass-by trips was ascertained.) These data were supplemented by information on the physical characteristics of the sites and the rent and sale price characteristics of residential areas - data which were drawn from secondary sources.

3. Interim Report - Following data collection in the Fall of 1986, an interim analysis was performed. This computed trip generation rates and presented tentative comparisons of these with ITE rates and those from other sources. The results of these analyses were used to confirm or modify the direction of the research and to set the sampling methods and sample sizes to be used for the Spring, 1987 data collection.

4. Spring, 1987: Final Data Collection - Based on reviews of the data collected in the Fall of 1986 and the analysis of these data by the Technical Steering Committee, a decision was made that the Spring, 1987 data collection should concentrate on office, shopping center, residential and fast food sites. (Originally, we were also to survey hotels and housing for the elderly in the Spring.) In addition, the Spring sampling was modified slightly to add sites for which historical data were available to serve as points of comparison. The modification in the sampling did not bias the results since many of the sites were already included in the

statistically drawn random sample, and the few that were not were added to a group already large enough for purposes of statistical reliability.

5. Analysis and Recommendations - The final phase of the project was a comparison of the rates empirically derived from the field work with rates published in other sources and an analysis of differences between them. The trip rates recommended by this study reflect both the statistical distribution of the rates measured and the sources of variation identified by the analysis.

2.4 ESTABLISHING TRIP RATES

For purposes of estimating future traffic, we need to understand the relationship between the number of vehicle trips and some measurable (and alterable) characteristic of a proposed development, such as the number of employees, square feet of retail space, etc. This presents several challenges for the transportation planners and public officials responsible for site approvals. Often the developer has only a rough idea of the final design of the development--what size it will be, where entrances will be located, how many tenants of what type there will be. Consequently, precise trip rates related to details of the project which may change or are vague are not trustworthy.

The use of office or shopping center space is not predictable to the same level of precision that we can measure trip rates. For example, the first tenants in an office building may rent most of the space for prestigious corporate offices with low employee density (2 - 2.5 employees per thousand gross square feet (GSF)). Succeeding tenants may have more intense office use until, at some point, the density may reach 5 to 7 employees per thousand GSF with a consequent impact on trip rates. We have attempted to minimize these kinds of difficulties in this study by surveying a large sample of buildings in Montgomery County randomly selected from all buildings in the County of certain sizes.

The ITE 4th Edition offers a new approach to estimating vehicle trips, based on new equations fitted to the observed data, as an alternative to the use of fixed trip rates. These new equations may be used to estimate trips over a continuous range of development sizes based on the linear or non-linear relationship which best fits the data.

In this study we examined the data collected from large samples to determine average trip rates for morning and afternoon periods, and the relationship between the trips generated by each building site and the entire group surveyed. The rates and equations presented cover both the average building and also 84% of all buildings in the sample (roughly all buildings with trip rates below one standard deviation above the mean rate). Comparisons with ITE rates (from the 3rd Edition) and equations (from the 4th Edition) are included. This should provide a basis for discussions as to which trip rates are most appropriate for adoption and application.

CHAPTER 3

GENERAL OFFICE TRIP GENERATION RATES

Trips generated by office uses represent one of the most important components of both peak hour and peak period traffic congestion. With the change in the traditional role of the 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.

During the Fall of 1986 and Spring of 1987, we surveyed 79 office buildings of different sizes and in different locations within the County. The results were rather surprising:

- For all sizes of buildings and at all times of day, office buildings in Montgomery County have lower average trip rates than those presented in the ITE 3rd Edition;
- Commuters to Montgomery County offices generally travel alone-only 10% of the vehicles contain more than one person;
- As building size increases, the average number of trips per 1,000 square feet (SF) of gross floor area (GFA) decreases;

In all categories and at all times of the day, the average number of vehicle trips generated by Montgomery County office buildings is from 34% to 47% lower than the average peak hour trip estimates reported by ITE in their 3rd Edition. Comparing our average trip generation rates with those reported in a 1982 Trip Generation Study prepared by JHK & Associates for M-NCPPC in neighboring Prince George's County [3], we found that our observed trip generation rates are 35% lower than those observed in Prince George's County for buildings above 100,000 square feet in size, and 50% to 60% lower than those observed there for buildings under 100,000 square feet.

In response to the concerns expressed by the Advisory Committee, we gathered auto occupancy data during the peak periods. Here again, the results were surprising: at only ten sites (12% of all those surveyed) was the auto occupancy rate greater than 1.20 in either the morning or afternoon peak hour. Details of the trip generation rate study of general office sites are presented in the following sections.

3.1 SELECTION OF CANDIDATE SITES

The survey of general office sites in Montgomery County started with an inventory of more than 600 office buildings. Buildings which were:

- located within 2500 feet of a Metrorail station,
- under construction, or
- in their initial leasing period and not yet fully leased

were eliminated from the list. The resulting 265 buildings were stratified into four size categories:

- Size Code A - less than 50,000 gross square feet (GSF);
- Size Code B - 50,000 to 99,999 GSF;
- Size Code C - 100,000 to 199,999 GSF;
- Size Code D - 200,000 GSF and above.

Buildings were selected randomly from each size group to form a pool of sites to be surveyed. We decided to emphasize the buildings larger than 100,000 square feet because they represent the predominant type of building now being built in the County and are thus more likely to appear in future development applications. As may be seen in Table 3.1, buildings over 100,000 gross square feet in size are more heavily represented in our sample than others. In part, this is the unexpected result of an anomaly in the way buildings were grouped by size. A number of the buildings listed in the inventory as being in Size Code A turned out to be part of office building clusters which shared common parking and entrance facilities. As a result, when the total floor spaces of all the buildings in these clusters were added together, the smaller sites were reclassified as parts of larger ones containing more than 100,000 square feet.

For the purposes of the analysis, **we combined size groups A and B together** to correspond to ITE size groupings. (The ITE places all buildings under 100,000 feet into one category.)

Our final site selection produced a sample of 79 sites generally well-distributed across size groups and across divisions of Montgomery County. These sites were surveyed to produce a rich data base. The geographical spread of our randomly drawn stratified sample is illustrated in Figure 3.1; the sampling percentages for surveyed sites are presented in Table 3.1.

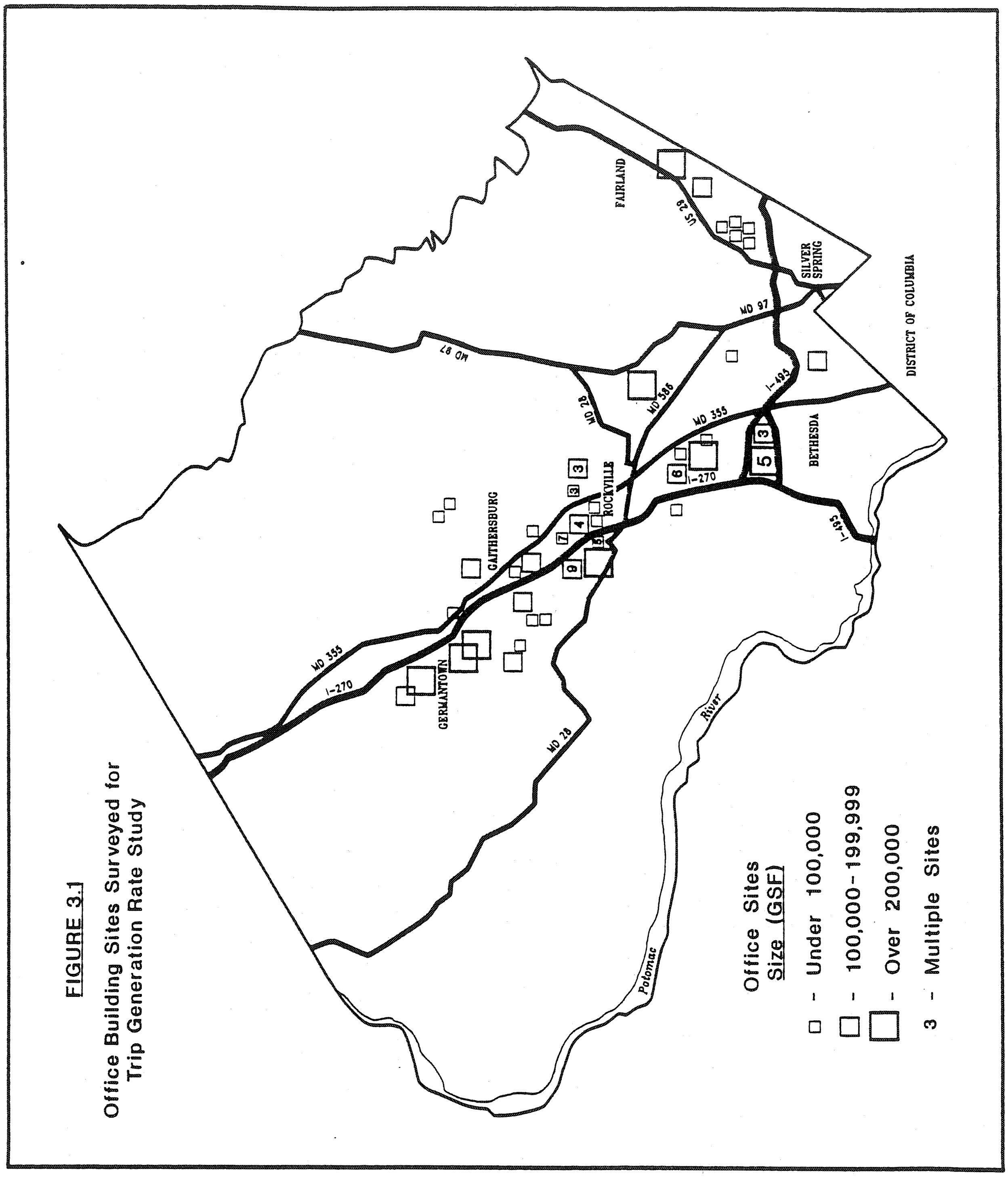


FIGURE 3.1
Office Building Sites Surveyed for Trip Generation Rate Study

Table 3.1

Survey Rates for General Office Sites by County Division* and Size

Division	Size Groups: A Under 50K GSF	B 50K-99.99K GSF	C 100K-199.99K GSF	D 200K and Above	All Sizes	Sampling Percentages
Up-County						
Total	37	40	25	4	106	100%
Surveyed	4	14	10	3	31	29%
Mid-County						
Total	41	26	37	9	114	100%
Surveyed	9	4	19	8	40	35%
Down-County						
Total	17	8	2	0	27	100%
Surveyed	0	0	1	0	1	4%
Eastern Mont. Co.						
Total	6	9	2	1	18	100%
Surveyed	2	3	1	1	7	39%
All Subareas						
Total	102	83	66	14	265	100%
Surveyed	15	21	31	12	79	30%
% Surveyed	14.7%	25.3%	47.0%	85.7%		

Source: Douglas & Douglas, Inc.

* See Table A.1 in Appendix A for a list of the Planning Areas lying within each division of the County.

The list of candidate sites, and therefore our sample, contains proportionally more up-county and mid-county locations than does the total population of office buildings in the County. (See Table A.2 in Appendix A for addresses and survey dates.) In explanation of this skewed geographic distribution, note that most down-county buildings are located within 2,500 feet of a Metrorail station and so were explicitly excluded from this study. Further, several candidate sites in the down-county division were excluded because they lacked definable driveways and/or parking lots and because of owner refusals.

The office data base in this study contains about 2.5 times the number of sites found in the ITE 3rd Edition data base for equivalent land uses. And while the ITE 4th Edition rates are derived from a larger set of data (50 observations) than are the 3rd Edition rates, this is still less than the number of sites surveyed during the course of the Montgomery County study. The localized nature of our research, plus these sample size differences, suggest the greater reliability and usefulness (in Montgomery County) of the statistics produced by this analysis.

3.2 GENERAL OFFICE TRIP GENERATION RATES

Trips entering and leaving the office site drive-ways during the morning peak period (7 a.m. to 9:30 a.m.) and the afternoon peak period (4:00 p.m. to 6:30 p.m.) were counted and classified by the number of occupants. The results of these surveys are summarized in Tables 3.2a and 3.2b. Table 3.2a presents the average trip rates per thousand gross square feet (GSF) of occupied space for the AM and PM peak hours on the adjacent road network. Table 3.2b presents similar data for the generator peak hour. The total peak hour trip rates--both AM and PM peaks--decrease as building size increases. During the generator AM and PM peak hours, buildings with fewer than 100,000 gross square feet have higher average trip generation rates than larger buildings, but there is little difference between buildings with 100,000 to 199,999 GSF (ITE Code 712) and those with more than 200,000 GSF (ITE Code 713). Details of individual site trip rates are in Tables A.3 and A.4 in Appendix A.

The decision to calculate trip rates on the basis of occupied gross square feet of building floor area followed careful consideration of alternatives and review of other trip generation rate reports. In this study "occupied" denotes space utilized by persons and their supporting equipment and storage needs. In a rental building the occupied gross floor area also includes public restrooms, hallways and foyers.

For office land uses, several other popular indices of trip rates are the number of employees and the net rentable (or gross leasable) area. Two aspects of these other measures made them less desirable in our opinion: 1) the number of employees and the net rentable area may vary greatly during the life of the building even if its use as "general office" space remains unchanged; and, 2) we suspect that the employment levels and/or rentable area reported in many studies were not measured, but rather were calculated from gross floor area using assumed rates for employee

Table 3.2

(a.) General Office Trip Rate Summary for Adjacent Street Peak Hour: Average Trips/1,000 GSF Grouped by Size of Site

		Under 100,000 GSF ITE Code 711	100,000-199,999 GSF ITE Code 712	200,000 GSF And Over ITE Code 713
Average Size (GSF)		55,693	136,069	379,692
-AM Peak	In	1.37	1.17	1.13
	Out	0.28	0.14	0.12
	Total	**1.65**	**1.31**	**1.25**
Auto Occupancy Rate (In)		1.10	1.09	1.10
-PM Peak	In	0.41	0.24	0.14
	Out	1.35	1.05	0.95
	Total	**1.76**	**1.29**	**1.09**
Auto Occupancy Rate (Out)		1.13	1.13	1.10

(b.) General Office Trip Rate Summary for Site Generated Peak Hour: Average Trips/1,000 GSF Grouped by Size of Site

		Under 100,000 GSF ITE Code 711	100,000-199,999 GSF ITE Code 712	200,000 GSF And Over ITE Code 713
Average Size (GSF)		55,693	136,069	379,692
-AM Peak	In	1.64	1.38	1.51
	Out	0.35	0.18	0.13
	Total	**1.99**	**1.56**	**1.64**
Auto Occupancy Rate (In)		1.11	1.10	1.12
-PM Peak	In	0.52	0.28	0.17
	Out	1.61	1.27	1.30
	Total	**2.13**	**1.55**	**1.47**
Auto Occupancy Rate (Out)		1.11	1.14	1.12

Source: Douglas & Douglas, Inc.

density or rentable space. Consequently, the occupied gross floor area (measured in thousands of square feet) was chosen as the parameter most suitable for estimating trips.

During the surveys we also collected employment and parking space data. The employment density and the number of parking spaces provided per thousand gross square feet of building area vary widely. The lowest density (1.1 employees per thousand occupied GSF square feet) represents employment at a corporate headquarters building. A number of buildings have more parking spaces than employees, but even in those cases where the number of employees outnumber the number of parking spaces, there seems to be little impact on auto occupancy rates during the peak hour.

3.2.1 *Variation by Location in Montgomery County*

Average trip generation rates by county division are presented in Table 3.3a for adjacent street peak hours and in Table 3.3b for the site-generated peak hours. Generally, trip rates decrease with increasing urbanization: up-county and Eastern Montgomery County trip rates are higher than mid-county and down-county trip rates. In part this may be caused by the percentage of small office sites (fewer than 100,000 GSF) in the sample for each division. There is a direct and consistent relationship between the proportion of small office buildings and the average trip rate for all times of day (see Table 3.3): more small buildings mean more peak hour trips. For example, 72% of the sites surveyed contained fewer than 100,000 GSF in Eastern Montgomery County, the division with the highest average peak hour trip rates. In the up-county, mid-county, and down-county divisions, sites less than 100,000 GSF in size represented 53 percent, 36 percent, and 9 percent of the total respectively. The sample percentages approximate the population distribution except in the downcounty division where the exclusion of buildings within 2,500 feet of Metrorail stations, combined with survey difficulties and a high rate of owner refusals, produced a small sample biased towards larger buildings. Details by Planning Area are presented in Tables A.5 and A.6 in the Appendix.

3.2.2 *Comparison of Montgomery County Trip Rates with Other Trip Rates*

An objective of this study is to ascertain whether ITE trip rates and equations are suitable estimators of trips generated at Montgomery County sites. Table 3.4 permits a comparison of the rates from our survey with those reported by the ITE 3rd Edition for both the AM and PM peak hours for three building size categories utilized by the ITE 3rd Edition. Chapter 7 presents an analysis of the suitability of the ITE 4th Edition rates and techniques for use in Montgomery County. The differences between our observed rates in Montgomery County and the ITE 3rd Edition rates are rather surprising, not so much because of their size but because of their consistency across time periods and building size categories. Our average rates were 34% to 47% lower than the ITE 3rd Edition rates in each size category and in every time period. The Montgomery County trip rates are also lower than those derived from similar data collected in Prince George's County in 1982 for M-NCPPC [3]. However, they could not be meaningfully

Table 3.3

(a.) General Office Site Trip Rate Summary for Adjacent Street Peak Hour: Average Trips/1,000 GSF Grouped by County Division*

		Eastern Co.	Up-County	Mid-County	Down-County
Average Size (GSF)		239,290	148,565	216,746	162,568
-AM Peak	In	1.75	1.20	1.07	0.95
	Out	0.12	0.19	0.12	0.13
	Total	**1.87**	**1.39**	**1.19**	**1.08**
Auto Occupancy Rate (In)		1.12	1.10	1.09	1.09
-PM Peak	In	0.26	0.21	0.18	0.20
	Out	1.13	1.16	0.92	0.72
	Total	**1.39**	**1.37**	**1.10**	**0.92**
Auto Occupancy Rate (Out)		1.13	1.12	1.11	1.11

(b.) General Office Site Trip Rate Summary for Site Generated Peak Hour: Average Trips/1,000 GSF Grouped by County Division*

		Eastern Co.	Up-County	Mid-County	Down-County
Average Size (GSF)		239,290	148,565	216,746	162,568
-AM Peak	In	1.86	1.57	1.39	1.25
	Out	0.17	0.20	0.14	0.28
	Total	**2.03**	**1.77**	**1.53**	**1.53**
Auto Occupancy Rate (In)		1.12	1.11	1.12	1.09
-PM Peak	In	0.33	0.27	0.20	0.29
	Out	1.75	1.47	1.18	0.92
	Total	**2.08**	**1.74**	**1.38**	**1.21**
Auto Occupancy Rate (Out)		1.16	1.13	1.11	1.17

Source: Douglas & Douglas, Inc.

* See Table A.1 for Planning Areas in each County Division

Table 3.4

Comparison of Trip Generation Rates Reported by ITE (3rd Edition)* and M-NCPPC Trip Generation Rate Studies for Adjacent Street Peak Hour at General Offices

ITE Category		ITE (3rd Ed.) Trip Rates Mean	ITE (3rd Ed.) Trip Rates Min / Max	Montgomery County Trip Rates Mean	Montgomery County Trip Rates Min / Max	M.C. ITE % Diff.
AM Peak Hour						
711:Under	Enter		1.28/1.90	1.37	0.52/2.50	
100,000 GSF	Exit		0.15/0.80	0.28	0.06/1.50	
(15 ITE Sites)	**Total**	**2.50**	**1.40/3.79**	**1.65**	**0.72/3.44**	**-34.0%**
(36 MC Sites)						
712:100,000-	Enter		1.64/2.10	1.17	0.54/2.45	
199,999 GSF	Exit		0.19/0.25	0.14	0.04/0.68	
(8 ITE Sites)	**Total**	**2.00**	**1.06/2.66**	**1.31**	**0.62/2.77**	**-34.5%**
(31 MC Sites)						
713: Over	Enter		1.45/2.30	1.13	0.32/2.43	
200,000 GSF	Exit		0.11/0.30	0.12	0.02/0.24	
(4 ITE Sites)	**Total**	**2.13**	**1.56/2.60**	**1.25**	**0.45/2.57**	**-41.3%**
(12 MC Sites)						
PM Peak Hour						
711:Under	Enter		0.06/0.70	0.41	0.10/2.50	
100,000 GSF	Exit		0.74/2.60	1.35	0.52/3.00	
(17 ITE Sites)	**Total**	**2.82**	**0.80/6.39**	**1.76**	**0.80/5.25**	**-37.6%**
(36 MC Sites)						
712:100,000-	Enter		0.38/0.47	0.24	0.05/0.79	
199,999 GSF	Exit		1.13/2.21	1.05	0.42/2.33	
(10 ITE Sites)	**Total**	**2.03**	**0.82/2.69**	**1.28**	**0.55/2.77**	**-36.9%**
(31 MC Sites)						
713:Over	Enter		0.23/0.25	0.14	0.03/0.38	
200,000 GSF	Exit		1.50/2.00	0.95	0.44/1.85	
(4 ITE Sites)	**Total**	**2.04**	**1.73/2.25**	**1.09**	**0.60/2.23**	**-46.6%**
(12 MC Sites)						

Source: Douglas & Douglas, Inc.

* See Section 7.4 for a comparison with ITE 4th Edition equations.

compared with FHWA rates [2] as the office buildings considered in that research were combined to calculate a single average trip rate.

Examining further the relationship between ITE 3rd Edition and MC trip rates for the adjacent street PM peak hour, Figure 3.2 compares the trip rate range, weighted average and average size of the buildings in each study. For buildings with more than 100,000 GSF (ITE Codes 712 and 713), the range of trip rates observed in Montgomery County includes values as great as the maximum rates reported by ITE in the 3rd Edition, but the average rates are much lower. Ninety-five percent of all buildings in these two categories have PM peak hour trip rates lower than the ITE 3rd Edition average trip rate.

A number of factors related to changing travel behavior, changing lifestyles and changing business patterns may be contributing to the apparent discrepancies between average Montgomery County trip generation rates and the generally older, national ITE 3rd Edition rates. Two possible explanations for part of these differences are lower employment densities and peak spreading. To illustrate the former, consider that many of the tenants in new office buildings may have leased more space than needed for current operations in anticipation of future growth and possibly to take advantage of favorable long-term leasing agreements. As a result, the intensity of their use of the space they occupy may be lower than might be expected five years from now. The peak spreading may be the result of employees trying to avoid the traffic congestion associated with the rush hour. In many cases employers listed flextime as their only transportation systems management activity.

3.2.3 *Peak Spreading*

Evidence for peak spreading is available if we compare the percentage of trips to and from the sites during the two hour peak period that occurred during the adjacent street's peak hour with the corresponding percentage of trips that occurred during the generator's own peak hour. These percentages are presented in Table 3.5. The consistently higher percentages for the generator peak hour tell us that while the generator peak and the adjacent street peak might overlap, they do 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 further reduction in peak hour congestion without measures which increase vehicle occupancy (e.g., carpools, vanpools, bus use, etc.).

FIGURE 3.2

Comparison of Trip Generation Rates Reported by ITE and Mont. Co. for Office Sites by Size Groups (Adjacent Street PM Peak Hour)

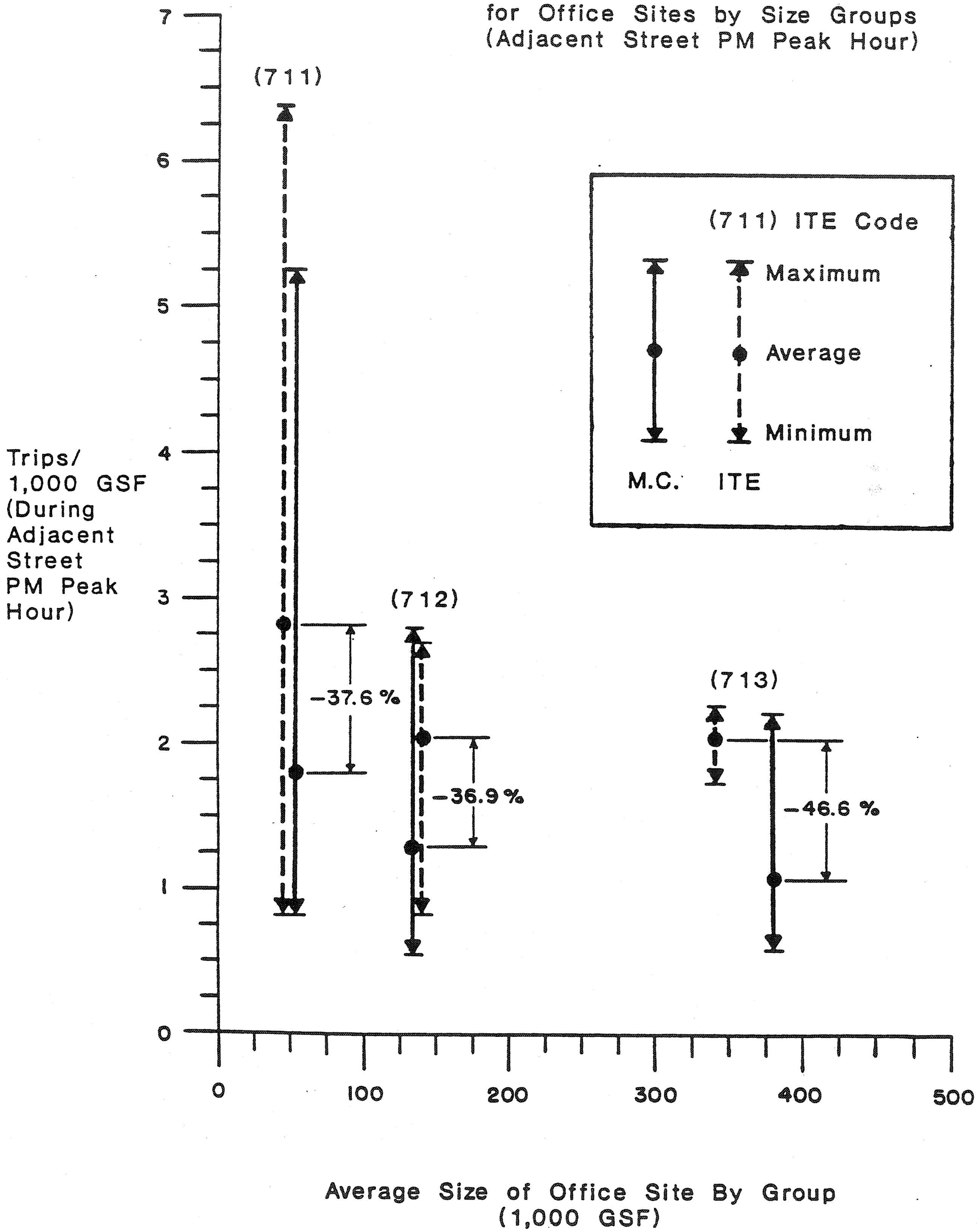


Table 3.5

Peak Spreading

Percentage of Peak Period Trips 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	
	AM	PM
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.

3.3 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 to Montgomery County offices. The 1982 Prince George's County Trip Generation Study [3] 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. In our study, auto occupancy averaged 1.1 persons per vehicle, and in the AM peak hour, more than 65% of all sites had auto occupancy rates at or below 1.10, 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 Prince George's County may account for some of this difference insofar as more households own a car for each worker in Montgomery County. Lower auto occupancy may also reflect the high levels of service employment in Montgomery County in that many employees, driving company-provided cars, 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.

3.4 TRENDS IN OFFICE TRIP RATES IN MONTGOMERY COUNTY

There are limited time-series data available to examine trends in trip rates generated by office buildings within the county. Several sites for which we obtained data are listed in Table 3.6. The average trip rates were calculated from counts collected by other consulting firms. Some points to keep in mind when interpreting these data are:

- There are significant differences in data collection techniques used: the States Highway Administration (SHA) consultant, Hunnicutt and Neales, collected 24 hour counts and reported that figure plus the percentage of trips in the peak hour; meanwhile, Barton-Aschman Associates reported trip rates based on net rentable square feet but gave the conversion factor to calculate trips per gross square feet;

- The peak hours reported from earlier surveys may have been selected from 60-minute or 30-minute counts rather than from 15 minute counts. The former produce a trip rate equal to or lower than the rate derived from 15-minute counts;

- The building occupancy rates were not reported in the earlier studies; and

- Gross floor area figures, necessary to verify compatible bases for computation of trip rates, were not available for all past studies.

3.4.1 *Ten-Year Trend*

The statistics for the three buildings surveyed in 1976 and again in 1986/7 as part of our research show a significant and relatively similar decrease in peak hour rates during the intervening 10 years (see Table 3.6). In general, this decline is greater if we compare adjacent street peak hour data rather than generator peak hour data. Additional confounding factors include falling employment densities at Fairchild and Gillette which we inferred from public accounts and the sale of the Gillette building not long after our survey.

3.4.2 *Five-Year Trend*

Changes in the trip rates measured at five sites in 1981 and again in 1986/7 show an almost entirely different pattern from that exhibited by the buildings surveyed over the 1976-86 period. 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 have no information regarding site characteristics to explain this phenomenon. The 1986/7 rate for the Harris Building represents the average for three surveys over a two month period covering different days of the week. The range

Table 3.6

Comparison of General Office Trip Generation Rates: 1976, 1981, AND 1986/7

Name	Data Year	Peak Hour	AM Trips/ 1,000 GSF (Total)	Peak Hour	PM Trips/ 1,000 GSF (Total)	%Change AM Peak	%Change PM PK
Fairchild	'76	8:00	1.98	5:00	2.44		
Gen.Peak	'87	7:00	1.52	5.45	1.66	-23.1	-32.0
Adj.Peak	'87	8:00	0.51	5:00	0.60	-74.2	-75.4
Tracor	'76	8:00	1.80	5:00	2.02		
Gen.Peak	'86	7:30	1.15	4:15	1.49	-36.1	-26.2
Adj.Peak	'86	7:30	1.15	5:00	0.90	-36.1	-55.4
Gillette	'76	7:00	0.79	4:00	1.14		
Gen.Peak	'87	7:30	0.44	4:00	0.44	-44.3	-61.4
Adj.Peak	'87	8:00	0.41	5:00	0.15	-48.1	-86.8
Harris	'81	8:00	0.91	4:45	0.71		
Gen.Peak	'86	8:00	1.43	4:45	1.36	+57.4	+91.3
Adj.Peak	'86	8:00	1.36	4:30	1.29	+50.4	+80.5
Willco	'81	8:30	1.39	4:45	1.14		
Gen.Peak	'86	8:15	1.39	4:30	1.36	+0.0	+18.9
Adj.Peak	'86	8:00	1.26	5:00	1.17	-9.4	+2.3
ADP Bldg	'81	8:15	2.00	5:00	1.48		
Gen.Peak	'87	8:00	2.81	5:00	2.88	+40.7	+94.8
Adj.Peak	'87	8:00	2.81	5:30	2.50	+40.7	+69.1
Ward Bldg	'81	7:30	1.87	4:30	0.98		
Gen.Peak	'86	7:45	1.60	4:15	1.06	-14.6	+8.5
Adj.Peak	'86	8:00	1.43	4:30	1.00	-23.7	+2.4
NCR Bldg	'81	7:30	1.43	4:45	1.50		
Gen.Peak	'86	8:00	1.53	4:30	1.21	+7.3	-19.6
Adj.Peak	'86	7:30	0.77	4:30	0.73	-46.0	-51.5

Sources: Douglas & Douglas; Barton-Aschman; State Highway Administration (collected by Hunnicut & Neale).

of rates over the two months for that building were anywhere from +/- 5% to +/- 19% depending on the peak hour in question. This range is 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 has changed significantly and/or space utilization has increased as firms have matured. Unfortunately, data from earlier surveys which could be used to test these possibilities are not available.

The comparison of simultaneously measured trip rates among buildings with similar characteristics coupled with this 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 casual observer can have an impact on trip rates. Firms expand (and also 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 trip rates. Increases in office rents may mean increased 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.

3.5 TRIP GENERATION RATE STATISTICS

An important outcome of this study is the recommendation of trip generation rates to be used in the site approval process and perhaps also for other functions in the planning, zoning, and impact fee assessment processes within the County. The ITE 3rd Edition office rates currently used in Montgomery County and elsewhere in the nation are rather dissimilar to and somewhat higher than the average trip generation rates for offices measured in this study.

Selecting an appropriate rate can be aided by examination of statistics and their implications for the level of traffic anticipated. The statistics commonly used to examine the magnitude and dispersion of data include the mean, the median, and the standard deviation. In Table 3.7 we have calculated not only the average or mean value for the AM and PM peak hour trips but also the median, standard deviation and 84th percentile for each ITE building class. (All these statistics are weighted according to the sizes of the buildings within each size group.) Comparison of these statistics with the ITE 3rd Edition mean value given in the table shows that the ITE average for each building class tends to be close to the 84th percentile value though somewhat less than one standard deviation above the mean for the size class. (That the 84th percentile and one standard deviation above the mean are significantly different in this case reflects the distribution of the trip rate data about their mean in each size class; the reader is referred to Figure 3.2 where it can be seen that for each group there is a pronounced clustering of data at the lower end of the range as evidenced by the relative position of the mean. In this situation, the standard deviation will tend to be relatively wide.)

Table 3.7

Comparison of General Office Trip Generation Rate Statistics

(a.) Adjacent Street AM Peak Hour

	Under 100,000 GSF ITE Code 711	**100,000-199,999 GSF** ITE Code 712	**200,000 GSF And Over** ITE Code 713
Montgomery Co. Study Mean	1.65	1.31	1.25
--Mean + 1 Std. Deviation	3.05	2.57	2.51
Montgomery Co. Study Median	1.89	1.40	1.41
--84th Percentile	2.56	2.09	2.03
ITE 3rd Edition Mean	2.50	2.00	2.13

(b.) Adjacent Street PM Peak Hour

	Under 100,000 GSF ITE Code 711	**100,000-199,999 GSF** ITE Code 712	**200,000 GSF And Over** ITE Code 713
Montgomery Co. Study Mean	1.76	1.28	1.09
--Mean + 1 Std. Deviation	3.38	2.54	2.20
Montgomery Co. Study Median	1.92	1.33	1.19
--84th Percentile	2.79	2.10	1.59
ITE 3rd Edition Mean	2.82	2.03	2.04

Source: Douglas & Douglas, Inc.

Thus, when we use the ITE 3rd Edition mean value, we are estimating an average number of AM and PM peak hour trips which is almost as high, if not higher, than 84% of all the sites in Montgomery County of that size class.

The statistics for the Montgomery County study are weighted by the floor area of the buildings surveyed. Consequently, the mean is a weighted mean and the median is a weighted median. These terms were discussed in the preceding chapter, but recall that the median trip rate of a set of buildings is the trip rate associated with that building whose size takes the cumulative floor area to 50% of the total floor area of all buildings if they are arranged by trip rates in ascending order of magnitude. Frequently, the weighted median trip rate does not represent exactly half of all the buildings, but something more or less depending upon the individual structure sizes.

The results of this analysis, which are shown graphically in Figures 3.3a and 3.3b, support the conclusion that there is a statistical difference between the ITE 3rd Edition and Montgomery County Study mean values. A statistical test is not possible without more data about the ITE 3rd Edition sample, however. Figures 3.3a and 3.3b show that ITE 3rd Edition mean values lie at the upper end of the range of values measured in Montgomery County for every category and for each time period. Thus, continued use of the ITE 3rd Edition rates is roughly equivalent to using the 84th percentile or something just below one standard deviation above the average rates measured in Montgomery County.

3.6 TRIP RATES FOR OFFICES LOCATED IN METRORAIL WALKSHEDS

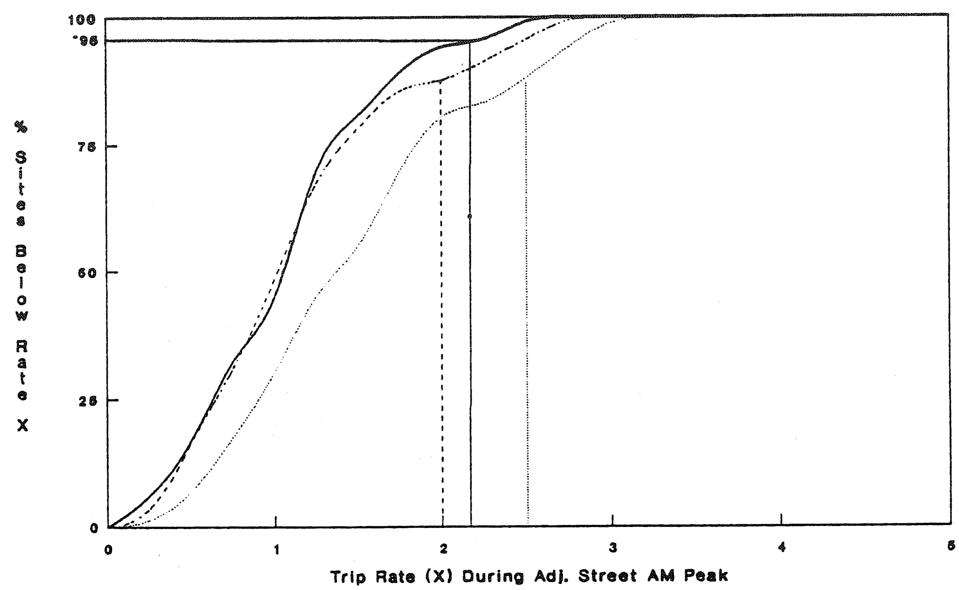
The study design for this project specifically excluded data collection at trip generators located within 2500 feet of a Metrorail Station. Consequently, previous sections of this report present vehicular trip rates only for buildings outside the range of normal walk-access distances for Metrorail services. During the late Spring and Fall of 1986 JHK & Associates collected trip generation rate data for sites located in Metrorail station areas as part of their "Post-Metrorail Transportation Characteristics Study" prepared for M-NCPPC. In this section we will summarize these data and compare Metrorail walkshed observations with our data which is collected from outside these walksheds.

Trip generation data collection covered 21 office buildings located from 200 to 2500 feet from a Metro Station. The sites were distributed across Metrorail station walksheds, both inside and outside the beltway, in the manner indicated in the list below.

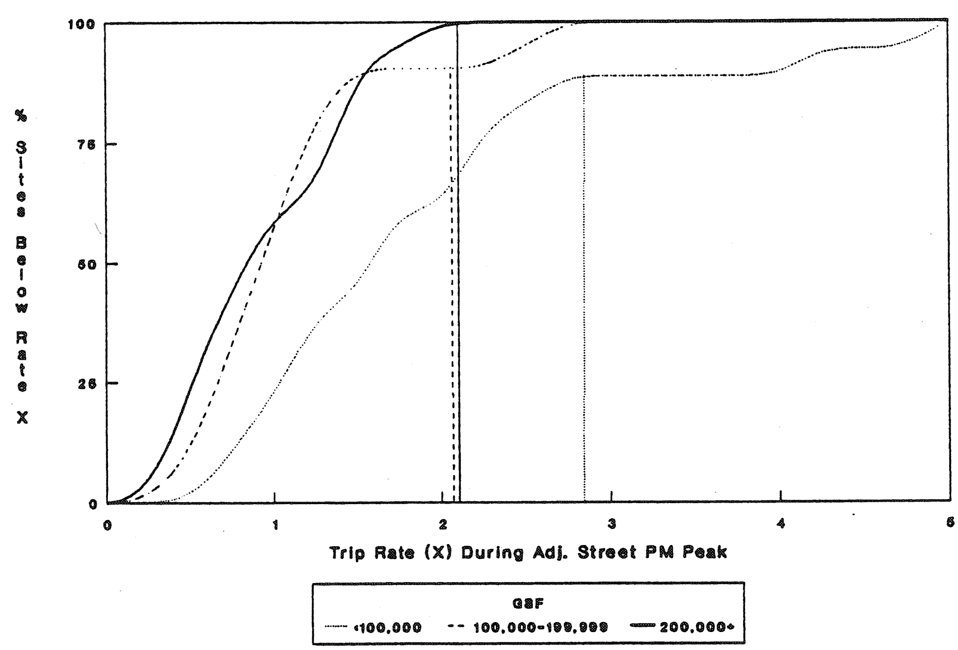
Figure 3.3

General Office Peak Hour Trip Rates

a. AM Peak Hour (Adjacent Street)



b. PM Peak Hour (Adjacent Street)



Note: Vertical Lines are ITE Trip Rates

Station Location	Number of Sites
- Inside the Beltway	
Bethesda	7
Friendship Heights	3
Silver Spring	3
Total	12
- Outside the Beltway	
Rockville	2
Twinbrook	6
White Flint	1
Total	9

Although results for 21 sites are available, we have not presented the summary statistics for one site at Twinbrook station because the tenant is a government social service agency; hence, the building trip rates were almost twice those of the building with the second highest rates and almost three times the average rate for all the other eleven buildings in its size group. Without further research, we decided that the high density of employees and heavy visitor traffic at the social service agency should remove the building from the general office category. This case also illustrates the possible impact of an unexpectedly high employee density and the estimation error made using "average" trip rates.

The vehicle trip rates measured at the Metrorail walkshed sites follow the patterns exhibited at the other general offices in the county; trip rates generally decline as building sizes increase. A comparison of rates shown in Table 3.8 illustrates this. What does come as a surprise is that vehicle trip rates for buildings with 100,000 to 199,999 GSF (ITE Code 712) are higher for buildings near stations and inside the beltway than for buildings located near stations outside the beltway. (This difference in rates may be the result of small sample sizes, or differences in floor area or occupancy levels.)

A comparison of the station walkshed trip rates with those rates measured outside, as shown in Tables 3.9 and 3.10, reveals unexpected differences. The morning peak hour data suggest that office buildings located near Metro stations have lower trip rates as might be expected (transit mode shares for this group ranged from 0% to 24% with a median of 8%). But the PM peak hour data indicate that walkshed sites generate almost as many vehicle trips as those outside the walkshed during the generator peak hour. When the site generator trip rates for buildings inside station walksheds are compared with the adjacent street peak hour data for sites outside Metrorail walksheds, they are 15% to 33% higher. However, the significance of this last result is uncertain. This is because we do not have data for trips at office buildings inside station walksheds for any time except the generator peak hour, and so cannot calculate trip rates for the adjacent street peak at these buildings.

Table 3.8

Trip Rates for General Office Buildings Located Within Metrorail Walksheds: Average Trips/1,000 GSF Grouped by Size of Site

(a.) Metrorail Walksheds Inside Beltway

		Under 100,000 GSF ITE Code 711 (5 Sites)	**100,000-199,999 GSF** ITE Code 712 (4 Sites)	**200,000 GSF And Over** ITE Code 713 (3 Sites)
Average Size (GSF)		65,300	134,250	241,667
-AM Peak	In	1.01	0.89	0.62
	Out	0.21	0.17	0.07
	Total	**1.22**	**1.06**	**0.69**
Auto Occupancy Rate		1.17	1.18	1.07
-PM Peak	In	0.55	0.26	0.29
	Out	1.05	1.33	1.16
	Total	**1.60**	**1.59**	**1.45**
Auto Occupancy Rate		1.13	1.10	1.06

(b.) Metrorail Walksheds Outside Beltway

		Under 100,000 GSF ITE Code 711 (6 Sites)	**100,000-199,999 GSF** ITE Code 712 (2 Sites)
Average Size (GSF)		40,167	170,500
-AM Peak	In	1.49	0.72
	Out	0.17	0.15
	Total	**1.66**	**0.87**
Auto Occupancy Rate		1.09	1.06
-PM Peak	In	0.36	0.30
	Out	1.77	0.97
	Total	**2.13**	**1.27**
Auto Occupancy Rate		1.12	1.04

Source: JHK & Associates; Calculations by Douglas & Douglas, Inc.

Table 3.9

Comparison of Trip Rates Measured at All Montgomery County General Offices Inside and Outside Metrorail Walksheds During the Generator Peak Hour

ITE Category (Sites Inside Walkshed/ Outside Walkshed)		Inside Walkshed Trip Rates		Outside Walkshed Trip Rates		In Wkd Out Wkd
		Mean	Min / Max	Mean	Min / Max	% Diff.
AM Peak Hour						
711:	Under 100K GSF (11 Ins/36 Outs)	1.41	0.49/2.24	1.99	0.84/2.81	-29.1%
712:	100K-199.99K GSF (6 Ins/31 Outs)	0.99	0.33/1.50	1.55	0.76/2.90	-36.1%
713:	Over 200K GSF (3 Ins/12 Outs)	0.69	0.52/0.82	1.64	0.77/2.57	-57.9%
PM Peak Hour						
711:	Under 100K GSF	1.83	1.17/2.72	2.13	1.06/6.03	-14.1%
712:	100K-199.99K GSF	1.47	0.47/2.32	1.54	0.77/2.77	-4.5%
713:	Over 200K GSF	1.45	1.21/1.63	1.47	0.79/2.27	-1.3%

Source: JHK & Associates; Douglas & Douglas, Inc.

Table 3.10

Comparison of Trip Rates Measured at General Offices Inside and Outside Metrorail Walksheds and Outside the Capital Beltway During the Generator Peak Hour

ITE Category (Sites Inside Walkshed/ Outside Walkshed)		Inside Walkshed Trip Rates Mean	Inside Walkshed Trip Rates Min / Max	Outside Walkshed Trip Rates Mean	Outside Walkshed Trip Rates Min / Max	In Wksd Out Wkd % Diff.
AM Peak Hour						
711:	Under 100K GSF (6 Ins/36 Outs)	1.66	1.12/2.24	1.99	0.84/2.81	-16.6%
712:	100K-199.99K GSF (2 Ins/30 Outs)	0.87	0.33/1.33	1.55	0.76/2.90	-43.9%
PM Peak Hour						
711:	Under 100K GSF	2.13	1.34/2.72	2.13	1.06/6.03	-0.0%
712:	100K-199.99K GSF	1.26	0.47/1.93	1.54	0.77/2.77	-18.2%

Source: JHK & Associates; Douglas & Douglas, Inc.

Statistical comparisons suggest that there is no significant difference between the total number of entering/exiting vehicle trips that one might expect during the PM peak hour at an office building near a Metro station and one of equivalent size, age and tenant composition located beyond walking distance. But given a median transit share of 8%, ranging from 0% to 24%, and auto occupancy rates which are roughly comparable to those of office buildings situated outside the walksheds, we can conclude that the person trip rates are higher for buildings near Metro stations than for those beyond walking distances. The higher rates could be the result of greater employment density resulting from higher office rents.

3.7 CONCLUSIONS AND RECOMMENDATIONS

The collected data appear to be stable and reliable indicators of the behavior of commuters to office buildings in Montgomery County. Although the resulting average rates are lower than might be expected from comparison with ITE 3rd Edition and Prince George's County reports, we believe our findings are valid. Not only are the average values consistent within the size groups, but the ranges are also consistent. One interesting difference is that in many cases the minimum trip rate we report is below that reported by ITE (3rd Edition). This finding suggests that during the past decade there has been a change in the density of employees per thousand square feet of space, and perhaps a greater acceptance of staggered work hours. Staggered work hours have long been in favor in the Washington area because of the Federal Government's practice of staggering agency arrival and departure times.

One area that is of concern and deserves further research is the impact of employer-sponsored TSM programs on auto occupancy rates through increased ride-sharing. There have been county-wide vanpool and carpool programs in operation for years, but organized transportation management associations (TMAs) were in their infancy during our data collection phase. Our data can therefore serve as a baseline for future evaluation of the impact of these programs on peak period vehicle trips to and from the TMA areas.

It is strongly suggested in this chapter that the procedures for estimating vehicle trips induced by general office buildings in Montgomery County should be derived from the data gathered in this study. Not only does the data base accumulated during the course of this research contain more data points than either the 3rd or the 4th Edition ITE data bases for the entire nation, but also, since it was collected locally, it is more likely to reflect current conditions in Montgomery County than any national data base could.

The particular method selected to produce estimates of vehicle trips at general office sites in Montgomery County may be developed from one or more of the statistics generated by this research. There are several options including:

1. Use of average values from the collected data;

2. Use of a selected percentile. An example would be the 85th percentile, in which 85% of all floor area has a trip rate below this value (the 85th percentile is at or below all ITE 3rd Edition values);

3. Use of the standard deviation (or some function of the standard deviation);

4. Continued use of ITE 3rd Edition rates or introduction of the ITE 4th Edition methodology; or

5. Use of equations analogous to those presented in the recent ITE 4th Edition report.

The final adoption of vehicle trip estimation equations or rates and methods for their application will require a thorough knowledge of the size and variety of trip rates to be found at Montgomery County sites. We must also consider the distribution of the rates and the consequences of estimating traffic using rates that might be exceeded by a significant proportion of all sites. A comparison of Montgomery County and ITE 4th Edition data is presented in Chapter 7. A method for estimating vehicle trip rates is recommended in Chapter 8.

CHAPTER 4

RETAIL TRIP GENERATION RATES

Shopping centers attract large traffic volumes daily. Many who visit shopping centers do so as part of a longer journey; these may be considered as either "passing by" the center or as having been "diverted" to it. There is a debate about whether the shopping center should be held responsible for generating "pass-by" trips. Reflecting this concern, we collected data on both retail trip generation rates and on "pass-by" and "diverted" trips during the Fall of 1986 and Spring of 1987. We restricted our attention to those trips generated by shopping centers which are classified as neighborhood or community centers. Regional and super-regional malls were not surveyed.

The highlights of our findings were that:

- Large community shopping centers (more than 100 thousand square feet store area) generate fewer trips per 1,000 square feet than do smaller neighborhood centers;

- The presence of a supermarket increases a shopping center's trip generation rate;

- About one-third of the trips to shopping centers are pass-by trips so that the shopper would have driven by even if not stopping to shop;

- The average trip rates for small neighborhood centers in Montgomery County are much lower (by 30%) than ITE (3rd Edition) rates for similar activities;

- Average trip rates for large neighborhood and community centers in Montgomery County are much higher (by 22% to 40%) than ITE (3rd Edition) rates for similar centers.

After eliminating regional malls and shopping centers located within the walksheds of Metrorail stations, there were 44 candidate shopping centers in the county. Of those, we surveyed 11 during October and November, 1986 and 4 during May and June, 1987 for a total of 15 sites. We found that the PM peak hour trip generation rates for shopping centers with less than 50,000 square feet (SF) of gross leasable area (GLA) (ITE category 820) were approximately 30% lower than rates for equivalent centers as reported by the ITE. On the other hand, for centers larger than 50,000 SF GLA (categories 821 and 822), the rates we observed were approximately 20% to 40% higher than those reported by ITE.

In addition to counting cars and occupants entering and leaving the retail sites, we also interviewed shopping center patrons to determine if their shopping trip was the primary purpose of their travel or if they had simply been "captured" as they were passing by the center. At nine shopping centers we interviewed a sufficient number of individuals for us to answer this question with some certainty. The results varied widely by size of shopping center, by location and by the composition of the stores. The percentage of pass-by trips ranged from 15% to 65% during the PM peak hour; many of these trips were the result of "last-minute" shopping on the way home from work. The breadth of the range from 15% to 65% may reflect the relative strength of individual shopping centers in terms of: the size and/or attractiveness of the anchor supermarket or other store; the quality of merchandise available; or the relative ease of access and parking. The results are discussed more fully in the following sections.

4.1 RETAIL CENTERS AND SELECTION OF CANDIDATE SITES

The Urban Land Institute (ULI) defines a shopping center as a group of architecturally unified commercial establishments built on a site which is planned, developed, owned, and managed as an operating unit. It provides on-site parking in quantities related to the types and total size of the stores. The ULI provides the following definitions for shopping centers on three different market scales:

- "Neighborhood Center - provides for the sales of convenience goods (food, drugs, etc.) and personal services (laundry, dry cleaning, etc.) for day-to-day living needs of the immediate neighborhood with a supermarket being the principal tenant. In theory, the typical neighborhood center has a GLA of 50,000 square feet; in practice the GLA may range from 30,000 to 100,000 square feet.

- "Community Center - has a wider range of facilities for the sale of soft lines (apparel) and hard lines (hardware, appliances, etc.) than the neighborhood center. It is built around a junior department store, variety store or discount department store as the major tenant in addition to a supermarket. It does not have a full line department store although it may have a strong specialty store. The typical size of a community center is 150,000 square feet. In practice a community center can range from 100,000 to 300,000 square feet. A community center is an intermediate shopping center and is the most difficult to estimate for size and pulling power.

- "Regional Center - provides shopping goods, general merchandise, apparel, furniture and home furnishings in full depth and variety. It is built around the full-line department store, with a minimum GLA of 100,000 square feet, as the major drawing power. For even greater comparative shopping, two, three or more department stores may be included. In theory a regional center has a GLA of 400,000 square feet, and can range from 300,000 to more than 1,000,000 square feet. Regional centers in excess of

750,000 square feet GLA with three or more department stores are considered super-regional."

This study focused on neighborhood and community centers. Regional centers such as Montgomery Mall, White Oak, Lakeforest Mall, Wheaton Plaza and White Flint were excluded from consideration at the request of M-NCPPC since, at the time of this study, no site approval applications for new centers of this size were anticipated in the near future. Our list of candidates also excludes those few neighborhood and community shopping centers which are located within walking distance (2,500 feet) of a Metro station.

Altogether, 44 shopping centers eligible for investigation were located in Montgomery County. Details of their size and location are indicated in Table 4.1. In order to draw a sample of sites, we stratified all shopping centers into two groups: those smaller than 100,000 SF GLA, and those larger than 100,000 SF GLA. Half the candidate sites were located in Gaithersburg and Rockville. The remaining 22 centers were scattered among 13 planning areas. Field inspection of the sites selected sometimes led to their rejection because of: construction activities at the site; entrance designs which precluded accurate counting of vehicular traffic; or, in one or two cases, unusually high vacancy rates. Figure 4.1 indicates the location of the 15 shopping centers surveyed; their addresses may be found in Table A.7 in Appendix A. The centers were selected using a random-number generator, thus achieving an unbiased geographical distribution as illustrated in Table 4.1.

4.2 RETAIL TRIP GENERATION RATES

There appears to be a consensus that average trip generation rates for retail activities are extremely difficult to explain. This is so because of the large number of explanatory variables involved. These factors include the character of anchor stores, the mix of stores, the quality of merchandise, the level of marketing effort, and the character of nearby communities. As a result, the attractiveness to the market of shopping centers can vary tremendously from one center to another.

Table 4.2 presents the results of the field data collection with the centers grouped by size. Appendix Tables A.8 and A.9 contain details for each site. The average trip generation rates were calculated on the basis of trips per thousand square feet of occupied space for the peak hour on the adjacent roadway. In Montgomery County, as is generally found elsewhere, trip generation rates for centers over 100,000 SF are lower than those for centers with fewer than 100,000 SF. This tends to reflect relative prices: day-to-day convenience goods are somewhat less expensive than "big-ticket" shopping goods. Also, people consistently spend more time comparison shopping for big-ticket items than for fairly standardized "convenience" goods. Consequently, larger centers with stores that sell hard goods and big-ticket items will have fewer trips per hour and longer shopping stays.

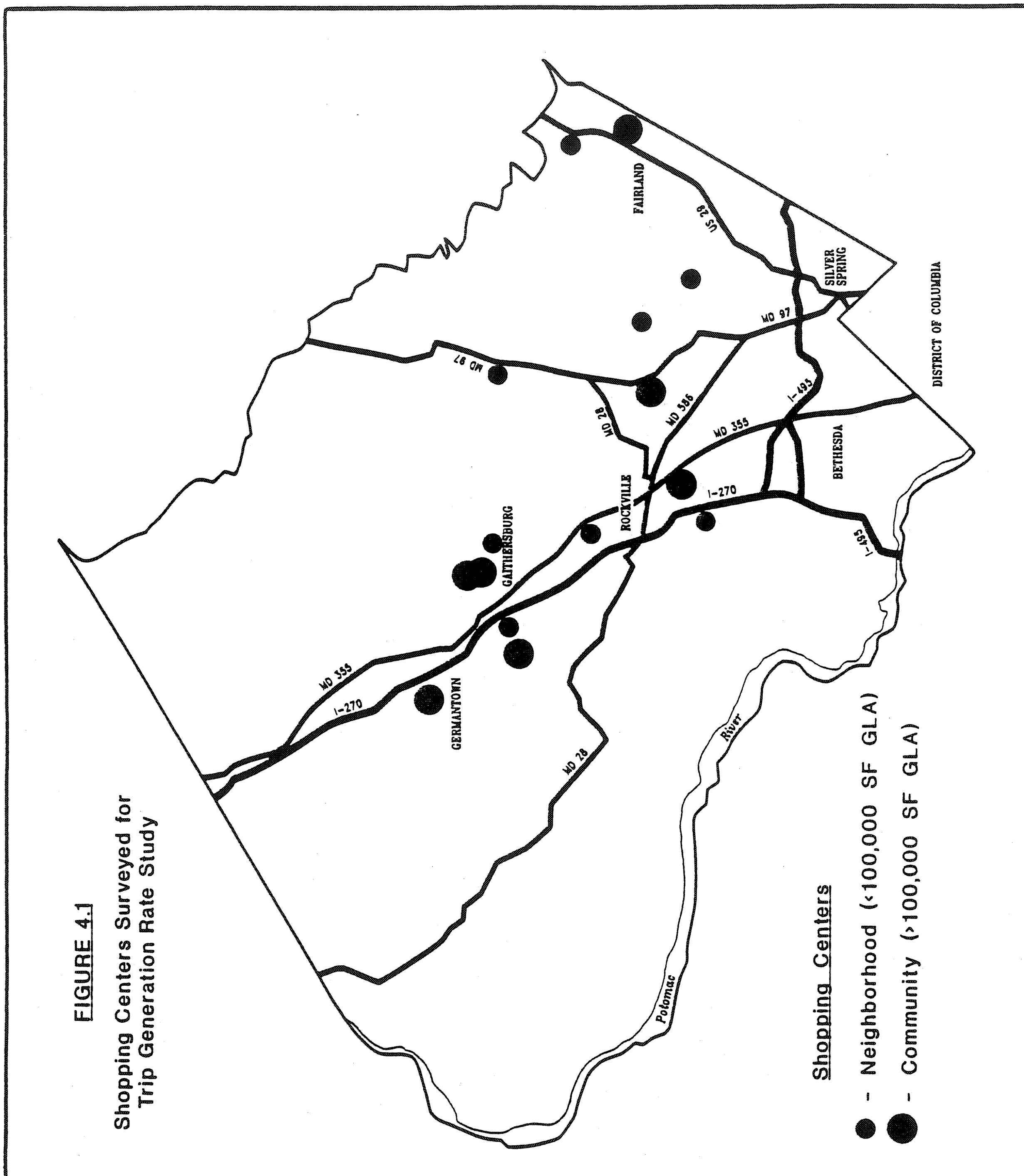


FIGURE 4.1
Shopping Centers Surveyed for Trip Generation Rate Study

Table 4.1

Sample and Survey Rates for Retail Sites by County Division* & Size

	Neighborhood Centers (Under 100K SF GLA)	**Community Centers** (100K SF GLA And Over)	**Total** All Centers	Sampling Percentages
Up-County				
Total	9	9	18	100%
Surveyed	3	4	7	39%
Mid-County				
Total	13	6	19	100%
Surveyed	3	2	5	26%
Down-County				
Total	2	0	2	100%
Surveyed	0	0	0	0%
Eastern M.C.				
Total	3	2	5	100%
Surveyed	2	1	3	60%
All Subareas				
Total	27	17	44	100%
Surveyed	8	7	15	34%
% Surveyed	29.6%	41.2%		

* See Table A.1 in Appendix A for a list of the Planning Areas lying within each division of the County.

Source: Douglas & Douglas, Inc.

Table 4.2

Retail Site Trip Rate Summary: Trips Per Thousand Square Feet Occupied Gross Leasable Area (GLA) Grouped by Size of Site

		Under 50,000 SF (2 Sites)	50,000-99,999 SF (6 Sites)	100,000 SF And Over (7 Sites)
Average Size (Square Ft GLA)		50,000	69,239	135,916
Adjacent Street				
-PM Peak:	In	5.76	5.62	3.86
	Out	4.20	5.22	3.31
	Total	**9.96**	**10.84**	**7.17**
Auto Occupancy Rate (Out)		1.45	1.30	1.36
Site Generated				
-Mid-Day Peak:	In	4.31	4.57	4.52
	Out	4.40	4.12	3.69
	Total	**8.71**	**8.69**	**8.21**
Auto Occupancy Rate (In)		1.35	1.36	1.27
-PM Peak:	In	5.48	5.95	4.32
	Out	5.84	5.87	3.66
	Total	**11.32**	**11.82**	**7.98**
Auto Occupancy Rate (Out)		1.52	1.36	1.36

Source: Douglas & Douglas, Inc.

In our field surveys we observed an inverse correlation between the average trip generation rate and the amount of parking provided. In many cases shopping centers with higher numbers of trips had lower ratios of parking spaces to sales floor area. This phenomenon is particularly noticeable at small centers with convenience stores or dry cleaners. Parking spaces may have a turnover of ten to twelve vehicles per hour. The turnover rate for a dry goods store will rarely exceed two to three cars per hour, however. From these observations, we can conclude that the relationship between vehicle trip rates and the number of parking spaces provided is more apparent than real. Both the parking required and the number of trips generated by a retail site are influenced by the types and mix of tenants.

One of the study objectives was to compare the average number of trips generated by land uses in Montgomery County with the corresponding rates reported by ITE (3rd Edition). Table 4.3 presents the necessary data for three ITE shopping center categories (820-822). It is interesting and somewhat surprising that the trip generation rates observed in Montgomery County do not each possess the same relationship with the corresponding ITE rates for the three shopping center types. Those shopping centers with 50,000 square feet or less floor space (category 820) have observed rates which are significantly lower than the national averages, although certainly well within the very wide ranges reported by ITE (3rd Edition). (However, since the Montgomery County data describe only two sites, comparison with the ITE data may be statistically unwarranted.) On the other hand, for categories 821 and 822, the Montgomery County rates are significantly higher than those reported nationally (see Figure 4.2). In some cases, such as shopping centers in ITE category 821, the highest site entry or site exit trip rate we observed in Montgomery County exceeded the maximum total trip rate as reported by ITE (3rd Edition). To verify this, refer to Table 4.3.

Possible explanations for the difference between ITE and Montgomery County rates might include: changes in life style influencing the total amount of shopping since the ITE (3rd Edition) data were collected in the 1960's and 1970's; the high disposable incomes in Montgomery County relative to the rest of the country; and the high proportion of working women in the Washington metropolitan area. (The labor force participation of wives and mothers might encourage them, as well as their husbands, to save time by picking up items on the way home from work during peak hour traffic. Note that the proportion of working mothers in this metropolitan area--about 70%--is reported to be the highest in the country.)

In Table 4.4, data are summarized by County division. The table indicates that trip generation rates for retail centers are roughly equivalent. The trip rates for the adjacent street PM peak hour vary across a range of only 11% and, for the site-generated PM peak hour, the highest average rate is only 5% greater than the lowest average rate. It appears that there is no significant difference by County division; each has the same mix of large and small shopping centers and same proportion of supermarkets.

The summary by planning areas (see Tables A.10 and A.11 for details) is inconclusive because of the small number of cases in most planning areas. The results also reflect the difference in center size and tenant mix. In one case, Gaithersburg Vicinity (Planning Area 20), we surveyed two centers with unusually low trip rates. Competition from both an adjacent regional mall and another nearby shopping center, plus inconvenient access from major highways, may have contributed to the lower rates.

Table 4.3

Comparison of Trip Generation Rates for Shopping Centers as Reported by ITE and This Trip Rate Study: Adjacent Street PM Peak Hour

ITE Category (No.ITE Studies/ No. of MC Sites)		ITE Trip Rates Mean	ITE Trip Rates Min / Max	Montgomery County Trip Rates Mean	Montgomery County Trip Rates Min / Max	M.C. ITE %Diff.
820: 50K SF GLA	Enter		1.42/11.43	5.76	4.68/ 6.84	
And Under	Exit		1.73/11.43	4.20	3.88/ 4.52	
(8 ITE/2 MC)	**Total**	14.42	**3.15/29.27**	9.96	**8.56/11.36**	-30.9%
821: 50K-99.99K	Enter		1.48/ 5.10	5.62	4.17/ 6.34	
SF GLA	Exit		1.78/ 5.50	5.22	3.56/ 6.22	
(6 ITE/6 MC)	**Total**	7.80	**3.10/13.30**	10.84	**7.74/12.38**	+39.0%
822: 100-199.99K	Enter		1.80/ 5.80	3.86	2.02/ 5.28	
SF GLA	Exit		1.80/ 5.40	3.31	1.57/ 4.33	
(18 ITE/7 MC)	**Total**	5.90	**3.10/11.10**	7.17	**3.59/ 9.31**	+21.5%

Source: Douglas & Douglas, Inc.

4.3 THE IMPACT OF SUPERMARKETS ON TRIP RATES

The mix of tenants in a shopping center has a direct but not clearly understood impact on trip generation rates. Although our data are not sufficient for a comprehensive analysis of all facets of this relationship, we did notice that the presence of a supermarket in a shopping center plays a significant role in the number of trips generated during the afternoon peak hour. The difference in trip rates for centers with supermarkets is probably the result of shoppers stopping by to pick up a few items on their way home from work.

FIGURE 4.2

Comparison of Trip Generation Rates Reported by ITE and Mont. Co. for Retail Sites by Size Groups (Adjacent Street PM Peak Hour)

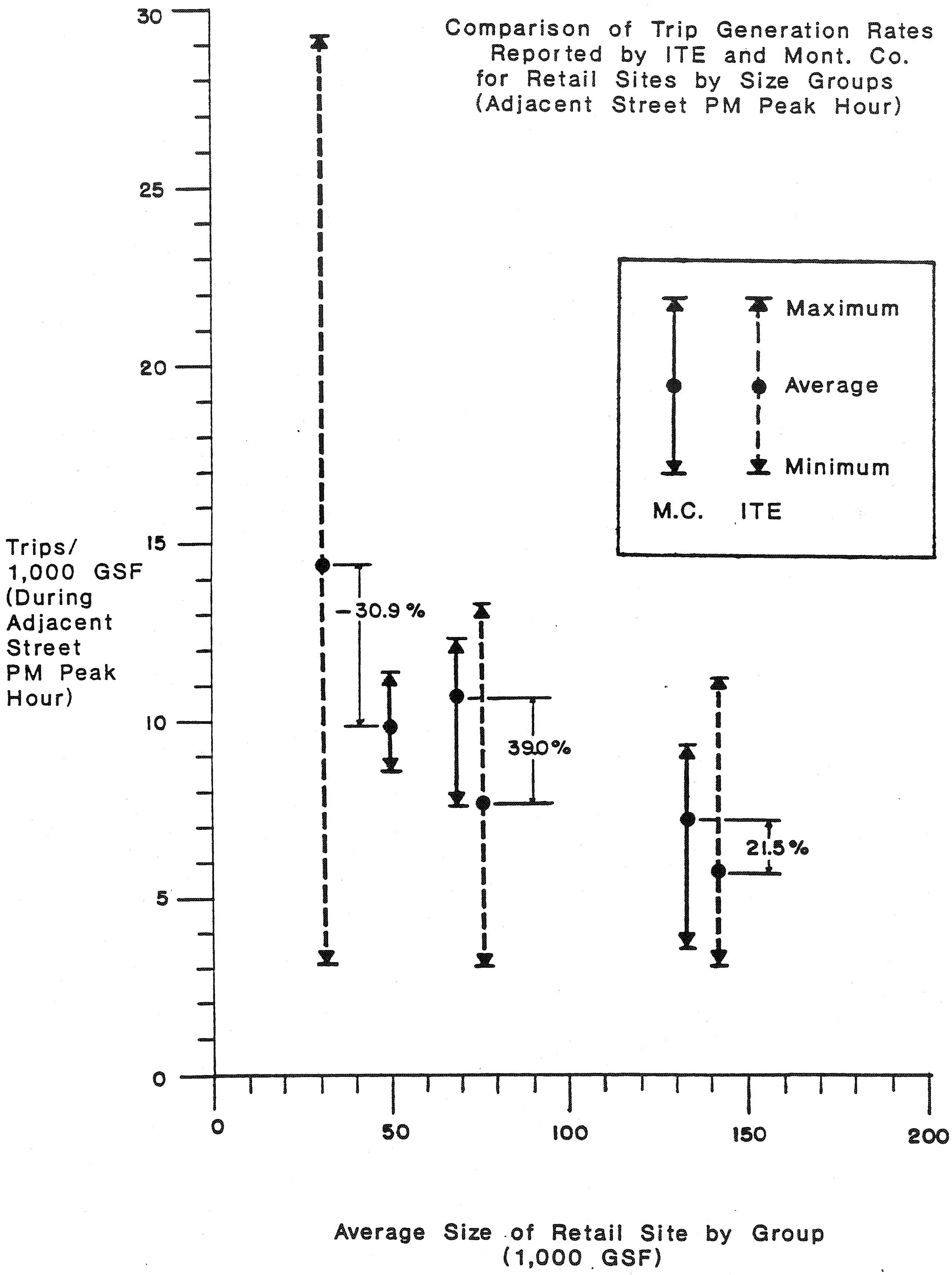


Table 4.4

Summary of Retail Site Trip Rates as Grouped by County Division

		Up-County (7 Sites)	Mid-County (5 Sites)	Eastern (3 Sites)	All (15 Sites)
Average Size (Occupied SF GLA)		83,165	95,413	136,062	97,740
Adjacent Street					
-PM Peak	In	4.32	4.74	4.58	4.51
	Out	3.70	4.15	4.07	3.92
	Total	**8.02**	**8.89**	**8.65**	**8.43**
Auto Occupancy Rate (Out)		1.38	1.31	1.33	1.34
Site Generated					
-Midday Peak	In	4.79	4.22	4.10	4.51
	Out	4.43	3.26	3.56	3.95
	Total	**9.22**	**7.48**	**7.66**	**8.46**
Auto Occupancy Rate (In)		1.35	1.20	1.37	1.32
-PM Peak	In	4.83	4.92	4.88	4.87
	Out	4.27	4.65	4.54	4.45
	Total	**9.10**	**9.57**	**9.42**	**9.32**
Auto Occupancy Rate (Out)		1.39	1.36	1.37	1.38

Source: Douglas & Douglas, Inc.

Table 4.5

Comparison of Retail Trip Rates at Shopping Centers With and Without Supermarkets

		Centers With Supermarkets (10 Sites)	Centers Without Supermarkets (5 Sites)	Centers With vs.W/O Supermarket
Average Size (Occ. SF GLA)		105,648	82,072	
Adjacent Street				
-PM Peak	In	4.76	3.79	+25.6%
	Out	4.16	3.26	+27.6%
	Total	**8.92**	**7.05**	**+26.5%**
Auto Occ. Rate	(Out)	1.35	1.33	+ 1.5%
Site Generated				
-Midday Peak	In	4.61	4.10	+12.4%
	Out	3.98	3.80	+ 4.7%
	Total	**8.59**	**7.90**	**+ 8.9%**
Auto Occ. Rate	(In)	1.30	1.40	- 7.1%
-PM Peak	In	5.04	4.38	+15.1%
	Out	4.72	3.69	+27.9%
	Total	**9.76**	**8.07**	**+20.9%**
Auto Occ. Rate	(Out)	1.38	1.37	+ 0.7%

Source: Douglas & Douglas, Inc.

The impact of supermarkets on shopping center trip rates is presented in Table 4.5. During the adjacent street PM peak hour (usually 5:00-6:00 PM), the shopping centers with supermarkets generated 26.5% more trips than those without. Even during the traffic generator PM peak hour, which can start any time between 3:45 and 7:15 PM, centers with supermarkets generated 20.9% more trips than those without supermarkets. Centers with supermarkets had generator mid-day peak hour trip rates 8.9% higher than centers without supermarkets. (The generator mid-day peak hour is the hour between 10 AM and 2 PM with the highest trip rate. In our surveys, 50% of the mid-day peak hours started at 11:30 AM; the rest started between 11:45 AM and 1 PM.) In all cases, the presence of a chain food store resulted in more trips.

For site approval purposes we are interested in adjustments to average trip rates which reflect the differences between sites which are currently identified by the same ITE code. The ITE categorizes shopping centers by total square footage of leasable area without consideration of the type of stores, particularly supermarkets. Table 4.6 presents the average adjacent street PM peak hour trip rates for the three ITE categories surveyed. However, the impact of food stores is not uniformly reflected in the data for each size category. There is no significant difference among the six centers in ITE Category 821 of which four have supermarkets, but for the larger and smaller centers the presence of a supermarket represents a significant increase in traffic of almost 3 trips/1000 square feet during the PM peak hour.

4.4 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 this report, as in other 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.

Table 4.6

Shopping Center Trip Rates by Size of Center and Presence of Supermarkets: Adjacent Street PM Peak Hour

Shopping Centers ITE Category			All	**Shopping Centers:** With Spr-Mkts	W/O Spr-Mkts	**Comparisons:** With Smkt VS. Total	W/Out Smkt VS. Total	With Smkt VS. W/Out
820:	50K SF GLA	Enter	5.76	6.84	4.68	+18.8%	-18.8%	+46.2%
	And Under	Exit	4.20	4.52	3.88	+ 7.6%	- 7.6%	+16.5%
		Total	**9.96**	**11.36**	**8.56**	**+14.0%**	**-14.0%**	**+32.7%**
	(2 MC Sites)							
821:	50K-99.99K	Enter	5.62	5.66	5.51	+ 0.7%	- 2.0%	+ 2.0%
	SF GLA	Exit	5.22	5.26	5.10	+ 0.8%	- 2.1%	+ 2.4%
		Total	**10.84**	**10.92**	**10.61**	**+ 0.7%**	**- 2.1%**	**+ 2.9%**
	(6 MC Sites)							
822:	100K-199.99K	Enter	3.86	4.22	2.73	+ 9.3%	-29.3%	+54.6%
	SF GLA	Exit	3.31	3.65	2.21	+10.3%	-33.2%	+65.2%
		Total	**7.17**	**7.87**	**4.94**	**+ 9.8%**	**-31.1%**	**+59.3%**
	(7 MC Sites)							

Source: Douglas & Douglas, Inc.

Previous ITE reports estimate 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 for two small centers (50,000 SF or less) which contain supermarkets and at community centers (100,000 SF 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 ITE (3rd Edition). The most striking difference between these data and our observations was the percentage of trips diverted from another route--our average observed value of 19% is only half that reported by ITE.

The question of the rate of pass-by and diverted trips has taken on new interest 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

Table 4.7

Retail Trip Diversion

Percentage of Entering Vehicles Captured from Pass-by Traffic or Diverted from Another Route During PM Peak Hour of Adjacent Street

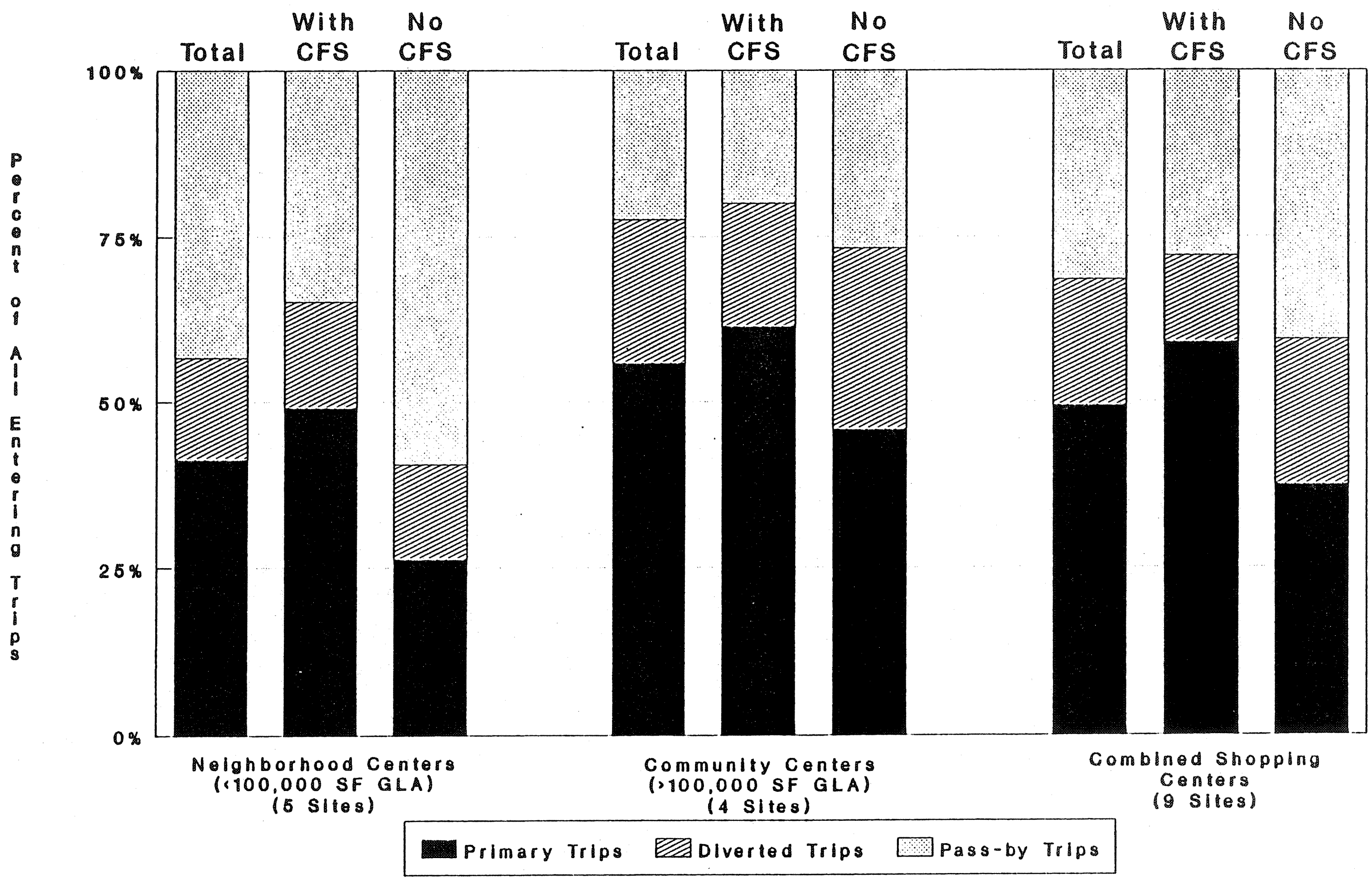
Survey No.	Sq.Ft GLA	Plan. Area	County Divn	Percentage Of PM Peak Hour Trips Primary Trip	Passby Captured	Diverted	Sample Rate	Spr-Mkt (Y/N)
22	50,000	26	Mid-Co.	66.3	25.5	8.2	22.2%	Y
23	50,000	15	Eastn	29.2	52.9	17.9	18.2%	N
19	55,250	21	Up-Co.	52.1	27.8	20.1	41.8%	Y
15	56,184	27	Mid-Co.	23.9	64.8	11.3	24.4%	N
17	80,000	33	Eastn	30.0	50.9	19.0	19.7%	Y
Neighborhood Center Average				41.2	43.3	15.4		
135	105,797	20	Up-Co.	39.7	27.8	32.5	66.9%	N
140	116,110	20	Up-Co.	38.6	35.1	26.3	39.5%	Y
149	144,881	26	Mid-Co.	48.3	26.2	25.4	33.7%	N
130	192,125	34	Eastn	68.8	14.9	16.3	40.9%	Y
Community Center Average				55.8	22.3	21.9		
All Sites Total				49.4	31.5	19.1		

Source: Douglas & Douglas, Inc.

who argue that even diverted trips which are "already on the network" should be eliminated from impact fee assessment. As we can see in Table 4.7, the percentage of PM peak hour trips captured from traffic passing by trips varies widely, even within one size category. In the small sample that we investigated, there seems to be little difference among planning areas. 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. As plotted in Figure 4.3, centers without supermarkets exhibit a higher percentage of pass-by trips than do centers of equivalent size which contain supermarkets. The effect is more pronounced for neighborhood centers (fewer than 100,000 SF GLA) because the supermarket represents a higher

Figure 4.3. Variation in Pass-by Trips for Retail Centers as Function of Size and Presence of Chain Food Stores



Note: CFS = Chain Food Stores

Source: Douglas & Douglas, Inc.

proportion of the total square footage. For these smaller centers, as much as 60% of the PM peak hour traffic are pass-by trips if there is no supermarket. In the larger community centers, pass-by trips account 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 is primary, as opposed to diverted, is 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.

To carry this analysis one step further, the combined primary plus diverted trip percentages for each size category were applied to the trip rates measured for sites with and without supermarkets. As presented in Table 4.8, during the adjacent street PM peak hour, there is a dramatic difference between the number of "new" trips generated by centers with supermarkets and that generated by centers without supermarkets. This difference ranges from 74% to 110% more "new" (primary plus diverted) trips in centers with supermarkets than in centers without them. Thus, the presence of a supermarket in a shopping center is reflected in an additional 2.6 to 4.4 trips per thousand SF GLA during the PM peak hour. These results are consistent with the view that much food shopping is currently done during the evening rush hours, reflecting the increase in the numbers of two-earner families and one-person households (both of which face considerable time constraints to shopping activities).

4.5 CONCLUSIONS AND RECOMMENDATIONS

Because of the different sizes of centers and the mix of tenants, our survey data tend to illustrate the difficulty in explaining variations in shopping center trip rates that is faced by traffic and transportation engineers in different parts of the country. The number of possible explanatory variables is so large that it is virtually impossible to find enough data points to deal with this problem satisfactorily.

From our research, however, two variables which do exhibit a measurable and a significant influence on trip rates for neighborhood and community shopping centers are: 1) the size of the center, and 2) the presence or absence of a supermarket in the shopping center. The influence of supermarkets is reflected not only in the total number of trips generated during the PM peak hour but also in the proportion of trips which are pass-by trips. Centers without supermarkets have lower trip rates and a higher proportion of pass-by trips than their counterparts with supermarkets. With respect to the size of the shopping center, trip rates tend to decrease as size increases. This is particularly true for primary and diverted trips.

Table 4.8

Primary/Diverted Retail Trip Rates for Shopping Centers With/Without Supermarkets: Adjacent Street PM Peak Hour

Shopping Centers ITE Category		Without Sprmkts: Observ Trip Rates	Without Sprmkts: % Prim./Divert Trips	Without Sprmkts: Prim./Divert Trip Rate	With Sprmkts: Observ Trip Rates	With Sprmkts: % Prim./Divert Trips	With Sprmkts: Prim./Divert Trip Rate	%Diff Trip Rates w/Spr vs.w/o
820: Less Than 50K SF GLA								
	Enter	4.68		2.20	6.84		5.10	231%
	Exit	3.88		1.83	4.52		3.37	184%
	Total	**8.56**	**47.10%**	**4.03**	**11.36**	**74.50%**	**8.47**	**210%**
821: 50-99.99K SF GLA								
	Enter	5.51		1.94	5.66		3.44	177%
	Exit	5.10		1.80	5.26		3.20	178%
	Total	**10.61**	**35.20%**	**3.73**	**10.92**	**60.80%**	**6.64**	**178%**
822: 100-199.99K SF GLA								
	Enter	2.73		2.00	4.22		3.38	169%
	Exit	2.21		1.62	3.65		2.92	180%
	Total	**4.94**	**73.30%**	**3.62**	**7.87**	**80.10%**	**6.30**	**174%**

Source: Douglas & Douglas, Inc.

The research to date suggests that:

1. Retail trip generation rates specific to Montgomery County are needed as suggested by the large differences between ITE (3rd Edition) trip rates and those observed in this research.

2. Two different rates should be used for centers in ITE Category 822 (100,000 - 199,999 SF GLA) depending on the presence of a supermarket.

3. The Commission should consider allowance of a credit for pass-by trips in the assessment of the impact of shopping center traffic on off-site roads and streets, but not for site access and nearsite improvements.

The Montgomery County data are compared with the new ITE (4th Edition) data in Chapter 7. The results of those comparisons are reflected by the trip estimation procedures recommended in Chapter 8. These recommendations are also sensitive to the concerns raised by the analyses and the conclusions presented in this chapter.

CHAPTER 5

FAST FOOD RESTAURANTS

Fast food restaurants are the source of a large number of vehicle trips in urban areas. This fact of modern life can be verified simply by driving in the vicinity of several fast food restaurants during the morning, mid-day or evening peak traffic periods.

We surveyed nine fast food restaurants and found that:

- During the afternoon peak hour, a vehicle enters or leaves a typical fast food restaurant every 30 seconds.

- Average afternoon peak hour trip rates for restaurants in Montgomery County are the same as ITE nationwide rates.

- The average trip rate appears to be most affected by the volume of traffic passing by, not by the size or kind of fast food restaurant or whether it has drive-through service.

- Most fast food patrons are on the road for other purposes in the morning and afternoon peak hours--eating at the fast food restaurant is not the primary purpose of their trip.

Contrary to expectations, perhaps, the "brand name" of the restaurant, the numbers of seats or parking spaces provided, and even the size of the restaurant do not appear to be related to the trip volumes measured at fast food sites. Our survey results suggest that there are two major factors which are correlated with the peak hour and mid-day trip generation rates at Montgomery County fast food restaurants. These are:

- The volume of traffic on nearby arterials. We found a strong positive relationship between traffic volumes on adjacent roads and the number of peak hour trips in and out of the fast food restaurants.

- The density of urban development in the immediate area. Generally, the higher the density, the greater the number of trips generated.

Overall, Montgomery County fast food restaurant PM peak hour trip generation rates cluster in the general range of 30 to 45 trips per thousand square feet of floor space. Lower rates were found in less urbanized areas. Note that fast food restaurants in some of the densest areas of the County were not surveyed because they lay within 2,500 feet of a Metrorail station and, hence, were surveyed during the course of the JHK study [5].

Fast food restaurants generate a great many trip ends per hour. But one could argue that many of the vehicles passing in and out of fast food restaurant driveways are not adding to the volume of traffic on the road network because they represent trips which have been captured from passing traffic en route to other (primary) destinations. Our research indicates that, during the PM peak hour on the adjacent street, 33% of the trips are captured from pass-by traffic. If one adds to this diverted trips (which are already on the road network for other purposes), then the percentage of vehicle trips captured or diverted during the adjacent street's PM peak hour stands at 67%. On a daily basis, pass-by traffic represents roughly 25% of the total traffic to a fast food restaurant. As might be expected, captured pass-by traffic in the morning rush hour is considerably higher (50%) than the daily average percentage, while at noontime it is considerably lower (10%). During the 11 a.m. to 1 p.m. lunch period, 80% of the inbound trips had a visit to the fast food restaurant as their primary purpose--their reason for being on the road. In the morning peak, 25% of the trips had a visit to the fast food restaurant as their primary purpose, and in the evening peak, 33% did.

Comparing Montgomery County fast food trip generation rates gathered in this study with ITE (3rd Edition) and FHWA nationwide studies, we found that the ITE afternoon average trip rate of about 32 in-and-out vehicles (ranging from 21 to 73) was fairly representative of PM peak hour traffic at Montgomery county fast food restaurants (see Table 5.1). Our mid-day peak rate was somewhat higher than the ITE rate--85.6 trips versus 78.8 trips per thousand square feet.

Table 5.1

Fast Food Restaurant Trip Rates: Comparing Peak Hour Trips/1,000 Square Feet of Total Space

Source Of Rates	Morning Peak	Mid-day Peak Hr	Afternoon Peak
Montgomery Co. Survey	31.7	85.6	31.0
ITE	NA	78.8	31.6
FHWA	15.0	117.2	41.1

Sources: Douglas & Douglas, Inc; ITE (1982); FHWA (1985)

Our data agree considerably less well with the average trip generation rates developed for the Federal Highway Administration's <u>Development and Application of Trip Generation Rates</u> [2]: Montgomery County AM peak hour rates were twice as high as the FHWA rates (31.7 trips per thousand square feet versus 15.0 trips per thousand square feet) while the PM peak hour trip rates for Montgomery County were 25% below the FHWA rates (31.0 trips per thousand square feet versus 41.1 trips per thousand square feet).

The high volume of breakfast traffic at fast food restaurants in Montgomery County might be attributable to a recent trend toward eating breakfast out. Also, the size of fast food restaurants and the number of seats has been increasing since the 1960s which may be leading to more trips or longer stays, although our findings cast doubt on size as a causal variable.

The burgeoning number of people eating breakfast out at fast food restaurants may stem from:

- The aggressive entry of many fast food restaurants into the breakfast market in recent years; and

- A higher proportion of working wives and mothers not making breakfast at home so that one, or both, workers get breakfast on the way to work.

Fast food lunches in Montgomery County may be more common than in other areas because of:

- A relative shortage of other mid-day eating places in some Montgomery County employment centers (or possibly a shortage of reasonably priced, convenient, quick, eating places); and

- Large numbers of teenagers from relatively high income Montgomery County households having money for discretionary spending on fast food.

5.1 SELECTION OF CANDIDATE SITES

The 3rd Edition of the ITE report grouped fast food restaurants into Category 833 - drive-in restaurants. The characteristics of this restaurant type, according to ITE, are that it has: "no, or only a limited number of, sit-down facilities. Generally, food is ordered and taken out to be consumed outside the restaurant building." The ITE (3rd Edition) survey collected data for twelve fast food restaurants such as McDonalds, Burger Chef, "and others." The facilities covered by ITE averaged 2900 SF per restaurant (with a range from 1,590 to 5,400 SF) with an average number of 30 seats. (For the 4th Edition, ITE collected more trip data for fast food restaurants, including those without drive-through facilities. Further discussion is contained in Chapter 7.)

During the first phase of this study, we inventoried fast food restaurants in Montgomery County to identify 53 stores operated by the traditional fast food chains plus several small companies specializing in fried chicken. The distribution of fast food restaurants is relatively uniform throughout the populated areas of the county with minor concentrations in Gaithersburg and the

Kensington/Wheaton area (see Table A.12 in Appendix A for further details.) In order to find suitable trip generation survey sites, we canvassed the fast food restaurants to determine whether they were located within 2,500 feet of a Metrorail station and to evaluate the nature of the physical facilities with respect to parking and their relationship to other retail activities. Twenty-three restaurants located inside shopping malls or within 2,500 feet of a Metrorail station were excluded from further consideration. This greatly reduced the number of down-county sites. From the 30 remaining candidates, we randomly selected sites for survey using a random number generator. We surveyed nine sites as shown in Table 5.2 and Figure 5.1. The surveyed sites, as may be seen in Figure 5.1, were located in up-county and mid-county locations. All but two of the sites had drive-through facilities.

5.2 MONTGOMERY COUNTY FAST FOOD TRIP GENERATION RATES

We collected trip generation rate data at fast food restaurants between the hours of 7 a.m. and 7 p.m. Virtually all the free standing fast food restaurants in Montgomery County, except those which specialize in chicken, now serve a breakfast menu.

During the 7 a.m. to 7 p.m. time period, we also interviewed patrons to determine what percentage of the trips were primary, pass-by, and diverted traffic. The nine fast food restaurants surveyed had an average area of about 3,400 square feet, approximately 12% larger than the 2,900 square feet average reported by ITE (3rd Edition). The Montgomery County fast food restaurants surveyed had considerably more seating space than the ITE average of 30 seats; there was an average of 87 seats per restaurant (ranging from 62 to 120 seats) in the County.

The results for the nine fast food restaurants surveyed are shown in Table 5.3a and 5.3b. (Further details can be found in Table A.13 in Appendix A.) Table 5.3a presents the trip generation rates during the AM and PM peak hours of the adjacent street traffic. Table 5.3b indicates the traffic generated during the site-generated peak which falls in the AM or PM peak period. In all cases, the site-generated peak hour falls at a time other than the adjacent street peak hour, but not always in the same direction. For example, the afternoon peak hour for the two fast food restaurants located in the Germantown planning area (Surveys 8 and 11) occurs before 4 p.m. while the site-generated PM peak hour for the other restaurants starts at or after 5:30 p.m.

In surveying trip generation behavior at Montgomery County fast food restaurants, we tried to identify characteristics which could explain the variation in trip generation rates. No explanation for the morning peak is forthcoming from the data we have. However, for the afternoon peak hour, the data arrayed in Table 5.4 suggest two interesting observations. These are:

Table 5.2

Sample and Survey Rates for Fast Food Restaurants by County Division

Division	Number	Sample %
Up-County		
Total	14	100%
Surveyed	6	43%
Mid-County		
Total	10	100%
Surveyed	3	30%
Down-County		
Total	2	100%
Surveyed	0	0%
Eastern M.C.		
Total	4	100%
Surveyed	0	0%
All Divisions		
Total	30	100%
Surveyed	9	30%

Source: Douglas & Douglas, Inc.

1. The number of trips generated by a fast food restaurant appears to be closely related to the volume of traffic on the adjacent street and at nearby intersections. To verify this, we collected PM peak traffic volumes from the major intersection closest to each restaurant. These data are listed in Table 5.4. Examination of Table 5.4 suggests a linear relationship in which fast food trips are positively and strongly correlated with adjacent street traffic volumes.

   The regression line between adjacent street traffic volumes and fast food restaurant trips is:

   Total PM Peak Trips = 39 + 0.0125 (Adjacent Street Intersection Volumes); (R^2 = 0.75).

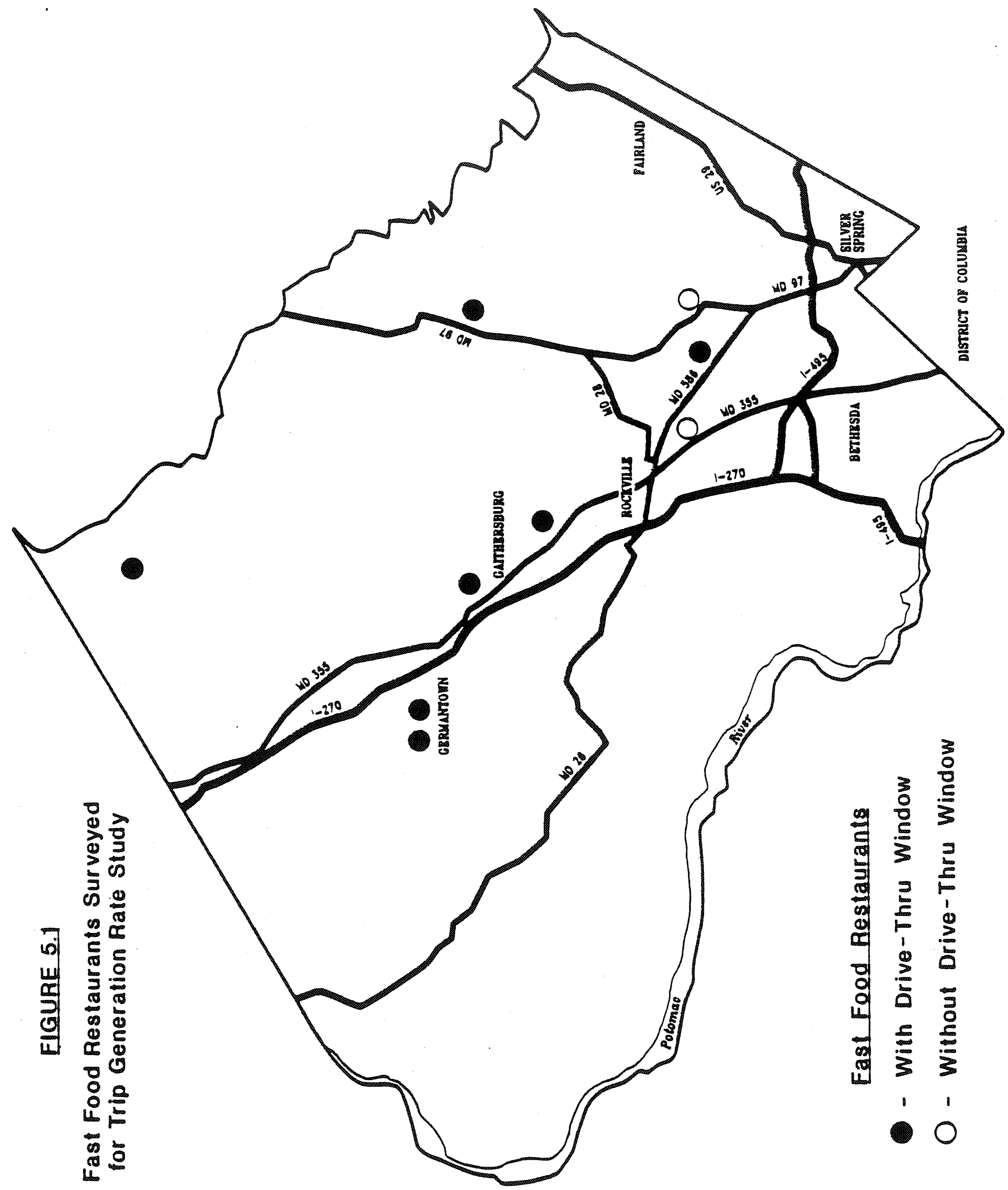


FIGURE 5.1
Fast Food Restaurants Surveyed for Trip Generation Rate Study

Table 5.3

Fast Food Site Trip Rate Summary

(a.) Adjacent Street Peak

Survey No.	AM Peak Hour Start	AM Trips/1,000 GSF Total	AM Auto Occ. In	PM Peak Hour Start	PM Trips/1,000 GSF Total	PM Auto Occ. Out
2	0800	58.53	1.22	1700	52.32	1.80
8	0730	42.81	1.21	1700	12.81	1.45
11	0730	10.40	1.53	1700	19.60	1.40
13	0745	14.06	1.19	1700	43.75	1.34
21	0800	31.67	1.16	1700	38.67	1.77
116	0730	42.00	1.33	1700	36.00	1.73
117	0800	28.16	1.13	1700	36.40	1.62
136	0800	45.45	1.18	1700	36.36	1.42
150	0700	37.00	1.37	1600	30.67	1.62
Average		35.09	1.24		34.32	1.59

(b.) Site Generated Peak

Survey No.	AM Peak Hour Start	AM Trips/1,000 GSF Total	AM Auto Occ. In	PM Peak Hour Start	PM Trips/1,000 GSF Total	PM Auto Occ. Out
2	0800	58.53	1.22	1745	61.15	1.56
8	0730	42.81	1.21	1530	23.12	1.16
11	0715	14.40	1.94	1545	29.20	1.76
13	0830	21.88	1.18	1745	52.19	1.27
21	0800	31.67	1.16	1800	52.67	1.80
116	0900	68.33	1.36	1800	53.00	1.48
117	0900	34.34	1.33	1800	51.51	1.36
136	0715	59.38	1.31	1730	47.44	1.65
150	0715	41.67	1.44	1800	59.33	1.94
Average		42.21	1.31		47.94	1.56

Source: Douglas & Douglas, Inc.

Table 5.4

Fast Food Restaurant Trip Generation Rates Related to Adjacent Street Traffic Volumes (Measured at Nearest Intersection)

Survey Number	Planning Area	Peak Hour Start	PM Peak Hour Volume	PM Peak HR Fast Food Total Trips	Trips/1,000 GSF Total
8	Germantown	1700	2265	41	12.81
11	Germantown	1700	2265	49	19.60
150	Damascus	1600	2374	92	30.67
117	Olney & Vic.	1700	4166	106	36.40
136	Rockville	1700	4708	128	36.36
21	Kens./Wheaton	1700	6673	116	38.67
116	Kens./Wheaton	1700	6792	108	36.00
13	Gaithersburg	1700	7706	140	43.75
2	Gaithersburg	1700	9736	160	52.32
	Average			104	34.32

Source Douglas & Douglas, Inc.

More research will be needed to develop a model which explains all the locational aspects of fast food restaurants, but this work does illustrate the strong correlation between fast food trips and adjacent street traffic levels. The impact on traffic of the presence or absence of a drive-through is inconclusive (compare sites 116 and 136 which did not have drive-throughs with data from the other sites).

2. There is a strong hint of a correlation between the density of development and the PM peak hour volume. The restaurants in Germantown had much lower traffic levels (site numbers 8 and 11) possibly because of lower development densities in this area than in the more urbanized sections of the County.

The adjacent street peak hour volume is probably a more useful measure of fast food trips than surrounding development density, however, since it is more directly related to the traffic at the restaurant.

We found no statistical support for the hypothesis that brand name--the kind of fast food restaurant--affects traffic volumes. For example, the most active restaurant surveyed (site 2) and the second-least active facility (site 11) are both operated by the same chain. It should be remembered, however, that we surveyed only nine sites representing four different fast food chains or brands. This represents a very small sample for this type of stratification.

By way of a summary, our survey of nine representative sites appears to indicate that fast food restaurant trips in Montgomery County are strongly related to:

- The volumes of adjacent street traffic providing "exposure" to the restaurants; and
- The density of urban development in the vicinity of specific fast food restaurant sites.

Table 5.5

Comparison of Fast Food Restaurant Trip Generation Rates per Thousand Sq. Ft.: Average Vehicle Trip Rates During Adjacent Street Peak Hour*

	ITE(1)		FHWA(2)	Montgomery County		% Diff.	
	Mean	Min/Max	Mean	Mean	Min/Max	MC/ITE	MC/FHWA
AM Peak Hour							
Enter			8.2	19.4	6.0/29.1		+136.6%
Exit			6.8	15.7	4.4/29.4		+130.9%
Total			**15.0**	**35.1**	**10.4/58.5**		**+134.0%**
PM Peak Hour							
Enter	17.0		21.8	18.4	6.6/28.1	+8.2%	-15.6%
Exit	14.6		19.3	15.9	6.3/24.2	+8.9%	-17.6%
Total	**31.6**	**21.1/73.0**	**41.1**	**34.3**	**12.8/52.3**	**-8.5%**	**-16.5%**

(1) Reference 1; (2) Reference 2;

*Comparisons for ITE AM trip rate are not applicable.

Source: Douglas & Douglas, Inc.

5.3 COMPARISON WITH LOCAL AND NATIONAL RATES

Comparison of the average trip generation rates measured in Montgomery County with those reported by ITE (3rd Edition) and FHWA show some interesting differences. These are presented in Table 5.5. Montgomery County AM peak hour rates are more than 100% higher than those reported by FHWA, a result which may reflect the recent trend towards more "stop-and-go" breakfast eating. The PM peak hour rates measured in Montgomery County are essentially equivalent (minus 2%) to the ITE (3rd Edition) rates, but are 25% lower than those measured in the FHWA study. We cannot account for these differences.

5.4 TRIPS CAPTURED FROM PASS-BY AND DIVERTED TRAFFIC

One of the major fast food chains asserts that its patrons may be divided into one-third primary trips, one-third captive by-pass trips, and onethird diverted trips. Our experience is that the proportions of diverted and pass-by (captured) trips both vary widely from site to site and from hour to hour throughout the day. Morning and evening peak hour pass-by trip percentages are listed in Table 5.6.

Table 5.6 and other data suggest some general conclusions about the nature of trips to Montgomery County fast food restaurants:

- Morning peak fast food visits are composed of about 25% primary trips, almost 50% captured pass-by trips, and about 25% diverted trips;
- Mid-day fast food restaurant visits between 11 a.m. and 1 p.m. are almost entirely primary in nature (about 80%) with only 10% captured pass-by trips and 10% diverted trips; and
- Afternoon peak fast food visits are about one-third for each of the three categories.

It appears that morning fast food visits are substantially embedded within primary trips for more basic purposes like commuting to work or school, while evening visits are more evenly distributed. Noon-time visits are usually primary trips for lunch.

5.5 CONCLUSIONS AND RECOMMENDATIONS

Our results suggest that a considerable part of the variation in trips generated by fast food restaurants can be explained by the traffic volumes on adjacent streets and highways as well as by the density of development in the area surrounding the site. Physical factors associated with the restaurant, such as the numbers of square feet, seats, or parking spaces, do not appear to affect the number of trips generated to any significant degree.

Our findings on whether the trips were primary, pass-by capture or diverted in nature indicate that these types of trips vary considerably through the day for all restaurants surveyed, but that morning trips were predominantly passby in origin, lunch trips were overwhelmingly primary trips, and evening trips were fairly evenly divided. Our data also seem to indicate that there has been an increase in fast food breakfast consumption.

Table 5.6

Trip Generation Rate Study: Fast Food Trips Captured From Pass-by Traffic

	AM Percentages					PM Percentages				
Svey No.	Peak Hour	Prim (1)	Cap (2)	Divn (3)	No. Obs	Peak Hour	Prim (1)	Cap (2)	Divn (3)	No. Obs
Adjacent Street										
2	N/A					1700	66.6	16.7	16.7	30
8	0730	22.2	57.3	20.6	19	1700	37.8	62.2	0.0	34
11	N/A					1700	60.9	29.7	9.4	50
13	0745	46.0	54.0	0.0	116	1700	25.0	24.7	50.3	40
21	0800	9.4	30.2	60.4	32	1700	53.3	36.2	10.5	89
116	0730	22.3	53.8	23.9	57	1700	37.3	35.5	27.2	61
117	0800	24.4	32.1	43.5	81	1700	37.1	32.8	30.1	70
136	0800	56.0	22.8	21.1	103	1700	30.0	26.4	43.6	97
150	0700	28.6	46.7	24.7	67	1600	28.7	42.9	28.4	85
Average		27.1	47.4	25.6			37.0	32.8	30.2	
Site Generated										
2	0800	0.0	100.0	0.0	5	1745	35.9	18.3	45.9	24
8	0730	22.2	57.3	20.6	19	1530	0.0	100.0	0.0	22
11	0715	0.0	50.0	50.0	80	N/A				
13	0830	41.1	49.4	9.5	57	1745	20.9	23.9	55.3	37
21	0800	9.4	30.2	60.4	32	1800	47.0	30.5	22.5	49
116	0900	42.2	37.8	20.0	64	1800	41.5	39.1	19.4	50
117	0900	42.6	31.8	25.6	84	1800	51.3	24.3	24.4	95
136	0715	26.4	37.6	36.0	64	1730	38.0	30.5	31.5	100
150	0715	24.8	45.7	29.5	72	1800	40.1	37.9	22.1	87
Average		27.6	45.9	26.5			38.7	30.1	31.2	

(1) Primary - single purpose trip
(2) Captured from pass-by traffic
(3) Diverted from route otherwise taken

Source: Douglas & Douglas, Inc.

Fast food restaurant trip generation rates in Montgomery County fall in the general range of 30 to 45 trips per hour for each thousand square feet of floor space. Generally, the most important determinants of fast food restaurant trip rates are:

- The volume of traffic on adjacent arterial streets; and
- The density of urban development in the immediate area.

There was no specific brand name preference indicated by the survey data. When compared with ITE (3rd Edition) and FHWA nationwide study rates, our data appear to be:

- Significantly higher during the morning peak hour; and
- Approximately the same as the ITE data, but lower than the FHWA study data, during the evening peak hour.

The morning peak hour rate may well be a local phenomenon reflecting the fact that Montgomery County has the highest percentage of working mothers in the country.

In Chapter 7, we compare the Montgomery County data with the new relationships and equations presented by ITE (4th Edition). In Chapter 8, we recommend a procedure for estimating trips generated at fast food restaurants in Montgomery County.

CHAPTER 6

RESIDENTIAL TRIP GENERATION RATES

Trip generation rates for residential land uses have received more attention nationally than those for any other land use, principally because they form the foundation of most regional modeling processes. Highlights of the findings from our survey of 59 residential sites include:

- Single-family detached homes generate more trips than multifamily homes and townhouses;
- Trip rates for Montgomery County single family homes are similar to the ITE trip rates for single family homes;
- Multi-family homes in Montgomery County generate fewer trips than estimated by ITE data, but the difference is small; and
- Garden apartments, townhouses and mid-rise apartments (under 9 stories) have very similar PM peak hour trip rates.

Our review of the research by others indicates that: (1) average trip generation rates by type of dwelling have varied widely by time and locale - and not necessarily in predictable fashion - and (2) dwelling units have been a less-than-satisfactory measure of trip rates. The data collection and subsequent analysis in this study of trip generation rates for residential sites have been influenced by these two issues. The sample data set contains sites from all parts of the County, stratified by type and number of dwelling units.

In order to collect data for relatively homogenous sets of observations, we isolated residential sites by the type of structure and the level of dwelling unit price. We also stratified the total stock of residential sites into classes, defined by type and size of dwelling unit, in the following manner:

- Single-family detached homes;
- Townhouses;
- Multi-Family Dwellings;

- Garden Apartments/Condominiums;

- Mid-rise Apartments/Condominiums;

- High-rise Apartments/Condominiums.

The dilemma presented by residential land uses in trip generation studies is that variables which tend to have a great deal of explanatory power (e.g., auto ownership, income and household size) are variables which are hard to forecast during the site review process, difficult or impossible to enforce in the planning and zoning process, and difficult or impossible to mandate in the subdivision or development review process. As a result, we must look for surrogate measures which are known in advance of construction and which capture as much of the explanatory power as possible. Thus, we think it is necessary to continue to rely on the dwelling unit as the basic variable for computing and comparing residential trip rates at this time.

6.1 SELECTION OF CANDIDATE SITES

Two different approaches were used to select a list of suitable residential sites from which samples could be drawn. With respect to single-family housing and townhouses, a site-oriented approach was used. For multifamily dwelling units, an inventory-based approach was utilized in which an existing inventory of all such sites in the County was consulted.

Single-family home developments and townhouse sites were checked for street access and potential traffic counting problems before including them as candidate sites. Single-family detached housing complexes suitable for investigation were identified by examining aerial photographs, county maps, and site conditions, and by talking with knowledgeable members of the MNCPPC staff. The guiding principles were to select groups of dwelling units with more than 50 houses of relatively similar size, preferably constructed by the same developer, and not mixed with townhouse or garden apartment structures unless the traffic was separable. Many otherwise suitable sites had to be discarded because of streets which permitted through traffic which could not be isolated from resident-oriented traffic.

Multi-family housing survey sites were selected from a county-wide inventory and then field checked for traffic counting problems after initial random selection. The Montgomery County Office of Landlord-Tenant Affairs provided the inventory of multi-family residential sites (Apartment Directory, Guide to Rental Facilities in Montgomery County, MD) which included information on the number of units, rental rates, number of bedrooms, and provisions for special groups.

We adopted the Montgomery County definitions of size and type since ITE's 3rd Edition had only two distinct size class categories (1-2 stories (ITE category 221) and 3 or more stories (ITE category 222)) as well as a general category including any size apartment (ITE category 220). Garden apartments are defined by the Office of Landlord-Tenant Affairs as having 1 to 4 stories. Mid-rise multi-family apartments and condominiums are 5 to 8 stories high. Highrise apartments are 9 or more stories high.

Random selection of candidate multi-family residential sites followed stratification along the characteristics of type (height), number of units, and owner-occupied versus rental. The focus groups identified these variables as possible explanations of variation in trip generation rates. We chose to use stratified random sampling because of the wide variation in the number of candidates in each group. This variation is apparent in Table 6.1.

The target number of surveys for this project was 60, or roughly 20% of the total sites identified. The distribution of the surveyed sites among the four major residential groups was not uniform. More high-rise and mid-rise multi-family residences and townhouses were surveyed because the Planning Staff believed that these newer housing types better represented the types of multi-family units likely to be submitted for development approval in the future. Consequently, although garden apartment candidates represented 67% of the total stock of multi-family dwelling units, they made up only 35% of those surveyed. We did not distinguish between high and mid-rise multi-family residences in the selection of samples. Most of the complexes with more than 250 units fell into the high-rise category. Most of the multi-family residences with fewer than 100 units fell into the mid-rise category.

The spatial distribution of residential sites is shown in Figure 6.1 and Table 6.2. (Refer to Table A.14 in Appendix A for a list of these sites with their addresses.) It is apparent that the residential sites were scattered throughout the County; single-family homes tended to be located in the less urban and upcounty areas--Gaithersburg, Potomac, Fairland/White Oak for instance--while multi-family units, particularly mid-rise and high-rise apartments, were more heavily represented in down-County areas. Note that the selected sites were not distributed uniformly among the various planning areas. The explanation for this is quite simple and relates to the fact that the random selection process stratified the land uses by type and size, but not by planning area. The effects of this are most readily seen with respect to garden apartments which formed a large majority of the sites in a number of planning areas. Since we surveyed only 9% of the garden apartments in the County, there was a tendency for planning areas with large stocks of garden apartments to be under-represented in our sample. To put it another way, the apparent bias in the number selected by planning area is the result of a non-uniform geographic distribution of the different size and tenancy groups.

Table 6.1

Distribution of Residential Land Use Sites by Type and Size

Land Use Type & Size	Total	Number Surveyed *		Percentage Surveyed
Single-Family DU	81	21	(1)	25.9%
Townhouses				
Over 250 Units	6	2		33.3%
100-250 Units	11	3	(1)	27.3%
Under 100 Units	7	0		0.0%
Total All Townhouses	24	5	(1)	20.8%
Garden Apartments				
Over 250 Units	48	4		8.3%
100-250 Units	65	5		7.7%
Under 100 Units	40	5		12.5%
Total Garden Apartments	153	14		9.2%
High-Rise and Mid-Rise Multi-Family Residences				
Over 250 Units	9	5	(1)	66.6%
100-250 Units	24	9		33.3%
Under 100 Units	17	5		29.4%
Total High/Mid-Rise	50	19	(1)	38.0%
Total Residential Sites	308	59	(3)	19.2%

Source: Douglas & Douglas, Inc.

* Number in parentheses indicates the number of sites surveyed more than once. Additional surveys for a given site are not included in the 'Number Surveyed' or the percentages.

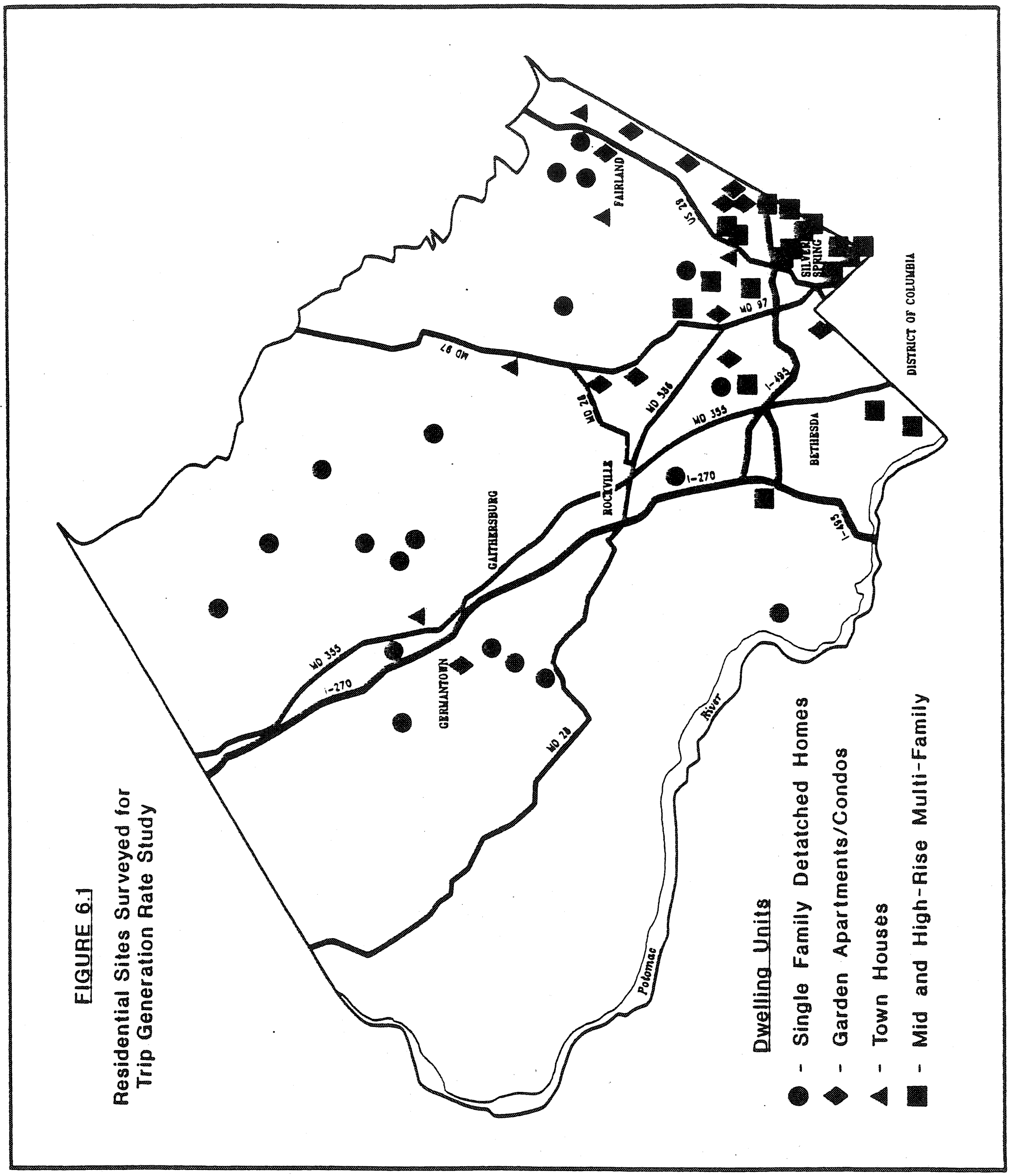


FIGURE 6.1

Residential Sites Surveyed for Trip Generation Rate Study

Table 6.2

Sample and Survey Rates for Residential Sites by County Division and Dwelling Type

	Type: Det. Sing-Fm Homes		Sing-Family Twnhses		Mul-Fm: Gdn Apts.	Mul-Fm: Mid+ Hi-Rise		All Sites		Smplng %'s
Up-County										
Total	51		15		50	3		118		100%
Surveyed	12	(1)	2		1	0		15	(1)	13%
Mid-County										
Total	21		3		49	7		80		100%
Surveyed	5		0		5	3		13		16%
Down-County										
Total	1		3		36	34		74		100%
Surveyed	1		0		1	14		16		22%
Eastern M.C.										
Total	8		3		18	6		35		100%
Surveyed	3		3	(1)	7	2	(1)	15	(2)	43%
All Divisions										
Total	81		24		153	50		308		100%
Surveyed	21	(1)	5	(1)	14	19	(1)	59	(3)	19%
% Surveyed	25.9%		20.8%		9.2%	38.0%				

Source: Douglas & Douglas, Inc.

Note: The numbers in parentheses indicate the number of sites in which additional surveys were done.

6.2 RESIDENTIAL TRIP GENERATION RATES

Peak hour average trip generation rates for single-family detached homes were higher than those for multi-family dwelling units. These findings support the results of other research into trip generation rates throughout the region. In the morning peak, the trip rates at single-family housing sites were approximately twice the multi-family apartment and townhouse rates. In the afternoon peak hour, the single-family trip rates were approximately two and one-half times greater than the rates for townhouses and apartments.

Our findings are summarized by type of residence in Table 6.3 for the adjacent street peak hour and site generated peak hour. We tested for variation in trip rates due to geographical location but found no statistically significant difference among locations in the county.

Based on a statistical test of means, we concluded that the AM peak hour trip rates are uniquely different for each dwelling type except the midrise and high-rise categories which have rates which are not statistically distinguishable. In the afternoon peak hour the trip rates for single-family dwelling units, special townhouses, and high-rise units are statistically unique, but the rates for garden apartments, mid-rise apartments and market rate (that is, non-subsidized) townhouses are not. This means that the differences in the trip rates measured at garden apartments, townhouses and mid-rise apartment complexes may arise because we only surveyed a small sample of all possible sites. If we were to sample a very large number of sites, the trip rates at these three land use types might well be equal.

The single-family detached average trip generation rates measured in Montgomery County are quite similar to those reported by the ITE (3rd Edition) and in the FHWA report (see Table 6.4). (The reader is referred to Table A.15 in Appendix A for details.)

The Montgomery County trip rates for multi-family dwelling units are lower than the ITE 3rd Edition rates and, where applicable, the FHWA rates for both AM and PM peak hours. The actual level of trip rates shown for all apartments (ITE Category 220) depends on the relative proportions of garden apartments (ITE Category 221) and high-rise apartments (ITE Category 222) in the total stock of apartments. This is because garden apartment trip rates are generally between 20 and 65 percent higher than the rates for high-rise apartments. For this reason, one should be extremely cautious when comparing the trip rates for all apartments as produced in this research with the corresponding rates provided by ITE and the FHWA. This difference is somewhat greater for garden apartments than it is for highrise apartments.

The single-family rates measured in Montgomery County are somewhat closer to the ITE rates than are the corresponding rates for multifamily dwellings. This suggests that:

- Life styles and family size for households in single-family dwellings in Montgomery County are more similar to the national picture than is true for households in garden apartments and other multi-family dwellings;

- Households in single-family units enjoy a lifestyle which has altered less over time than that which characterizes the residents of garden apartments and other multi-family units. This relative stability in lifestyle translates into trip generation rates. Thus, the older ITE trip rate data are closer to the corresponding Montgomery County data for single-family housing than they are for multi-family housing; and

- Any increase in the numbers of citizens embracing new life styles, such as single living, plus the increase in retired persons who make fewer peak hour trips, will tend to have more impact on trip rates at multi-family sites than at single-family sites.

Table 6.3

Residential Site Trip Rate Summary by Type of Dwelling Unit: Trips/Dwelling Unit

	Time of Day			
	AM Peak Hour		PM Peak Hour	
Dwelling Type	Adjacent Street	Site Gen.	Adjacent Street	Site Gen.
Single-Family Det. (19 Surveys)	0.71	0.80	0.88	0.97
Special Townhouses (1 Survey)	0.70	0.73	0.72	0.73
Townhouses (Mkt Rate) (4 Surveys)	0.44	0.49	0.41	0.44
Garden Apartments (12 Surveys)	0.37	0.41	0.43	0.47
Mid-Rise Apartments (7 Surveys)	0.31	0.35	0.40	0.44
High-Rise Apartments (12 Surveys)	0.27	0.32	0.33	0.38

Source: Douglas & Douglas, Inc.

6.3 TRIP RATES VERSUS HOUSING COSTS

We examined the trip rates for single-family dwelling units as a function of the housing values and household size (1980 census tract data) at each development surveyed. The results were interesting but not statistically significant. The 1980 median house values in the census tracts in which the sites were located ranged from $75,000 to $200,000 with a median value of $98,900. The corresponding range for household size (1980 census tracts) is 2.68 to 3.92 persons.

Trip rates increase as house values increase. This is perhaps because more expensive dwellings are larger and hence contain larger families. Alternatively, it may be that a more expensive home signals a higher disposable income which is associated with more trips. A simple regression of trips per dwelling unit (for the adjacent street PM peak hour) on housing values yields this linear equation:

$$\text{PM Peak Hour Trips/DU} = 0.155 + 0.072\ (\text{House Value}/\$10{,}000)$$

$$R^2 = 0.49$$

Table 6.4

Comparison of Trip Generation Rates Reported by ITE (3rd Ed.), FHWA and the Montgomery County Trip Rate Study: Residential Uses in the Adjacent Street Peak Hour

Residential Land Use Category		Mean Total Trips/Dw.Unit ITE (3rd Ed.)	FHWA (suburban)	Montg. County	% Difference in Rates MC/ITE	MC/FHWA
ITE 210	AM	0.76	0.68	0.71	-6.6%	+4.4%
(SF Det.)	PM	1.00	0.91	0.88	-12.0%	-3.3%
(19 Sites)						
ITE 220	AM	0.50	0.50	0.30	-40.0%	-40.0%
(Tl Apts)	PM	0.70	0.64	0.37	-47.1%	-42.2%
(31 Sites)						
ITE 221	AM	0.50		0.37	-26.0%	
(GdnApts)	PM	0.60		0.43	-28.3%	
(12 Sites)						
ITE 222	AM	0.30		0.28	-7.0%	
(Hi-Rise)	PM	0.40		0.34	-15.0%	
(19 Sites)						

Sources: Douglas & Douglas, Inc.; ITE (3rd Edition), 1982 [1]; FHWA, 1985 [2].

This means that for every $10,000 increase in housing costs (1980 dollars) we would expect (on average) an additional 0.07 vehicle trips per dwelling unit during the adjacent street PM peak hour. The R^2 statistic of 0.49 indicates that the single variable, "house value," explains 49% of the variation within the observed trip rates, a highly respectable amount for a single predictor. The net regression coefficients for the other time periods (site generator AM and PM peak hours, and adjacent street AM peak hour) were similar though R^2 values were lower (0.34 to 0.40).

There is a positive relationship between trip rates and housing values. The site generated peak hour volume is, by definition, always equal to or greater than the adjacent street peak hour volume. The data suggest a nonlinear relationship, as if there is a saturation point beyond which no more travel can be consumed regardless of income or household size. The small number of data points for higher priced housing stopped us from further curve fitting attempts.

6.4 TRIP RATES AT "SPECIAL" TOWNHOUSES

Montgomery County defines Special Townhouses as units priced below market rates to provide housing for low- and moderate- income families. Although we collected data for only one example, the results indicate some interesting behavior differences. The total peak hour trip rates for "special" townhouses are much higher than the trip rates for "market" price townhouses for all time periods. More importantly, the trip rates in the off-peak direction are roughly three times the rates for the other townhouses. In other words, during the morning peak when most trips at market price townhouses are out-bound (presumably to go to work and school), the special townhouses generate a surprisingly large number of ingoing trips.

These findings might reflect the movement of carpool vehicles in the process of picking up or dropping off riders. Certainly, auto occupancy rates for special townhouses are much higher than those for other residential land uses, lending some support to this interpretation. It is important to note, however, that these observations are extremely tentative, in view of the lack of sufficient data to develop a statistically reliable sample. Much more research into the trip generation characteristics of Special Townhouses is needed before any firmer conclusions can be developed.

6.5 TRIP RATES FOR SITES AT METRORAIL STATIONS

During the Post-Metrorail Transportation Characteristics Study [5], M-NCPPC had trip rate data collected at eight multi-family residential sites. These eight apartment complexes are within Metrorail station walksheds--that is within walking distance (2,500 feet) of Metrorail stations. Four buildings are within the Beltway near the Silver Spring, Bethesda or Friendship Heights stations. The remaining four apartment complexes are near the Rockville, White Flint and Grosvenor stations--all of which are located outside the Beltway.

The morning and afternoon peak hour trip rates for these residential complexes are presented in Table 6.5. It is interesting to note that the trip rates for the high-rise apartments outside the

Beltway are considerably (40-50%) higher than trip rates for high-rise apartments inside the Beltway. Possible explanations include:

- Older complexes inside the Beltway may have older tenants more likely to be retired and thus less likely to generate peak hour trips;

- Apartments near Metro stations outside the Beltway are within walking distance of the rail system, but not much else.

Comparing the trip rates for multi-family sites within Metrorail walksheds to those generated by sites investigated during our research (see Table 6.6), we see a significant difference for multi-family residential sites inside the Beltway.

Table 6.5

Generator Peak Hour Trip Rates for Multi-Family Residential Sites Located Within Metrorail Walksheds

		Inside Beltway	**Outside Beltway**	
		High-Rise Apt (ITE 222) (4 Sites)	Gdn Apt (ITE 221) (1 Site)	High-Rise Apt (ITE 222) (3 Sites)
Average No. DUs		588	954	272
AM Peak	In	0.08	0.05	0.07
	Out	0.14	0.29	0.25
	Total	**0.22**	**0.34**	**0.32**
PM Peak	In	0.15	0.28	0.23
	Out	0.09	0.11	0.11
	Total	**0.24**	**0.39**	**0.34**

Source: JHK & Associates; Calculations by Douglas & Douglas.

Table 6.6

Comparison of Trip Rates Measured at Multi-Family Residential Sites Inside and Outside Metro Station Walksheds: Generator Peak Hours

(a.) Sites Inside Beltway

Land Use (Metro Sites/ Nonmetro Sites)	Inside Walkshed Trip Rates		Outside Walkshed Trip Rates		Outside Inside Walkshed
	Mean	Min / Max	Mean	Min / Max	% Diff
-----AM Peak Hr-----					
High Rise (4 Metro/12 Not)	0.22	0.16/0.28	0.32	0.19/0.55	-31.2%
-----PM Peak Hr-----					
High-Rise	0.24	0.18/0.30	0.41	0.19/0.60	-41.5%

(b.) Sites Outside Beltway

Land Use (Metro Sites/ Nonmetro Sites)	Inside Walkshed Trip Rates		Outside Walkshed Trip Rates		Outside Inside Walkshed
	Mean	Min / Max	Mean	Min / Max	% Diff
-----AM Peak Hr-----					
Garden Apartments (1 Metro/11 Not)	0.34	N/A	0.39	0.18/0.60	-12.8%
High-Rise (3 Metro/7 Not)	0.32	0.26/0.40	0.32	0.22/0.42	0.0%
-----PM Peak Hr-----					
Garden Apartments	0.40	N/A	0.48	0.22/0.73	-20.0%
High-Rise	0.34	0.29/0.40	0.37	0.34/0.45	-8.8%

Source: JHK & Associates; Douglas & Douglas, Inc.

We suspect that differences in trip rates are partly the result of differences in occupants and their life styles. Therefore, we can expect that residential properties will go through cycles of trip rates throughout their lives. As residential populations age, trip rates are likely to diminish due to decreased household size and reduced trip making. Economic or rent cycles will also be associated with trip rate changes.

Table 6.6b indicates that, for residential sites located outside the Beltway, there is no statistical difference between the trip rates of those situated inside and those situated outside Metrorail walksheds. The garden apartment statistics are, with only one data point inside a station walkshed, too unreliable for comparison with our results. Our conclusion is that, outside the Beltway, location within a station walkshed will not affect vehicular trip rates to or from residential sites during the peak hours. It appears that not enough peak hour destinations can be reached by Metro to produce a significant change in vehicular trips.

More research on the characteristics of tenants in multi-family residential sites, and how they differ from one site to the next, is warranted for areas both within and outside Metrorail walksheds.

6.6 CONCLUSIONS AND RECOMMENDATIONS

This study investigated trip making patterns at single-family and multifamily sites in Montgomery County. The trip rates recorded at developments of single-family detached homes were statistically indistinguishable from the ITE rates. They were also considerably higher than trip rates recorded at sites with townhouses or apartments. Tenants of townhouses have trip rates resembling those of garden apartments--implying similar family size and life styles.

Montgomery County residents of garden apartments make peak hour trips at a rate around 27% less than ITE estimates. County residents of high-rise apartments also travel less during peak hours than ITE estimates by a margin of up to 15% - not an overwhelming difference.

Finally, outside the Beltway, locating residential complexes near Metro stations has no significant impact on vehicular trip rates. Within the Beltway, however, a location inside a Metrorail station walkshed is associated with a lower trip generation rate. This reduced vehicular traffic may reflect the employment and shopping opportunities and other amenities within the older CBDs of Bethesda, Silver Spring and Friendship Heights, as much as the proximity to Metrorail services.

CHAPTER 7

COMPARISON OF MONTGOMERY COUNTY TRIP RATES WITH ITE 4TH EDITION TRIP GENERATION RATES

In December, 1987 the Institute of Transportation Engineers (ITE) published the 4th Edition of Trip Generation, the standard source for trip generation rate information in the United States. The 4th Edition is noted for its use of new and innovative methods for calculating development-related vehicle trips relative to those used in the first three editions. Further, ITE used about 50% more data in the 4th Edition than in the 3rd in order to develop new trip rates and equations.

With the publication of the 4th Edition and the significant change in the methods used to calculate trip rates, the M-NCPPC extended the original Montgomery County Trip Generation Rate Study to compare data collected in Montgomery County with this most recent ITE information. This chapter:

- Reports the results of our tests of the adequacy of the ITE 4th Edition equations in estimating average trips for development projects in Montgomery County; and

- Compares ITE's equations and estimates with similar equations and estimates developed from the Montgomery County data.

In this chapter we discuss: methods for computing vehicle trip volumes; the relationship between vehicle trips and the characteristics of the sites studied; comparisons between current and past ITE rates and Montgomery County rates; and the implications of these differences for selecting trip rates and estimating equations in Montgomery County. Our recommendations for trip generation procedures and estimating equations for Montgomery County are presented in Chapter 8.

Note that this chapter compares Montgomery County and ITE methods for estimating the average number of trips generated by each land use category. The techniques and equations recommended in Chapter 8 for application in Montgomery County's site approval process include the addition of the standard error of estimate to the relevant regression equation for certain tests. However, in order to compare ITE methods and results with those for Montgomery County it was necessary to use the average number of trips because the ITE methods and results are in this form.

Section 7.1 briefly summarizes the remainder of the chapter, which is fairly technical. Section 7.2 is a theoretical discussion on the equations which describe how many vehicular trip ends are to be expected from a particular type and size of land use. Section 7.3 describes the analysis conducted to construct and compare the different equations. Unique equations, defining relationships between variables, were developed for Montgomery County data and compared with similar equations developed by ITE. Sections 7.4 through 7.7 present the results of our investigations for each of the land use categories in this study.

7.1 SUMMARY

The number of vehicle trips predicted by using either the new ITE 4th Edition methods or the ITE 3rd Edition rates differs in varying degrees from the number of trips actually observed in Montgomery County. For example, new ITE 4th Edition rates for both general offices and retail sites are lower than 3rd Edition rates. For office buildings, this brings the ITE rates closer to those observed by this study in Montgomery County. In the case of shopping centers, however, the discrepancy between ITE predictions and our observations widens. For residential units, the new ITE rates are in some cases higher and in others lower than those reported in the 3rd Edition.

In our analysis we identified the relative performance of the different Montgomery County and ITE equations in predicting the average number of peak hour trips generated by each land use in Montgomery County. The results were sometimes surprising and varied widely:

- General Office - The ITE 4th Edition equations predict fewer trips than the earlier 3rd Edition rates but still more trips than observed in Montgomery County. Montgomery County equations are superior estimators of Montgomery County trips for all time periods and for all building sizes. Office buildings located near Metrorail stations exhibit surprising trip generation characteristics: the number of PM peak hour vehicle trips generated at these buildings is as high (or even higher) than the number of trips generated at buildings of similar size, but located more than 2,500 feet from a station (where fewer commuters use transit).

- Shopping Centers - The ITE 4th Edition equations for shopping centers with fewer than 200,000 SF GLA underestimate PM peak hour Montgomery County trip ends by as much as 50%! Montgomery County equations provide separate estimates for small neighborhood centers (fewer than 100,000 SF GLA) and medium-sized community centers (100,000 to 200,000 SF GLA). The presence of a major chain food store greatly increases shopping center patronage and is associated with lower proportions of pass-by traffic.

- Fast Food Restaurants - No equations based on floor area proved to give satisfactory estimates of traffic for Montgomery County restaurants smaller than 3,600 square feet (the largest restaurant in our sample) Thus, it may be inappropriate to use a trip rate linked to building size for this land use.

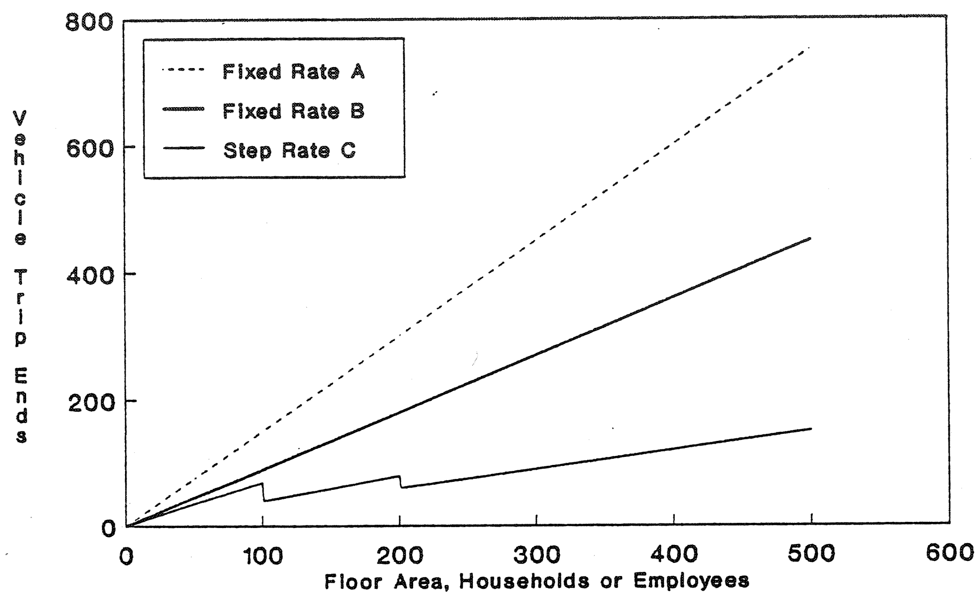
- Residential - ITE 4th Edition trip equations agree quite closely with Montgomery County equations for single-family detached housing and high-rise apartment categories. ITE's 4th Edition trip end estimates for low-rise apartments and for their General Apartment category, however, are considerably higher than estimates based on Montgomery County data and equations. The townhouses surveyed in this study exhibit trip generation characteristics similar to garden apartments and to low-rise apartments. Meanwhile, they had trip generation characteristics dissimilar to those of single-family detached housing.

7.2 TRIP RATE EQUATIONS

The relationship between the characteristics of a developed site and the number of vehicle trip ends generated during selected time periods, such as one hour or one day, may be described in the form of an equation. These equations traditionally calculate trips using a fixed rate of tripmaking with respect to some independent characteristic of the development. Examples of development characteristics used in this way include floor area, households, employees, or acres of land. Thus, to illustrate with an example, an equation might be stated as: 16 trips per thousand square feet of gross leasable area for the weekday PM peak hour.

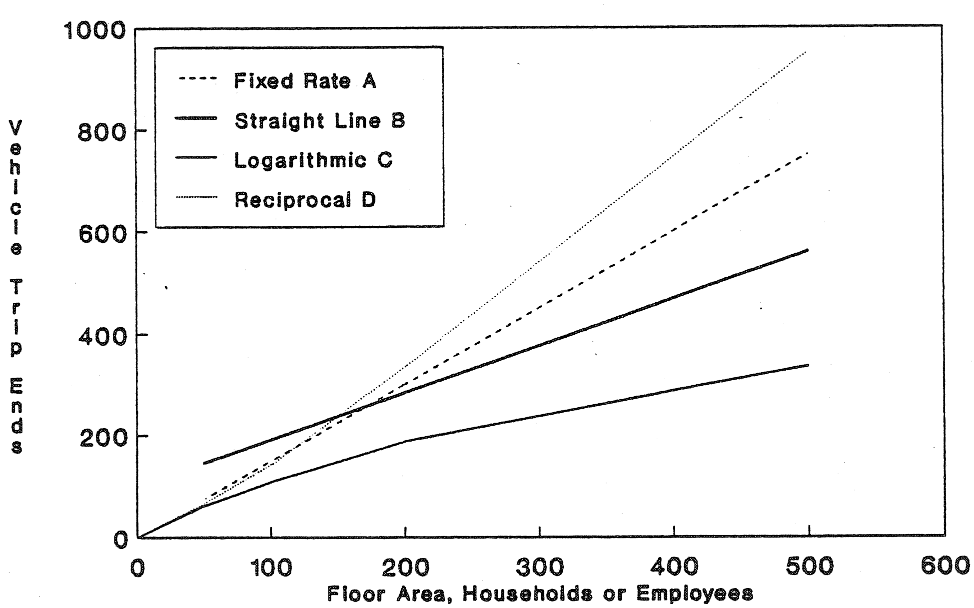
The concept of trip rates is pictured in Figure 7.1. This represents a generalized graph of different trip rates. In this example land use type A has a higher trip rate than land use type B. Trip rates A and B are examples of fixed rates which estimate zero trips for zero activity and a constant increase in the number of trips as the size of the development (and by extension the level of activity) increases. Every increment in the level of activity is associated with an increase in the number of trip ends by an amount equal to the rate times the size of the change in the activity level. Fixed rates form a fan shape when a large number of them are graphed together; the steeper the slope, the higher is the trip rate. A fixed rate can be an unsatisfactory representation of trips through the full spectrum of building or site development sizes found in a land use category. For example, the small shopping centers and small office buildings surveyed in this study have more trips per thousand square feet of development than the large shopping centers and large office buildings, respectively, that were surveyed. In the 3rd Edition of Trip Generation, the situation where trip rates vary with size was usually represented by stratified trip rates which resemble a set of stairs when graphed. An example of a stratified or step rate is shown in Figure 7.1 as Step Rate C. If the numbers along the X, or horizontal, axis stand for thousands of square feet of floor area, then the trip rate for offices or shopping centers with fewer than 100,000 SF is higher than those for buildings with 100,000 to 200,000 SF which are in turn higher than those for buildings with more than 200,000 square feet. In each case we assume the trip rate to be fixed between the two points defining the step.

Figure 7.1
Typical Trip Generation Equations
Used in ITE 3rd Edition



Source: Douglas & Douglas, Inc.

Figure 7.2
Typical Equations Used in
ITE Trip Generation, 4th Edition



Source: Douglas & Douglas, Inc.

In the new 4th Edition of Trip Generation, the ITE has introduced several new equations to describe trip generation. Their formulations are shown in Table 7.1. The advantage of these new equations is that they help to account for part of the variation in trip rates within one land use type throughout its range of sizes. Two simple equations are the linear equation shown in Figure 7.2 as 'Straight Line B' and the even simpler 'Fixed Rate A' equation which is essentially the linear equation when the coefficient 'a' is equal to zero. (Differences in their slopes as they are illustrated in Figure 7.2 reflect different values of the coefficient 'b.')

In the linear model, if 'a' is equal to zero, the rate of tripmaking is equal to a constant 'b.' If 'a' is not equal to zero, the trip rate is not constant over the size range of the land use. For example, if 'a' has a large positive value, referred to as the Y-intercept value, the average trip rate will get smaller as the size of the development increases. This characteristic has some appeal for offices and shopping centers where the aggregation of uses and offices tends to decrease vehicular tripmaking.

Table 7.1

Trip Generation Models

Linear Model:	$T = a + b X$
Fixed Rate:	$T = b X$
Logarithmic Model:	$Ln(T) = a + b\, Ln(X)$ or $T = \exp(a + b\, Ln(X))$
Reciprocal Model:	$T = 1 / ((b/X) - a)$

where:
T = number of vehicle trip ends
X = unit of land use (area, employees, etc.)
a, b = coefficients
Ln(X) = natural logarithm of X

For land uses where we observe an even greater decline in trip rates as size increases, such as in mixed-use developments, the logarithmic model can be used. Logarithmic functions tend to dampen the 'T' value as the 'X' value increases. This means that as the development gets larger, the average number of trips per unit of activity declines, and declines at an accelerating rate. As may be seen in Figure 7.2, the logarithmic curve tends to pull away from the others as site size increases.

For rare cases the ITE developed a reciprocal equation which has somewhat unstable characteristics. Its formulation is shown in Table 7.1 and depicted in Figure 7.2 with a set of coefficients that create an equation which estimates slightly higher trip rates as the size of the site increases. In the reciprocal equation, a negative coefficient can cause the average rate to increase until a critical inflection point is reached at which point the function may turn negative. As a result, it must be used very carefully and within well-defined limits. In the cases formulated by ITE, when 'a' is positive, the rates decline with increasing size of development; and if 'a' is negative, the rates increase with increasing size of development.

The ITE developed equations of the form discussed above to estimate the average or mean value for the number of trips generated by a particular development for a specific period of time. As is evident in Figure 7.3, the straight line defined by the linear regression equation 'Y = a + bX' defines the estimated value of the mean or average of 'Y' for each value of 'X.' But this is only an estimate of the true mean value, whose exact value is unknown. If repeated samples were taken, we would expect the calculated values of the average 'Yi' for a given 'Xi' to be distributed normally around the regression line (as shown by the normal curve indicated in Figure 7.3). An individual data point may lie either above or below the line, but the total population of true 'Y' values for each value of 'X' are distributed normally about the regression line with a mean deviation of zero and a variance equal to sigma squared. The values for one standard error above and below the mean are also shown in Figure 7.3. In a normal distribution, 68 percent of the data points lie between these two values. It is implied that approximately 84 percent of all the data points lie below one standard error above the mean. These relationships are important in testing alternative trip generation equations and in selecting equations for use in the site development approval process.

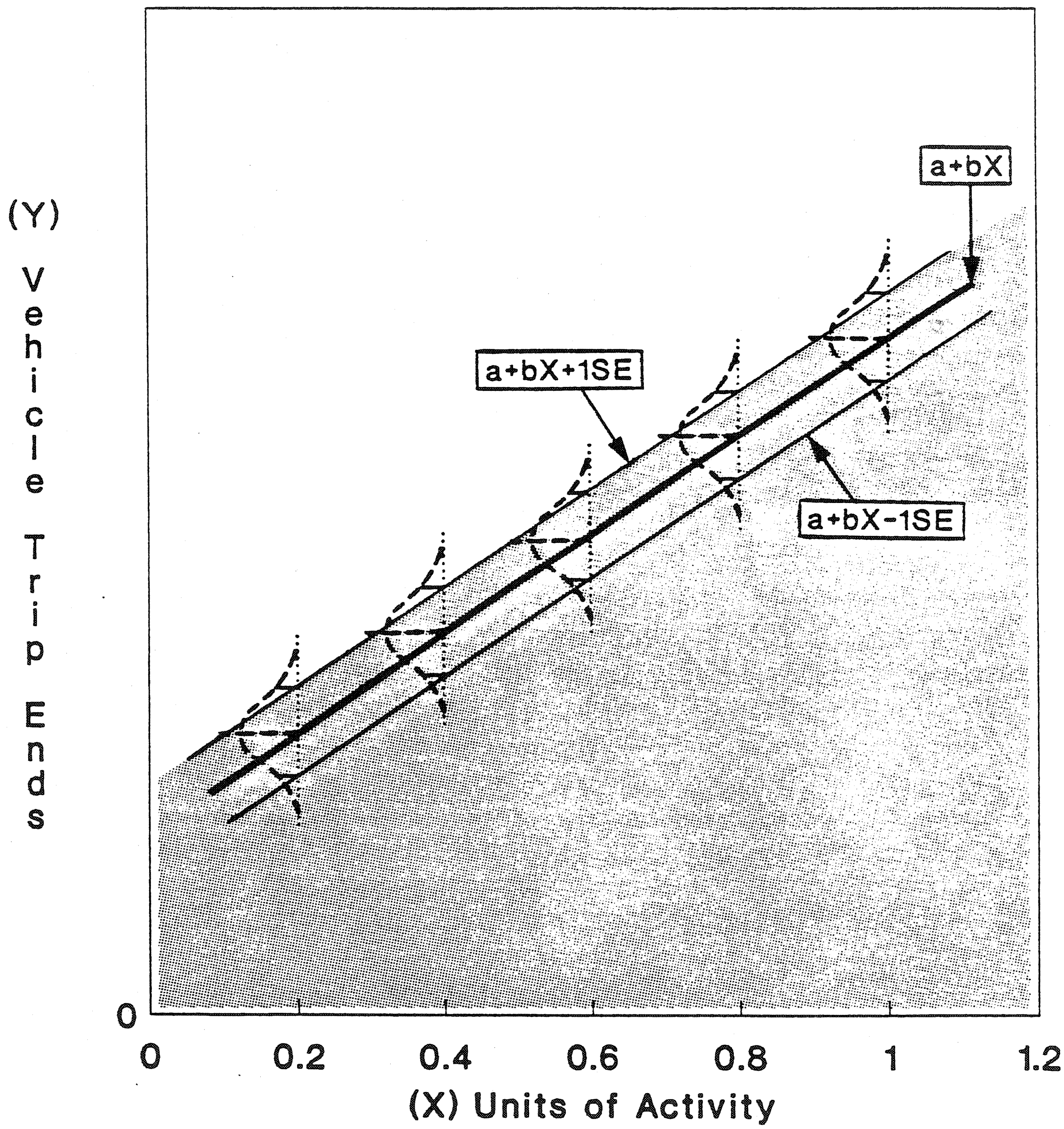
7.3 DEVELOPING A METHOD FOR COMPARING MONTGOMERY COUNTY AND ITE TRIP RATES

7.3.1 *Questions to be Addressed*

The overall objective of this study is to develop a method for estimating the traffic impacts of new development in Montgomery County as part of the site review process. This objective naturally leads to a series of questions concerning the ITE 4th Edition and Montgomery County trip generation equations:

- Do the ITE 4th Edition equations adequately estimate average vehicle trips ends for Montgomery County development projects?

Figure 7.3
Distribution of Mean Values Around Regression Line Y=a+bX



Source: Douglas & Douglas, Inc.

- Do equations developed from Montgomery County data provide more accurate trip end estimates than do the ITE 3rd and 4th Edition data?

- How do trip end estimates using the ITE 4th Edition and Montgomery County equations compare with the ITE 3rd Edition data?

- Which form of equation (e.g., linear, non-linear) is the preferred description of the relationship between development and trip ends?

- What equation should be used to estimate the number of trips generated by a new development?

- What adjustments to basic trip end estimates should be made to reflect differences within land use categories, such as location and tenant mix?

7.3.2 *Comparison Process Developed*

The first four questions motivated the analysis presented in this chapter and resulted in the following process for comparing Montgomery County data and equations with ITE 3rd and 4th Edition equations:

1. Formulate equations to estimate average vehicle trip ends per unit of development activity to parallel the ITE (4th Edition) equations. For example, if, for a particular land use category, the 4th Edition presents a non-linear equation for PM peak hour trips, then we also hypothesize such an equation. In addition we tested a linear equation for each land use and for every time period. We also tested the same non-linear equation for all time periods if ITE (4th Edition) presented the model for any one time period (i.e., AM adjacent street peak hour, AM generator peak hour, PM adjacent street peak hour, PM generator peak hour). The ITE 3rd Edition equations all take the form of trip rates, and were discussed in Chapters 3 through 6. ITE did not make available any statistics for these equations.

   In some instances, ITE (4th Edition) presents a different equation for each time period. Thus, the AM generator peak hour trip generation equation may be a logarithmic curve while the PM generator peak hour trip generation equation is a straight line, for example. We could find no evidence to suggest that trip end relationships might change by time of day for the same land use. Consequently, in many cases we investigated several models across all time periods to ensure that we would have a consistent set of equations for each land use.

2. Estimate coefficients and standard error and goodness-of-fit statistics for each Montgomery County equation. Montgomery County data were processed using

SPSS/PC+ (1986) regression routines. Stepwise regression was used for the multivariate equations.

3. Compute R^2 for ITE (4th Edition) equations when fitted to Montgomery County data. In most cases the fit was not very good.

4. Compare Montgomery County models with ITE 3rd and 4th Edition equations. This comparison usually relied on goodness-of-fit (R^2) statistics (not available in the 3rd Edition of the ITE manual) or visual inspection and tests of means in the case of rates.

5. Select preferred Montgomery County equations for mean trip end estimates. This selection was not based on selecting the equation with the highest R^2 alone. Other considerations included the form of the equation used for other time periods and the potential for constructing equations for site review using the 'a' and 'b' coefficients and the standard error.

6. Calculate differences and percentage differences in trip estimates using the ITE 3rd and 4th Edition and Montgomery County methods.

7. Develop an equation to estimate the mean trip rate plus one standard deviation for each time period. This is constructed by adding the standard error of the estimate to the regression equation. These equations are identified by numerical labels which end with even integers (e.g., 1.4, 2.6, etc.) and are discussed in detail in Chapter 8.

7.3.3 *Equations for Application*

Although this chapter deals primarily with a comparison of estimates of average trips in Montgomery County as computed with ITE 4th Edition and Montgomery County equations, it is appropriate at this point to discuss the application of trip generation equations in general. The primary equations derived by ITE and by this research estimate the number of trips one would expect from an average building of a specified size. If we were to survey a number of buildings of this size, the measured trip volumes would be distributed above and below the value estimated by the equation. Also, the average number of trips measured at the sites surveyed would, in all likelihood, be different from the trip level for that size of building as predicted by an equation such as that illustrated in Figure 7.3. The average values thus calculated seem appropriate for certain long range planning activities if one can assume that development characteristics will, in the long run, approximate those of our sample.

Site approval and short range planning needs pose a slightly different question. The objective is to predict the expected traffic generated by proposed development and estimate impacts on adjacent, and possibly more removed, streets and highways. Use of average trip end estimates will result in underestimating trip ends in many cases, perhaps seriously. (Naturally, there is an equal likelihood of overestimating trip ends). Underestimating trip ends may lead to unexpected traffic congestion. Overestimating may lead to inefficient use of public resources. Therefore, the challenge is to determine an appropriate level of risk for public investment decisions and to select estimating methods accordingly.

Our suggested approach to selecting appropriate estimating methods is based on statistical properties of the regression equations. As an example, trip end data for several equations are plotted in Figure 7.4. The primary equation, passing through the center of the shaded area, is the estimating equation for the average number of trip ends. The other equations are constructed from this by adding or subtracting a given number of standard errors. (In this discussion, the term standard error refers to the standard error of the estimate which measures how well a regression line describes a scatter of points on a graph.) Adding or subtracting one standard error produces the dashed lines (---) while two standard errors define the boundary of the shaded area. For all practical purposes, 68 percent of the points will fall between the dashed lines and 95 percent will fall within the shaded area, and indeed this is the case in this example. Most importantly, 84.13 percent of the data points (10) lie below the upper dashed line; the equation for this line is calculated by adding one standard error to the regression line which represents the equation for the mean trip rate. Thus, we have a method for estimating trip ends which should only underestimate traffic levels at 15 percent of the buildings and for 15 percent of the time.

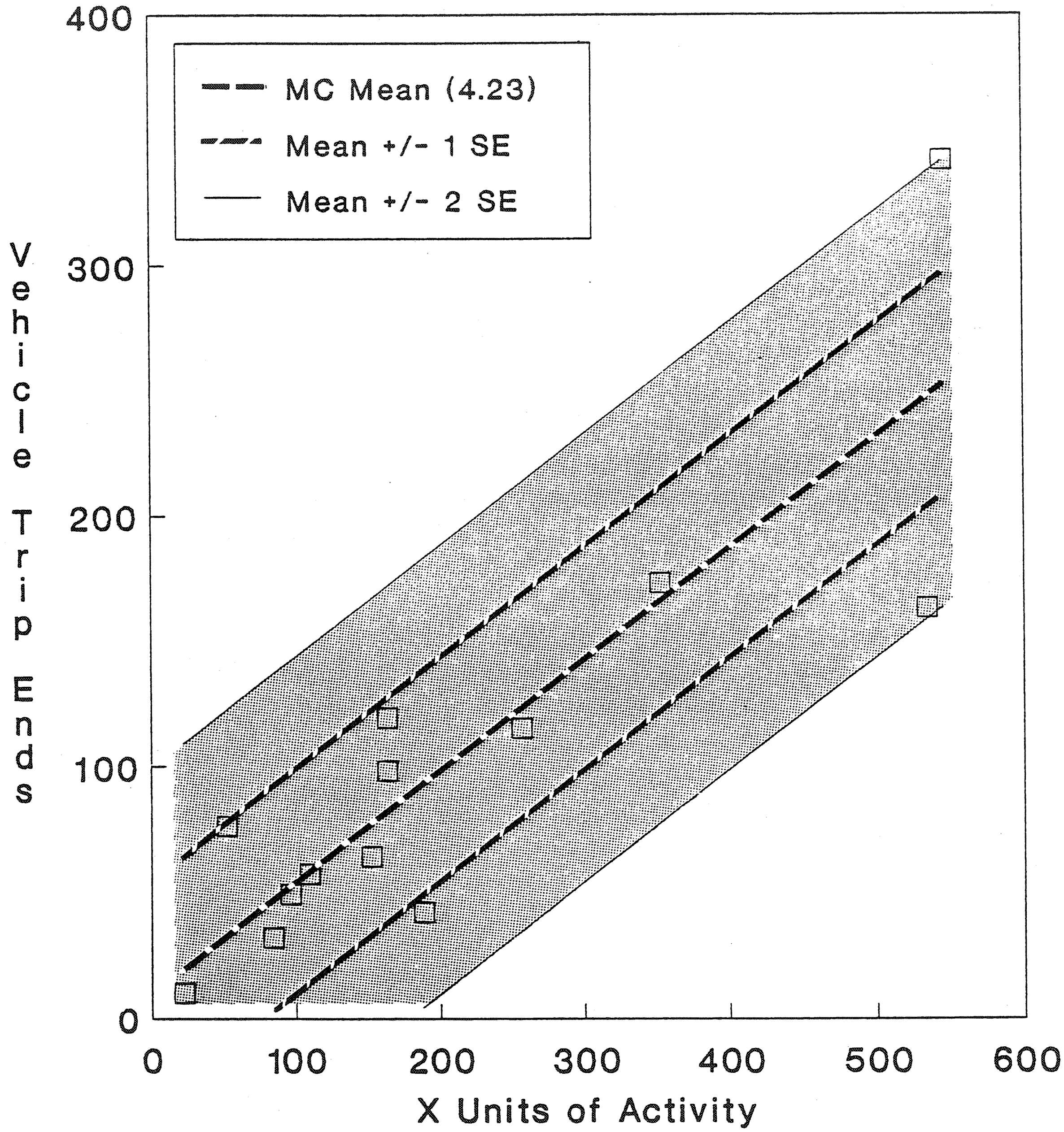
The discussions in the following sections compare ITE and Montgomery County equations for estimating average numbers of trip ends. Separate equations based on the mean plus one standard error are included in the tables. The equations for estimating the mean trip ends are numbered with a trailing odd digit (e.g., 1.3, 4.17). Equations which estimate the location of the 84th percentile (84.13%) have a trailing even digit (e.g., 1.4, 4.18). These latter equations are included, for purposes of completeness and reference, in Chapter 8.

7.3.4 *Graphic Presentation Format*

On the graphs shown in the remainder of this chapter, we present data points for Montgomery County sites surveyed in this study, plus several curves. In each graph, the curve for the ITE 4th Edition equation or rate is displayed as a solid, bold line. The Montgomery County mean equation is graphed as a line with long dashes (e.g., MC Mean (1.3)). The ITE 3rd Edition rate is shown as a line with short dashes to give some perspective on the changes in rates between editions of the ITE Trip Generation manuals.

In the office trip charts we have added an additional curve (e.g., MC Mean + SE (1.4)) which is calculated by adding the value of one standard error to the equation line for the mean trip rate. It is represented by a line with slanted dashes. We have termed this the 84th percentile curve as statistically it is a close approximation to the curve which lies one standard deviation above the regression mean and which covers trip volumes at 84.13% of the floor area of our sample. Throughout this chapter, the 84th percentile equations are provided in tables but shown only on the graphs for general offices.

Figure 7.4
Location of Data Points Around Estimation Equation Plus/Minus One and Two Standard Errors



Source: Douglas & Douglas, Inc.

7.4 COMPARISON OF ITE AND MONTGOMERY COUNTY ESTIMATES OF GENERAL OFFICE TRIPS

Analysis of the data for office buildings located within 2500 feet of a Metrorail station indicate that their trip generation characteristics may be significantly different from those of sites located further away. Consequently, the comparisons between Montgomery County and ITE 4th Edition equations are divided into two sections. Offices located more than 2500 feet from a Metrorail station are classified as being outside the Metrorail walkshed, and their trip characteristics are analyzed in section 7.4.1. Trip generation at office buildings located inside the Metrorail walkshed is examined in 7.4.2.

7.4.1 *Offices Located outside the Metrorail Walkshed*

The new ITE 4th Edition trip generation equations for office buildings (Category 710) give trip estimates which are much closer to the observed Montgomery County generator peak hour trip volumes than do the rates from the 3rd Edition of ITE's Trip Generation. The ITE (4th Edition) only provides equations for generator peak hours (for this land use category) and asserts that the generator (or site) peak hour is identical to the adjacent street (all traffic on the street) peak hour.

For this study we calculated trip rates, linear equations and non-linear equations for the adjacent street and generator peak hours in both the morning and afternoon peak periods. For each time period we chose the Montgomery County equation with the highest goodness-of-fit (R^2 statistic) for comparison with the ITE trip generation equation. The resulting equations are listed in Table 7.2. The goodness-of-fit statistics for the Montgomery County equations are lower than those reported for the ITE 4th Edition equations, but they are still within an acceptable range. The Montgomery County equations exhibit goodness-of-fit statistics that are superior to the ITE 4th Edition equations when fitted to Montgomery County data. The morning equations are shown in Figures 7.5a and 7.5b, while those for the afternoon are shown in Figures 7.6a and 7.6b.

The most interesting contrasts between the Montgomery County and ITE trip equations are that:

- In every case the trip rates in the ITE 3rd Edition predict higher average trip rates than either the 4th Edition or Montgomery County equations;

- The ITE 4th Edition equation and the Montgomery County equation for the mean value agree rather closely for both the AM and PM generator peak hours. In each case the two curves cross at a point where the building size is very large (375,000 to 575,000 SF). Thus, the ITE equations will estimate more trips in buildings below 575,000 SF than will the Montgomery County equations. The ITE equations estimate far more trips during the adjacent street peak hour than do the Montgomery County equations.

Table 7.2

Vehicle Trip Generation Equation for General Offices (ITE Category 710): Vehicle Trip Ends on a Weekday per 1000 Gross Square Feet Floor Area

<u>AM Adjacent Street Peak Hour</u> (one hour between 7 and 9 AM)		
ITE 4th Edition	T=exp(0.86Ln(A)+1.34)	R^2=0.92
M.C. Mean (1.1)	T=1.14(A)+28.65	R^2=0.579
M.C. Mean+S.E.(1.2)*	T=1.14(A)+167.06	

<u>AM Peak Hour of Generator</u>		
ITE 4th Edition	T=exp(0.86Ln(A)+1.34)	R^2=0.92
M.C. Mean (1.3)	T=1.70(A)-7.86	R^2=0.796
M.C. Mean+S.E.(1.4)	T=1.70(A)+114.99	

<u>PM Adjacent Street Peak Hour</u> (one hour between 4 and 6 PM)		
ITE 4th Edition	T=exp(0.83Ln(A)+1.46)	R^2=0.86
M.C. Mean (1.5)	T=0.92(A)+49.62	R^2=0.687
M.C. Mean+S.E.(1.6)	T=0.92(A)+139.78	

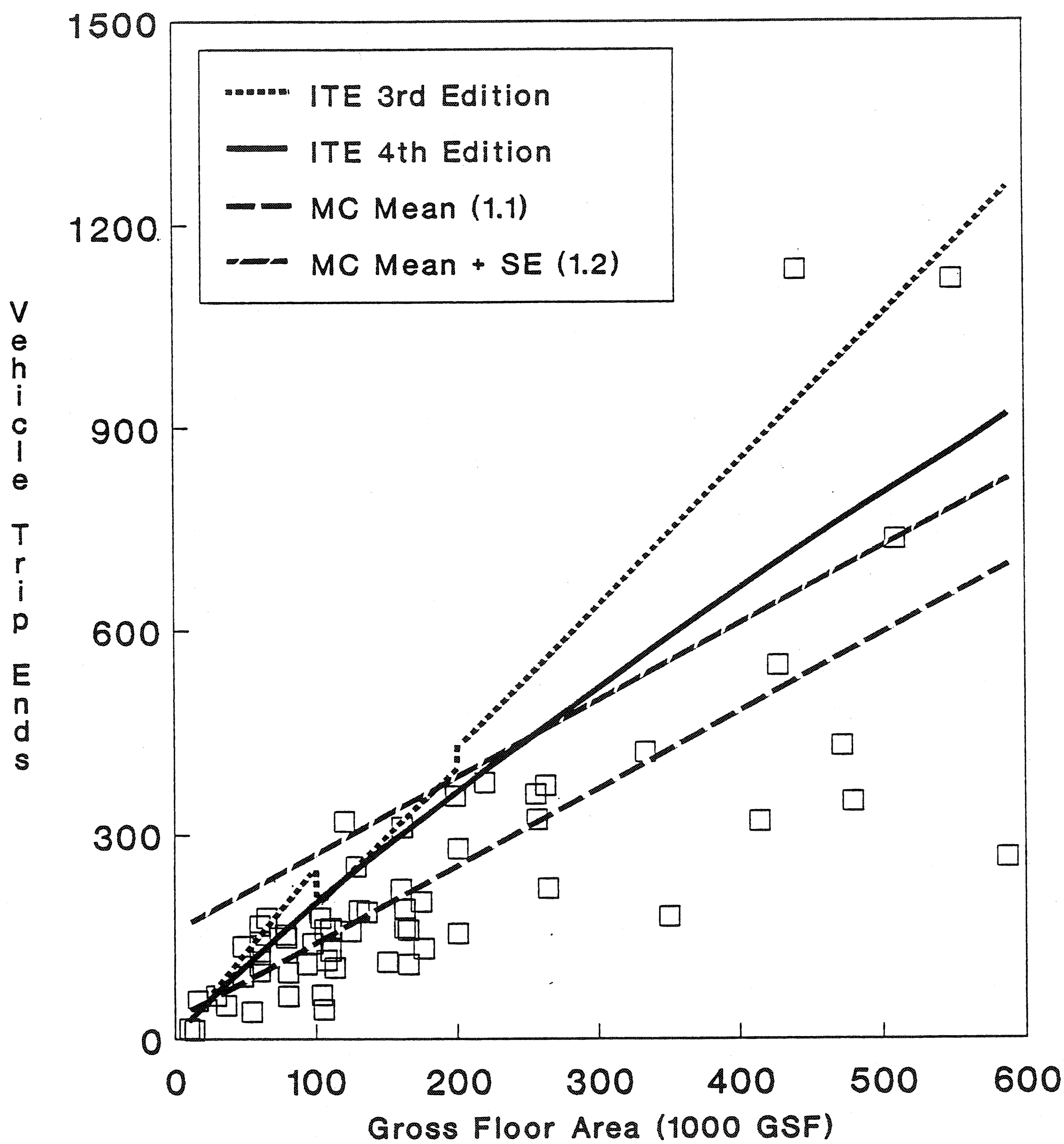
<u>PM Peak Hour of Generator</u>		
ITE 4th Edition	T=exp(0.83Ln(A)+1.46)	R^2=0.86
M.C. Mean (1.7)	T=1.44(A)+20.39	R^2=0.793
M.C. Mean+S.E.(1.8)	T=1.44(A)+126.58	

Notes: * Equation constructed from MC Mean equation by adding the standard error of the estimate onto it.
T = Average 2-way Vehicle Trip Ends
A = Occupied Gross Floor Area (1000 Square Feet)

Source: Douglas & Douglas, Inc.

Figure 7.5a
General Office (ITE 710) Average Vehicle Trip Ends

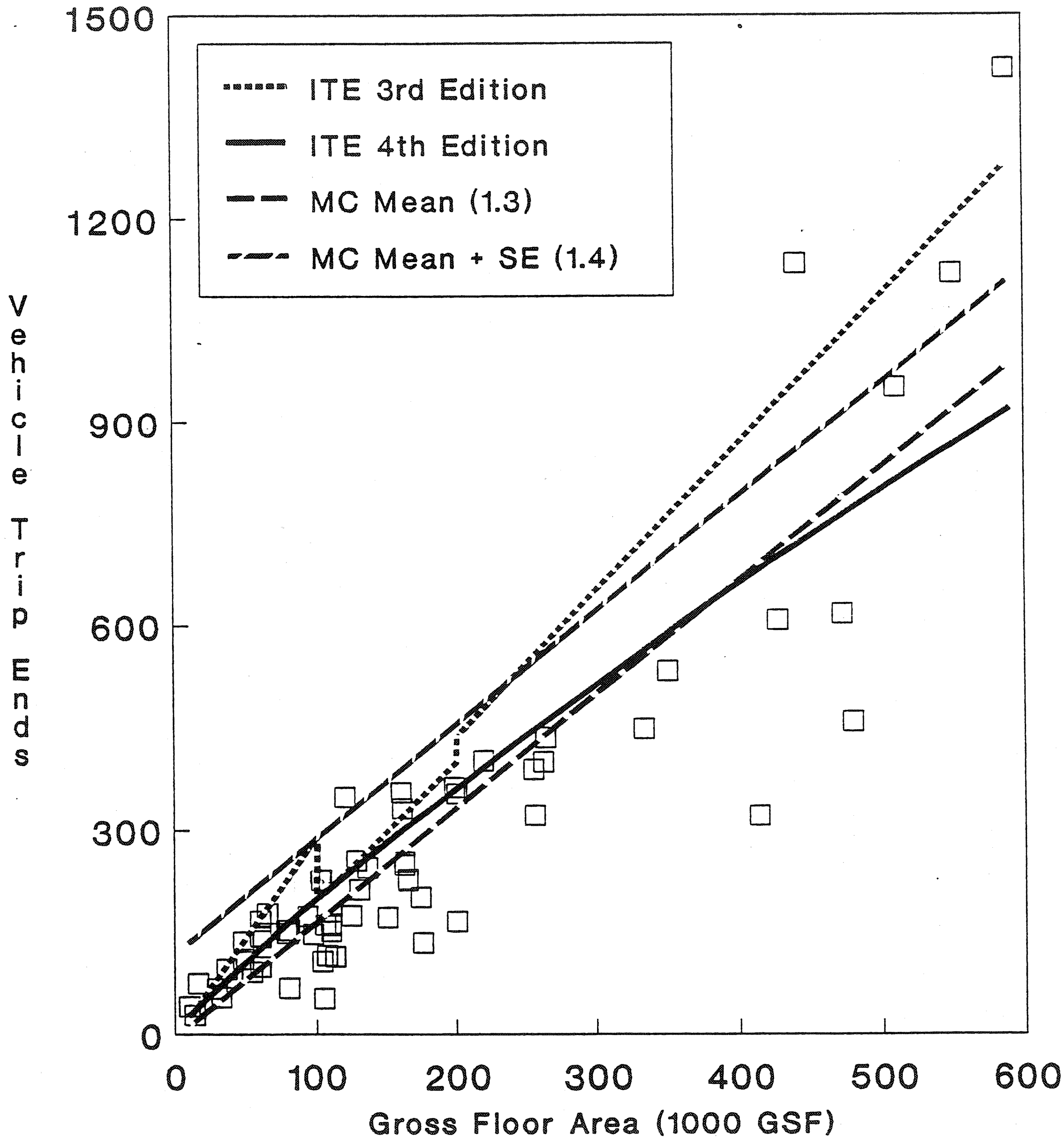
AM Adjacent Street Peak Hour on a Weekday



Source: Douglas & Douglas, Inc.

Figure 7.5b
General Office (ITE 710) Average Vehicle Trip Ends

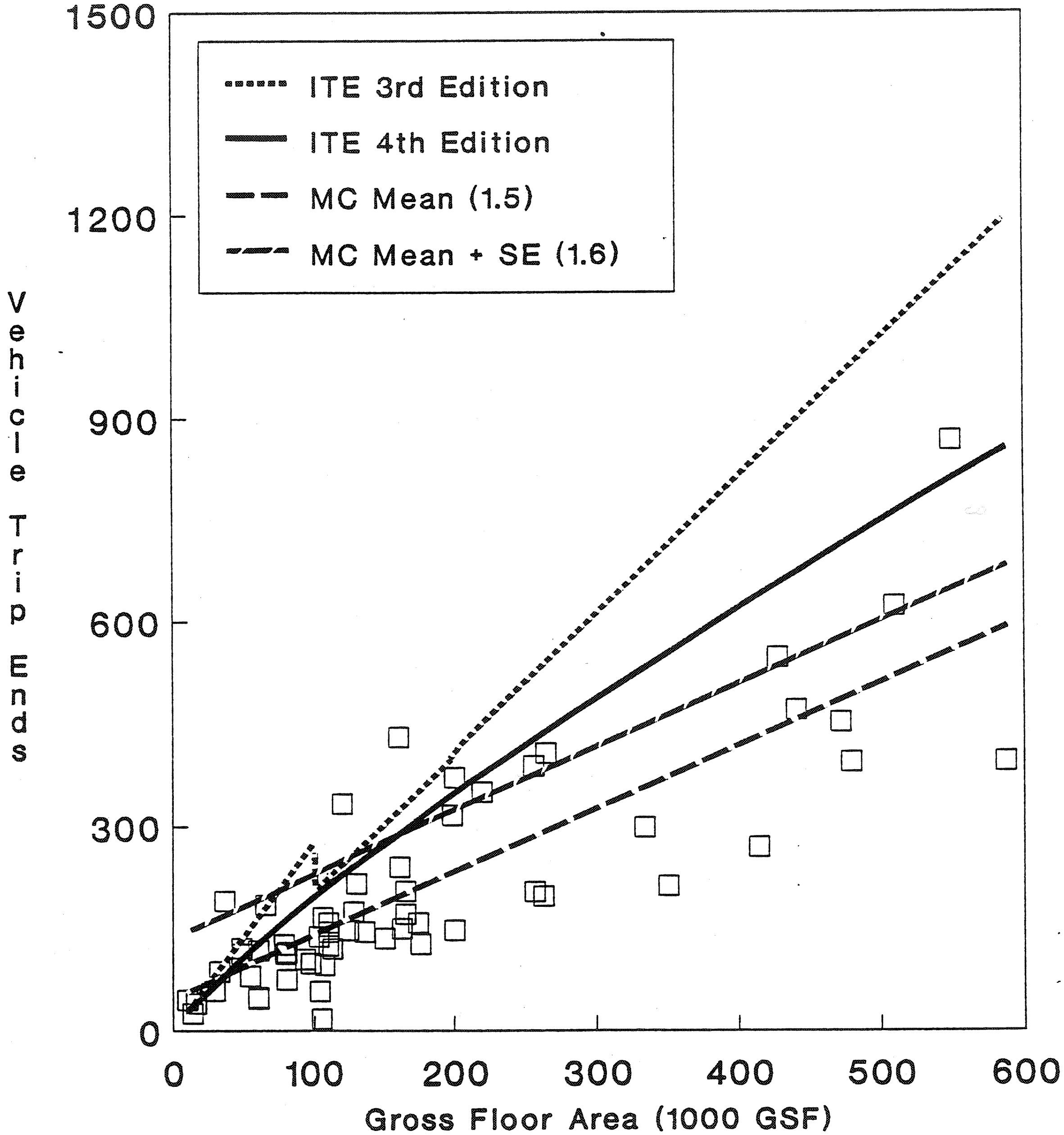
AM Peak Hour of Generator on a Weekday



Source: Douglas & Douglas, Inc.

Figure 7.6a
General Office (ITE 710) Average Vehicle Trip Ends

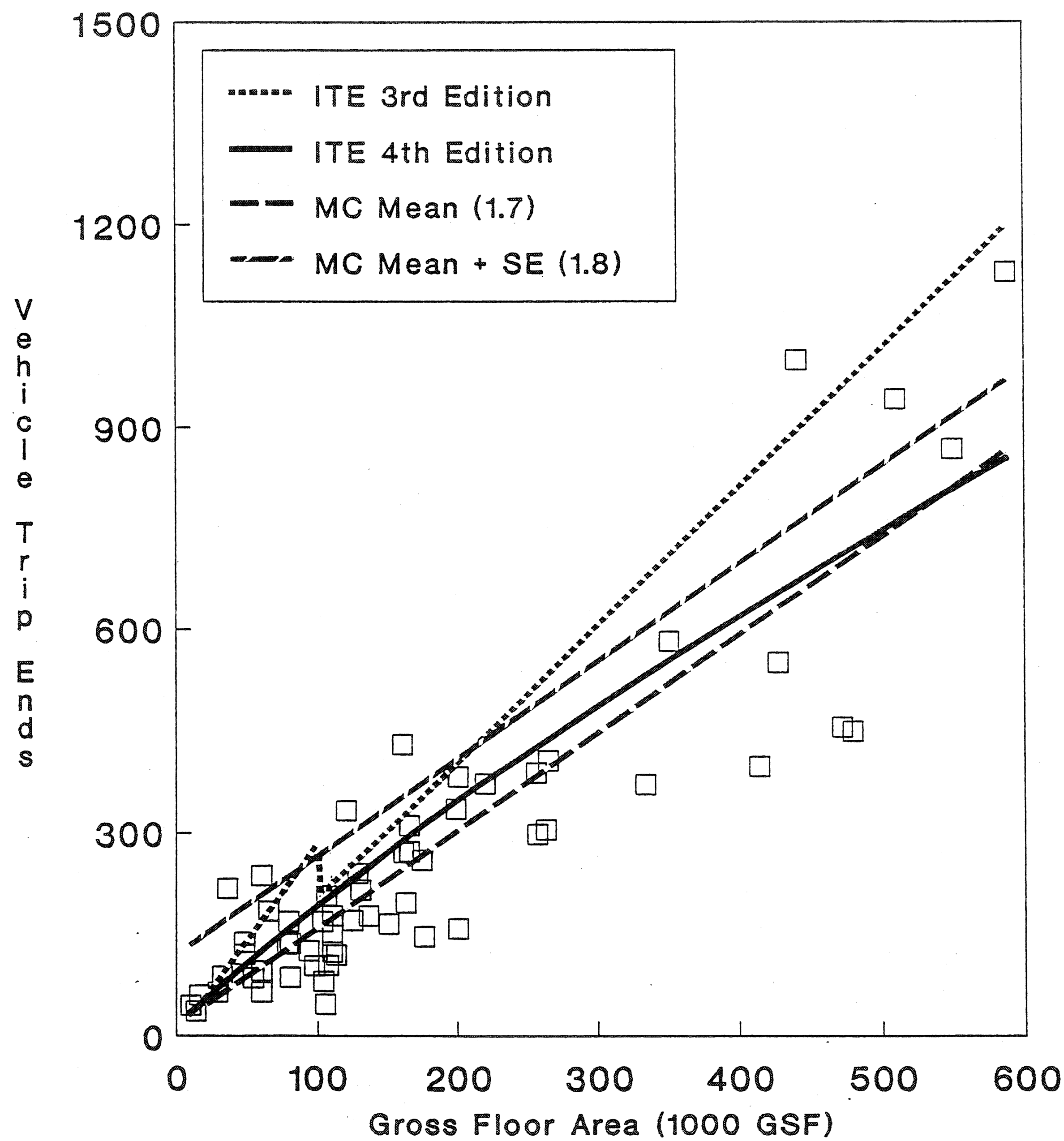
PM Adjacent Street Peak Hour on a Weekday



Source: Douglas & Douglas, Inc.

Figure 7.6b
General Office (ITE 710) Average Vehicle Trip Ends

PM Peak Hour of Generator on a Weekday



Source: Douglas & Douglas, Inc.

Table 7.3 shows a numerical comparison of the ITE and Montgomery County trip equations for office buildings. The numbers indicate the estimated trip ends for various building sizes using the four equations listed; these equations are identical to the four equations shown in Figures 7.5 and 7.6. The comparison between the ITE 4th Edition equations and those developed for Montgomery County supports our findings in Chapter 3 and that which is demonstrated by the graphs in Figures 7.5 and 7.6; that is that, except for very large buildings, the Montgomery County trip rates are lower than those estimated by the ITE equations. The differences are greater for the adjacent street peak hour than for the generator peak hour. (The ITE 4th Edition contains only one equation for each time period with the implication that adjacent street and generator peak hour trip equations are believed to be identical.)

The trip estimates in Table 7.3 and the curves in Figures 7.5 and 7.6 may be interpreted as follows. Vehicle trip estimates computed using the equations derived from the mean (average) values measured in Montgomery County (equations 1.1, 1.3, 1.5, and 1.7) will be lower than estimates calculated from the ITE 3rd Edition rates. They will also be lower than estimates made using the ITE 4th Edition equations for buildings smaller than 500,000 GSF.

For both the AM and the PM adjacent street peak hours, the trip estimates made with the more conservative equations based on the mean plus one standard error (1.2, 1.4, 1.6, and 1.8) are lower than ITE 4th Edition estimates for the larger buildings and higher for the smaller buildings. Those generator peak hour trip estimates which are derived by adding the standard error and the regression equation yielded by the Montgomery County data are consistently higher than the ITE 4th Edition estimates. This conservatism is especially marked with respect to smaller buildings. Comparing these results with the trip estimates presented in the ITE 3rd Edition, we see that there is a tendency for the former to be higher for smaller buildings and lower for larger ones.

The form of the trip equation affects the application method. In the ITE 3rd Edition, trips are estimated using rates which are constant throughout the specified range of the independent variable. Thus as the development increases, the number of trips increases proportionally. For example, using the 3rd Edition, a site with one 900,000 GSF office building would have an estimated number of trips equal to a second site with three 300,000 GSF office buildings. Using either the ITE 4th Edition or the Montgomery County equations would result in a smaller estimated number of trips from the site with the single large building. This relationship between individual building size and trip rate was borne out in the data collected for this study. Consequently, we suggest that trip volumes for large developments be estimated by aggregating the number of trips estimated for each component structure, rather than aggregating the floor areas and then calculating the trips for the total development.

<u>We recommend that the straight line equations estimated from Montgomery County data be chosen as the best estimators of average peak hour trip ends for general office buildings in Montgomery County</u>. These equations better fit the observed data than do the ITE 4th Edition equations (as well as the ITE 3rd Edition rates). The Montgomery County equations also

Table 7.3

Comparison of Trip Estimates: General Offices (ITE 710): Montgomery County Equations versus ITE Equations

a. AM Adjacent Street Peak Hour

Total Hourly Vehicle Trips Estimated By	Building Size in 1000 GSF 50	100	200	500	800
ITE 3rd Edition	125	200	400	1065	1704
ITE 4th Edition	110	200	364	800	1198
M.C. Mean Eq. 1.1	86	143	257	599	941
M.C. S.E. Eq. 1.2	224	281	395	737	1079
Comparisons:					
M.C. Mean (1.1)					
vs. ITE 4th Edition	-24	-57	-107	-201	-257
% Difference	-21.8%	-28.5%	-29.4%	-25.1%	-21.5%
M.C. S.E. (1.2)					
vs. ITE 4th Edition	114	81	31	-63	-119
% Difference	103.6%	40.5%	8.5%	-7.9%	-9.9%
M.C. S.E. (1.2)					
vs. ITE 3rd Edition	99	81	-5	-328	-625
% Difference	79.2%	40.5%	-1.2%	-30.8%	-36.7%

b. PM Adjacent Street Peak Hour

Total Hourly Vehicle Trips Estimated By	Building Size in 1000 GSF 50	100	200	500	800
ITE 3rd Edition	141	203	406	1020	1632
ITE 4th Edition	111	197	350	749	1104
M.C. Mean Eq. 1.5	96	142	234	510	786
M.C. S.E. Eq. 1.6	186	232	324	600	876
Comparisons:					
M.C. Mean (1.5)					
vs. ITE 4th Edition	-15	-55	-116	-239	-316
% Difference	-13.5%	-27.9%	-33.1%	-31.9%	-28.8%
M.C. S.E. (1.6)					
vs. ITE 4th Edition	75	35	-26	-149	-228
% Difference	67.6%	17.8%	-7.4%	-19.9%	-20.6%
M.C. S.E. (1.6)					
vs. ITE 3rd Edition	45	29	-82	-420	-756
% Difference	31.9%	14.3%	-20.2%	-41.2%	-46.3%

Table 7.3 (continued)

c. AM Generator Peak Hour

Total Hourly Vehicle Trips Estimated By	Building Size in 1000 GSF 50	100	200	500	800
ITE 3rd Edition	146	200	400	1090	1744
ITE 4th Edition	110	200	364	800	1198
M.C. Mean Eq. 1.3	77	162	332	842	1360
M.C. S.E. Eq. 1.4	200	285	455	965	1475
Comparisons:					
M.C. Mean (1.3) vs. ITE 4th Edition	-33	-38	-32	42	162
% Difference	-30.0%	-19.0%	-8.8%	5.2%	13.5%
M.C. S.E. (1.4) vs ITE 4th Edition	90	85	91	165	277
% Difference	81.8%	42.5%	25.0%	20.6%	23.1%
M.C. S.E. (1.4) vs. ITE 3rd Edition	54	85	55	-125	-269
% Difference	37.0	42.5%	13.8%	-11.5%	-15.4%

d. PM Generator Peak Hour

Total Hourly Vehicle Trips Estimated By	Building Size in 1000 GSF 50	100	200	500	800
ITE 3rd Edition	142	203	406	1020	1632
ITE 4th Edition	111	197	350	749	1104
M.C. Mean Eq. 1.7	92	164	308	740	1172
M.C. S.E. Eq. 1.8	199	271	415	847	1279
Comparisons:					
M.C. Mean (1.7) vs. ITE 4th Edition	-19	-33	-42	-9	68
% Difference	-17.1%	-16.8%	-12.0%	-1.2%	6.2%
M.C. S.E. (1.8) vs. ITE 4th Edition	88	74	65	98	175
% Difference	79.3%	37.6%	18.6%	13.1%	15.9%
M.C. S.E. (1.8) vs. ITE 3rd Edition	57	68	9	-173	-353
% Difference	40.1%	33.5%	2.2%	-17.0%	-21.6%

Source: Douglas & Douglas, Inc.

provide statistics from which equations may be constructed for utilization in the development review process.

7.4.2 *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 have the opportunity to do this because data on trip rates for buildings situated within 2,500 feet of Metrorail stations were recently collected by JHK & Associates for an M-NCPPC study entitled Post-Metrorail Transportation Characteristics Study [5], and we, in our turn, collected data only for buildings located further 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--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:

- During the PM peak hour, the average number of vehicle trips generated by office buildings located near Metrorail stations equals the average number of trips generated by office buildings located throughout the rest of Montgomery County.
- During the AM peak hour, the average number of vehicle trips generated by office buildings located near Metrorail stations is much lower (by approximately 50% to 60%) than the average number of trips generated by office buildings located throughout the rest of Montgomery County.
- At stations located inside the Beltway, there appears to be no strong and statistically significant relationship between the numbers of AM or PM peak hour vehicle trips generated by office buildings and their distances from Metrorail facilities.
- At stations located outside the Beltway, the numbers of AM and PM peak hour trips generated by office buildings increase with distance from Metrorail facilities and in the PM peak hour exceed the countywide trip rates beyond a distance of 1500-1600 feet from the station. (Note that the precise distance varies according to building size since smaller buildings have slightly lower vehicular trip rates than do larger buildings.)

Many of these results are counter-intuitive. We know that as many as 24% of the employees in the office buildings near Metrorail facilities that were surveyed used transit. But this did not reduce the number of PM peak hour vehicle trips at these buildings to levels below the average rates found outside Metrorail walksheds. The difference in rates between AM and PM peaks is particularly puzzling. 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 to rail facilities; and differences in work hours with offices near Metrorail starting later, perhaps after the end of the survey time. Certainly, there is strong evidence that, for some time periods and station locations, offices inside Metrorail walksheds should be treated separately from other office buildings in the County.

Table 7.4 presents the equations derived from the walkshed surveys. The stepwise regression program we used (SPSS PC+) would not admit distance as a significant variable for buildings located within the Bethesda, Silver Spring or Friendship Heights Metrorail walksheds, i.e., those within the Beltway. Regression equations, which include the airline distance from the station, are given for those stations located outside the Beltway and, as a reference, for all stations as a group.

The presence of a Metrorail station has a significant influence on vehicle trip rates, but this influence varies 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 7.7a, 7.7b, 7.8a and 7.8b. For stations located inside the Beltway (Figures 7.7a and 7.8a), only one curve is shown; the number of vehicle trips varies by size of building but not by distance from the station. In Figures 7.7b and 7.8b, 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 2500 feet from a station, the number of trips is given by the upper edge of the shaded area. The trip estimates for buildings located 1250 feet from the station are indicated by a dashed (---) line.

The curves for the morning peak hour (Figures 7.7a and b) indicate clearly that buildings in station walksheds generate fewer vehicle trips than do those outside. The slopes of the general office curves (equation 1.3 and ITE 4th Edition) are much steeper than those of the station walkshed curves. Because of these differences in slope, the differences in the volume of trip ends increases alongside building size. Table 7.5 shows that station walkshed offices generate fewer AM peak hour trips than do non-station walkshed offices for all station locations, all distances, and all building sizes. The percentage reduction in trips declines as airline distance to the station reaches 2,500 feet. The case for separate equations for offices located near Metrorail stations seems to be a strong one.

Table 7.4

Vehicle Trip Generation Equations: General Offices Near Metrorail Stations: Average Vehicle Trip Ends on a Weekday per 1000 Gross Square Feet Floor Area

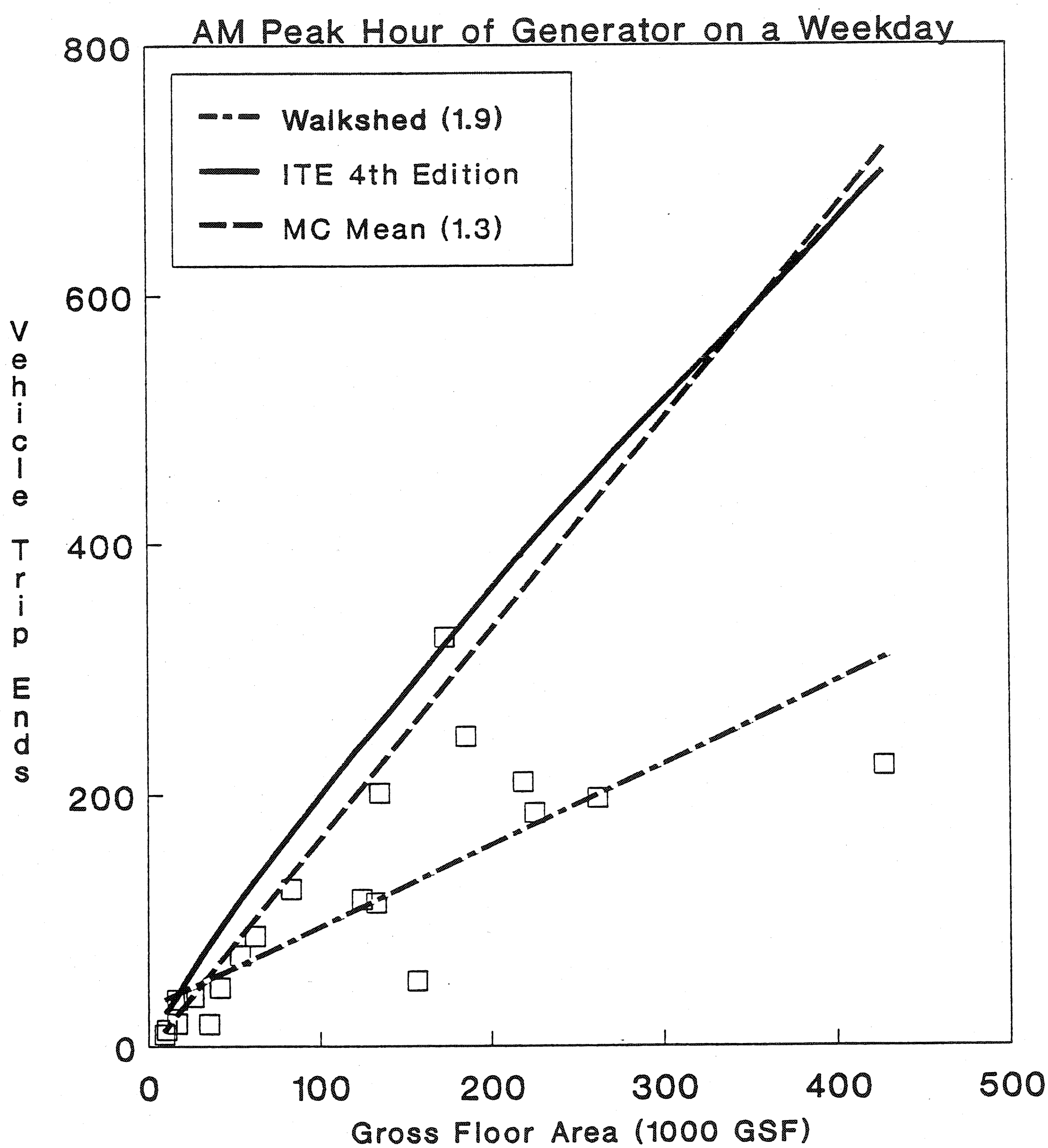
AM Peak Hour of Generator		
Inside Beltway:		
MC Mean (1.9)	T=0.52(A)+52	R^2=0.684
MC Mean + S.E. (1.10)	T=0.52(A)+93.6	
Outside Beltway:		
MC Mean (1.11)	T=0.93(A)+7.96(D)-100.65	R^2=0.825
MC Mean + S.E. (1.12)	T=0.93(A)+7.96(D)-50.95	
Average (All Stations):		
MC Mean (1.13)	T=0.65(A)+4.17(D)-21.55	R^2=0.631
MC Mean + S.E. (1.14)	T=0.65(A)+4.17(D)+33.95	

PM Peak Hour of Generator		
Inside Beltway:		
MC Mean (1.15)	T=1.46(A)+8.7	R^2=0.936
MC Mean + SE (1.16)	T=1.46(A)+53.98	
Outside Beltway:		
MC Mean (1.17)	T=1.37(A)+11.44(D)-146.62	R^2=0.821
MC Mean + S.E. (1.18)	T=1.37(A)+11.44(D)-73.19	
Average (All Stations):		
MC Mean (1.19)	T=1.50(A)+5.40(D)-66.65	R^2=0.870
MC Mean + S.E. (1.20)	T=1.50(A)+5.40(D)-2.76	

Note: T=Average 2-way Vehicle Trip Ends
A=Occupied Gross Floor Area in 1000 Square Feet
D=Distance from Station in 100 Feet

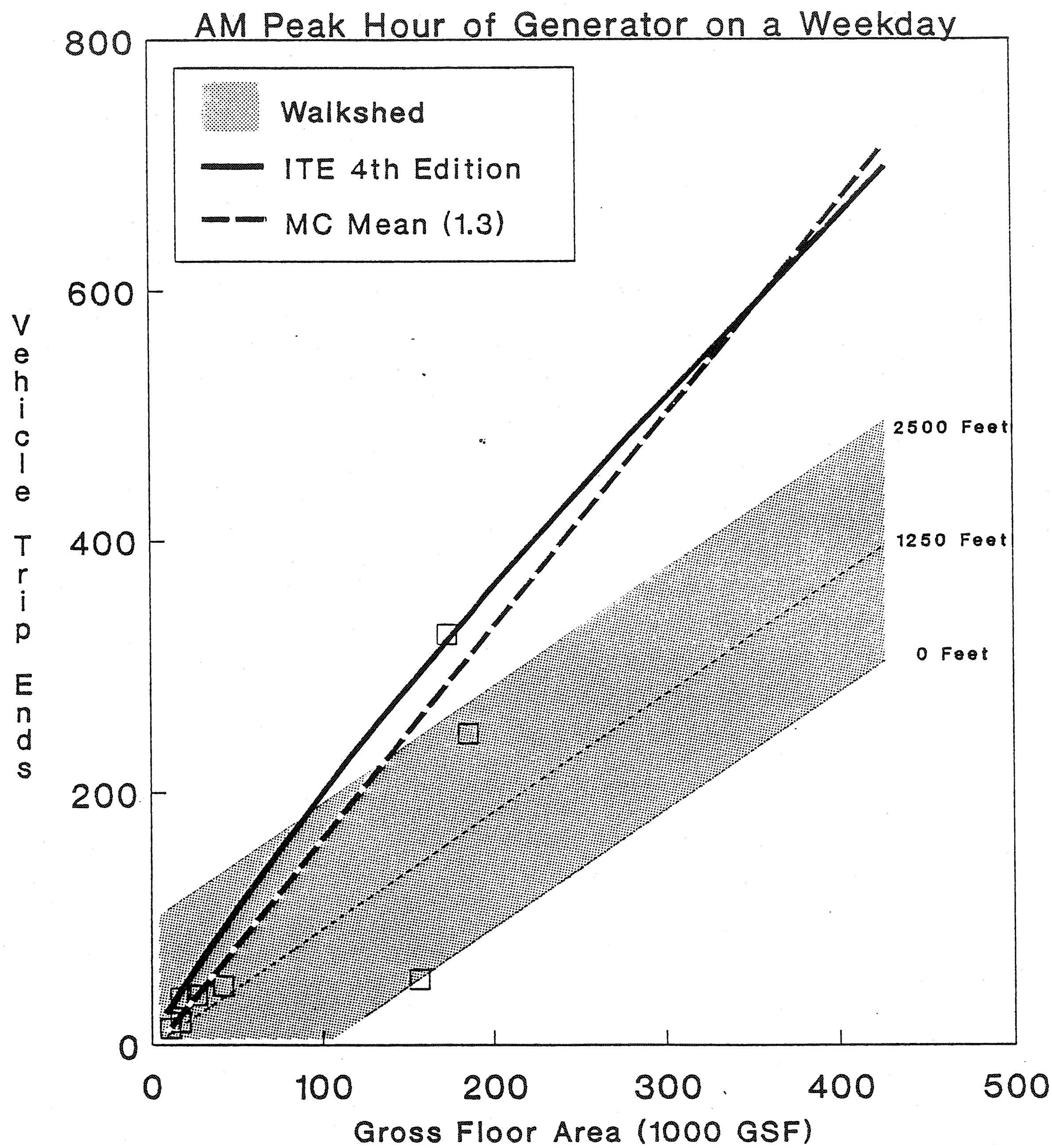
Source: Douglas & Douglas, Inc.

Figure 7.7a. General Office (ITE 710) Average Vehicle Trip Ends at Buildings Within Metrorail Walkshed Inside Beltway



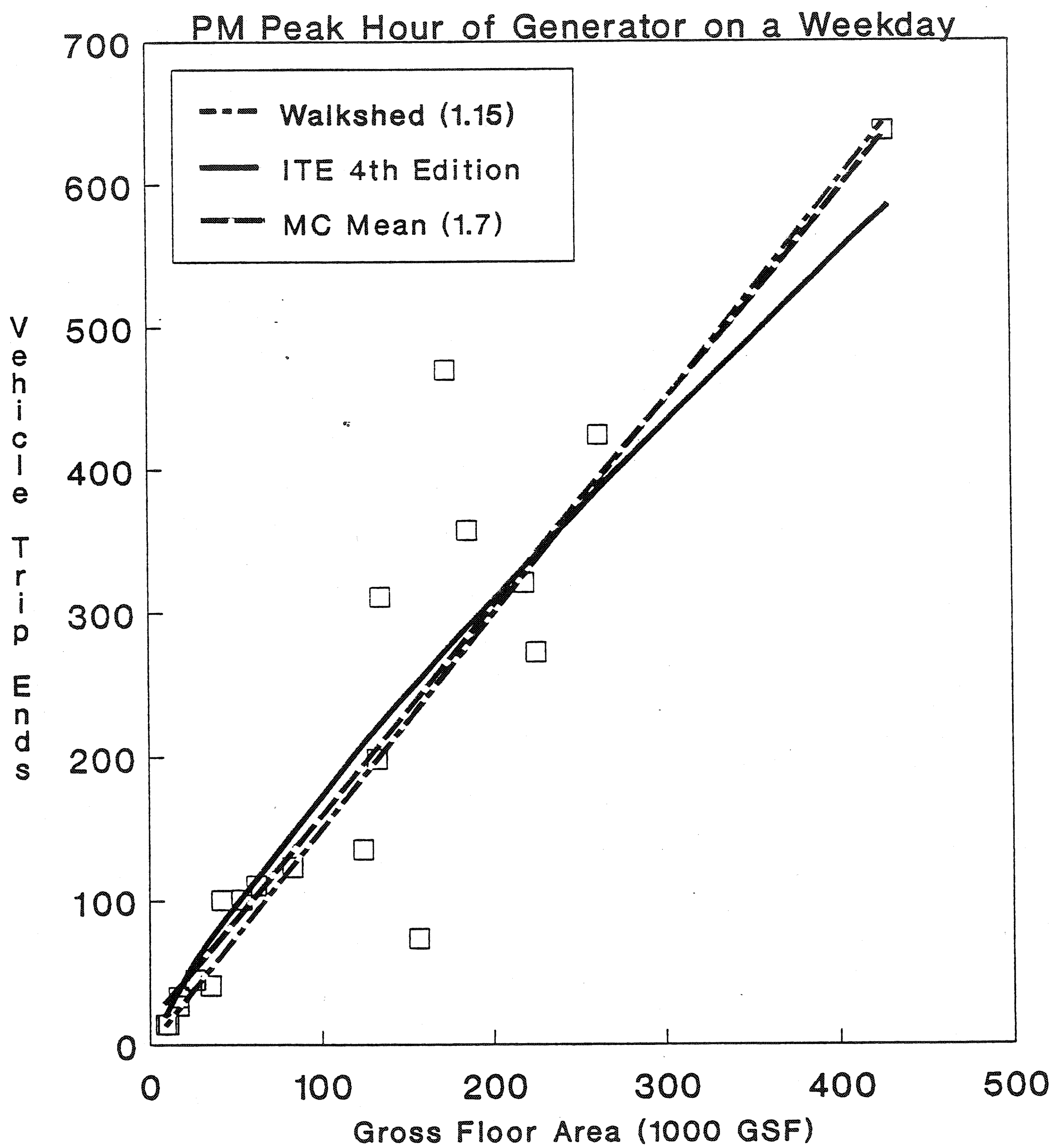
Source: Douglas & Douglas, Inc.

Figure 7.7b. General Office (ITE 710) Average Vehicle Trip Ends at Buildings Within Metrorail Walksheds Outside B'way



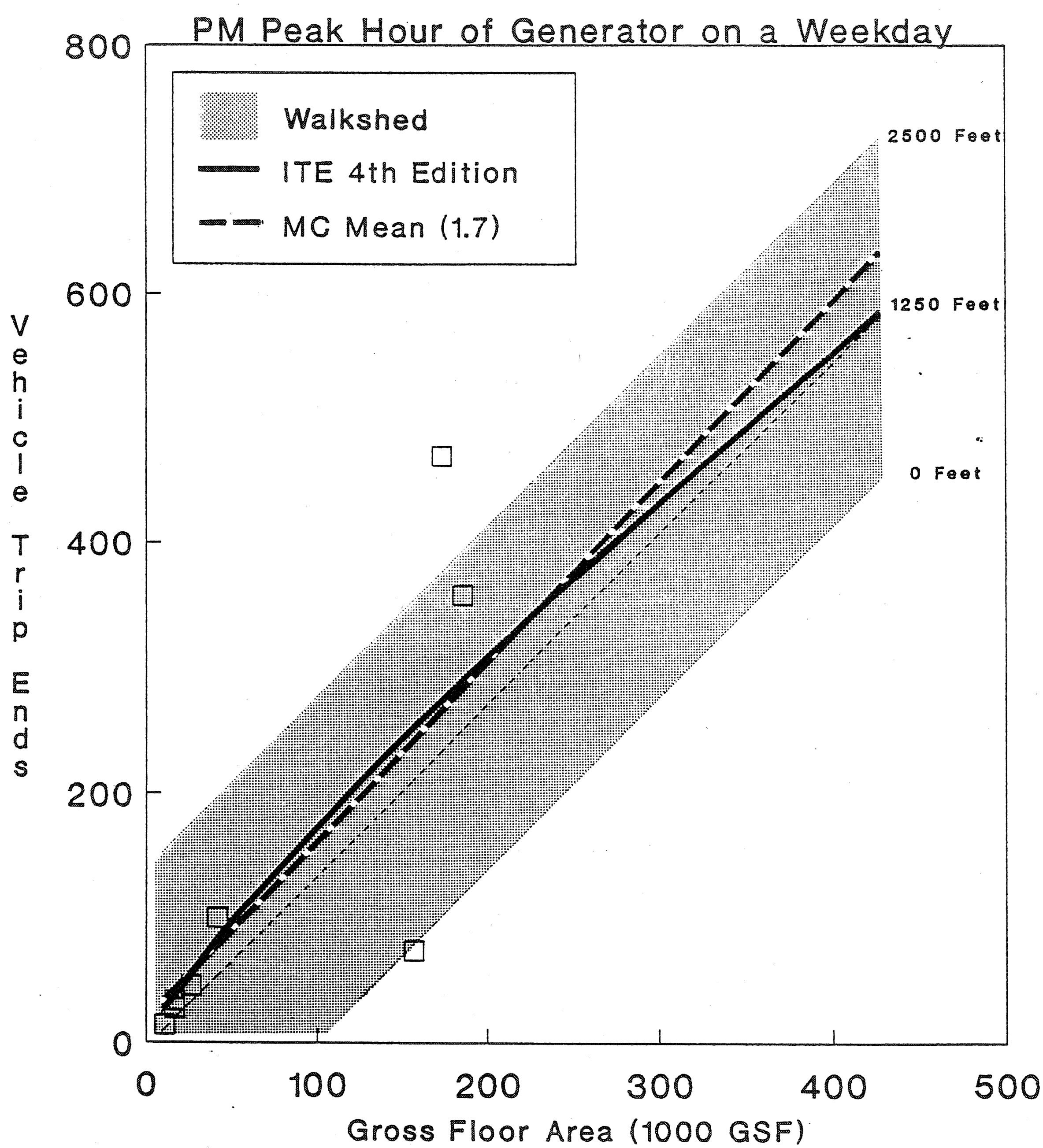
Source: Douglas & Douglas, Inc.

Figure 7.8a. General Office (ITE 710) Average Vehicle Trip Ends at Buildings Within Metrorail Walkshed Inside Beltway



Source: Douglas & Douglas, Inc.

Figure 7.8b. General Office (ITE 710) Average Vehicle Trip Ends at Buildings Within Metrorail Walkshed Outside B'way



Source: Douglas & Douglas, Inc.

Table 7.5

Comparison of Trip End Estimates for General Office Buildings as Predicted by Various Equations: Average Vehicle Trip Ends on a Weekday per 1000 square feet Gross Floor Area

AM Peak Hour of Generator

Source of Estimates	Distance From Station	Building Size (1000 SF GFA) 150	400
General Equation (1.3)	N/A	247	672
Station Walkshed Equation			
Inside Beltway (1.9)	0-2500 ft	130	260
Outside Beltway (1.11)	100 ft	47	279
	1250 ft	138	371
	2500 ft	238	470

PM Peak Hour of Generator

Source of Estimates	Distance From Station	Building Size (1000 SF GFA) 150	400
General Equation (1.7)	N/A	236	596
Station Walkshed Equation			
Inside Beltway (1.15)	0-2500 ft	228	593
Outside Beltway (1.17)	100 ft	70	413
	1250 ft	202	544
	2500 ft	345	687

Table 7.5 (continued)

Differences in Trip Estimates as Predicted by Various Equations for General Office Buildings: Percent Differences from General Equation

AM Peak Hour of Generator

Source of Estimates	Distance From Station	Building Size (1000 SF GFA) 150	400
General Equation (1.3)	N/A	0%	0%
Station Walkshed Equation			
Inside Beltway (1.9)	0-2500 ft	-48%	-61%
Outside Beltway (1.11)	100 ft	-81%	-58%
	1250 ft	-45%	-45%
	2500 ft	-5%	-30%

PM Peak Hour of Generator

Source of Estimates	Distance From Station	Building Size (1000 SF GFA) 150	400
General Equation (1.7)	N/A	0%	0%
Station Walkshed Equation			
Inside Beltway (1.15)	0-2500 ft	-2%	0%
Outside Beltway (1.17)	100 ft	-70%	-30%
	1250 ft	-13%	-8%
	2500 ft	+48%	+16%

Source: Douglas & Douglas, Inc.

The pattern of trips generated by offices within Metrorail walksheds during the PM peak hour resembles that found at offices throughout the County. At stations located inside the Beltway, the regression equation (1.15) gives results almost identical to those estimated by the general equation (1.7). The curves for stations outside the Beltway reflect the influence of distance from the station in that beyond 1500 to 1600 feet, the station walkshed curves predict more trips than the general equation (1.7) even though fewer trips are estimated for buildings close to the station (see Table 7.5). Because of the similarity in slopes, the difference in number of trips does not vary greatly with the size of building although the percentage difference does vary with size.

Based on our analysis, we recommend that adjustments be made to the general peak hour trip estimates for those offices located near Metrorail stations. For offices located at stations inside the Beltway, the suggested reduction is 45 percent for AM peak hour trips and no reduction for PM peak hour trips. For offices located near stations outside the Beltway, the suggested reduction varies with distance from the station.

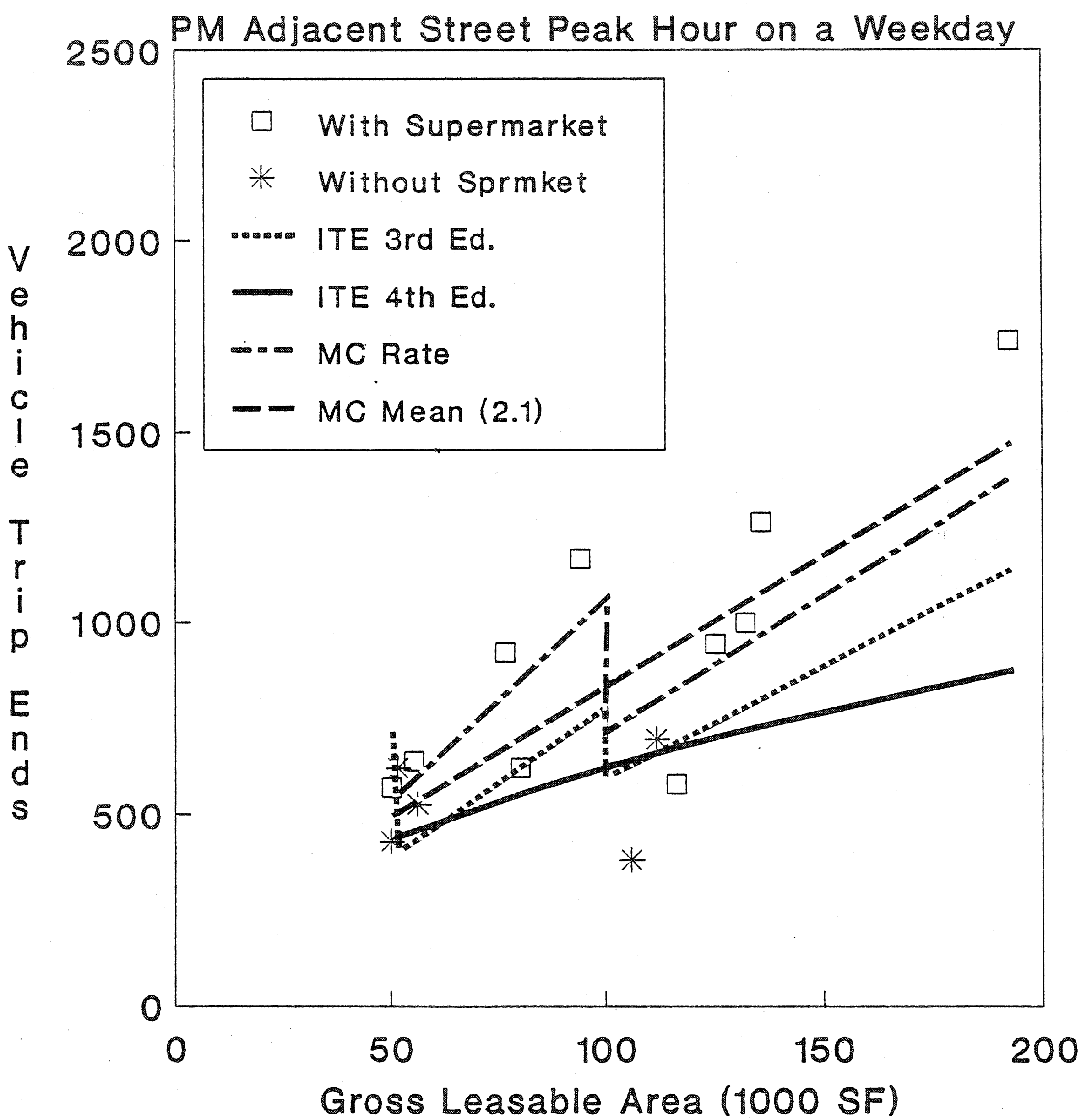
7.5 COMPARISON OF TRIPS GENERATED BY SHOPPING CENTERS

7.5.1 *Comparison of Trips from All Centers*

Shopping centers in Montgomery County appear to be much more active than the average shopping center nationwide. The Montgomery County average trip rates during the afternoon peak period for both the adjacent street peak hour and generator (site) peak hour are much higher than the national trip rates in either the ITE 3rd or 4th Editions. In fact, the new equations in the ITE 4th Edition show an even greater divergence from the data collected for Montgomery County than did the 3rd Edition. This phenomenon may be seen in Figures 7.9a and 7.9b which graphically illustrate how poorly the ITE 4th Edition equation represents data observed in Montgomery County. The large discrepancies may reflect the levels of disposable income which characterize Montgomery County households. Montgomery County residents have substantially more disposable income than Americans as a whole, and appear to be spending a substantial part of the difference in shopping activities.

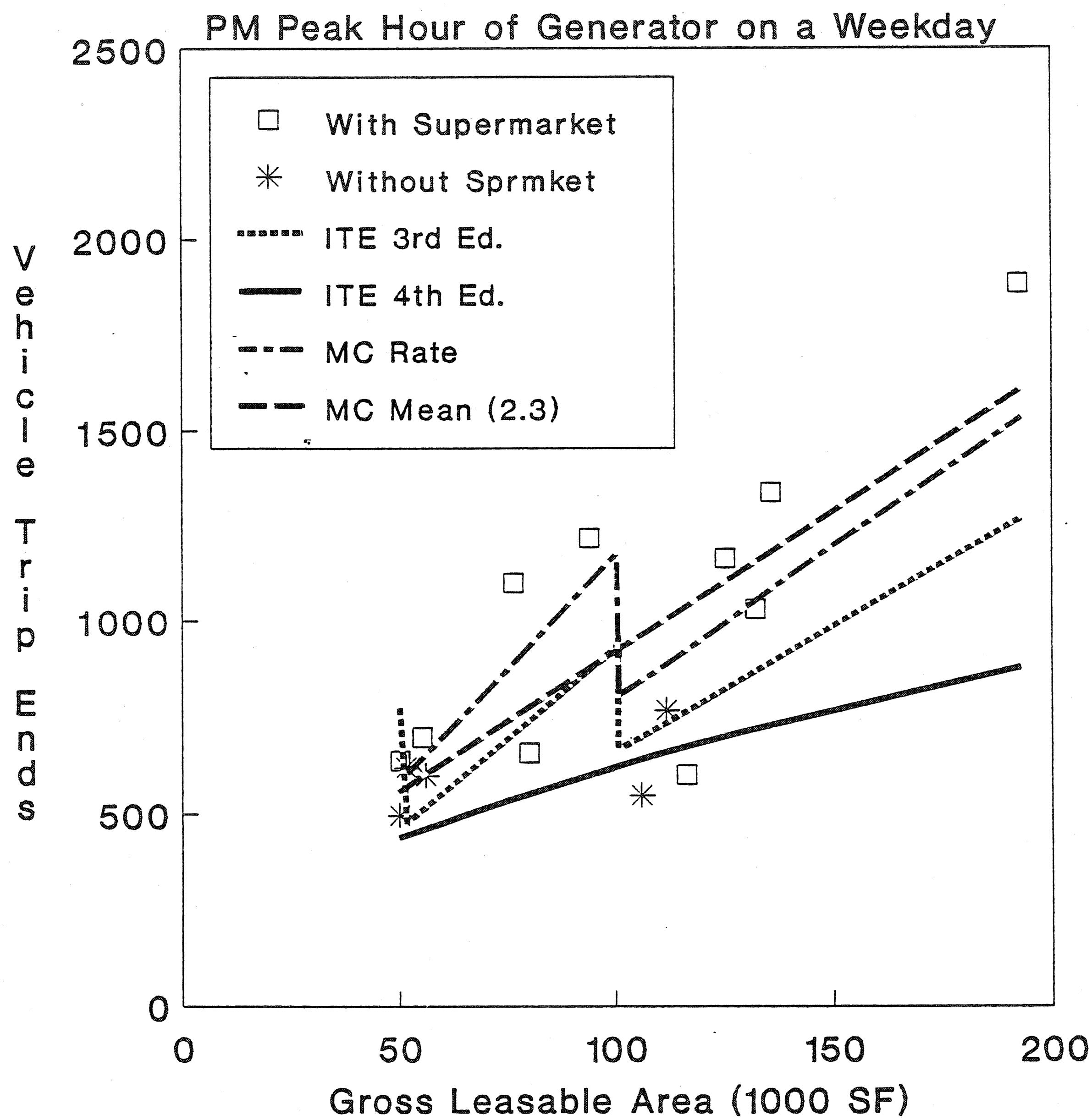
The linear equation for each time period developed from Montgomery County data is shown in Table 7.6. The R^2 or goodness-of-fit statistics are not particularly impressive but are approximately the same (slightly larger in fact) as those for the ITE 4th Edition equation. As may be seen in Figures 7.9a and 7.9b, regression lines 2.1 and 2.3 appear to be more suitable representations of the average trip rates than non-linear equations such as the ITE curve. The non-linear equations developed from the Montgomery County data had goodness-of-fit statistics inferior to those of the linear equations and were dropped from the analysis. The jagged lines in Figure 7.9 represent the stratified rate system used in ITE's 3rd Edition.

Figure 7.9a. Shopping Centers (ITE 820): Average Vehicle Trip Ends for All Shopping Centers



Source: Douglas & Douglas, Inc.

Figure 7.9b. Shopping Centers (ITE 820) Average Vehicle Trip Ends for All Shopping Centers



Source: Douglas & Douglas, Inc.

Table 7.6

Vehicle Trip Generation Equations for Shopping Centers (With Fewer Than 200,000 SF GLFA): Vehicle Weekday Trip Ends per Thousand Square Feet of Gross Leasable Floor Area

All Shopping Centers		
PM Adjacent Street Peak Hour (one hour between 4 and 6 PM)		
ITE 4th Edition	T=exp(0.52(Ln(A))+4.04)	R^2=0.58
MC Mean (2.1)	T=6.84(A)+151.55	R^2=0.555
MC Mean + S.E. (2.2)	T=6.84(A)+396.95	
PM Peak Hour of Generator		
ITE 4th Edition	T=exp(0.52(Ln(A))+4.04)	R^2=0.58
MC Mean (2.3)	T=7.366(A)+186.30	R^2=0.581
MC Mean + S.E. (2.4)	T=7.366(A)+437.8	

Shopping Centers With Supermarkets		
PM Adjacent Street Peak Hour		
ITE 4th Edition	(Not Available)	
MC Mean (2.5)	T=7.043(A)+197.91	R^2=0.621
MC Mean + S.E. (2.6)	T=7.043(A)+428.21	
PM Peak Hour of Generator		
ITE 4th Edition	(Not Available)	
MC Mean (2.7)	T=7.425(A)+246.76	R^2=0.587
MC Mean + S.E. (2.8)	T=7.425(A)+506.16	

Table 7.6 (continued)

Shopping Centers Without Supermarkets	
PM Adjacent Street Peak Hour	
MC Rate (2.9)	T=7.05(A)
PM Peak Hour of Generator	
MC Rate (2.10)	T=8.07(A)

Note: T=Average 2-way Vehicle Trip Ends
A=Occupied Gross Floor Area (1000 Square Feet)

Source: Douglas & Douglas, Inc.

7.5.2 Influence of Supermarkets on Shopping Center Traffic

Of the 15 shopping centers surveyed in this study, 10 had supermarkets. The 5 centers without them have been denoted by distinctive symbols in Figures 7.9a, 7.9b, 7.10a and 7.10b and cluster visibly at the low end of the curve. In view of this, we examined the impact of supermarkets on shopping center traffic. The equations for shopping centers with supermarkets are given in Table 7.6 and shown in Figures 7.10a and 7.10b. The equation for the average trips from all shopping centers is included also, for reference. The shopping centers with supermarkets have a trip equation with a slightly higher 'Y' intercept and a steeper slope; this indicates that centers with supermarkets will generate more trips than those without. The difference in trip rates between centers with supermarkets and those without decreases as the size increases.

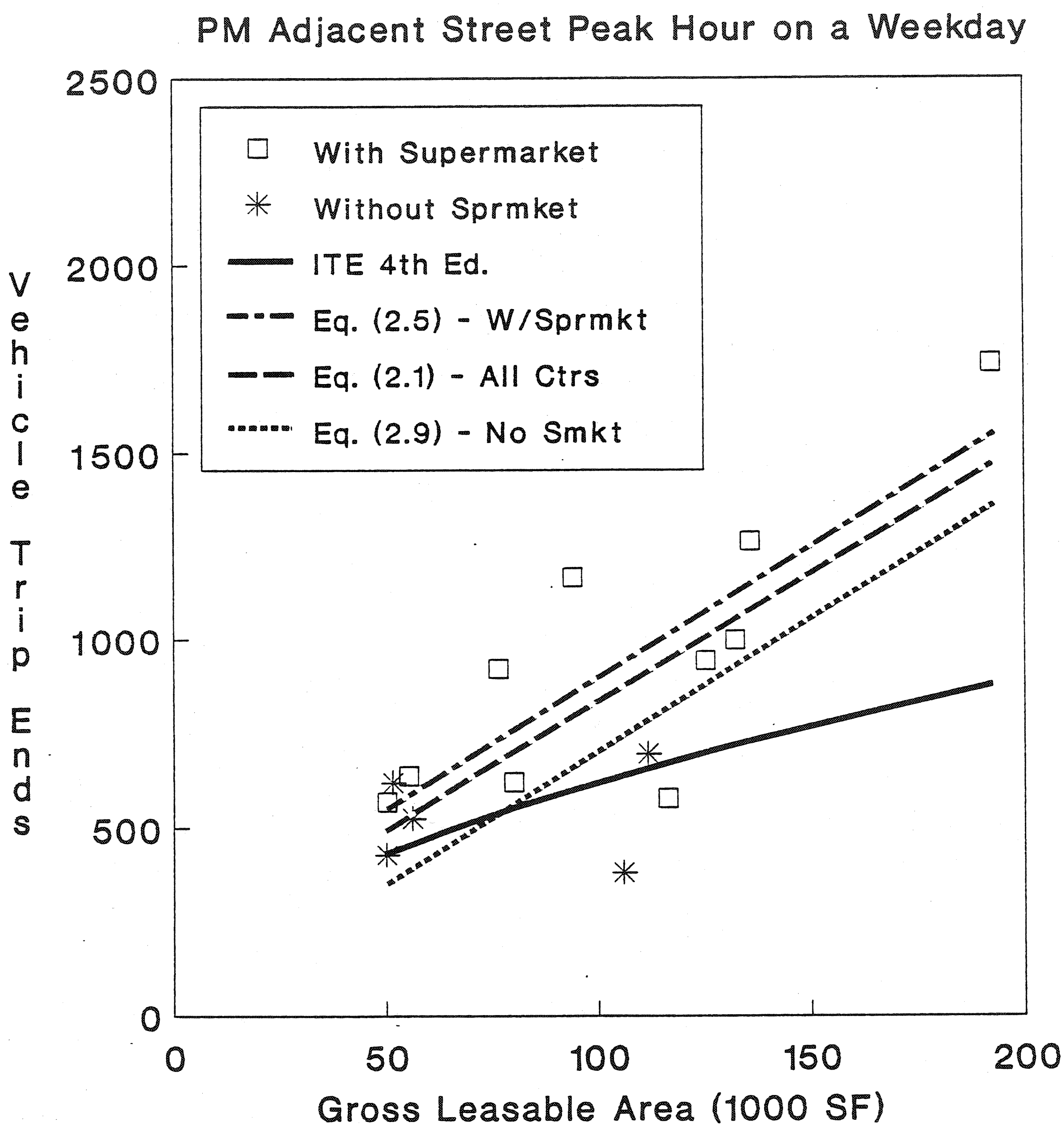
Either because of the small number of data points or their large scatter, we were unable to develop linear or logarithmic equations with satisfactory goodness-of-fit statistics for the five shopping centers without supermarkets. Consequently, we derived a single trip rate based on the average number of trips generated by these shopping centers. The rates for centers without supermarkets are also plotted in Figures 7.10a and 7.10b.

In Figures 7.9a and 7.9b, the Montgomery County average rates (equations 2.1 and 2.3) are obviously much higher than those predicted by either the ITE 3rd or 4th Edition equations. While the ITE 3rd Edition underestimates trips by 20% to 30% in comparison with Montgomery County rates, the 4th Edition curve underestimates trips by as much as 45%. (The various equations used to generate Figures 7.9a, 7.9b, 7.10a and 7.10b are given in Table 7.6.) The Montgomery County curves are equal or superior to the ITE curves in terms of goodness-of-fit (R^2) for Montgomery County data. The equations for shopping centers with supermarkets alone also exhibit goodness-of-fit statistics superior to those presented by ITE (4th Edition).

Neighborhood centers (less than 100,000 SF GLA) containing a major food chain supermarket exhibited significantly higher trip end volumes during the PM peak hours than did the centers without supermarkets. These differences are calculated in Table 7.7. The impact of a supermarket on retail trips diminishes as the overall size of the center increases. For small neighborhood centers, the difference in trips generated in the peak hour may be as much as 35.87% lower for centers without a supermarket than for those which have one. Among the community centers with more than 100,000 SF GLA, the difference in the numbers of trips at centers with and without supermarkets is between 6.8% and 21.9% with those containing supermarkets generating more trips. These comparisons are also shown in Table 7.7 and are presented graphically in Figures 7.9a, 7.9b, 7.10a and 7.10b.

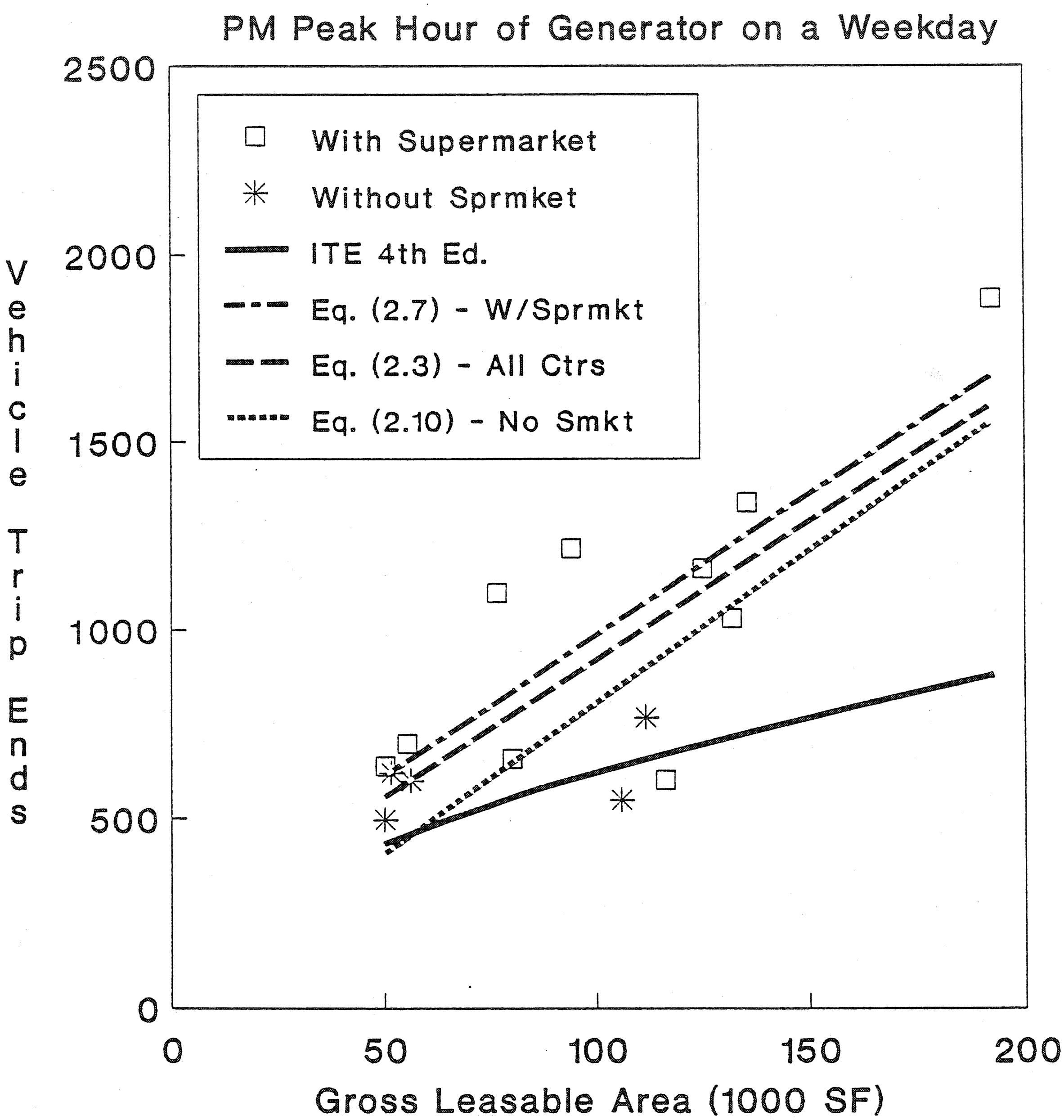
Based on this analysis, equation 2.3 appears to give the appropriate estimate of trip ends for the generator peak hour. Equations 2.7 for the generator PM peak hour and 2.5 for the adjacent street PM peak hour appear to give more accurate estimates of the average trips generated by shopping centers with supermarkets. For shopping centers without supermarkets, these rates

Figure 7.10a. All Shopping Centers (ITE 820): Impact of Supermarkets on Average Vehicle Trip Ends



Note: See Table 7.6 for Equations.
Source: Douglas & Douglas, Inc.

Figure 7.10b. All Shopping Centers (ITE 820): Impact of Supermarkets on Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Table 7.7

Comparing Vehicle Trip Estimates for Shopping Centers With and Without Supermarkets

a. PM Adjacent Street Peak Hour				
Total Hourly Vehicle Trips Estimated By:	**Shopping Center Size (1000 SF GLA)** 50	75	100	200
ITE 3rd Edition	390	585	590	1180
ITE 4th Edition	435	537	623	893
M.C. All Centers (2.1)	494	665	836	1520
M.C. Centers With Supermarkets (2.5)	550	726	902	1607
M.C. Centers Without Supermarkets (2.9)	353	529	705	1410
Comparisons:				
With Supermarket (2.5) versus Mean (2.1)	57	66	67	87
% Difference	11.4%	8.2%	8.0%	5.7%
Without Supermarket (2.9) versus Mean (2.1)	-141	-136	-131	-110
% Difference	-28.5%	-20.4%	-15.7%	-7.2%
Without Supermarket (2.9) versus With Supermarket (2.5)	-197	-197	-197	-197
% Difference	-35.8%	-20.4%	-21.9%	-12.2%
M.C. Mean (2.1) versus ITE 4th Edition	59	128	212	626
% Difference	12.0%	23.8%	25.4%	41.2%

Table 7.7 (continued)

Comparing Vehicle Trip Estimates for Shopping Centers With and Without Supermarkets

b. PM Generator Peak Hour

Total Hourly Vehicle Trips Estimated By:	Shopping Center Size (1000 SF GLA) 50	75	100	200
ITE 3rd Edition	465	698	660	1320
ITE 4th Edition	435	537	623	893
M.C. All Centers (2.3)	555	726	923	1660
M.C. Centers With Supermarkets (2.7)	618	804	989	1732
M.C. Centers Without Supermarkets (2.10)	404	605	807	1614
Comparisons:				
With Supermarket (2.7) versus Mean (2.3)	63	66	66	72
% Difference	11.4%	7.5%	7.2%	4.4%
Without Supermarket (2.10) versus Mean (2.3)	-151	-121	-116	-46
% Difference	-27.2%	-16.7%	-12.6%	-2.8%
Without Supermarket (2.10) versus With Supermarket (2.7)	-214	-199	-182	-118
% Difference	-34.6%	-24.8%	-18.4%	-6.8%
M.C. Mean (2.3) versus ITE 4th Edition	120	279	300	766
% Difference	21.7%	31.5%	32.5%	46.2%

Source: Douglas & Douglas, Inc.

should be reduced by approximately 7% to 35% for the generator peak hour figure and 12% to 36% for the adjacent street peak hour figure.

In summary, the Montgomery County shopping centers exhibit much higher levels of activity and traffic than estimated by the ITE formulas. New equations developed from the study results seem to be more appropriate than the ITE equations. It also appears that estimates for proposed shopping centers should be stratified according to whether they will contain a supermarket operated by a major food chain.

7.6 COMPARISON OF ESTIMATES OF TRIPS GENERATED BY FAST FOOD RESTAURANTS

The number of fast food trips observed in Montgomery County varied considerably from the number of trips estimated using the ITE 4th Edition equations. The difference between the ITE estimates and observed data varied significantly by time of day. On the one hand, estimates from the ITE equations for fast food restaurants with drive-through window service agree quite closely with the PM peak hour data from Montgomery County. On the other, the ITE equations provide poor estimates of the average trips observed during the morning peak hour at Montgomery County fast food restaurants, overestimating the number of vehicle trip ends by up to 100%.

As noted in Chapter 5, we found that in Montgomery County the floor area of a fast food restaurant in total gross square feet is a poor indicator of the amount of traffic generated by the facility. Floor area is the independent variable chosen for the ITE 4th Edition equations, however. The ITE equations, both linear and non-linear, have weak goodness-of-fit statistics (low R^2 values) which means that the variation in size of the restaurant does not explain very much of the variation in the number of trip ends. In Chapter 5, we pointed out that there was a much stronger correlation between the number of trips generated by a restaurant and the level of traffic on nearby roads. Based on this analysis and that of Chapter 5, we are prepared to recommend unique trip generation rates for fast food restaurants in Montgomery County. These recommendations are given in Chapter 8.

7.6.1 *Impact of Drive-Through Windows on Fast Food Restaurant Trips*

In its 4th Edition, the ITE designated two categories of fast food restaurants: those with a drive-through window (Category 834) and those without (Category 833). They developed regression equations for estimating trips based on gross floor area and using linear, reciprocal and logarithmic models. These equations, based on ITE data, are given in Table 7.8. The Montgomery County data suggest that the various linear and non-linear relationships reported by ITE are inappropriate equations for estimating fast food restaurant traffic in Montgomery County. Also, the ITE curves suffer from unacceptably low goodness-of-fit (R^2) statistics: the

Table 7.8

Vehicle Trip Generation Equations for Fast Food Restaurants With (834) and Without (833) Drive-Through Facilities

AM Adjacent Street Peak Hour		
ITE 4th Edition (833)	T=exp(2.57Ln(A)-0.26)	R^2=0.259
ITE 4th Edition (834)	T=44.44(A)+43.0	R^2=0.221
MC Rate (3.1)	T=32.34(A)	

AM Peak Hour of Generator		
ITE 4th Edition (833)	T=1/((0.005/A)+0.003)	R^2=0.428
ITE 4th Edition (834)	T=37.94(A)+102.0	R^2=0.217
MC Rate (3.3)	T=35.55(A)	

PM Adjacent Street Peak Hour		
ITE 4th Edition (833)	T=1/((0.024/A)-0.00039)	R^2=0.40
ITE 4th Edition (834)	T=31.67(A)+6.0	R^2=0.315
MC Rate (3.5)	T=33.73(A)	

PM Peak Hour of Generator		
ITE 4th Edition (833)	T=139.91(A)	
ITE 4th Edition (834)	T=19.63(A)+96.0	R^2=0.082
MC Rate (3.7)	T=47.29(A)	

Note: T = Average 2-way Vehicle Trip Ends
A = Occupied Gross Floor Area (1000 Square Feet)

Source: Douglas & Douglas, Inc.

equations for both AM adjacent street and generator peak hour trip ends explain only 22% to 26% ($R^2 = 0.221$ and 0.259) of the observed variation in the surveyed sites.

Table 7.8 lists trip generation rates developed from Montgomery County data. We estimated regression equations for Montgomery County data using the same models as the ITE 4th Edition. Although some of the goodness-of-fit statistics for Montgomery County equations were slightly better than the ITE equation statistics, we considered none of them satisfactory. Consequently, we eliminated the equations from further consideration.

We believe that the size of the fast food restaurant in gross square feet is an unsatisfactory independent variable because of the very weak association with trip generation data. As described in Chapter 5, the very presence of a fast food restaurant appears to be more important than its relative size. However, in Montgomery County the variation in size of fast food restaurants is quite small--between 2,500 and 3,500 square feet-- so our observations may not hold true for larger restaurants (ITE reports on fast food restaurants up to 7,000 SF in area).

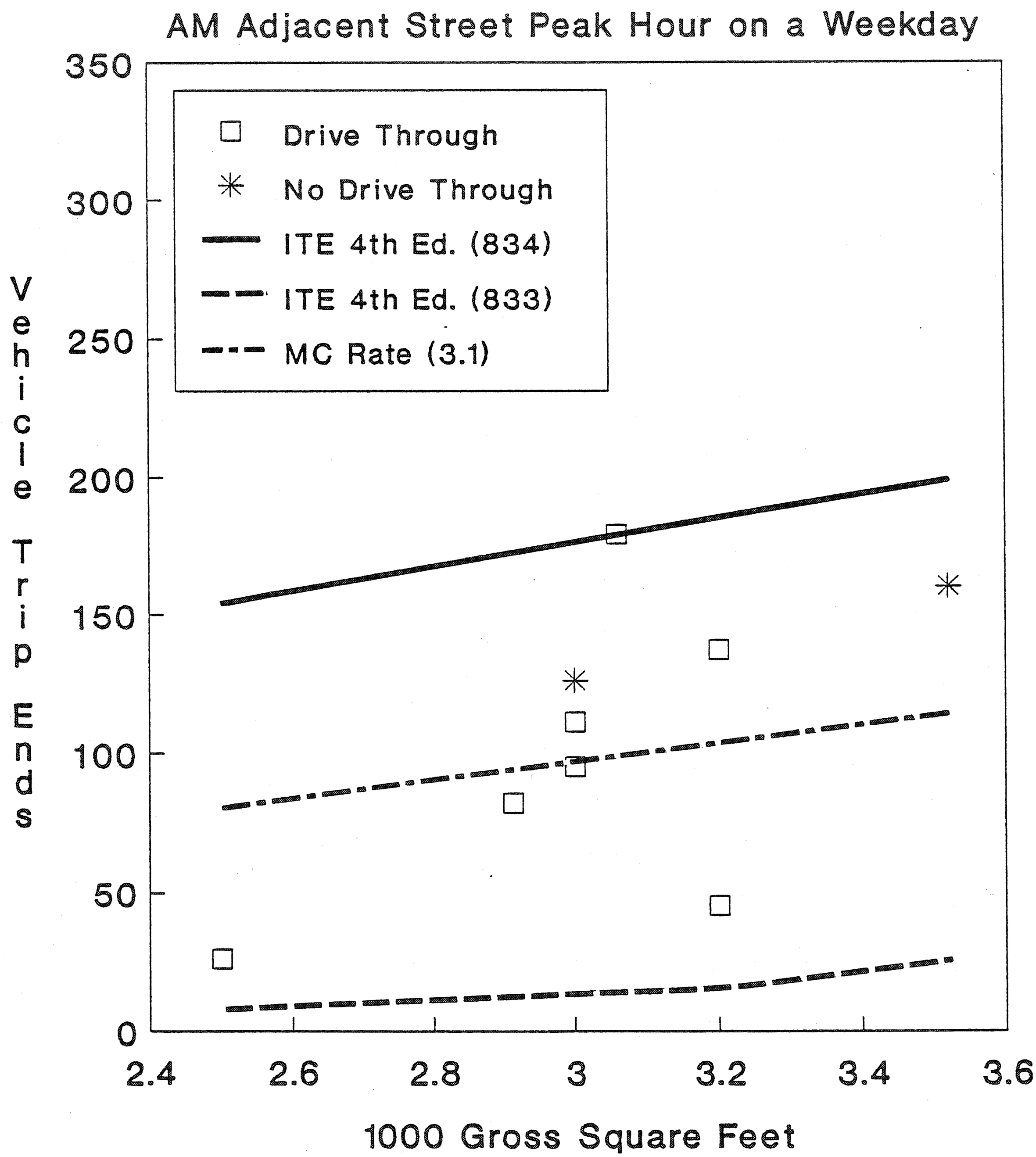
The ITE equations distinguish between restaurants with drive-through windows and those without. In most cases--the exception being the AM generator peak hour--the presence or absence of a drive-through window appears to have no impact on the number of peak hour vehicle trips to fast food restaurants in Montgomery County. During the busy peak periods our field crews observed that the service time at drive-through windows ranged from 60 to 90 seconds, so that only a small percentage of the restaurant's peak hour patrons can be accommodated at the drive-through. Therefore, the impact of the drive-through on total trips is blunted during the peak periods.

7.6.2 *Comparison of ITE and Montgomery County Trip Equations*

The estimated vehicle trip ends for fast food restaurants are shown in Figures 7.11a and 7.11b for the weekday AM peak hour. In the morning peak hour the ITE equation for restaurants with drive-through windows estimates much higher vehicle trip ends than estimated by the rates developed from Montgomery County data. The curves developed by ITE for fast food restaurants without drive-throughs (category 833) show a remarkable distinctness from the data for sites with a drive-through window (category 834). The trip estimates for category 833 are much lower than those for the adjacent street peak hour trips, but fall almost exactly on the curve for restaurants with drive-through windows for the generator AM peak hour. In both the adjacent street and the generator peak hours, the Montgomery County sites induced fewer trips than estimated by the ITE 4th Edition curve for restaurants with drive-through facilities (category 834).

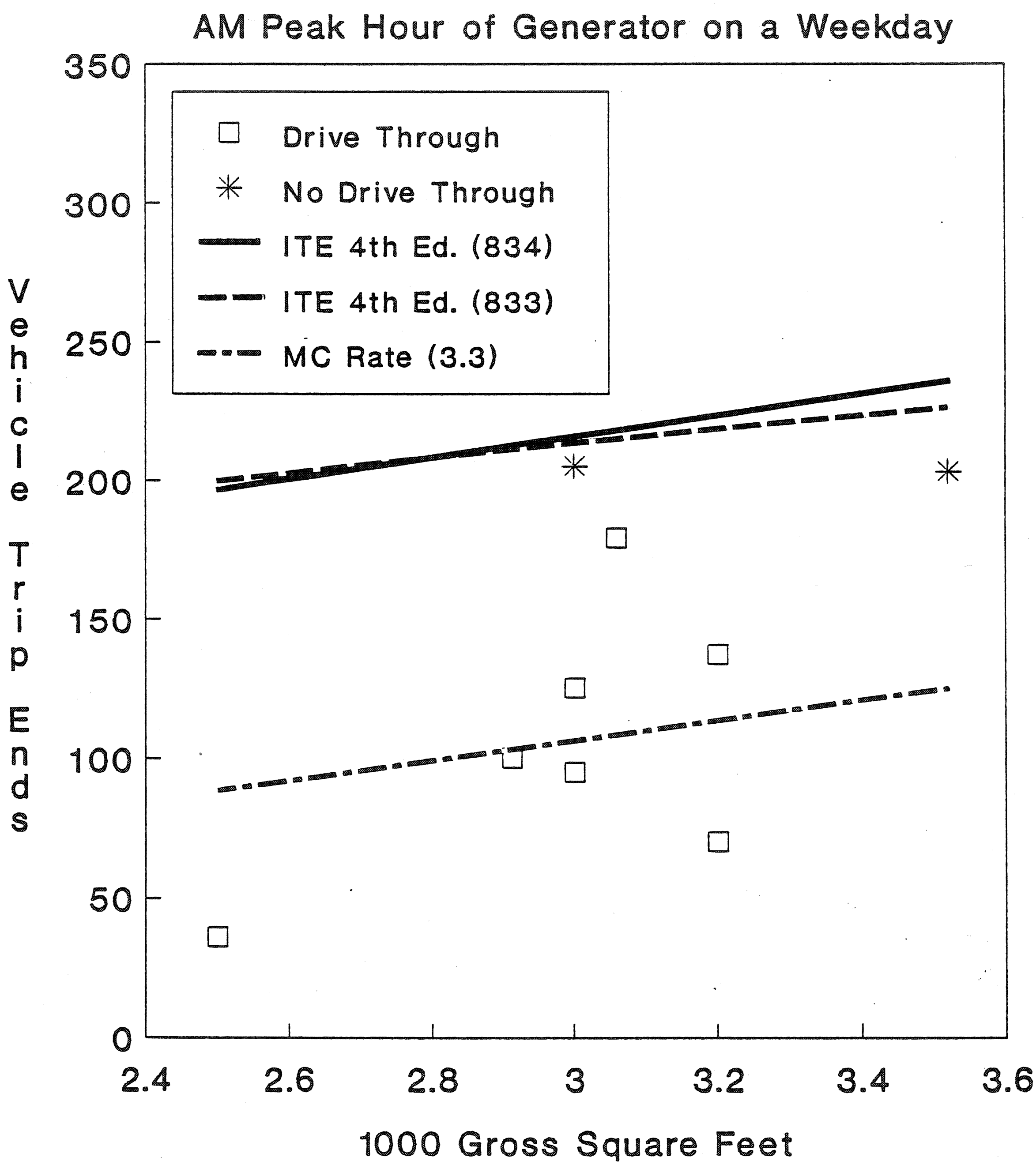
During the PM peak hours, both for the adjacent street and for the generator, the number of trips we estimated using the ITE 4th Edition equation for fast food restaurants with drive-through windows is quite close to the rates estimated for the Montgomery County data. These relationships are shown in Figures 7.12a and 7.12b. In the afternoon peak hour the ITE

Figure 7.11a. Fast Food Restaurants With (834) and Without (833) Drive-Throughs: Average Vehicle Trip Ends versus GSF



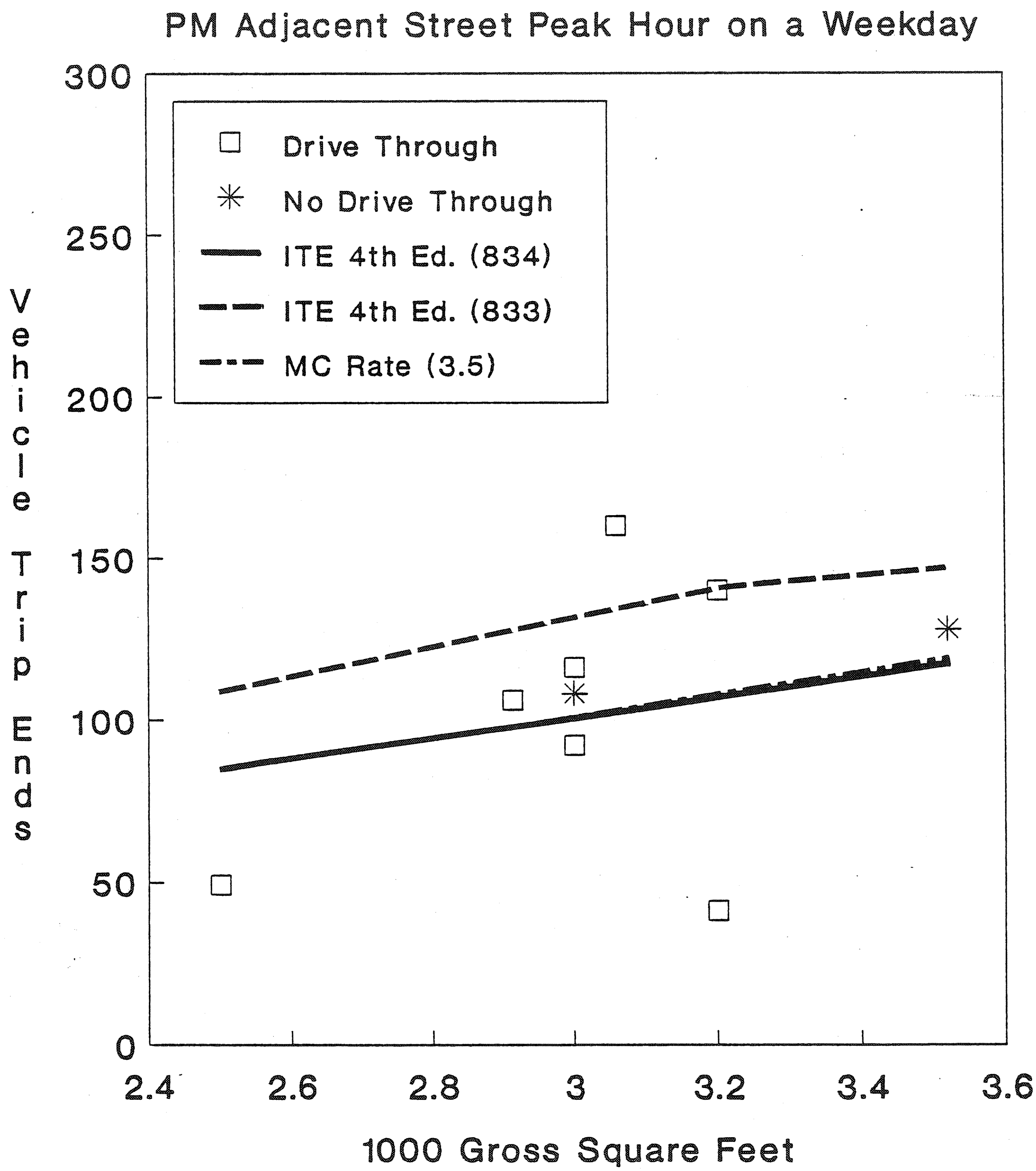
Source: Douglas & Douglas, Inc.

Figure 7.11b. Fast Food Restaurants With (834) and Without (833) Drive-Throughs: Average Vehicle Trip Ends versus GSF



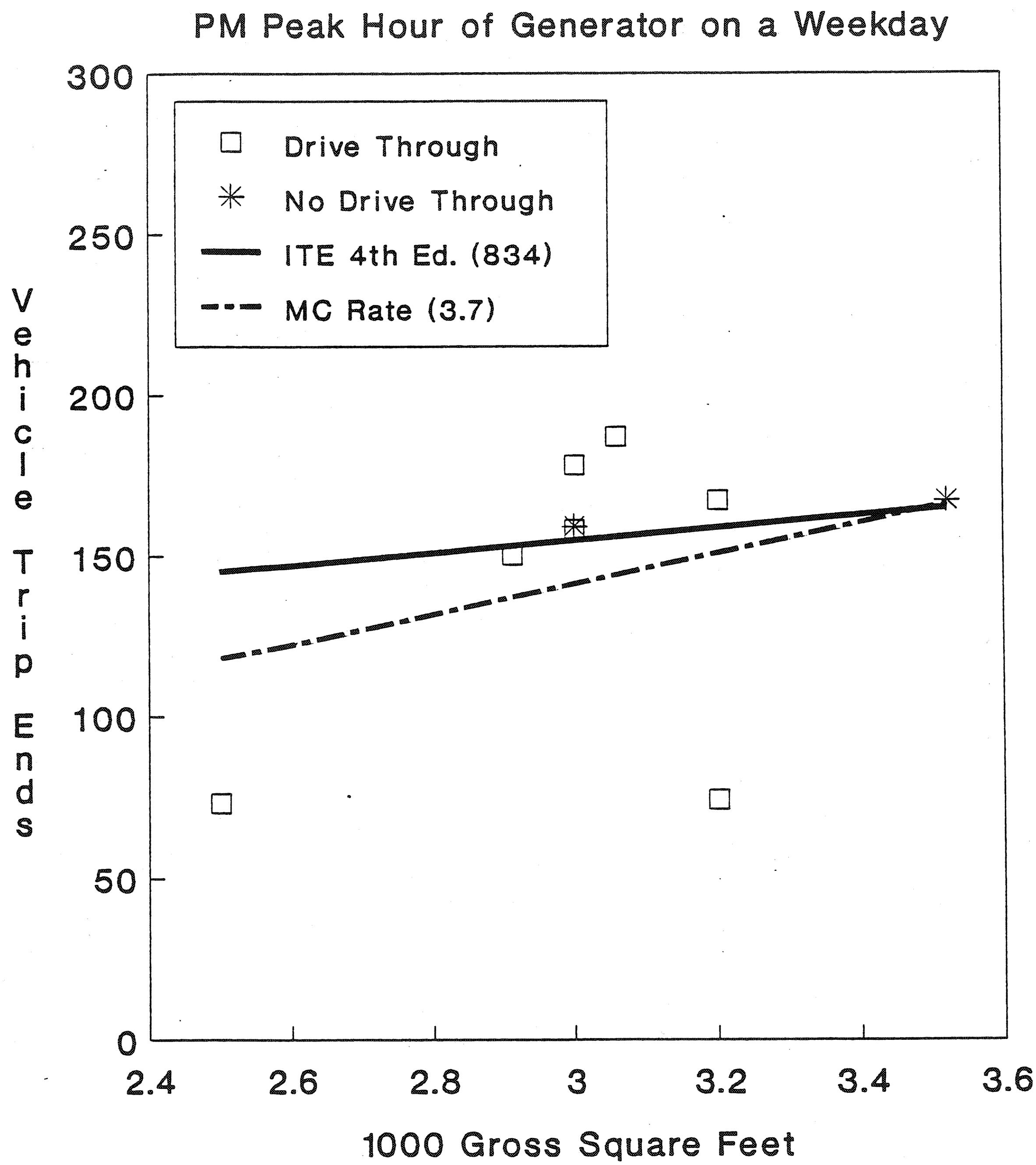
Source: Douglas & Douglas, Inc.

Figure 7.12a. Fast Food Restaurants With (834) and Without (833) Drive-Throughs: Average Vehicle Trip Ends versus GSF



Source: Douglas & Douglas, Inc.

Figure 7.12b. Fast Food Restaurants With (834) Drive-Throughs: Average Vehicle Trip Ends versus GSF



Source: Douglas & Douglas, Inc.

equations for fast food restaurants without drive-throughs give higher estimates than the data support. In the case of the generator peak hour, the ITE (4th Edition) curve for Category 833 (fast food restaurants without drive-throughs) is literally off the charts with trip estimates ranging between 350 and 500 vehicle trip ends per hour. During the afternoon peak hour there appears to be no significant difference between trips to restaurants with drive-through facilities and those without drive-through facilities in Montgomery County.

On the basis of the data from this study, we conclude that a single set of rates for fast food restaurants is appropriate for Montgomery County, irrespective of whether or not they have drive-through windows. The relationship between restaurant size and vehicle trip ends is so weak that we suggest using a flat rate for all restaurants between 2,500 and 3,500 square feet in size.

7.7 COMPARISON OF RESIDENTIAL TRIP GENERATION RATE ESTIMATES

Residential land uses fall into several categories; the principal divisions are between single-family detached housing and multi-family housing. The ITE and the Montgomery County Government define multi-family housing in slightly different ways, so we need to clarify the definitions that we will use in this study. Table 7.9 will be of assistance in this connection.

Table 7.9

Number of Floors in Dwelling Type as Defined by ITE and this Study

ITE Category	Multi-Family Dwelling Type	Height (Floors/Levels) ITE	MC Study
221	Garden Apartments	1-2	1-4
221	Low-Rise Apartment	1-2	1-4
222	Mid-Rise Apartment	N/A	5-8
222	High-Rise Apartment	3+	9+

There is an additional ITE category, "Apartments" (220), which includes all the apartment types listed above. ITE classifies townhouses under "Condominium," Category 230. Based on traffic data from this study, we have grouped townhouses into Category 221, "Low-Rise Apartments," which also includes garden apartments.

7.7.1 *Single-Family Detached Housing Trips*

The equations for vehicle trips from single-family detached housing developed by the ITE for the 4th Edition of Trip Generation give results which are quite similar to the trip rates in the 3rd Edition. The 4th Edition average rates tend to be just slightly higher than the rates estimated by equations we developed for Montgomery County data. The differences range from zero to approximately 10% for all time periods except the adjacent street PM peak hour. For this peak hour, the ITE 4th Edition equation estimates approximately 20% more trips than the Montgomery County equation (4.5). (We also discovered that, for projects with more than 150 dwelling units, the ITE 4th Edition adjacent street peak hour equation gives higher estimates of trip ends than the generator peak hour equation, something which is impossible by ITE's definition.)

The trip estimating equations for single-family detached housing are given in Table 7.10. Curves comparing the Montgomery County equations with the ITE 3rd and 4th Edition equations are shown in Figures 7.13a, 7.13b, 7.14a and 7.14b. The Montgomery County curves tend to lie close to and just below the ITE 4th Edition curves for larger subdivisions. In the case of the AM and PM generator peak hour curves, the Montgomery County curves have slightly lower slopes and, consequently, cross the ITE 4th Edition curves somewhere between 150 and 200 dwelling units. The single exception is the group of curves for the adjacent street PM peak hour, which have already been discussed.

The single-family housing land use category represents one of the few cases where ITE 4th Edition equations give reasonably close estimates of trip ends for Montgomery County data. This naturally raises a question about whether to use the ITE equations or those specifically derived from Montgomery County data. We suggest using the Montgomery County equations for two reasons:

1. The Montgomery County equations are all of the same form: in this case, they are all linear equations. The Montgomery County data do not support mixing different forms of equations for different hours for the same land use.

2. Because we have standard error data available for the Montgomery County curves, we can calculate equations based on the mean plus the standard error. This will allow us to construct equations which when graphed cover about 84 percent of the data points. The even-numbered equations (4.2 through 4.8 in Table 7.10) are these equations.

Table 7.10

Single-Family Detached Housing (ITE 210): Equations Estimating Vehicle Trip Ends

AM Adjacent Street Peak Hour		
ITE 4th Edition	T=exp(0.91(ln(U))+0.20)	R^2=0.885
MC Mean (4.1)	T=0.61(U)+13.44	R^2=0.743
MC Mean + S.E. (4.2)	T=0.61(U)+45.74	

AM Peak Hour of Generator		
ITE 4th Edition	T=0.71(U)+13.00	R^2=0.881
MC Mean (4.3)	T=0.62(U)+25.3	R^2=0.703
MC Mean + S.E. (4.4)	T=0.62(U)+61.44	

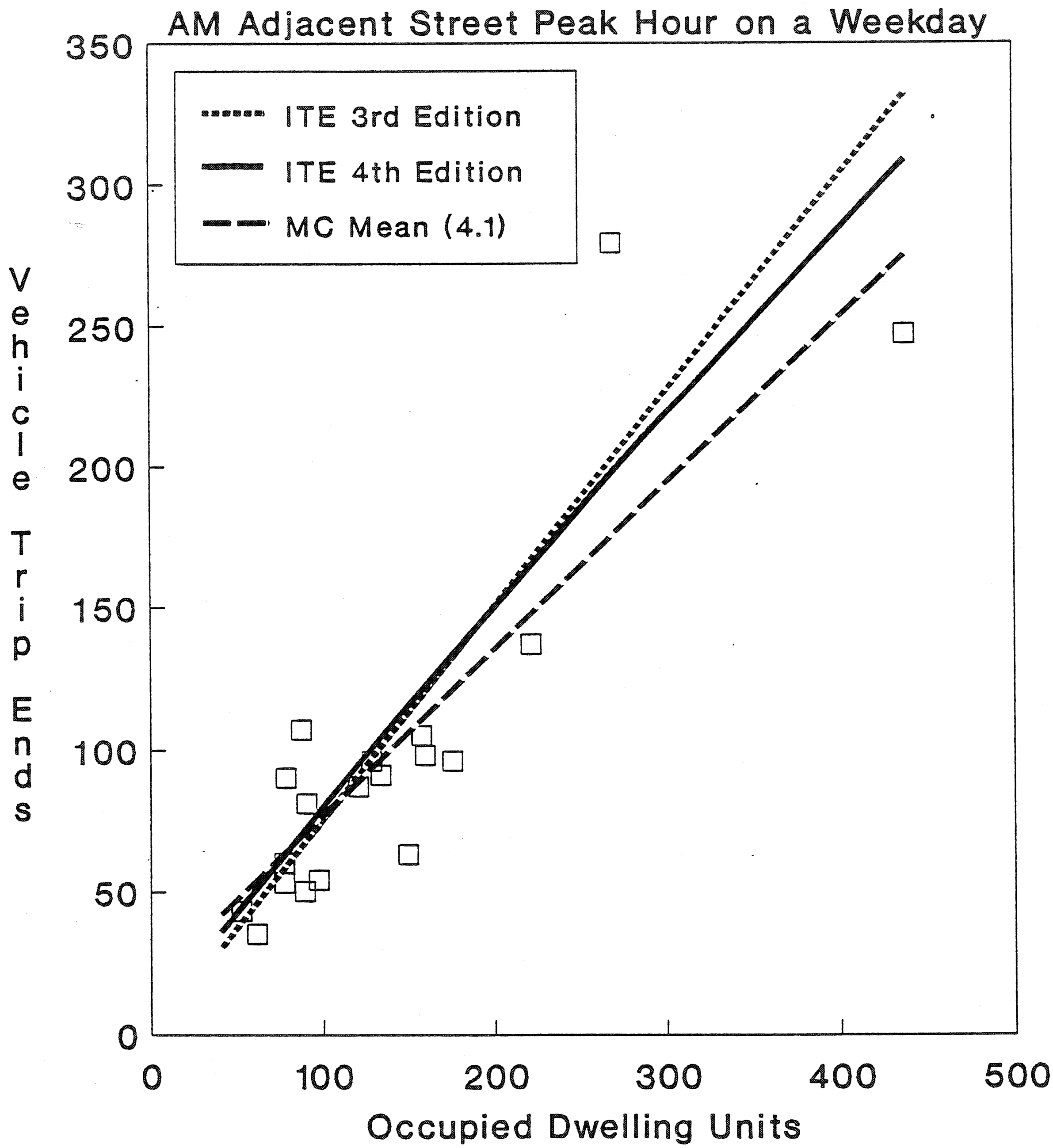
PM Adjacent Street Peak Hour		
ITE 4th Edition	T=exp(0.94(ln(U)+0.36)	R^2=0.918
MC Mean (4.5)	T=0.81(U)+8.21	R^2=0.738
MC Mean + S.E. (4.6)	T=0.81(U)+51.97	

PM Peak Hour of Generator		
ITE 4th Edition	T=exp(0.92(ln(U))+0.46)	R^2=0.898
MC Mean (4.7)	T=0.82(U)+21.24	R^2=0.758
MC Mean + S.E. (4.8)	T=0.82(U)+62.91	

Note: T = Average 2-way Vehicle Trip Ends
U = Occupied Dwelling Units

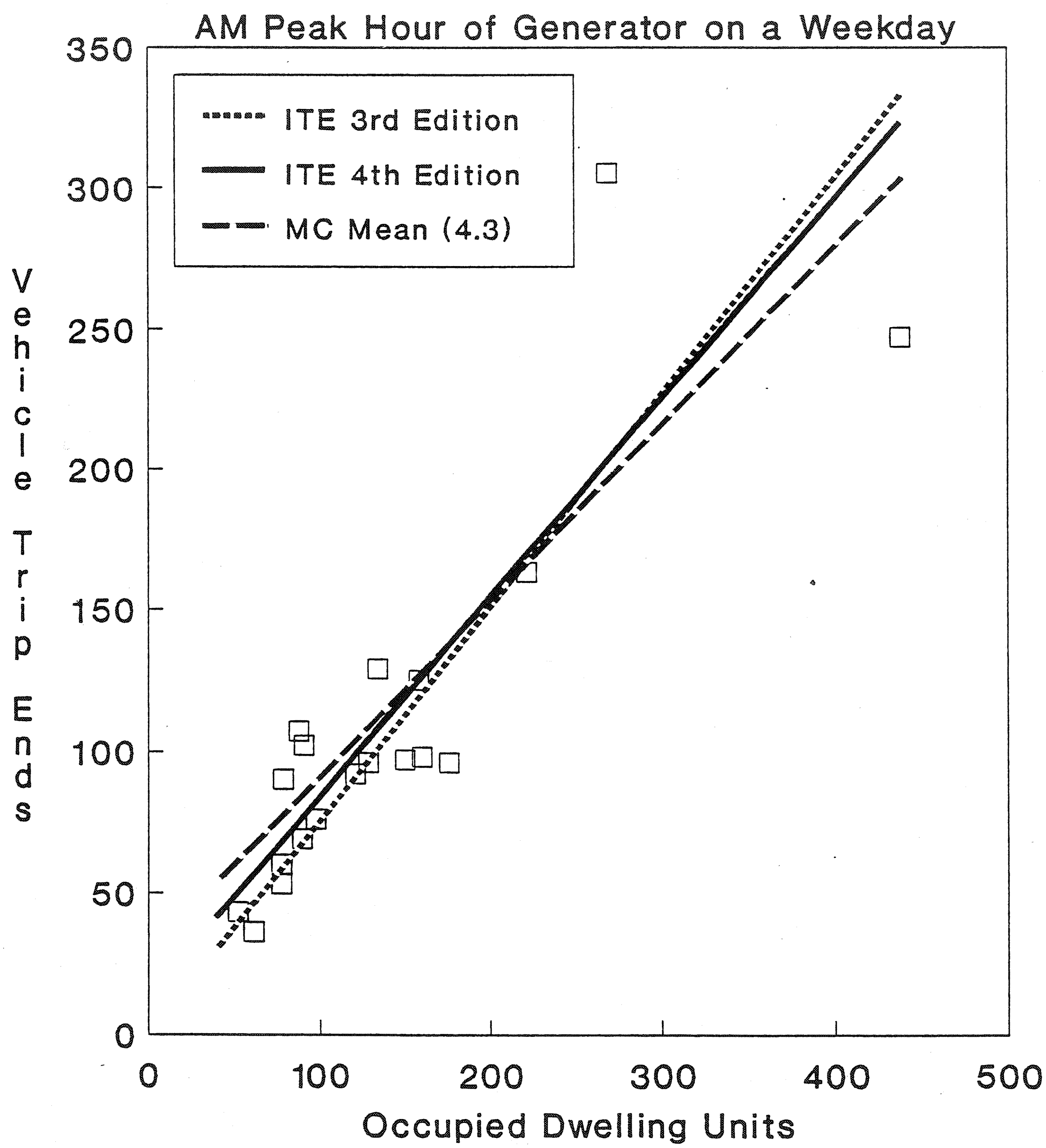
Source: Douglas & Douglas, Inc

Figure 7.13a. Single-Family Detached Housing (ITE 210): Average Vehicle Trip Ends



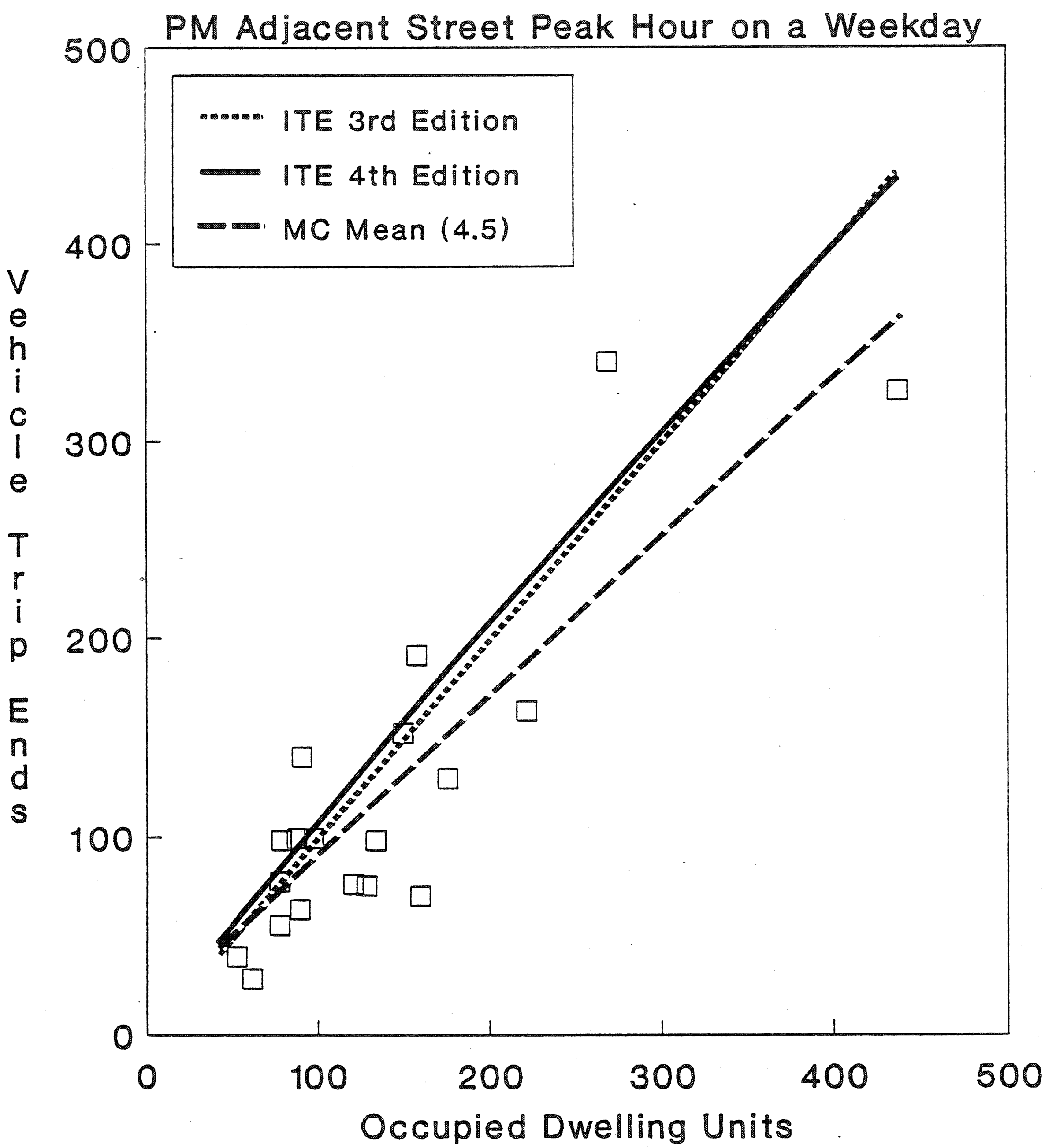
Source: Douglas & Douglas, Inc.

Figure 7.13b. Single-Family Detached Housing (ITE 210): Average Vehicle Trip Ends



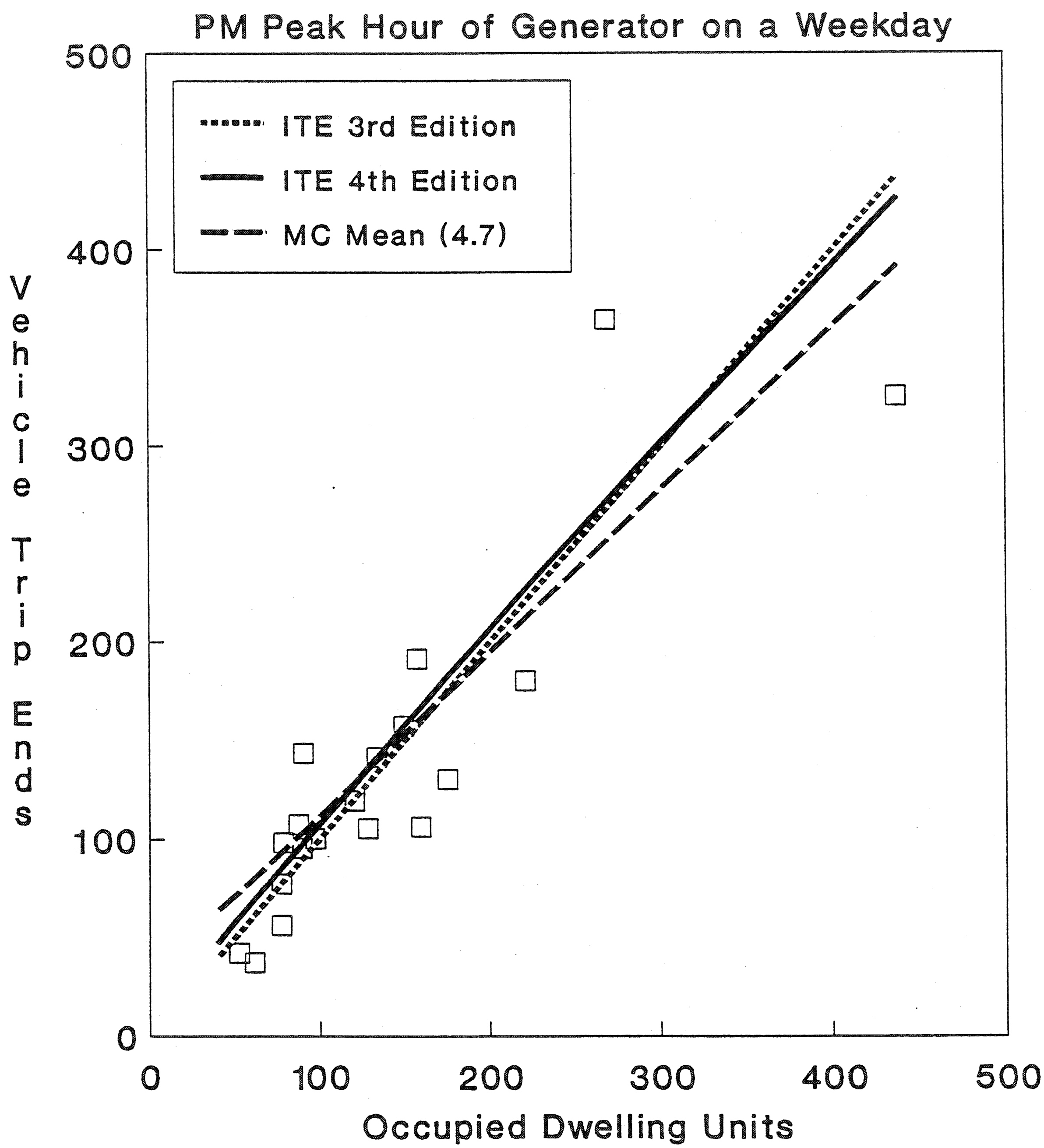
Source: Douglas & Douglas, Inc.

Figure 7.14a. Single-Family Detached Housing (ITE 210): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Figure 7.14b. Single-Family Detached Housing (ITE 210): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Among the land uses surveyed in this study, it perhaps is not surprising that the single-family detached housing trip equations are those most similar to those developed on a nationwide basis by the ITE and reported in ITE (4th Edition). 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 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. As we will see in subsequent sections, the same is not true for multi-family housing.

7.7.2 *Trips to/from All Apartments*

ITE land use Category 220 is entitled "Apartments" and includes multi-family housing of all descriptions--garden, mid-rise and high-rise apartments--with the exception of townhouses. The vehicle trips estimated by the ITE 4th Edition equations are much higher than the observed data in Montgomery County for all time periods. In some cases, the 4th Edition equations are lower than the trip rates given in the ITE 3rd Edition. In other cases, such as the AM adjacent street peak hour, they are virtually identical.

There are several possible explanations for the major differences between the ITE 4th Edition equations and apartment equations developed for Montgomery County:

1. The Montgomery County data were gathered in late 1986 and 1987 whereas the ITE data for apartments were by and large collected before 1973. ITE data for apartments gathered after 1973 was insufficient for equations to be developed from them.

2. Montgomery County demographic characteristics may be different from those in the localities containing the sites reported on by ITE.

3. The mix of low-rise and high-rise apartments in the overall sample may contribute to the differences in trip rates. As we shall see in subsequent sections, high-rise apartments have a lower trip rate than low-rise apartments. In the Montgomery County sample, 60% of the observations were taken at high-rise and mid-rise apartment houses (5 or more floors). There are no clear data for the distribution of high-rise and low-rise apartments in the ITE 4th Edition data set, but a comparison of individual entries for lowrise (ITE Category 221) and high-rise apartments (ITE Category 222) indicates that about 25% of the ITE observations may have been taken at high-rise apartment houses. Consequently, a higher percentage of mid-rise and high-rise apartments in the Montgomery County sample could explain the lower trip rates.

Because of the complications in averaging the trips from low-rise, mid-rise and high-rise apartments, we recommend that, whenever possible, separate rates be used for low-rise buildings on the one hand and mid- and high-rise buildings on the other. The general equations for Category 220 should be used only when no estimates of the mix of building sizes are available.

The individual equations for the generalized apartment category are shown in Table 7.11. The curves are displayed in Figures 7.15a, 7.15b, 7.16a, and 7.16b with Montgomery County data points. A brief glance at the equations in the table shows that they are all built on the same linear model. The constant terms are all positive which means that the average rates decrease slightly as the size of the subdivision increases. All of the equations have acceptable R^2 values, with the Montgomery County equations showing a slight superiority for the PM adjacent street and generator peak hours.

The AM peak hour trip estimates shown in Figures 7.15a and 7.15b illustrate clearly that the ITE 4th Edition equations produce estimates much higher than the Montgomery County data. The overestimation using ITE rates reaches as high as 75% to 90% for a complex of 1,000 units. The PM peak hour trip ends estimated by the ITE 4th Edition equations are also considerably higher than the Montgomery County equations estimated as shown in Figures 7.16a and 7.16b. The PM site generator peak hour equation from the 4th Edition produces estimates that range from about 50% to 60% higher than the corresponding Montgomery County equations. Curiously, the PM adjacent street peak hour equation presented by ITE (4th Edition) is more similar to the Montgomery County equation than it is to the ITE 3rd Edition trip rate. (Their slopes are almost identical such that the fourth edition equation predicts a level of trips constantly in excess of the Montgomery County equation by about 52 trips.) Clearly, the Montgomery County equations give more accurate estimates of peak hour trip ends in Montgomery County than do the ITE 4th Edition equations.

<u>We suggest that the equations derived for the General Apartment (ITE 220) category be used only in those cases where data on proportions of apartment types are not available. In all cases, it is preferable to use the individual Montgomery County equations developed for either low-rise or high-rise apartments wherever possible.</u>

7.7.3 *Trips from Low-Rise Apartments*

Low-rise apartments are defined in the ITE 4th Edition as "apartments in buildings which have only one or two levels." The examples cited include garden apartments and suburban apartments. For data collection purposes in Montgomery County, we defined low-rise apartments as buildings with 1-4 floors.

We found that low-rise apartments in Montgomery County generate only about half as many trips as single-family dwelling units, but more trips than highrise apartments. Table 7.12 indicates that the ITE 4th Edition rates estimate more trip ends than the equations derived from the Montgomery County data.

Table 7.11

All Apartments (ITE 220): Equations Estimating Vehicle Trip Ends

AM Adjacent Street Peak Hour		
ITE 4th Edition	T=0.50(U)+4.00	R^2=0.855
MC Mean (4.9)	T=0.26(U)+13.78	R^2=0.808
MC Mean + S.E. (4.10)	T=0.26(U)+40.67	

AM Peak Hour of Generator		
ITE 4th Edition	T=0.54(U)+5.00	R^2=0.863
MC Mean (4.11)	T=0.31(U)+12.48	R^2=0.817
MC Mean + S.E. (4.12)	T=0.31(U)+44.02	

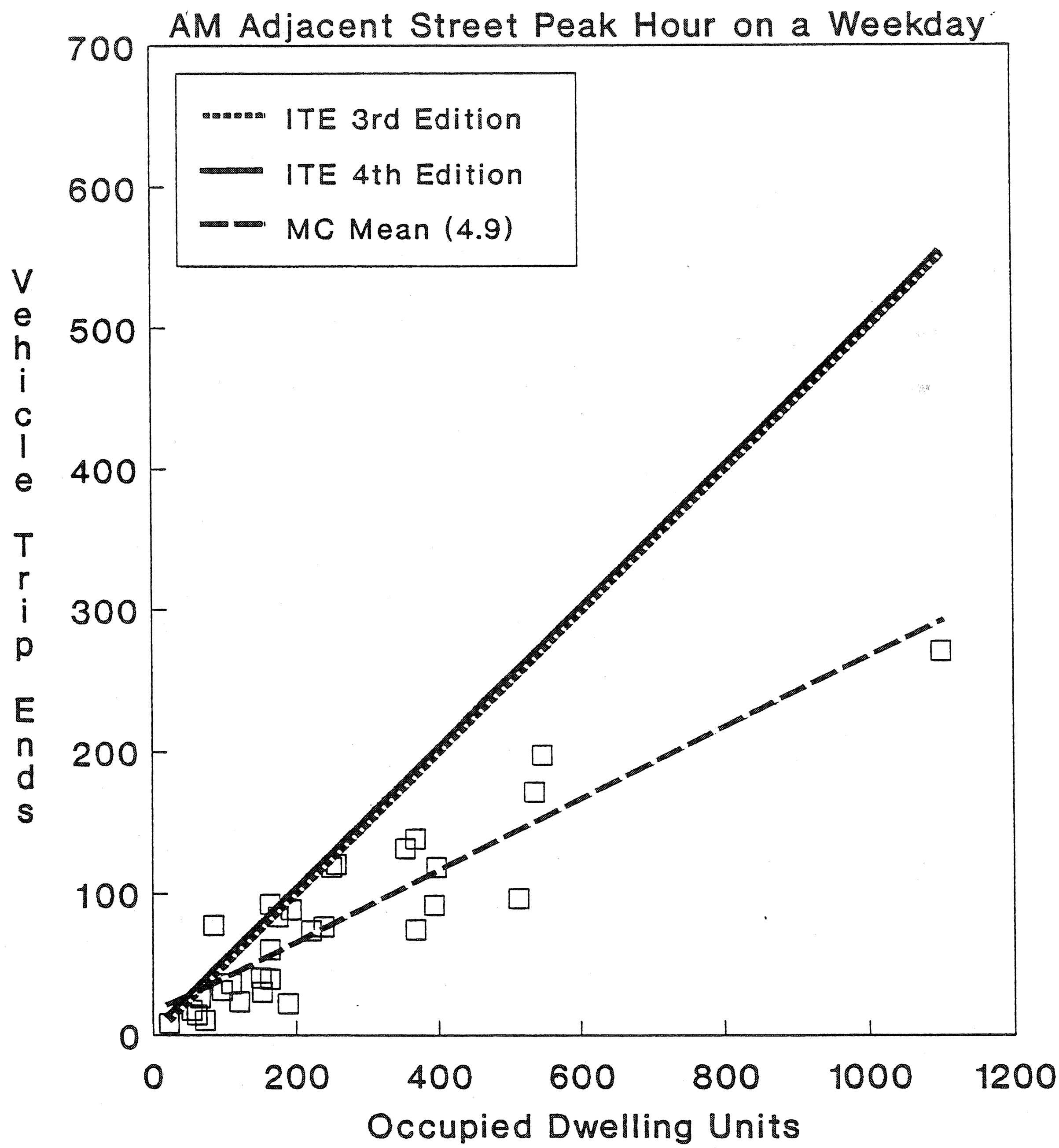
PM Adjacent Street Peak Hour		
ITE 4th Edition	T=0.39(U)+59.00	R^2=0.742
MC Mean (4.13)	T=0.33(U)+6.01	R^2=0.736
MC Mean + S.E. (4.14)	T=0.33(U)+49.13	

PM Peak Hour of Generator		
ITE 4th Edition	T=0.59(U)+24.00	R^2=0.804
MC Mean (4.15)	T=0.36(U)+13.10	R^2=0.829
MC Mean + S.E. (4.16)	T=0.36(U)+48.68	

Note: T = Average 2-way Vehicle Trip Ends
U = Occupied Dwelling Units

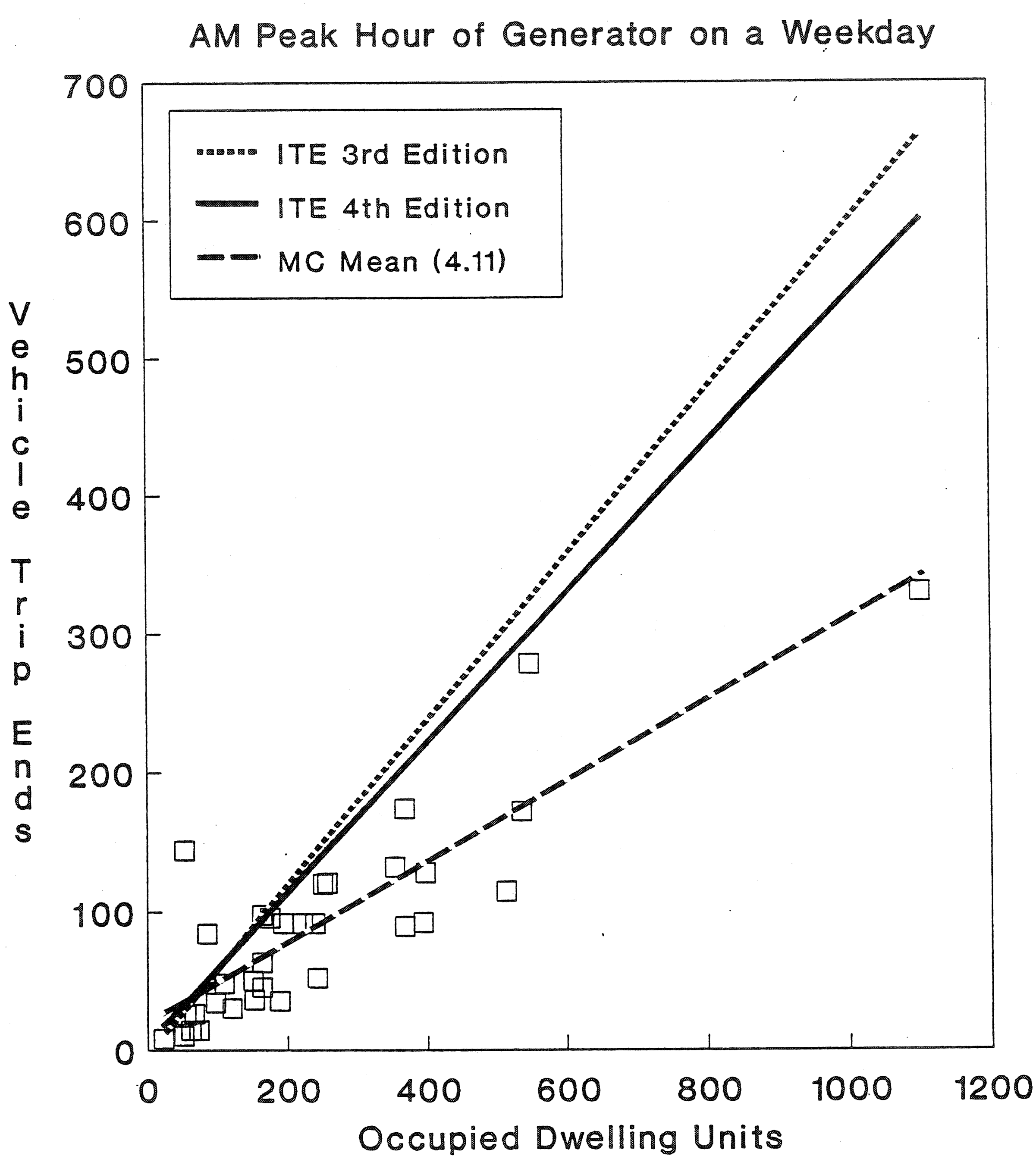
Source: Douglas & Douglas, Inc.

Figure 7.15a. Apartments (ITE 220 - both Low-Rise and High-Rise): Average Vehicle Trip Ends versus Occupied Dwelling Units



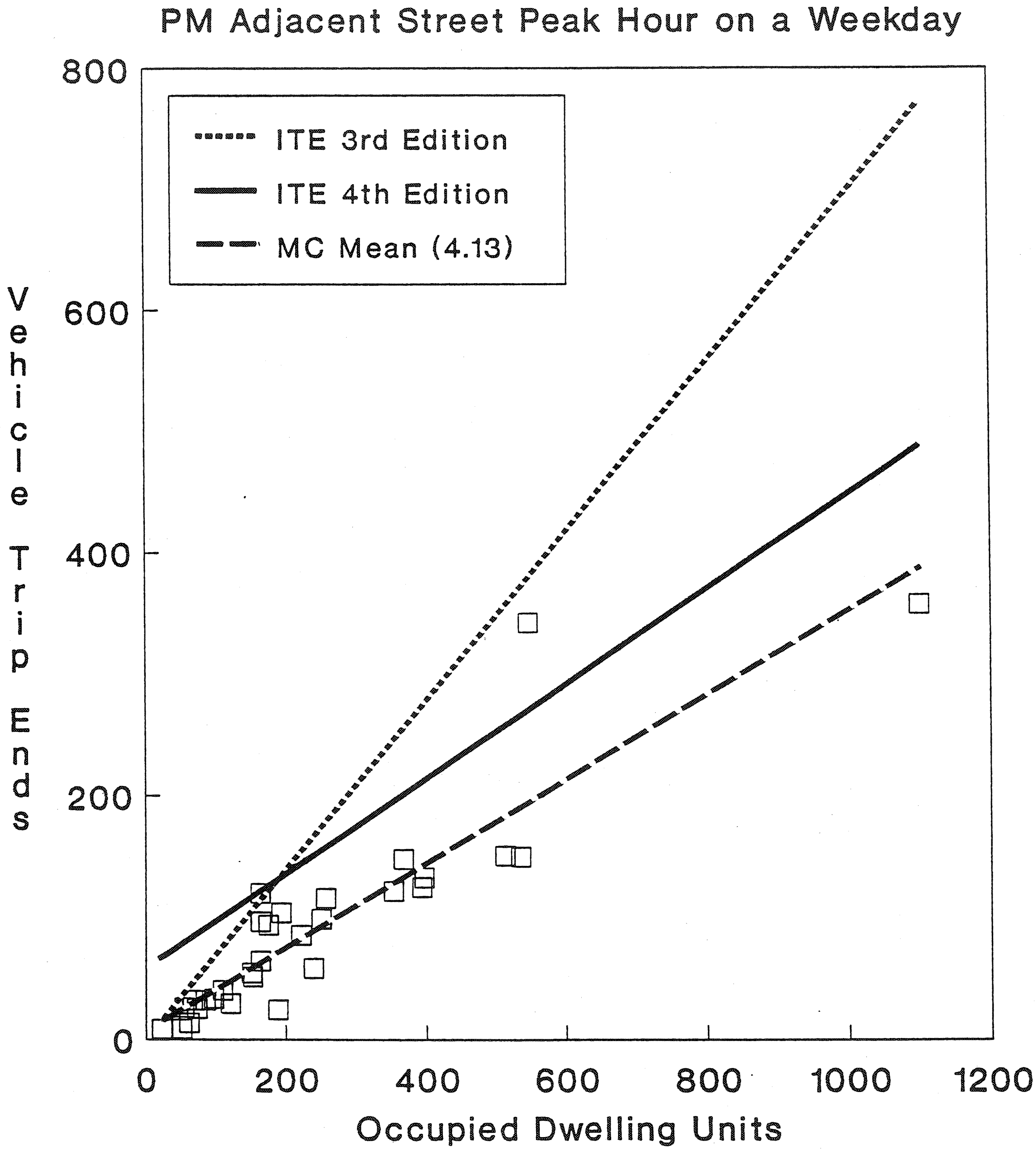
Source: Douglas & Douglas, Inc.

Figure 7.15b. Apartments (ITE 220 - both Low-Rise and High-Rise): Average Vehicle Trip Ends versus Occupied Dwelling Units



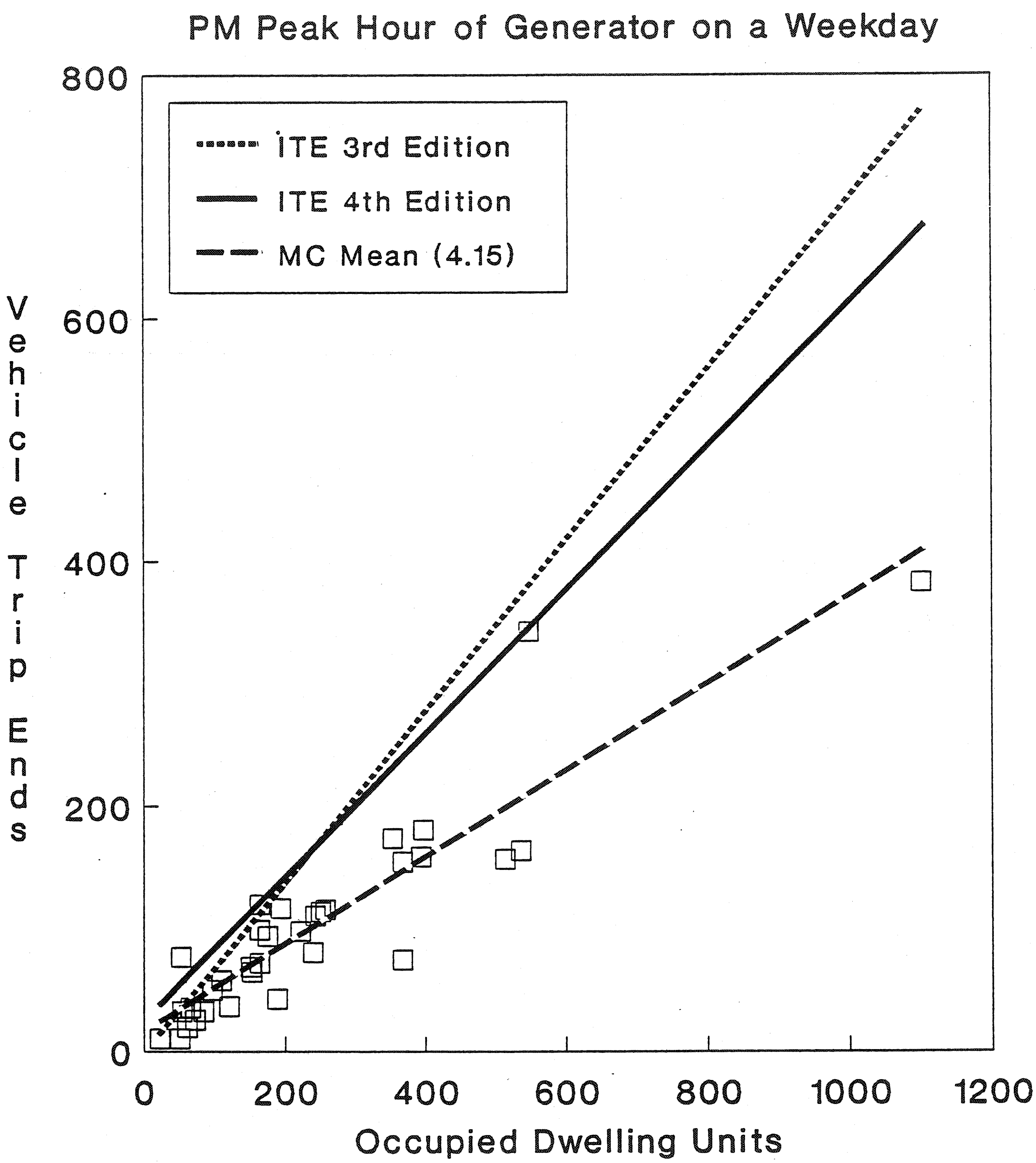
Source: Douglas & Douglas, Inc.

Figure 7.16a. Apartments (ITE 220 - both Low-Rise and High-Rise): Average Vehicle Trip Ends versus Occupied Dwelling Units



Source: Douglas & Douglas, Inc.

Figure 7.16b. Apartments (ITE 220 - both Low-Rise and High-Rise): Average Vehicle Trip Ends versus Occupied Dwelling Units



Source: Douglas & Douglas, Inc.

Table 7.12

Low-Rise Apartments (ITE 221): Equations Estimating Vehicle Trip Ends

AM Adjacent Street Peak Hour		
ITE 4th Edition	T=0.519(U)	
MC Mean (4.17)	T=0.331(U)+7.76	R^2=0.818
MC Mean + S.E. (4.18)	T=0.331(U)+34.17	

AM Peak Hour of Generator		
ITE 4th Edition	T=0.563(U)	
MC Mean (4.19)	T=0.40(U)+3.26	R^2=0.798
MC Mean + S.E. (4.20)	T=0.40(U)+37.24	

PM Adjacent Street Peak Hour		
ITE 4th Edition	T=0.628(U)	
MC Mean (4.21)	T=0.452(U)-6.17	R^2=0.692
MC Mean + S.E. (4.22)	T=0.452(U)+44.32	

PM Peak Hour of Generator		
ITE 4th Edition	T=0.682(U)	
MC Mean (4.23)	T=0.468(U)+1.43	R^2=0.759
MC Mean + S.E. (4.24)	T=0.468(U)+45.87	

Note: T = Average 2-way Vehicle Trip Ends
U = Occupied Dwelling Units

Source: Douglas & Douglas, Inc.

For each time period the ITE (4th Edition) rate produces an estimated number of trips which is roughly 40% to 50% greater than that observed in Montgomery County for a typical complex of 400 occupied units. The ITE 4th Edition includes only trip rates which essentially form a straight line model with no constant terms.

Curves for the Montgomery County equations and ITE 4th Edition average trip rates for low-rise apartments are shown in Figures 7.17a, 7,17b, 7.18a, and 7.18b. As is evident in the figures, the ITE 4th Edition rates are not good estimators of average trips for Montgomery County sites. Consequently, the Montgomery County equations should be used to estimate the average trips for low-rise apartments within the county. The choice of an equation for site approval purposes will be discussed in Chapter 8.

7.7.4 *Trips from High-Rise Apartments*

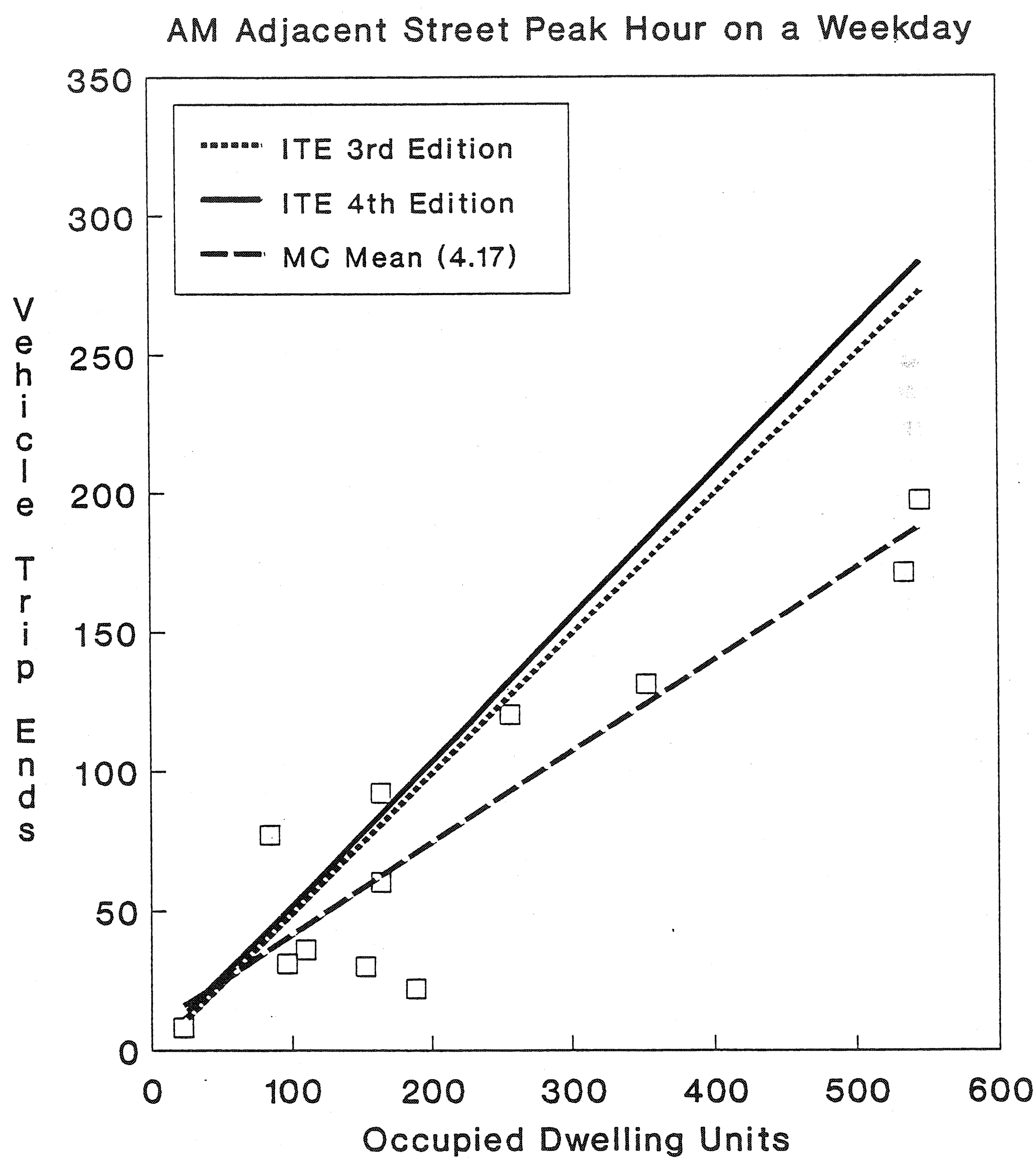
High-rise apartments, according to ITE (Category 222), are located in buildings with three or more floors. Their trip generation rates are the lowest of all the residential land uses covered in this study. In accordance with the Montgomery County Government's categories, we defined high-rise multi-family dwellings as having 9 or more stories and mid-rise dwellings as having 5 to 8 stories. Therefore, in order to compare the ITE high-rise classification with the Montgomery County data, we included our mid-rise and high-rise apartment data under the "high-rise apartment" category.

For high-rise apartments, the ITE 4th Edition developed three different models to describe tripmaking. Linear models are used for the adjacent street AM peak hour and the PM peak hour of the generator. Non-linear models are used for the other two time periods. As a result, the differences between the ITE (4th Edition) estimates and those derived from the equations for the Montgomery County data vary by time of day. The regression equations developed for the Montgomery County high-rise apartments are all based on the linear model. Not only did this model give the best goodness-of-fit statistics, but we found no evidence to support a non-linear relationship between occupied dwelling units and vehicle trip ends.

The ITE 4th Edition and Montgomery County equations are presented in Table 7.13. These equations and the Montgomery County data also are shown in Figures 7.19a, 7.19b, 7.20a and 7.20b. It is these figures which best illustrate the consequences of using different models to estimate equations. The non-linear equations in Figures 7.19b and 7.20a cross the linear Montgomery County equations so that the estimates are sometimes higher and sometimes lower.

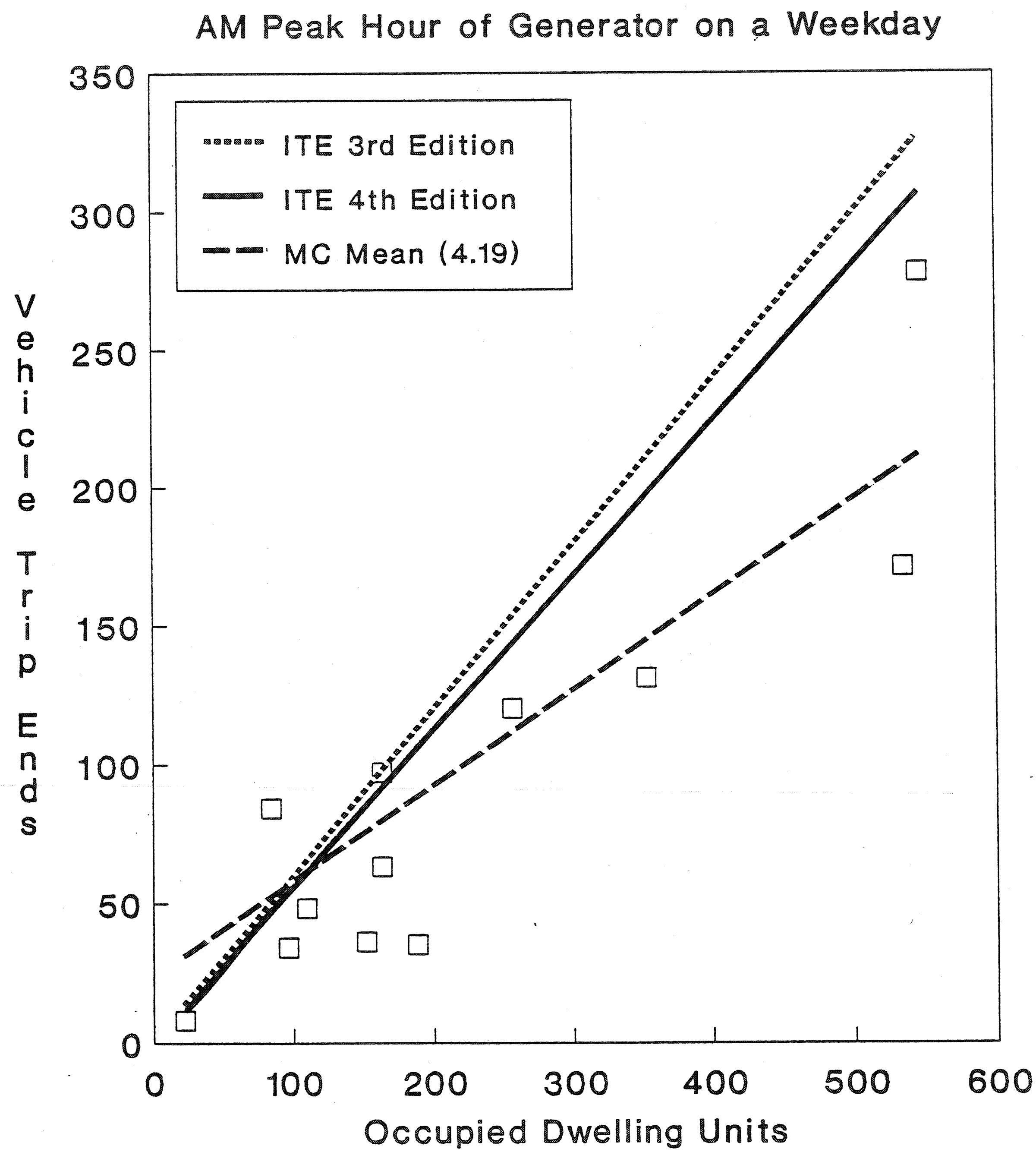
ITE (4th Edition) estimates for the AM adjacent street peak hour are higher than estimates from the Montgomery County equation (4.25), and the differences can range from 35% for an apartment house with 100 units down to 20% for an apartment complex with 1,000 units. Although the difference between the two estimates increases with the increased number of dwelling units, the percentage increase actually drops.

Figure 7.17a. Low-Rise(including Garden) Apartments (One or Two Floors): Average Vehicle Trip Ends



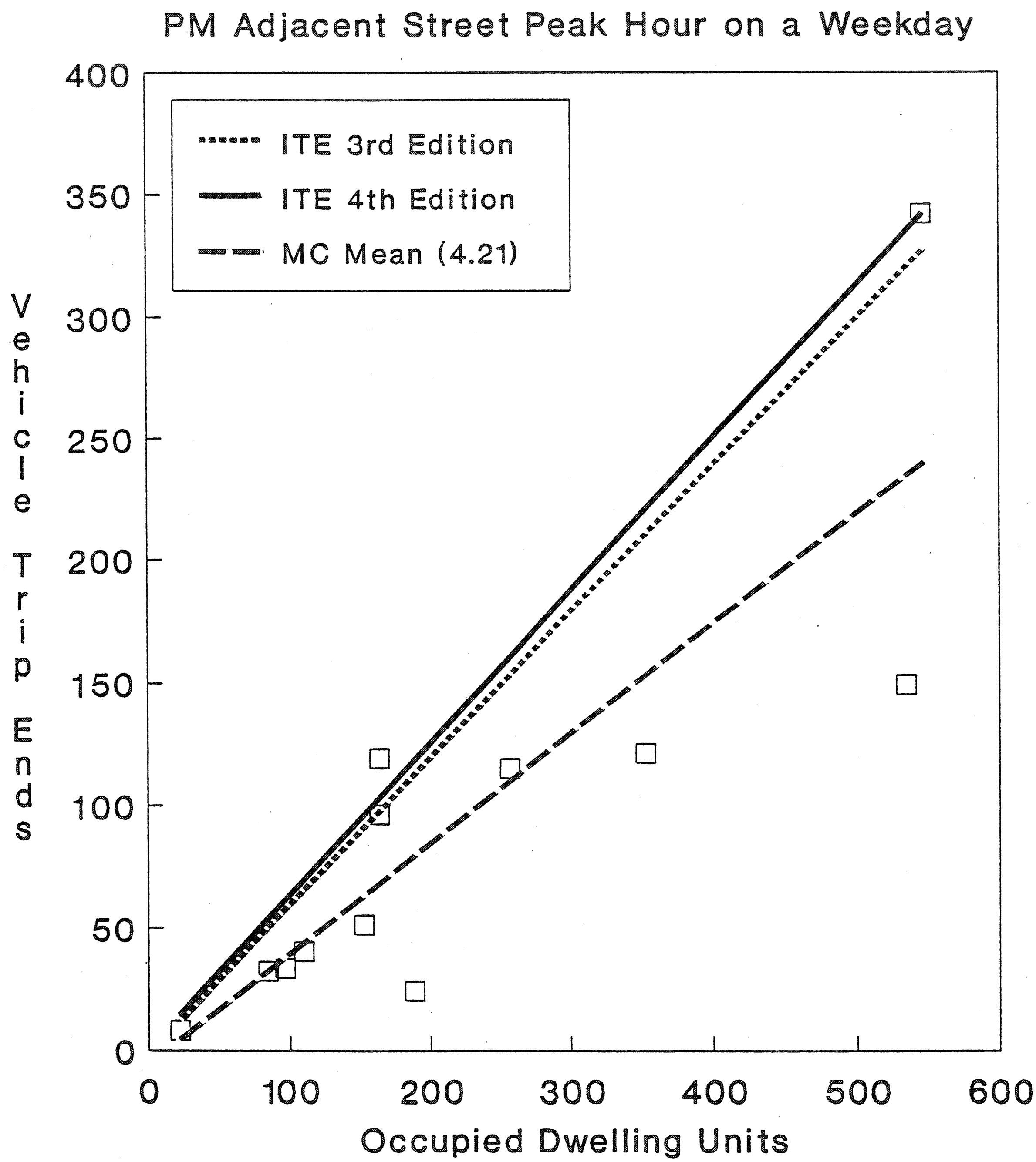
Source: Douglas & Douglas, Inc.

Figure 7.17b. Low-Rise(including Garden) Apartments (One or Two Floors): Average Vehicle Trip Ends



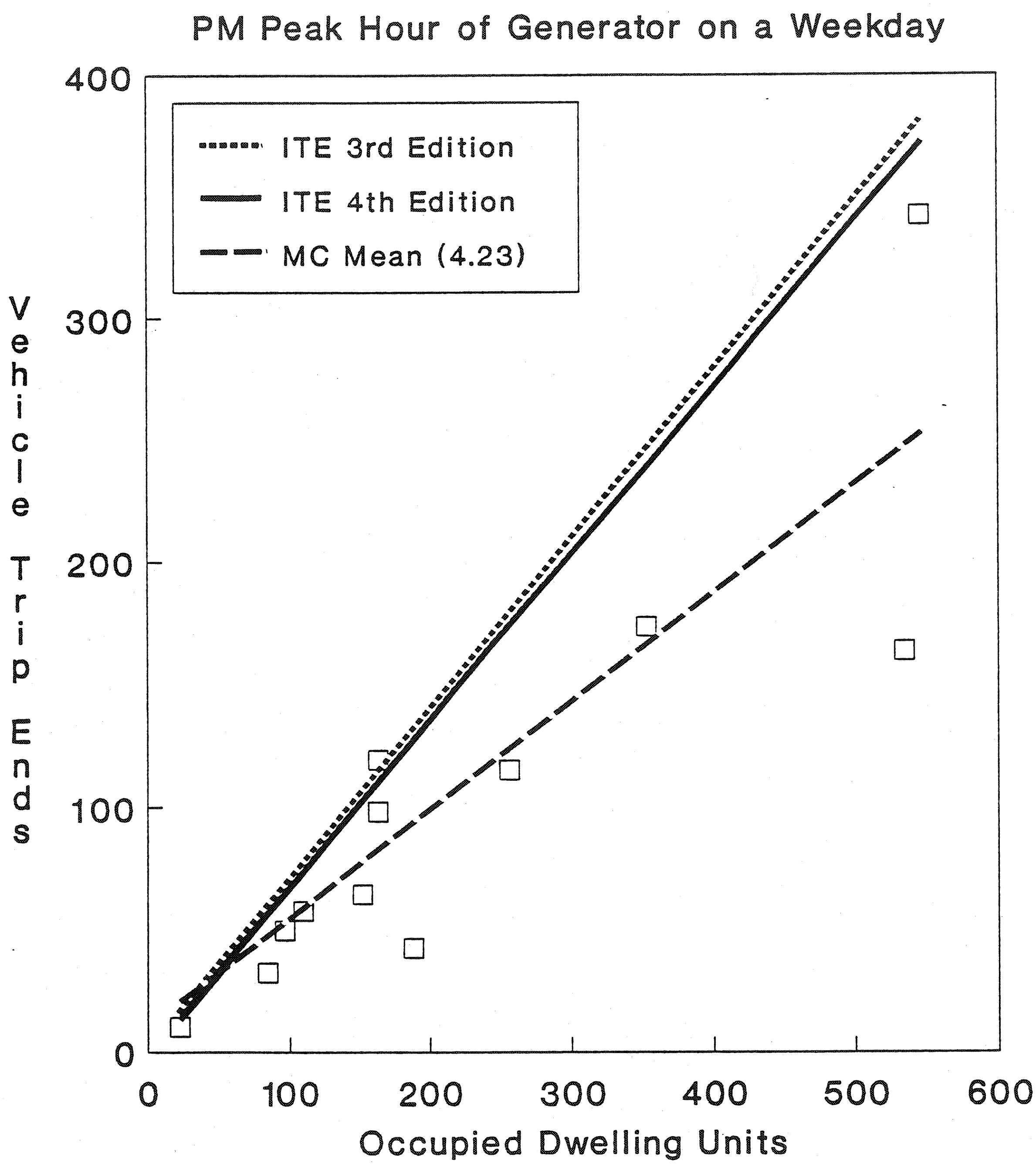
Source: Douglas & Douglas, Inc.

Figure 7.18a. Low-Rise(including Garden) Apartments (One and Two Floors): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Figure 7.18b. Low-Rise(including Garden) Apartments (One and Two Floors): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Table 7.13

High-Rise Apartments (ITE 222): Equations Estimating Vehicle Trip Ends

AM Adjacent Street Peak Hour		
ITE 4th Edition	T=0.27(U)+23.00	R^2=0.756
MC Mean (4.25)	T=0.24(U)+11.63	R^2=0.857
MC Mean + S.E. (4.26)	T=0.24(U)+35.34	

AM Peak Hour of Generator		
ITE 4th Edition	T=1/((2.65/X)+0.001)	R^2=0.808
MC Mean (4.27)	T=0.29(U)+11.24	R^2=0.877
MC Mean + S.E. (4.28)	T=0.29(U)+37.35	

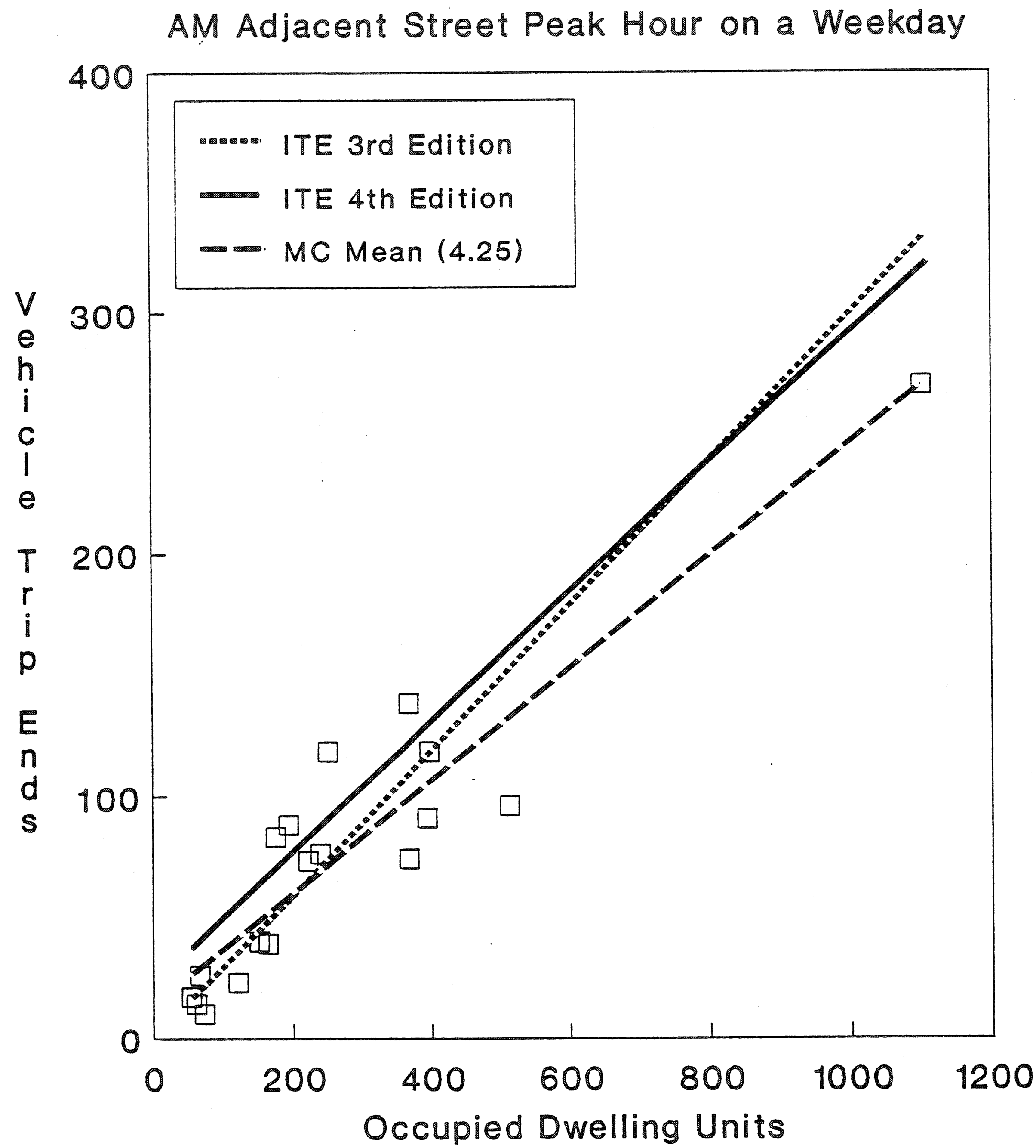
PM Adjacent Peak Street Hour		
ITE 4th Edition	T=exp(0.825(ln(U))+0.04)	R^2=0.856
MC Mean (4.29)	T=0.30(U)+4.70	R^2=0.830
MC Mean + S.E. (4.30)	T=0.30(U)+38.3	

PM Peak Hour of Generator		
ITE 4th Edition	T=0.41(U)+7.00	R^2=0.926
MC Mean (4.31)	T=0.34(U)+12.48	R^2=0.921
MC Mean + S.E. (4.32)	T=0.34(U)+36.61	

Note: T = Average 2-way Vehicle Trip Ends
U = Occupied Dwelling Units

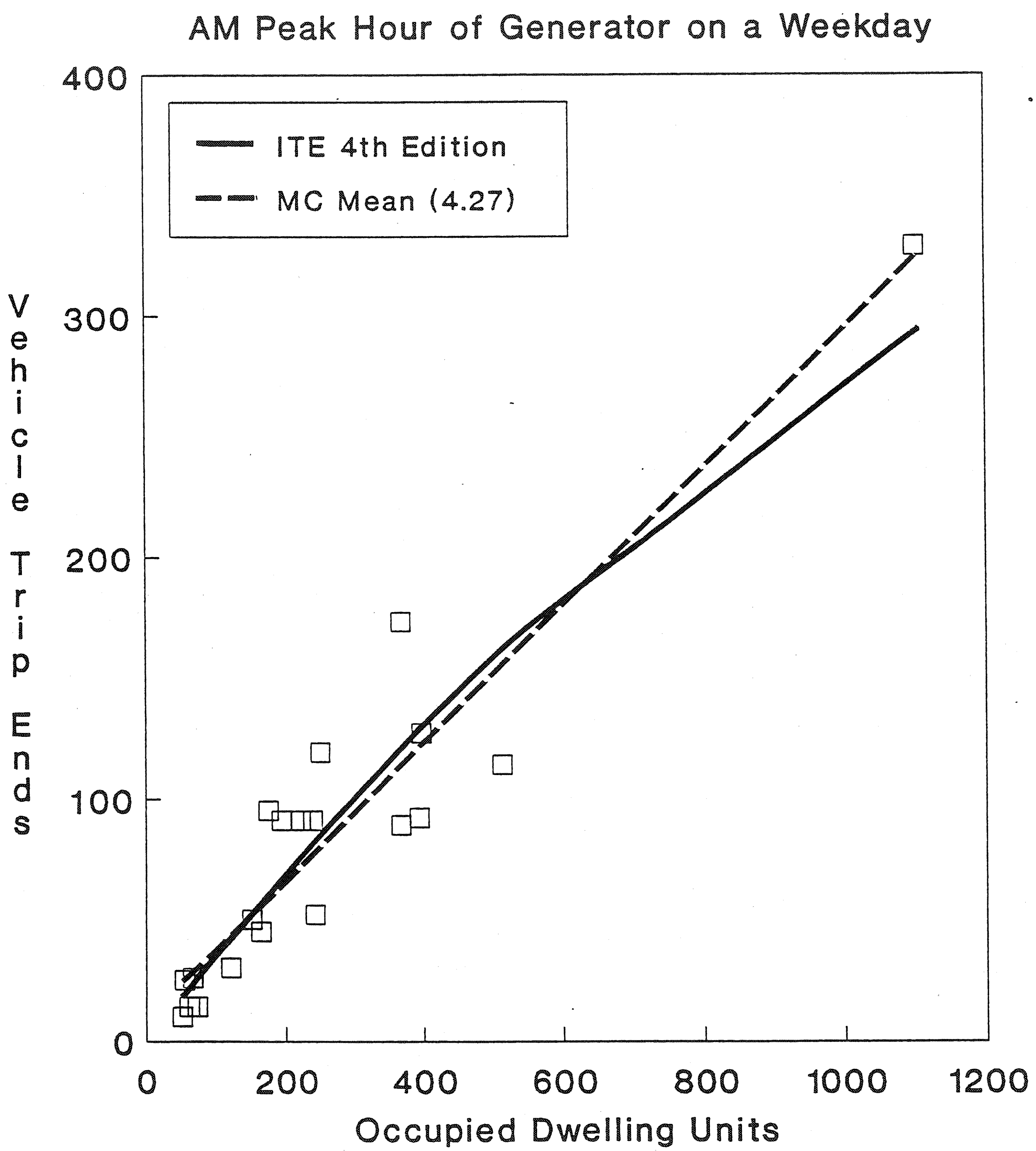
Source: Douglas & Douglas, Inc.

Figure 7.19a. High-Rise Apartments (ITE 222 - Three or More Floors): Average Vehicle Trip Ends



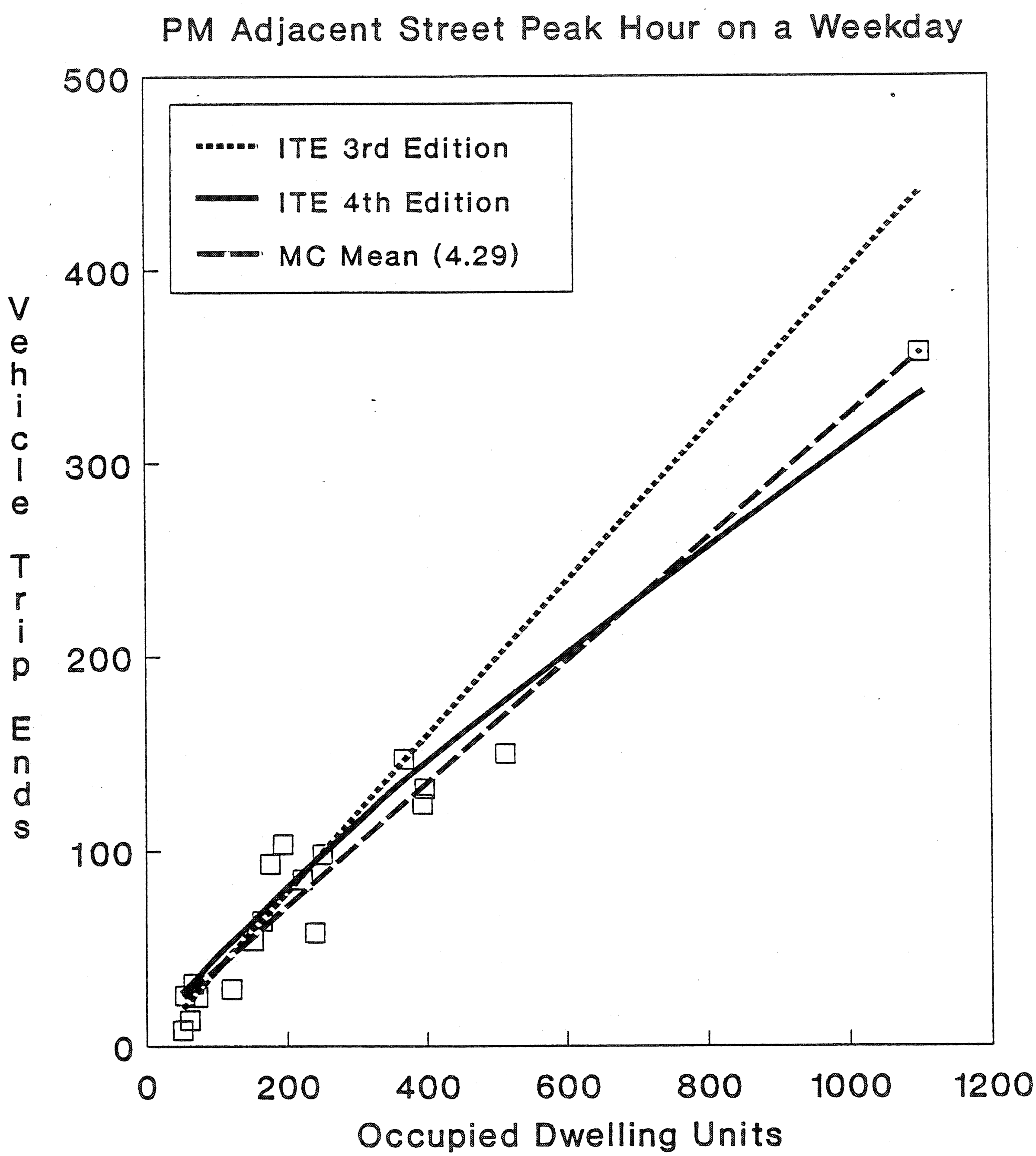
Source: Douglas & Douglas, Inc.

Figure 7.19b. High-Rise Apartments (ITE 222 - Three or More Floors): Average Vehicle Trip Ends



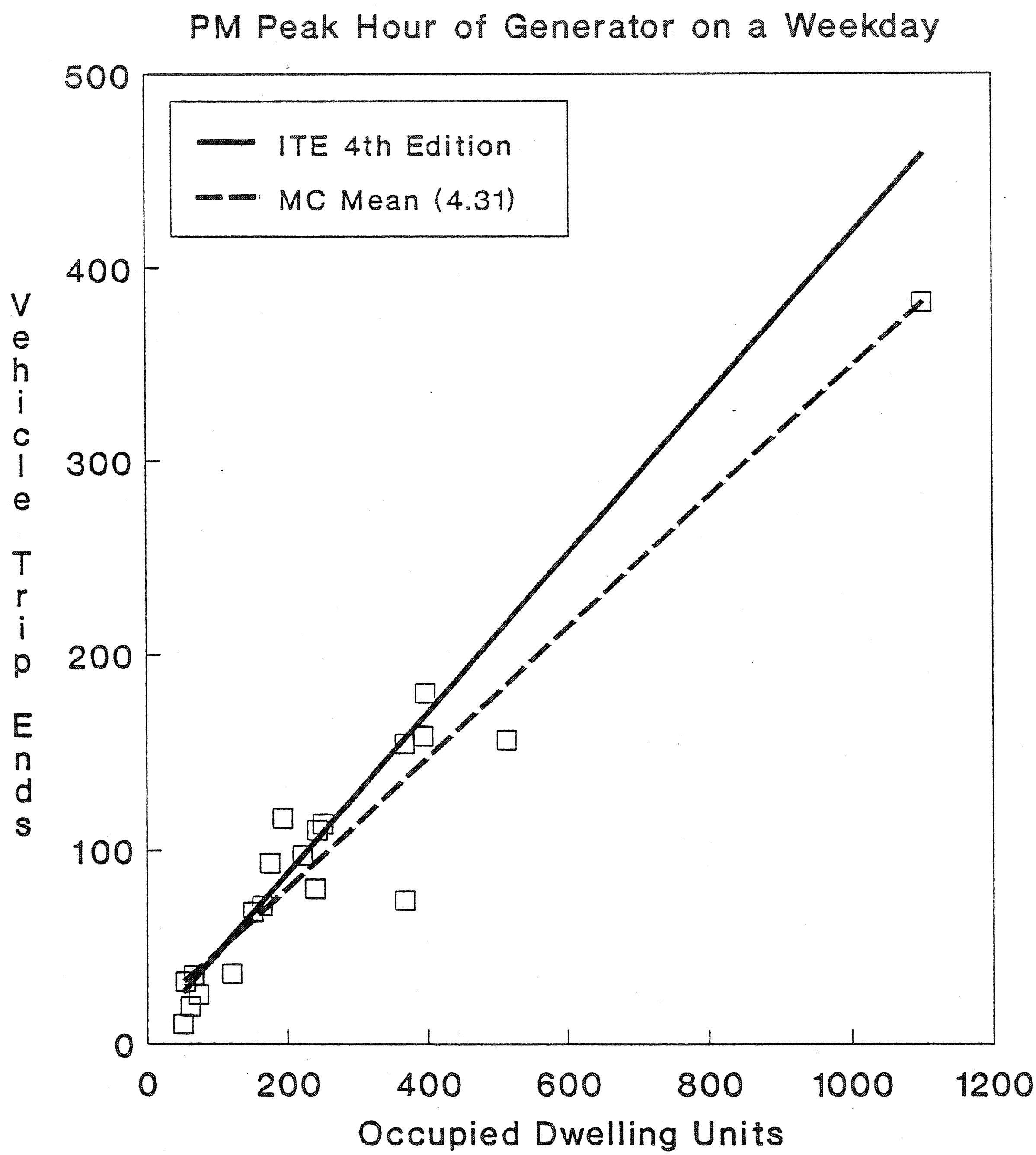
Source: Douglas & Douglas, Inc.

Figure 7.20a. High-Rise Apartments (ITE 222 - Three or More Floors): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Figure 7.20b. High-Rise Apartments (ITE 222 - Three or More Floors): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

When comparing the generator AM peak hour, the ITE (4th Edition) equation varies above and below the linear equation (4.27) as shown in Figure 7.19b. In the range between 150 and 600 dwelling units, the ITE equation slightly overestimates the number of trips. Outside of this range, the ITE equation underestimates by 5% to 10%. A similar phenomenon exists for the PM adjacent street peak hour as shown in Figure 7.20a where the ITE 4th Edition equation overestimates by approximately 5% to 10% for complexes with fewer than 700 dwelling units and underestimates by about 5% for larger complexes. The estimates of PM peak hour generator traffic (Figure 7.20b) from the ITE (4th Edition) equation tends to be higher than for the Montgomery County equations (4.31) by about 15% for complexes with more than 400 dwelling units. Based on our analysis, we suggest that the rates developed for the Montgomery County data be used for high-rise apartments. Not only are the goodness-of-fit statistics superior, but the linear form of the equation seems preferable to a non-linear relationship in the absence of any compelling evidence in support of a non-linear curve. Equations for site approval will be presented in Chapter 8.

7.7.5 Trips from Townhouses

The ITE's Trip Generation, 4th Edition, includes townhouses as part of category 230, which is called "Residential Condominium." The database collected from Montgomery County is limited in scope since there were only four townhouse developments sampled. The results should be approached with caution because the small sample size gave low goodness-of-fit statistics for the morning peak hours, and we were unsuccessful in finding a linear or nonlinear curve with satisfactory goodness-of-fit statistics for the afternoon peak hour. We have compared the Montgomery County and ITE (4th Edition) equations for the sake of completeness. However, we have suggested combining townhouses with garden apartments and other low-rise apartments until future data indicate that any differences between them warrant distinct categories.

The ITE 4th Edition and Montgomery County equations and rates for average trips generated at townhouses are presented in Table 7.14. Note that all of the ITE equations are logarithmic. The curves for ITE and Montgomery County equations are shown in Figures 7.21a, 7.21b, 7.22a and 7.22b. The Montgomery County equations for the morning peak hours (Figures 7.21a and 7.21b) cross the ITE curves, so that use of the ITE equations results in an overestimation of trips for small developments and an underestimation of trips for large developments. For townhouse complexes with 400 occupied dwelling units, the ITE equations underestimate the AM adjacent street peak hour trips by 17% and the generator AM peak hour trips by 22%.

The ITE 4th Edition equations overestimate Montgomery County afternoon trips for both the adjacent street and the generator peak hours. Adjacent street peak hour trips are overestimated by about 20%, and generator peak hour trips are overestimated by a little over 5% for a development of 400 townhouses.

Table 7.14

Townhouses (ITE 230 - included as Residential Condominiums): Equations Estimating Vehicle Trip Ends

AM Adjacent Street Peak Hour		
ITE 4th Edition	T=exp(0.80(ln(U))+0.29)	R^2=0.744
MC Mean (4.33)	T=0.55(U)-26.04	R^2=0.248
MC Mean + S.E. (4.34)	T=0.55(U)+65.07	

AM Peak Hour of Generator		
ITE 4th Edition	T=exp(0.82(ln(U))+0.18)	R^2=0.781
MC Mean (4.35)	T=0.56(U)-16.34	R^2=0.249
MC Mean + S.E. (4.36)	T=0.56(U)+75.58	

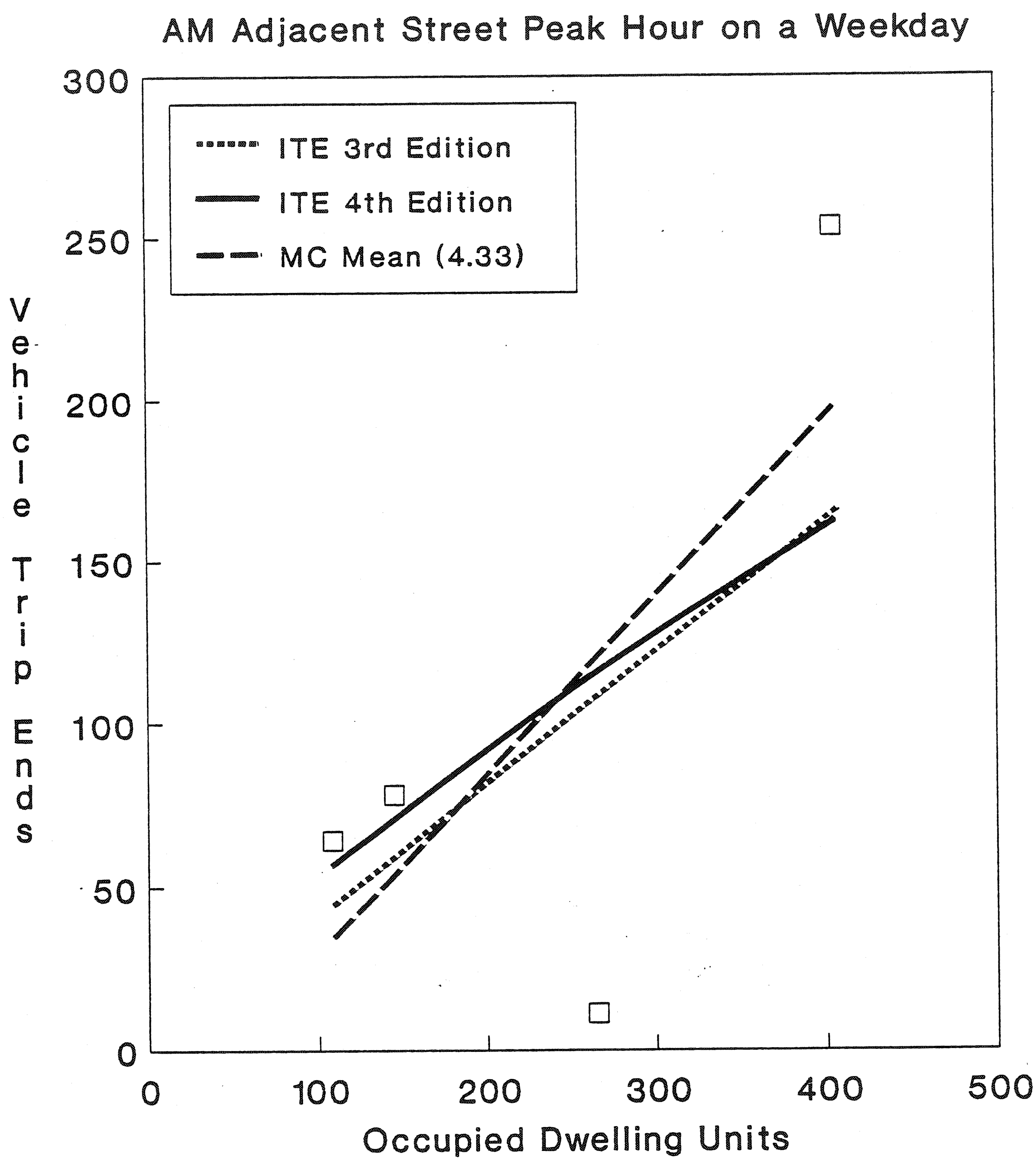
PM Adjacent Street Peak Hour		
ITE 4th Edition	T=exp(0.84(ln(U))+0.27)	R^2=0.798
MC Mean (4.37)	T=0.42(U)	
MC Mean + S.E. (4.38)	T=0.69(U)	

PM Peak Hour of Generator		
ITE 4th Edition	T=exp(0.79(ln(U))+0.52	R^2=0.811
MC Mean (4.39)	T=0.45(U)	
MC Mean + S.E. (4.40)	T=0.72(U)	

Note: T = Average 2-way Vehicle Trip Ends
U = Occupied Dwelling Units

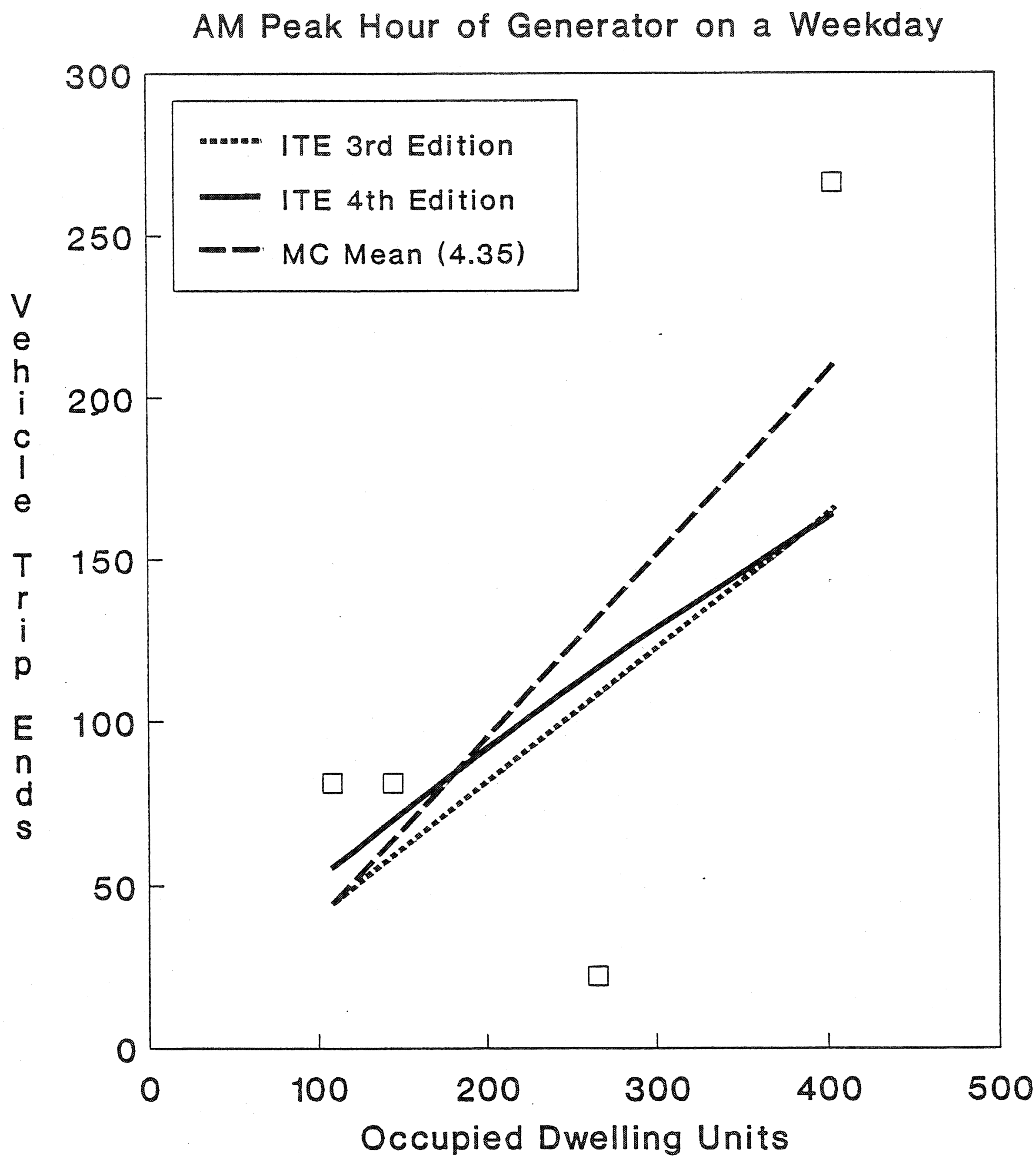
Source: Douglas & Douglas, Inc.

Figure 7.21a. Townhouses (Included as Residential Condominiums in ITE 230): Average Vehicle Trip Ends



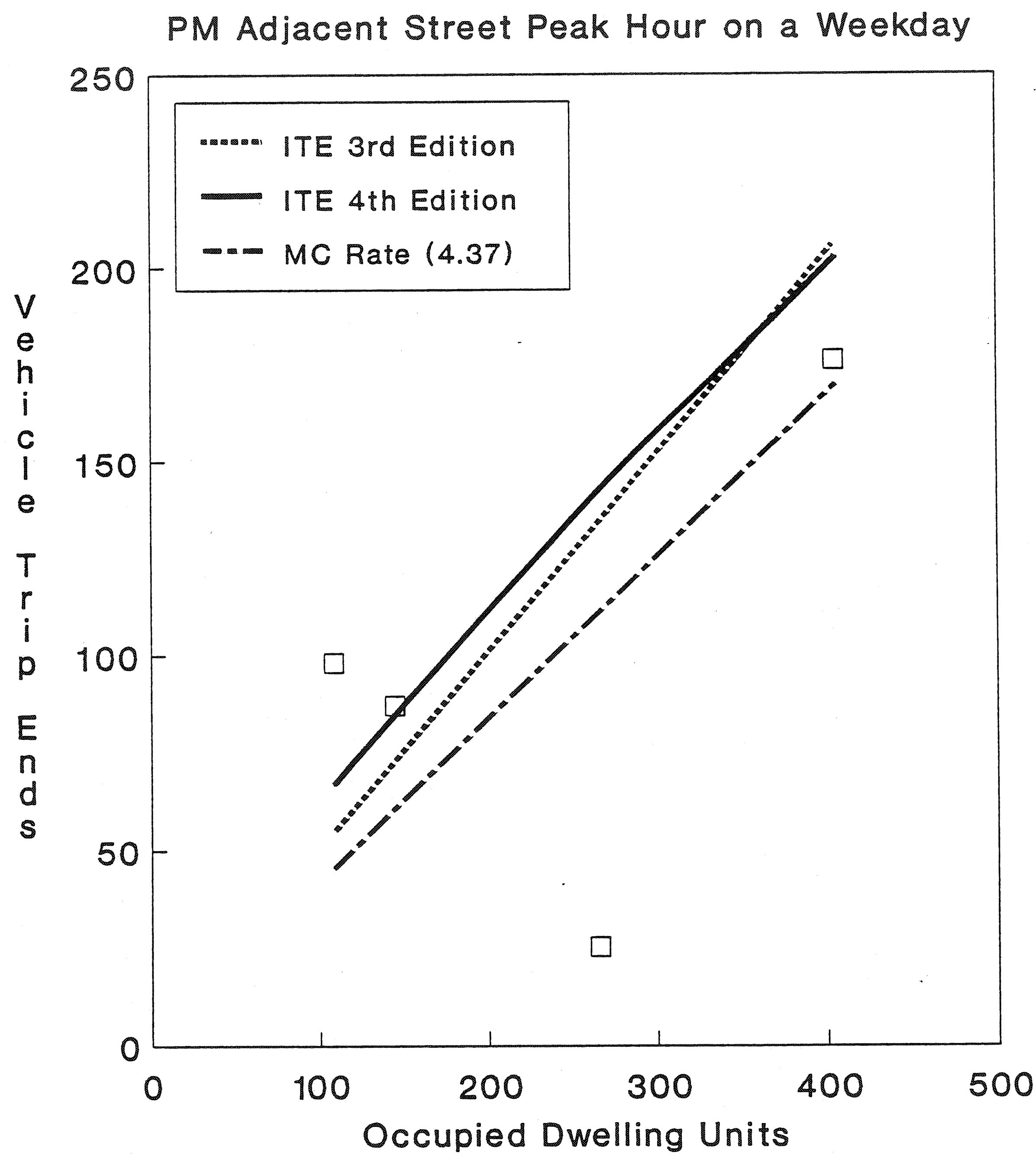
Source: Douglas & Douglas, Inc.

Figure 7.21b. Townhouses (Included as Residential Condominiums in ITE 230): Average Vehicle Trip Ends



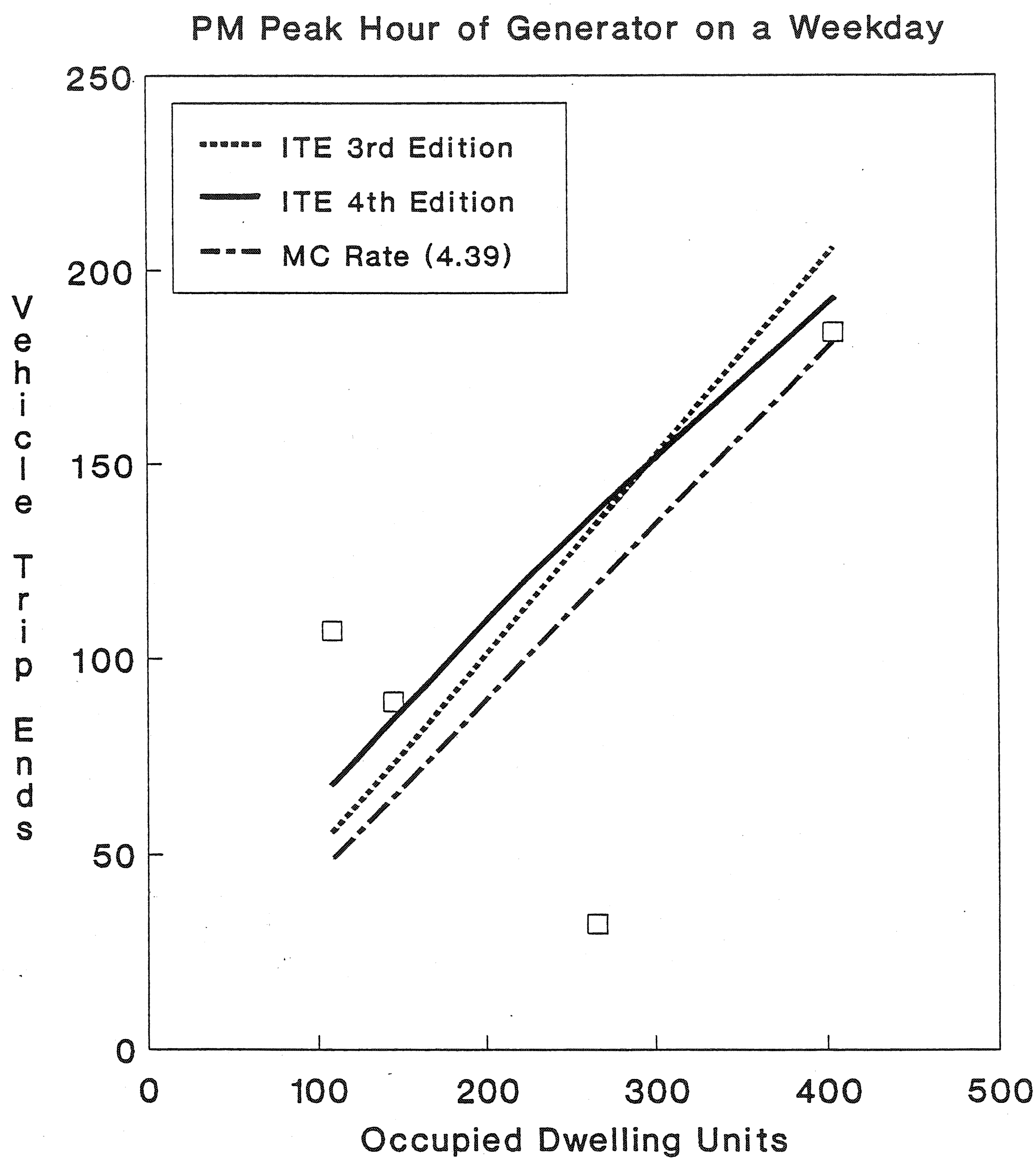
Source: Douglas & Douglas, Inc.

Figure 7.22a. Townhouses (Included as Residential Condominiums in ITE 230): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Figure 7.22b. Townhouses (Included as Residential Condominiums in ITE 230): Average Vehicle Trip Ends



Source: Douglas & Douglas, Inc.

Choosing an appropriate model for estimating townhouse traffic poses a dilemma. The Montgomery County equations are based on only four sample points which are scattered widely for each time period, as may be seen readily in Figures 7.21 and 7.22. As a result, the linear equations have poor goodness-of-fit statistics and large standard errors. The ITE 4th Edition equations appear by inspection to be no more accurate. A comparison of R^2 statistics calculated for Montgomery County data showed the ITE (4th Edition) equations to have an even lower goodness-of-fit than the relatively weak equations (4.33, 4.35) developed in this study. In addition, the ITE 4th Edition equations are all logarithmic with rates that fall as subdivision size increases. This implies that the average trip rates drop as the number of units increases.

We suggest combining the Townhouse category with the Low-rise Apartment category until sufficient data have been collected to improve the data base for Montgomery County townhouses. This suggestion is based on inspection of the data and curves as reported in the next section.

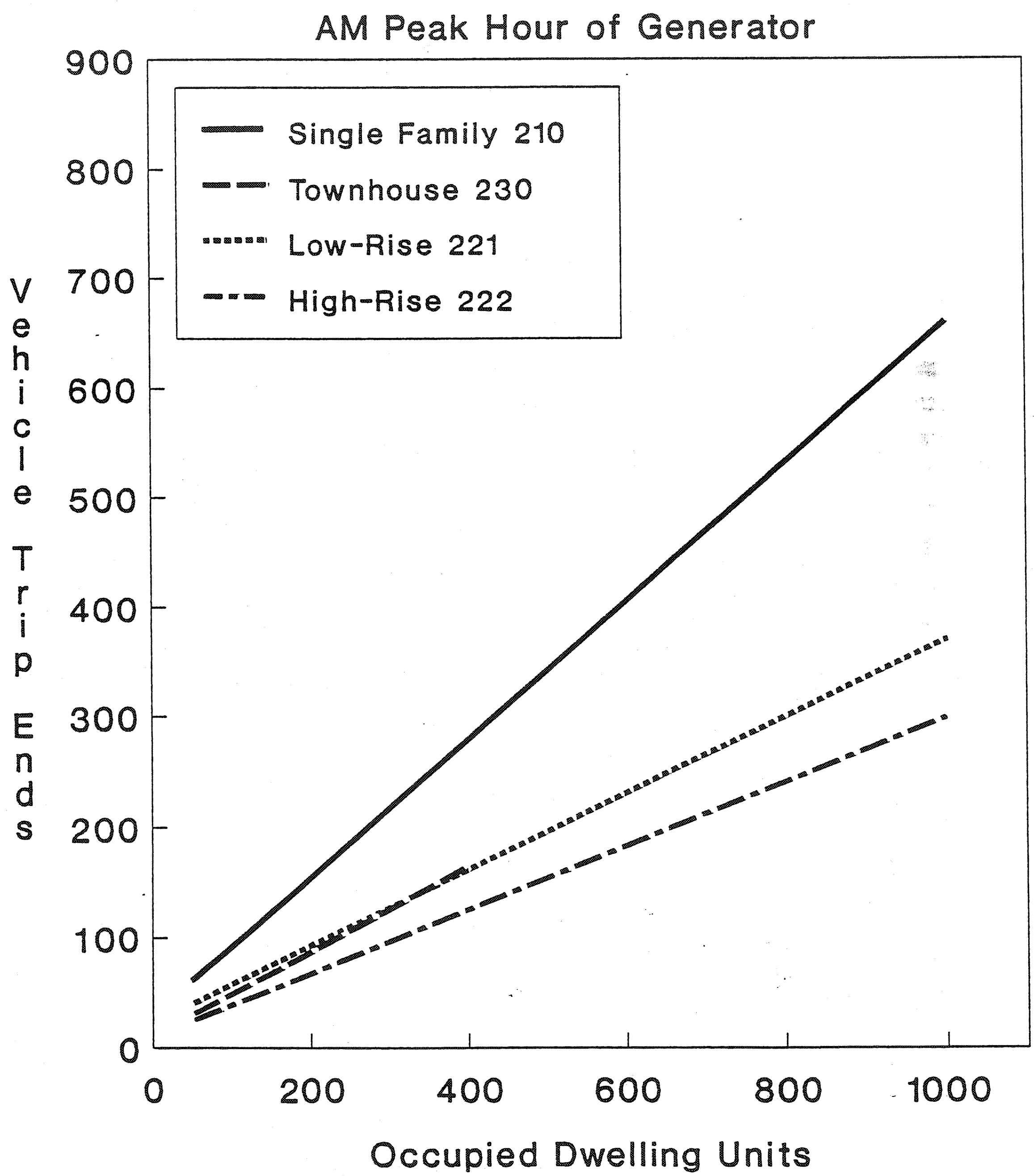
7.7.6 *Comparison of Residential Trip Rates*

Single-family dwelling units in Montgomery County generate more traffic than multi-family dwelling units. Low-rise apartments, including garden apartments, generate more traffic than high-rise apartment buildings. These differences in trip rates may be explained by differences in family size, the number of children, the number of workers in the household, the age of the inhabitants, and the overall household size. High-rise apartment buildings are generally occupied by smaller households with fewer children and often by older and retired inhabitants. These characteristics are all associated with lower rates of tripmaking during the peak hours. Conversely, single-family detached housing units are usually occupied by families of larger size. Consequently, more tripmaking occurs.

Figures 7.23 and 7.24 show graphs of the Montgomery County equations for AM and PM peak hour trip ends for four residential land use categories. A surprising statistic from the residential surveys is the low level of traffic generated by townhouses. The trip rates for the townhouses in Montgomery County, and the average rate for townhouses nationally, are more comparable with those of low-rise apartments than with those of single-family detached housing. The curves for townhouse trips lie almost on the low-rise apartment curves; therefore we suggest that townhouses be included in the low-rise apartment category until more data are available.

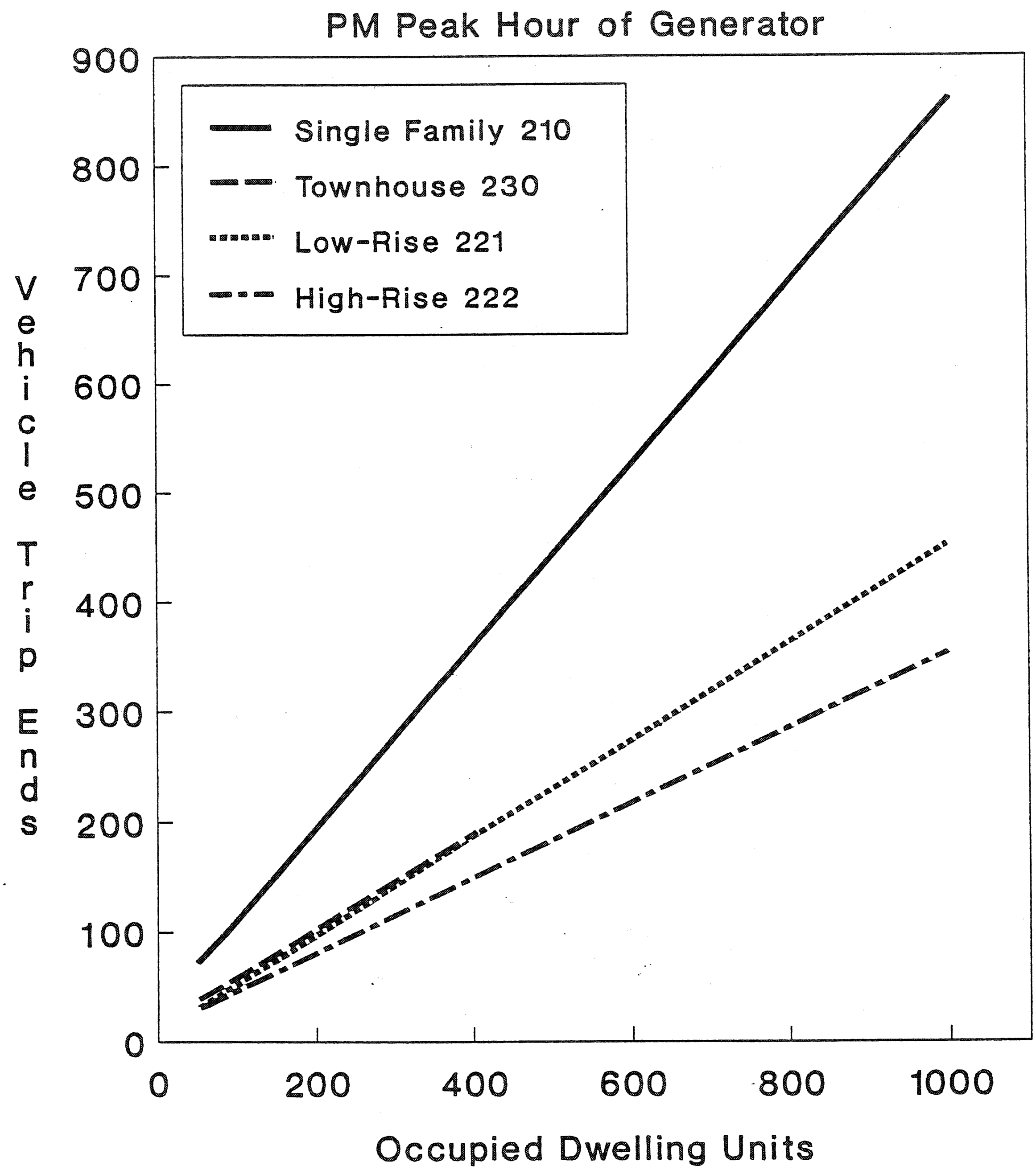
Based on the analysis in this study, separate trip rates and separate trip equations should be used for each of these three main housing types: 1) single-family detached housing, 2) townhouses, and low-rise and garden apartments, and 3) high-rise apartments. We suggest using the Montgomery County equations for all residential land use types.

Figure 7.23
Comparing Trips at Residential Land Uses Predicted by Montgomery County Equations



Source: Douglas & Douglas, Inc.

Figure 7.24
Comparing Trips at Residential Land Uses Predicted by Montgomery County Equations



Source: Douglas & Douglas, Inc.

7.8 SUMMARY

For most of the land uses included in this comprehensive trip generation rate study, the Montgomery County data and the trip estimating equations developed from them are more appropriate for estimating the average number of trip ends than are the equations provided by the ITE 4th Edition Trip Generation report. We decided on this after using the following criteria to guide us:

1. Is the Montgomery County equation of a more comprehensible and reasonable form than the corresponding ITE 4th Edition equation?

2. Does the Montgomery County equation have superior goodness-of-fit or R^2 statistics?

3. Is the difference between trip ends estimated by the ITE 4th Edition and Montgomery County equations greater than 10%?

4. Are the ITE 4th Edition and Montgomery County equations yielding similar results with comparable statistics? If so, we chose the Montgomery County equation because statistics are available to build parameters for equations to be used in the site approval process.

The differences between estimates of trip ends using the ITE Trip Generation 4th Edition and curves constructed from Montgomery County data vary by land use. In some cases, the ITE equations give higher trip end estimates and in others, lower estimates. In most cases, the differences between Montgomery County and ITE 4th Edition estimates are significant, and large enough for us to conclude that the Montgomery County equations give us more appropriate results. The differences among the land uses were as follows:

- Office - Generally, the ITE 4th Edition equations overestimate office trips by a significant margin when compared to Montgomery County average trip estimates;

- Shopping Centers - ITE 4th Edition equations for shopping centers tend to underestimate trip ends quite substantially for Montgomery County centers and, further, are insensitive to the presence or absence of a supermarket in the center;

- Fast Food Restaurants - The ITE 4th Edition rates for fast food restaurants give widely different results by time of day for Montgomery County establishments. They greatly underestimate trips in the morning peaks and wildly overestimate trips in the afternoon peak hour when compared with Montgomery County rates;

- Residential Land Uses - ITE 4th Edition equations produce reasonable results for Montgomery County single-family detached housing, high-rise apartments, and townhouses. They significantly overestimate trips from low-rise apartments and for the general apartment category, however, when compared to Montgomery County rates.

Based on an analysis of the land use types, we recommend appropriate equations for each. These recommendations, and any appropriate adjustment factors for pass-by traffic, are presented in Chapter 8.

CHAPTER 8

RECOMMENDED TRIP ESTIMATION PROCEDURES

8.1 INTRODUCTION

The purpose of this chapter is to recommend a method for estimating the number of peak hour vehicle trips likely to be generated by certain types of land development in Montgomery County, Maryland. The method recommended consists of a set of procedures and estimating equations which result from our analysis of trip generation data in Montgomery County. The equations reflect the particular characteristics of land use and traffic in Montgomery County and the variation in trip rates within each land use category.

In developing the recommended procedures and trip generation equations, we considered several thorny issues which complicate the site approval process:

- Which characteristics of the site should be used as the basis for estimating trip ends--floor area, number of units, number of employees, number of residents, or some other characteristic?

- Should the equations estimate the <u>average</u> number of peak hour trip ends or should they estimate some higher number which makes allowances for a less frequent but more serious traffic condition?

- Should the estimated peak hour trip ends represent the traffic generated during the peak hour of the site (the generator) or the peak hour of the street adjacent to the site? The two may or may not coincide.

- Should there be adjustments to the estimated trip ends produced by application of the basic equations for each land use category to reflect variation among sites or other special traffic characteristics?

There are conflicting pressures for selecting particular procedures or equations. Equations which give higher estimates would place less risk on the public sector, could possibly result in lower traffic congestion levels, and could even allow for some reserve capacity in the transportation infrastructure. Using equations which produce lower estimates could place more risk on the public sector which: 1) could involve more expenditure of public funds for transportation improvements, and 2) have a greater potential for creating unacceptable local--or even areawide-congestion if one or several major development projects have higher than average trip rates.

We believe government's role in the development/infrastructure supply process is to set a moderate course which conserves public resources and allows for reasonable growth and profit in the private sector. Our choice of a method to estimate future traffic recognizes these obligations and also considers the possibilities of variation in trip rates over the next decade or even longer. We tested several potential trip estimating methods to ensure that the selected approach would adequately predict traffic needs as a necessary prelude to making wise transportation facility investments. We believe a conservative approach is essential to careful management of the transportation infrastructure.

The methods and equations we recommend, while conservative in some cases, will generally allow for more development than do the trip generation rates which are currently being used. In general, lower trip end estimates will result from applying new equations for offices and multi-family residential sites. On the other hand higher trip end estimates will result from applying the recommended methods and equations to retail activities (shopping centers and fast food restaurants) and single-family detached housing. In each case we believe the new method and equations reflect actual traffic conditions in Montgomery County and thus are more desirable for development review applications.

In Section 8.2 we explore the important issues and assumptions which form the foundation for the recommended methods and equations. Section 8.3 outlines application procedures. Organized by land use category, the remaining sections describe the recommended equations and discuss the impact of using the methods we are advocating.

8.2 TRIP GENERATION ISSUES AND ASSUMPTIONS

All sites are <u>not</u> developed equally. As a result, the traffic consequences of variations in development patterns need to be acknowledged and, if possible, accommodated in the site impact assessment process. Several complicating issues pertinent to variation in trip end estimates are discussed here. In each case we outline our conclusions on the issues and recommend actions to deal with them.

8.2.1 *Choosing Independent Variables for Trip Generation Equations*

If we state that a shopping center generates 10 trips per 1,000 SF GLA, we mean that, on average, 10 trips will start or end at this center for each 1,000 square feet of gross leasable area (GLA). The GLA in units of 1,000 SF is called the "independent variable," and the number of trips is the "dependent variable." The number of trips, therefore, depends on the size of the facility--the square footage of sales space in the shopping center. Other characteristics could be used as the independent variable: number of employees, annual sales volume, and size of parking lot, for example; they have been rejected in favor of GLA either because they have proved to be inferior indicators of tripmaking, or are irrelevant or unknown during the development review process.

The basic equations for this study relate morning or afternoon peak hour traffic only to those attributes of development sites which can be evaluated and/or controlled within the development approval process. For example, while vehicle trip rates at office buildings are closely related to employment, current regulations in Montgomery County neither evaluate nor control employment densities in office buildings. For this reason, employment density is not a useful independent variable (although in California, apparently, employment densities are regulated in some instances). Consequently, office vehicle trips are estimated on the basis of gross square footage rather than on the number of employees.

8.2.2 *Accounting for the Risk of Underestimating Trip Ends*

The average trip generation equations developed through regression analysis from sample data give an estimate of the average or mean number of trips expected from a development of a given size. The actual data points often lie in a scatter pattern on either side of the line, usually about half on each side. The number of trips observed at a particular site is almost never the same as the number of trips estimated by the equation; rather it is almost always less or more than the estimated amount. In some cases the difference is substantial. This is amply illustrated by a review of the figures in Chapter 7. Thus, using an equation which predicts the average or mean volume of trip ends for each value of the independent variable will lead to underestimation for approximately half the sites and overestimation for the remaining half.

The context of the proposed development is a critical factor in evaluating future traffic impacts. Is the proposed development of average size or smaller? Will the proposed development be located near other similar sites or will it be isolated from them? The data from this study suggest that large, isolated development projects will require careful analysis and a test for the consequences of underestimating trips.

Clusters of similar sites may generate trip volumes which, in the aggregate, are quite close to the average volumes estimated by the equations developed in this study. This notion was tested on three clusters of office buildings in North Bethesda and Gaithersburg involving 22 buildings in all. Peak hour trip estimates, using the "average" equations, varied for individual buildings by minus 55% to plus 137%. But the estimated generator peak hour trips for each cluster varied only between +2% and +27% from the actual driveway counts. Therefore, using the "average" equations for these sites will give an adequate estimate of the combined trips from all sites.

Large, isolated developments present a different problem. Significant underestimation of trip volumes occurred most frequently at large buildings (more than 300,000 GSF) which are owner-occupied. In most cases the sites are located away from other development of similar size and use. Consequently, underestimates of trips will not be offset by compensating overestimates of trips at neighboring buildings. This can result in unexpected traffic congestion.

In reviewing proposed development, underestimating the traffic for a new project exacts a heavier penalty to the public than overestimating it. The effects of congestion and the need to rebuild a relatively new facility because it has insufficient capacity are considered much less desirable than having a slight excess capacity during the facility's early years.

For purposes of development approval in Montgomery County, we suggest using an approach which reduces the risk of underestimating traffic generated by a particular site. The approach is to use the equations which estimate the sum of the average trip ends for the given size of development, followed by a test for the impact on the road network of underestimating trips. This second test is to be applied to large projects, especially those proposed for isolated locations where their impact is potentially great.

We suggest this test be applied to general office, retail and residential land uses which are expected to generate more than 200 PM peak hour trips. For these projects, traffic impacts should also be computed for trip volumes, based on the average plus the standard error of the estimate. This higher trip volume is a statistical approximation of the 84th percentile. In other words, in 84% of the cases, the average number of trip ends for buildings of the size proposed in the development would be at or below the calculated value.

We believe this approach is reasonable because it parallels risk assumptions used in other infrastructure planning. For example, water resource plans often calculate design capacity as 80% of forecast demand rather than 50%, which would lead to frequent shortages, or 100%, which would be inefficient use of facilities much of the time. Consequently the facilities are undersized part of the time. Our suggested approach is also in line with our findings in Chapter 3 that variation in trip rates among office sites rarely exceeds one standard deviation above the average. For example, the average number of trip ends for office buildings in one age group (for instance, six to ten years old) may be above or below the average trip ends for all office buildings of similar size; but rarely are they more than one standard deviation above the average.

<u>The trip generation equations recommended for each land use are the regression equations for average trip ends presented in Chapter 7.</u> These equations are based on Montgomery County data and are identified as "MC Mean (X.XZ) where Z is an odd integer. For those cases requiring the test for congestion impact described immediately above, we have constructed a second set of equations which estimate the 84th percentile traffic volumes. These equations are identified in the text and figures as "Mean + SE (X.XZ)" where Z is an even integer. "Mean + SE" indicates that the equation has been constructed by adding the standard error (SE) to the original regression equation. The resulting equations for each land use type are listed in the appropriate tables and plotted in the figures for the remainder of the chapter.

8.2.3 *Selecting the Peak Hour*

When traffic engineers mention AM or PM peak hour trips, they are referring either to the peak hour of the street adjacent to the site ("adjacent street peak hour") or the peak hour of the site itself ("generator peak hour"). In both instances they are referring to the traffic volumes measured at the driveway(s) for the site under consideration. The generator peak hour is that hour of the peak period when the heaviest driveway volumes occur into and out of the site. The adjacent street peak hour is that hour of the peak period when the heaviest volume of traffic passes by on the major street adjacent to the site. These two peak hours may or may not coincide. By definition the driveway volumes measured during the generator peak hour will be equal to or greater than the driveway volumes measured during the adjacent street peak hour depending on whether or not the hours coincide.

The variation between adjacent street peak hour volumes and generator peak hour volumes has many causes, some connected with the activity at the site, others resulting from regional traffic patterns. A simple example is a fast food restaurant where the adjacent street peak hour is defined by early exodus from nearby offices (say from 4:30 to 5:30 PM) but the generator peak hour (5:00 to 6:00 PM) is determined by preferred times for supper. Variations in office peak hours appear to result in part from employees using flex-time to avoid rush hour traffic on adjacent streets.

In the long run, as congestion and peak spreading increase, the peak hour of each individual building will tend to converge with the peak hour of the adjacent street. This is because regional traffic levels throughout the two and one-half to three hour peak period may approach uniform distribution implying that congestion will be equally bad throughout the peak period. Thus, we recommend using equations for the peak hour of the generator rather than for the peak hour of the adjacent street. The generator peak hour is more important than the adjacent street peak hour for evaluating traffic impacts at site entrances and exits. When evaluating traffic impacts away from the development site, adding the generator peak hour volumes to the other peak hour roadway volumes will provide a conservative estimate of highway capacity requirements.

8.2.4 *Making Adjustments to Basic Trip Estimates*

The peak hour trip generation equations developed for each land use category estimate the number of trips for a "typical" site in that category. Where an identifiable subset of a land use category exhibited statistically different trip rates from those of the wider sample, we developed separate adjustment factors. The most notable examples of these clearly-defined subsets are office buildings constructed near Metro stations and shopping centers with major food chain supermarkets.

Some of the trips to retail centers and fast food restaurants are made by persons who are traveling by the site and who decide to stop in. These passby vehicles would be on the highway near the site even if the occupants did not stop and would thus contribute to traffic demand at nearby intersections. The pass-by trip adjustment deducts those vehicles which would have driven past the site even had a stop not been part of the journey. Further discussion of pass-by trips may be found in Chapters 4 and 5. We recommend making adjustments for pass-by trips when estimating retail and fast food restaurant trip ends. Note that pass-by trip adjustments do not apply to site circulation, only to off-site improvements.

The administrative context for application of trip rate adjustments was also considered. The suggested adjustments to the equations have been kept simple even when the data indicate minor variations throughout the full range of sites.

8.3 APPLICATION OF MONTGOMERY COUNTY TRIP ESTIMATING PROCEDURES

To ensure their equitable implementation, the methods and procedures for estimating trip ends should be clear, unambiguous and straightforward. The following steps are suggested to provide uniform guidance for interested parties in preparing trip estimates for proposed development sites.

Preparing Traffic Estimates for Site Development

1. Identify proposed land use(s).

This report covers four general land use categories:

- General Offices
- Shopping Centers with fewer than 200,000 SF GLA located more than 2,500 feet from a Metrorail station
- Fast Food Restaurants located more than 2,500 feet from a Metrorail station
- Residences located more than 2,500 feet from a Metrorail station including:
  - -- Single-Family Detached Housing
  - -- Multi-Family Apartments and Townhouses with subclasses for
    - Low-Rise Apartments and Townhouses (1-4 stories or levels)
    - High-Rise Apartments (more than 4 stories or levels)

2. Determine size of component structures. When the site will contain more than one office building or more than one apartment/condominium building, estimate the size of each structure or calculate the average size of each structure. Both the number and the size of buildings are important factors: trip end estimates are different for five small buildings versus one large building, even if total square footage is the same (see Section 7.4.1).

3. Estimate the size of the development. Where the project will involve a mixture of land uses, calculate or estimate the size of each land use component (for example: retail component, residential component) using measures appropriate to the land use type(s) identified in Step 1 (square feet or dwelling units, for example).

4. Select the appropriate equation for calculating basic trip end estimates. For each land use type, equations are provided to calculate AM and PM peak hour trip ends.

5. Calculate net trip ends for the critical peak hour (generally the PM peak hour) for each component of the site using the appropriate trip generation equation. Make adjustments for offices located near Metrorail stations and for shopping centers without supermarkets. Adjust the number of vehicle trip ends to reflect any transportation considerations which will affect automobile use. Examples include, but are not limited to, transportation demand management programs, developer-sponsored transit service, unusually high public bus transit use, or unusually high pedestrian and/or bicycle activity.

6. Calculate peak hour driveway volumes. Calculate entering and exiting directional volumes, the number of vehicles going in and out by using the in/out percentages provided for each land use category. Round answer to whole number of trips.

7. Calculate peak hour off-site volumes. Off-site volumes for general offices and residential uses will be equivalent to the driveway volumes. Off-site volumes for shopping centers and fast food restaurants may be reduced by the expected percentage of pass-by traffic. Adjustment factors are provided in the appropriate sections. Adjustments are made to traffic volumes on arterial streets and freeways only. Round answer to whole number of trips.

8. Perform secondary impact assessment for large or isolated development projects. This analysis should be required for proposed office, retail and residential projects which are expected to generate more than 200 PM peak hour trips. Steps 5 through 7 should be repeated using the 84th percentile equations. If the projected levels of service for the critical intersections fall below acceptable standards with these higher trip volumes, M-NCPPC staff should recommend that additional efforts be taken to assure that the adequate public facilities requirements will be satisfied.

In the sections to follow, appropriate equations and adjustment factors are presented for each land use category. They are shown graphically and their trip estimates are compared with those calculated using the ITE 4th Edition curves.

8.4 GENERAL OFFICE TRIP GENERATION EQUATIONS

After evaluating both the ITE 4th Edition equations for estimating office trips and those developed from Montgomery County data, we recommend using the Montgomery County equations. We have suggested equations for the morning and afternoon peak hours of the individual generator. The Montgomery County equations for the afternoon peak hour produce estimated trip volumes which are actually 10% to 20% lower than those given by the ITE 4th Edition equations for buildings with fewer than 300,000 square feet. Both the 4th Edition and Montgomery County equations represent a significant decrease in trip end estimates from the 3rd Edition rates, so that trip volumes based on Montgomery County equations will be considerably lower than those calculated from 3rd Edition rates which are still being used in many areas.

8.4.1 *Recommended Office Trip Generation Rate Equations*

We have developed trip generation equations for general offices using linear regression techniques as described in Chapter 7. Further explanation of this process is given in Section 8.2.2. Table 8.1 shows the appropriate equations for each time period. These equations have been constructed from the regression equations derived from Montgomery County data.

The recommended curve for the PM peak hour is shown in Figure 8.1. The ITE 4th Edition curve for the average number of trip ends and the MC 84th percentile curve are shown for reference purposes.

Even with the recommended approach there can still be large variations between actual conditions and the equation, as illustrated by buildings "A" and "B" in Figure 8.1. Building "A" at about 450,000 square feet was observed generating about 1000 trips which is about 300 trips, or 40% more than the expected value. Building "B" of about the same size was observed generating about 450 trips, which is about 300, or 40%, less than the expected value.

As discussed in Section 7.4.2, office buildings located near Metrorail stations exhibit unusual trip patterns and thus require special consideration. We suggest adjusting the basic trip rates for offices located near Metrorail stations.

8.4.2 *Adjustments to Basic Office Trip Estimates for Metrorail*

The use of adjustment factors for offices located near Metrorail stations reflects the major variation noticed among office buildings located in the County. The adjustment factors we have chosen are conservative and appropriate for the data available from the JHK study [5]. They are presented in section II of Table 8.1. Future studies will be able to extend our knowledge about the impact of location near transit stations on vehicle trip rates and perhaps result in revised adjustment factors.

Table 8.1

Suggested Trip Generation Equations
GENERAL OFFICE (ITE 710)

I. SUGGESTED EQUATIONS FOR GENERAL OFFICE BUILDINGS - (Generator Peak Hour)

A.	AM Peak Hour (1.3) In/Out Percentages: 87% Enter, 13% Exit.	T=1.70(A)-8	R^2=0.796
	PM Peak Hour (1.7) In/Out Percentages: 18% Enter, 82% Exit.	T=1.44(A)+20	R^2=0.793
B.	For Secondary Impact Assessment		
	AM Peak Hour (1.4)	**T=1.70(A)+115**	
	PM Peak Hour (1.8)	**T=1.44(A)+127**	

Where: T=2 Way Vehicle Trip Ends;
A=Building Gross Floor Area (1,000 Square Feet).

II. ADJUSTMENTS -

A. For office buildings located within 1000 feet of Metrorail stations

Metrorail stations inside Beltway

AM Peak Hour	Deduct 45% Total Trips
PM Peak Hour	No Adjustments

Metrorail stations outside Beltway

AM Peak Hour	Deduct 50% Total Trips
PM Peak Hour	Deduct P = 4%(1000-D)/100

Where: P = Percent Deduction From Total Trip Ends;
D = Airline Distance to Station (100 feet).

B. For Transportation Programs - See Text

Table 8.1
(continued)

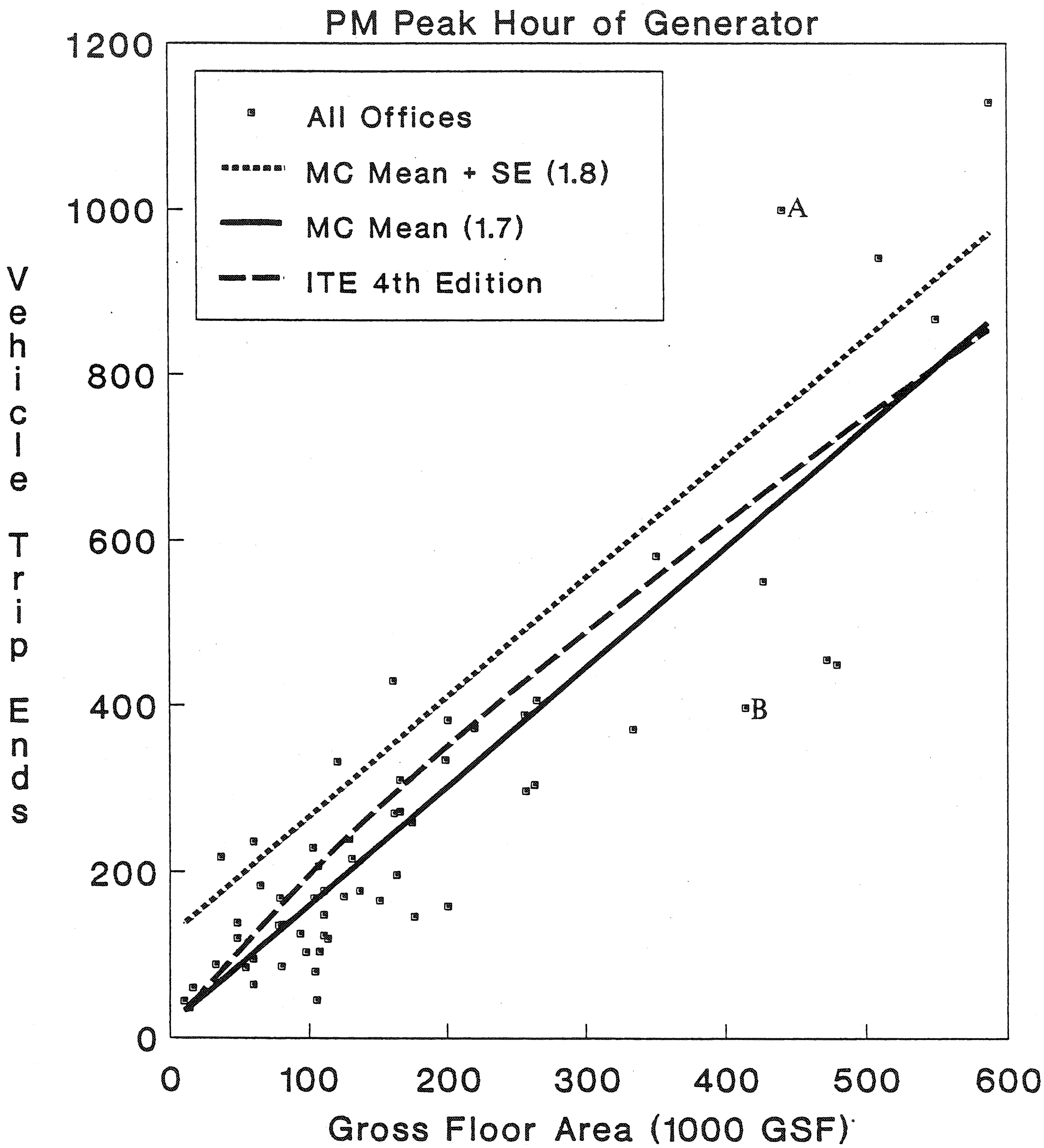
III. COMPARISON OF TRIP END ESTIMATES

AM Peak Hour	Building Size in 1000 SFGFA 100	200	500
MC Equation (1.3)	162	332	842
ITE 4th Edition	200	364	800
Metro Station (Within 500 feet)			
Inside Beltway	90	183	460
Outside Beltway	82	166	418

PM Peak Hour	Building Size in 1000 SFGFA 100	200	500
MC Equation (1.7)	164	308	740
ITE 4th Edition	197	350	749
Metro Station (Within 500 feet)			
Inside Beltway (1.7)	161	305	737
Outside Beltway	97/161	183/305	442/737

Source: Douglas & Douglas, Inc.

Figure 8.1 Suggested Equations for Vehicle Trip Ends Generated by General Office (ITE 710) Development



Source: Douglas & Douglas, Inc.

The Metrorail walkshed peak hour adjustment factors apply to all sites located within 1000 feet of a station. The distance of 1000 feet was selected because it was the maximum distance from the station for which the data showed a clear reduction in vehicle trip rates from the average rates calculated for the rest of the county. Buildings located more than 1000 feet from a station often had trip rates as high or higher than the county average. We suggest using the general county equation for these buildings.

The AM peak hour adjustment factors are not a function of distance to the station. They have been chosen from a range which varied by building size. For example, for stations located inside the Beltway, the number of AM peak hour vehicle trips was from 37% to 63% below the county average. The larger reductions occurred at the larger buildings. We chose a reduction of 45% as an appropriate adjustment factor for all sizes of buildings. The 50% reduction adjustment factor for station walksheds located outside the Beltway was similarly chosen. The range of observed differences between the county average trip estimates and the number of trips observed at Metrorail walkshed office buildings located outside the Beltway was generally between 35% and 50%.

No adjustment to PM peak hour trips is suggested for offices near stations located inside the Beltway. The observed trip rates were statistically identical to the county averages. We did find a distance-related function to describe trip reductions for PM trips to/from offices near stations located outside the Beltway. The limit of influence is constrained to within 1000 feet of the station, however. Beyond that distance, the number of vehicle trips generated during the peak hour equals the trip rates for the remainder of the County, assuming no special transit encouragement programs.

Separate adjustments may be made for extraordinary conditions which will change the peak hour vehicle trips generated by a specific site. Usual reasons for adjusting trip end estimates include:

- Presence of an active transportation management association with demonstrated effectiveness in reducing vehicle trips.

- A binding agreement between an owner/developer and Montgomery County for a transportation demand management program with specific trip generation/transit goals and remedies for non-performance.

- Higher-than-usual pedestrian, bicycle, or other non-motorized vehicle modal shares.

- Higher-than-usual use of bus transit, car pools, van pools or peak spreading policies which will decrease peak hour tripmaking.

The choice and extent of adjustment for these and similar trip regulating programs and activities depends on the conditions of the specific site. Recommended adjustment factors are outside the scope of this analysis and must be developed from other data.

8.4.3 *Comparing Recommended Equations with Current Practice*

The numbers of office trip ends estimated by the recommended equations are lower than the generalized estimates of the 3rd Edition. They are also lower than the number of trip ends estimated by the 4th Edition curves as well. Therefore, use of the new Montgomery County equations will permit more development than current Montgomery County procedures which are based on the ITE 3rd Edition trip rates.

Using the 84th percentile equations, which are constructed from the mean of the observed data plus one standard error, will be less generous than using the mean values alone. The estimated number of trips using these equations allows for future increasing employment densities as tenants expand their staff without renting new space and as the market for office space intensifies through the years.

Several representative calculations of trip rates using the various equations and adjustments are presented in Table 8.1, section III. For the typical Montgomery County office building located outside a Metrorail station walkshed, the Montgomery County equations (1.3, 1.7) provide estimates of trip ends equal to or just slightly smaller than the ITE 4th Edition equations. Thus, either equation will lead to about the same development levels at a particular site.

For development within the Metrorail walksheds, the differences in trip end estimates will vary by location and time of day. For this application, the walkshed is defined as a circle centered on the station and with a 1000-foot radius. During the AM peak hour the office buildings located within 1000 feet of a Metrorail station will generate lower numbers of trips than estimated by either the Montgomery County equation (1.3) for county-wide offices or the ITE 4th Edition equation.

During the PM peak hour, the trips estimated for offices located near stations inside the Beltway are the same as for the offices built in locations over 1000 feet from a Metrorail station. In the absence of special transit incentives, as are currently present in the Silver Spring CBD and in the Bethesda CBD, these rates should be used.

Office buildings at Metrorail stations located outside the Beltway have PM peak hour trip rates which are lower than those located in walksheds inside the Beltway <u>if</u> the buildings are located within 1000 feet of the station. Use of the PM peak hour adjustments will lead to lower trip estimates and consequently to development levels somewhat higher than will the North Bethesda Sector Plan rates (2.0 trips/1,000 GSF), particularly for buildings within 1000 feet of the station. Buildings farther from the station will have estimated trip ends similar to locations elsewhere in the County and outside Metrorail walksheds.

8.4.4 *Discussion and Comments for General Offices*

The general office equations developed from the Montgomery County data to estimate the 84th percentile trip ends give results that are remarkably close to those from the ITE 4th Edition equations. The significant difference between the two sets of curves is that the Montgomery County equations used for secondary impact assessment estimate the number of trip ends which is as great as or greater than that for 84% of the sample points (the 84th percentile) whereas the ITE 4th Edition equations estimate the average trip rate which is as great as or greater than only 50% of the sample (the 50th percentile).

Although the ITE 4th Edition equations and the Montgomery County equations give similar results, there are several compelling reasons for selecting the Montgomery County equations:

- The ITE 4th Edition does not provide guidance for rail transit station impact on vehicle trip rates.

- The linear equation developed from Montgomery County data has a 6% higher R^2 than does the ITE 4th Edition equation when the statistic for each equation is calculated for the Montgomery County data, even though the two curves lie relatively close.

- In our judgment there is no evidence to support the use of a logarithmic curve (as used in the ITE 4th Edition) with its accelerated decline in trip rate for Montgomery County sites.

- The Montgomery County curves explicitly include an assessment of the risk of underestimating the actual number of trips which will be generated by a proposed site. This is achieved through the use of the equations based on the average plus the standard error of the estimate.

8.5 SHOPPING CENTER TRIP RATE EQUATIONS

The shopping centers covered in this study all have fewer than 200,000 SF of GLA. Consequently, the results of this analysis apply only to malls or shopping centers of this size or smaller.

Shopping centers in Montgomery County generate significantly more PM peak hour trips ends than estimated by the ITE equations. The difference may be partly attributable to the large number of two-worker households resulting in more PM peak hour shopping or it may be the result of higher incomes and a long term trend towards shopping as a primary activity.

8.5.1 *Recommended Shopping Center Trip Generation Rate Equations*

We recommend using the equations derived from Montgomery County data for generating shopping center trip estimates. In Table 8.2 we present the suggested equations for shopping centers with fewer than 200,000 SF GLA. These equations were derived from the regression equations based on Montgomery County data. The goodness-of-fit statistics are just slightly better than those reported by the ITE. As may be seen in Figure 8.2, the selected curve provides a reasonably conservative estimate of total two-way trips at drive-way entrances. As we saw in Chapter 7, the linear curve derived from Montgomery County data is more appealing than rates from the older ITE 3rd Edition or the ITE 4th Edition curve, each of which gives trip end estimates considerably below the observed Montgomery County data.

8.5.2 *Adjustments to Shopping Center Trip Rates*

We identified two significant differences within the shopping center category. The first big difference was that shopping centers with supermarkets generated considerably more traffic than those without. The second observed phenomenon was that significant numbers of supermarket trips were pass-by trips, that is, trips made by people in autos which would have passed by the shopping center even had they not stopped to enter it.

We recommend a reduction in trips to centers without a major chain food store or supermarket based on the size of the center. The recommended procedure allows a 35% reduction in trips for centers with 50,000 SF GLA, declining to a 5% reduction for centers with 200,000 SF GLA (See Table 8.2, Section IIA).

When calculating the need for off-site improvements, there is equity in the argument in favor of reducing the total generated traffic volumes by those trips which would pass by the center even were the occupants not planning to stop. Consequently, in Table 8.2 the estimated reduction for pass-by trips taken from the work in Chapter 4 is given in section IIB. Note that the average reduction is significantly greater for the neighborhood-sized centers (under 100,000 SF GLA). This probably reflects the composition of tenants in small centers which frequently includes convenience food stores and personal services such as dry cleaners, etc. The difference in pass-by trips between centers with supermarkets and those without appears to be caused by the high volume of primary trips to supermarkets.

Table 8.2
Suggested Trip Generation Equations
SHOPPING CENTERS (ITE 820)

I. SUGGESTED EQUATIONS (Generator Peak Hour between 4 PM and 6 PM on a Weekday)

A. Shopping Centers with 5,000-200,000 Square Feet Gross Leasable Floor Area (GLA)

(2.7) **T=7.43(A)+247** R^2=0.587
In/Out Percentage: 53% Enter, 47% Exit.

B. For Secondary Impact Analysis

(2.8) **T=7.43(A)+506**
Where: T = 2-Way Vehicle Trip Ends
A = Shopping Center Area in 1,000 SF GLA

II. ADJUSTMENTS

A. Reductions for Centers without a Major Chain Food Store (Supermarket)

P = 5% + 0.2%(200-(A))
Where: P = Percent Deduction from Total Trip Ends
A = Shopping Center Floor Area in 1,000 SF GLA

B. Reduction for Pass-by Trips:

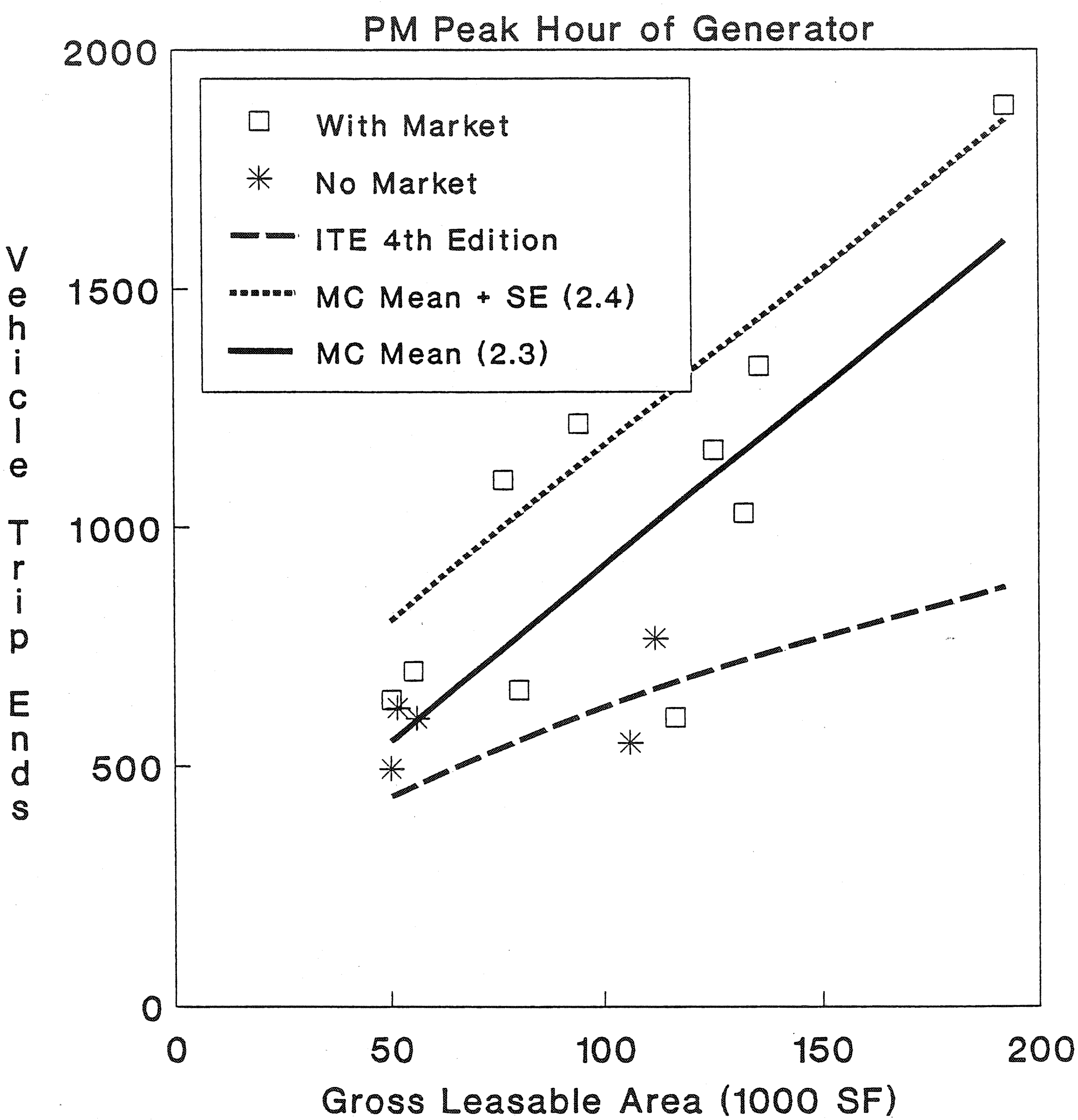
Center Type	Size (Sq.Ft GLA) 0-99,999	100,000-200,000
With Supermarket	33%	20%
Without Supermarket	50%	27%

III. COMPARISON OF TRIP END ESTIMATES

PM Peak Hour of Generator	Shopping Center Size 50,000 sq ft	150,000 sq ft
A. Centers with Supermarket (0-200,000 sq ft GLA):		
Basic Equation (2.7)	618	1360
Pass-by Trip Adjustment	-204	-272
Net 2-way Trip Ends	414	1088
B. Centers without Supermarkets (0-200,000 sq ft GLA):		
Basic Equation (2.7)	618	1360
Reduction for 'No Supermarket'	-216	-204
Net Drive Way Trip Ends	402	1156
Pass-by Trip Adjustment	-241	-312
Net 2-way Trip Ends	161	844
C. ITE 4th Edition Equation (No distinction between centers with and without supermarkets)		
Basic Equation	434	769
Pass-by Adjustm.(45.1%-0.0225(A))	-243	-321
Net 2-way Trip Ends	191	448

Source: Douglas & Douglas, Inc.

Figure 8.2 Trip Generation Equations for Shopping Centers (ITE 820) PM Weekday Peak Hour of Generator



Note: Curves and data show all trips-
no reduction for pass-by traffic.
Source: Douglas & Douglas, Inc.

8.5.3 *Comparison of Shopping Center Trip End Estimates*

In Table 8.2, section III, we have computed trip ends for two mid-point representative shopping centers. The underestimation of trips by the ITE equations as compared to the Montgomery County equations is significant and remarkable. For example, for a shopping center of 50,000 SF and with no supermarket, the Montgomery County equations estimate approximately 16% fewer trips than the ITE equations (161 versus 191 trips). But for a shopping center of the same size with a supermarket and using the Montgomery County estimates of pass-by trips, the Montgomery County procedures estimate twice as many trips as the ITE equations (414 versus 191 trips).

The percentage differences between Montgomery County and ITE trip estimates are even greater for a shopping center of 150,000 SF. A shopping center with a supermarket would have 1.8 times as many total trips at the driveway than the estimates from ITE equations (1,360 versus 769 trips). In terms of net trips, taking into account pass-by trip adjustments, centers with supermarkets would have about 30% more trips than those without (1,088 versus 844 trips) and about 2.5 times as many trips as estimated by the ITE equations (1,088 versus 448 trips). Even with all the reductions for pass-by trips and the lack of a supermarket, the peak hour traffic generated by a shopping center (844 trips) of 150,000 SF using the Montgomery County equations is still around 10% higher than the basic trip estimate using the ITE 4th Edition equations (769 trips) without adjusting for pass-by traffic. Differences of this magnitude clearly could explain a large part of afternoon peak hour congestion in corridors with high levels of retail development. The current traffic levels generated by Montgomery County shopping centers are two to three times the estimates prepared for development approval and highway capacity analyses.

8.5.4 *Discussion and Comments on Shopping Center Trip Estimates*

The trip end results from the data collected for shopping centers in Montgomery County differs so greatly from the ITE equations and rates in both the 3rd and 4th Editions of ITE Trip Generation that the decision to use Montgomery County equations was clearly appropriate. The use of Montgomery County equations also made it possible to account for the significant difference between shopping centers with a supermarket and those without. Finally, for those interested in reduced rates when considering the need for off-site improvements, appropriate reduction factors for pass-by trips have been provided.

8.6 FAST FOOD RESTAURANT TRIP RATE EQUATIONS

8.6.1 *Suggested Trip Generation Equations*

We developed the suggested equations for calculating trips generated by fast food restaurants directly from Montgomery County data. They include a uniform trip rate for the range of restaurant sizes in our data base--from 2,400 to 3,600 gross square feet of floor area. For restaurants greater than 3,600 square feet of floor area we have developed equations extrapolated from trip rates measured at Montgomery County sites. The specific equations developed for the AM and PM peak hours are presented in Table 8.3.

8.6.2 *Adjustments to Basic Fast Food Restaurant Trip Rates*

Adjustment factors are provided to account for pass-by trips. These factors are also presented in Table 8.3, section II. Note that pass-by traffic is much heavier in the morning peak hour than in the afternoon peak hour. This reflects the emerging practice of persons stopping for breakfast at fast food restaurants on the way to the office.

8.6.3 *Comparison of Fast Food Restaurant Trip End Estimates*

As may be seen in Table 8.3, section III, and in Figure 8.3, the recommended equation for the PM peak hour estimates approximately 15% more trips than the ITE 4th Edition curve for restaurants with drive-through windows. The morning equations are just the reverse with the Montgomery County equations estimating approximately 15% to 20% fewer patrons than the ITE 4th Edition curves.

8.6.4 *Discussion and Comments on Fast Food Restaurant Trip Estimates*

For the range of fast food restaurant sizes found in our sample (2,400 to 3,600 SF), we have elected not to use a trip rate related to the floor area of the restaurant. Examination of the ITE equations and Montgomery County data has convinced us that the relationship between the size of a fast food restaurant and the number of trips that it generates is not significant (at least in Montgomery County, and this may be true nationwide). The variable which does seem to be significantly related to the fast food restaurant trip estimates is simply the volume of traffic passing by on the adjacent street; the higher these traffic volumes, the greater the number of fast food restaurant trips.

Although the ITE equations have been developed for restaurants both with and without drive-through facilities, the Montgomery County data indicate no true distinction. Thus, the selected rate is a flat rate based on the average number of trip ends as measured from the peak hour data at Montgomery County sites.

Table 8.3
Suggested Trip Generation Equations
FAST FOOD RESTAURANTS (ITE 833, 834)
With and Without Drive-Thru Windows

I. SUGGESTED EQUATIONS (Generator Peak Hour)

A. Gross Floor Area: 2400-3600 Gross Square Feet

AM Peak Hour (3.4) T=128 Trips
Directional Distribution: 55% Enter, 45% Exit.

PM Peak Hour (3.8) T=170 Trips
Directional Distribution: 54% Enter, 46% Exit.

B. Gross Floor Area: Larger Than 3600 Gross Square Feet

AM Peak Hour (3.3) T=35.55(A)

PM Peak Hour (3.7) T=47.29(A)

II. ADJUSTMENT FACTORS

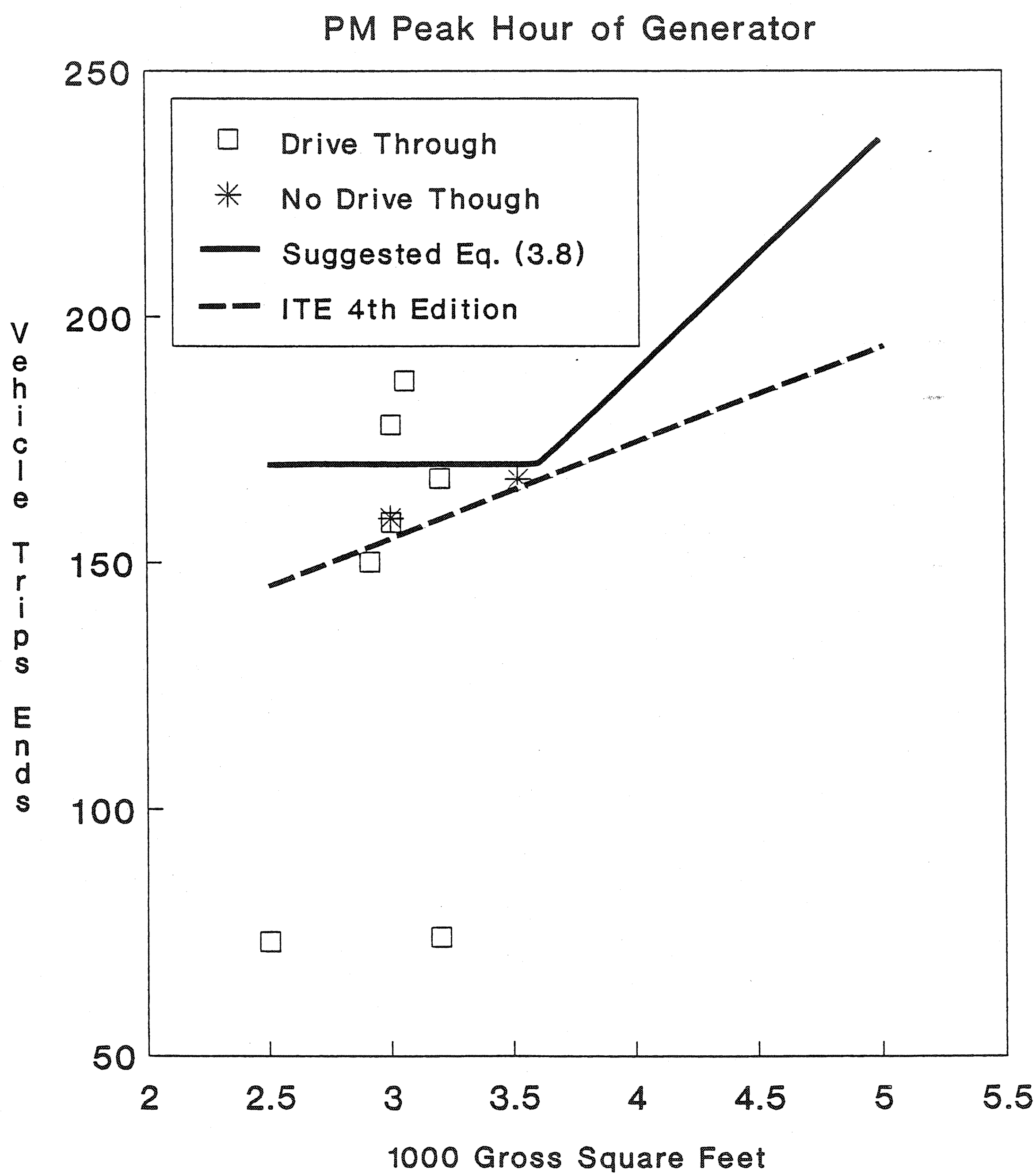
Pass-by Trips	**Reduction Factors**
AM Peak Hour	46%
PM Peak Hour	30%

III. COMPARISON OF TRIP END ESTIMATES (Generator Peak Hours)

	Restaurant Size	
AM Peak Hour:	**3000 sq ft**	**4000 sq ft**
Eq.(3.4)/(3.9)	128	142
Pass-by Reduction	-59	-65
Net 2-way Trip Ends	69	77
ITE 4th Edition (834)	216	254
Pass-by Reduction	-99	-117
Net 2-way Trip Ends	117	137
PM Peak Hour:	**3000 sq ft**	**4000 sq ft**
Eq.(3.3)/(3.7)	170	189
Pass-by Reduction	-51	-57
Net 2-way Trip Ends	119	132
ITE 4th Edition (834)	155	174
Pass-by Reduction	-46	-52
Net 2-way Trip Ends	109	122

Source: Douglas & Douglas, Inc.

Figure 8.3 Fast Food (ITE 833/834)
Average Vehicle Trip Ends
PM Weekday Peak Hour of Generator



Source: Douglas & Douglas, Inc.

8.7 RESIDENTIAL TRIP RATES

This study developed trip generation equations for four categories of residential land use and four types of dwellings:

- Single-family detached houses;
- Low-rise apartments including garden apartments and townhouses;
- High-rise apartments; and
- All multi-family dwellings.

We collected data at townhouses as a separate category and analyzed them as a separate category. However, for reasons discussed in Chapter 7, we include townhouses with low-rise and garden apartments in our recommendations.

For all land uses in the residential category with 50 or more dwelling units, we recommend using trip generation equations derived from Montgomery County data. Trip ends estimated, therefore, will be related explicitly to behavior observed in Montgomery County. As explained in Chapter 7, the average number of trip ends measured in Montgomery County for single-family detached housing and high-rise apartments were quite similar to the ITE 4th Edition curves. Data for low-rise apartments and garden apartments were considerably lower than the ITE 4th Edition estimates. Most of the equations suggested for use in development review will provide estimates which tend to be either just over or just under the number of trips which would be estimated using the 4th Edition equations.

The trip generation equations and procedures for each residential land use are presented separately in the following sections. Equations for the AM peak hour and the PM peak hour are indicated. No adjustment factors are suggested for any of the residential land uses. Comparisons of the trip end estimates produced by the Montgomery County equations and the ITE 4th Edition equations are provided for each land use.

8.7.1 *Single-Family Detached Housing Trip End Estimates*

The suggested trip end estimating equations are presented in Table 8.4. No adjustments are recommended for single-family detached housing. As is evident in Figure 8.4 and in section III of Table 8.4, the Montgomery County equations estimate more trips per occupied dwelling unit during the peak hours than do the ITE 4th Edition equations for small developments. The suggested equations estimate approximately 5 to 10% fewer trips for the larger subdivisions. The relationship reverses for small subdivisions (for example, 100 units). For these smaller

Table 8.4
Suggested Trip Generation Equations
Single Family Detached Housing (ITE 210)

I **SUGGESTED EQUATIONS (Peak Hour of Generator)**

A. AM Peak Hour on a Weekday

(4.3) **T=0.62(X)+25** R^2=0.703
In/Out Percentages: 27% Enter, 73% Exit

PM Peak Hour on a Weekday

(4.7) **T=0.82(X)+21** R^2=0.758
In/Out Percentages: 62% Enter, 38% Exit

B. Secondary Impact Assessment

AM Peak Hour on a Weekday

(4.4) T=0.62(X)+61

PM Peak Hour on a Weekday

(4.8) T=0.82(X)+63

Where: T = 2-way Trip Ends
X = Number of Dwelling Units

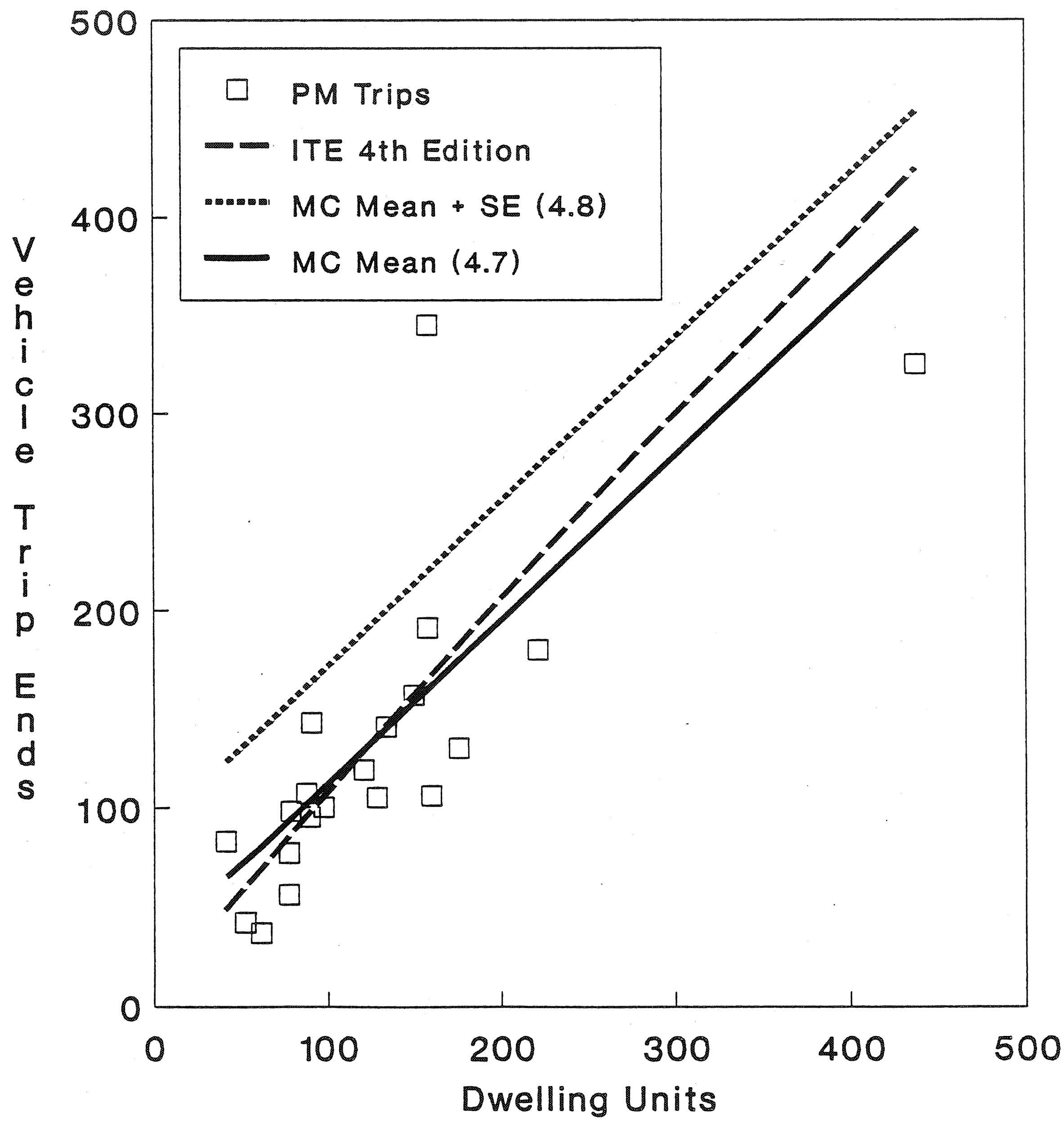
II **ADJUSTMENTS: None**

III **COMPARISON OF TRIP END ESTIMATES**

	Dwelling Units		
AM Peak Hour Trip Ends	**100**	**500**	**1000**
MC Equation (4.3)	87	335	645
ITE 4th Edition	84	368	723
ITE 3rd Edition	100	500	1000
PM Peak Hour Trip Ends	**100**	**500**	**1000**
MC Equation (4.7)	103	431	841
ITE 4th Edition	110	482	912
ITE 3rd Edition	100	500	1000

Source: Douglas & Douglas, Inc.

Figure 8.4: Suggested Trip Generation Equations for Single Family Detached Housing (ITE 210): Generator PM Peak



Source: Douglas & Douglas, Inc.

subdivisions, use of the Montgomery County equations will produce slightly higher results than would be obtained using the ITE 4th Edition equations.

8.7.2 *Apartment Trip End Estimates*

ITE's Land Use Category 220, "Apartments," includes garden apartments, townhouses, low-rise, mid-rise and high-rise apartments--virtually all types of multi-family dwelling units. For any given survey the average number of trips estimated will depend on the proportion of each type of multi-family dwelling units included in the sample. As a result, we could expect wide variation in the number of trips from surveys in other jurisdictions because of the differences in the proportions of high and low-rise facilities. We recommend not using this category for development review purposes. If the type of multi-family housing is not specified in the site plan, we suggest using the equations for Low-Rise Apartments and Townhouses.

8.7.3 *Low-Rise Apartment and Townhouse Trip End Estimates*

Preliminary findings in this study indicated that we should include townhouses with low-rise apartments to form one category (see Section 7.7.5 for reasons). This Montgomery County-specific category includes townhouses and low-rise apartments in buildings with one to four stories. Comparisons of the average rates derived from Montgomery County data may be seen in Figures 7.23 and 7.24. It is clear from these figures that the townhouse developments in this study exhibit trip end characteristics typical of other low-rise and garden apartment facilities rather than the much higher rates exhibited by single-family detached housing. These statistics support the hypothesis that Montgomery County townhouses typically contain smaller households and perhaps fewer drivers than single-family detached housing.

The suggested trip estimating equations which are shown in Table 8.5 and in Figure 8.5 were derived from Montgomery County data. The ITE 4th Edition did not have trip estimating equations but instead supplied a trip rate. No adjustments for other factors are proposed.

Use of the new Montgomery County equations will result in trip estimates just slightly lower than ITE 4th Edition morning and afternoon peak hour estimates for smaller complexes with up to 200 dwelling units. In complexes with more than 200 dwelling units, the Montgomery County equations estimate fewer (10-30%) trip ends than the ITE 4th Edition equations.

8.7.4 *High-Rise Apartment Trip End Estimates*

For purposes of development approval, this category includes apartments and condominiums in buildings with five or more floors. The suggested trip generation equations were derived from Montgomery County data using the procedures outlined in Section 8.2.2. They are shown in Table 8.6 and Figure 8.6. Recall from Chapter 7 that the ITE equations for high-rise apartments gave average trip estimates which were very close to those produced by the Montgomery County

Table 8.5
Suggested Trip Generation Equations
LOW-RISE APARTMENTS (ITE 221)
TOWNHOUSES (ITE 230)

I SUGGESTED EQUATIONS (Peak Hour of Generator)

A. AM Peak Hour on a Weekday

(4.19) T=0.40(X)+3 R^2=0.798
In/Out Percentages: 24% Enter, 76% Exit

PM Peak Hour on a Weekday

(4.23) T=0.47(X)+1 R^2=0.759
In/Out Percentages: 59% Enter, 41% Exit

B. For Secondary Impact Assessment

AM Peak Hour on a Weekday
(4.20) T=0.40(X)+37

PM Peak Hour on a Weekday

(4.24) T=0.47(X)+46

Where: T = 2-way Trip Ends
X = Number of Occupied Dwelling Units

II ADJUSTMENTS: None

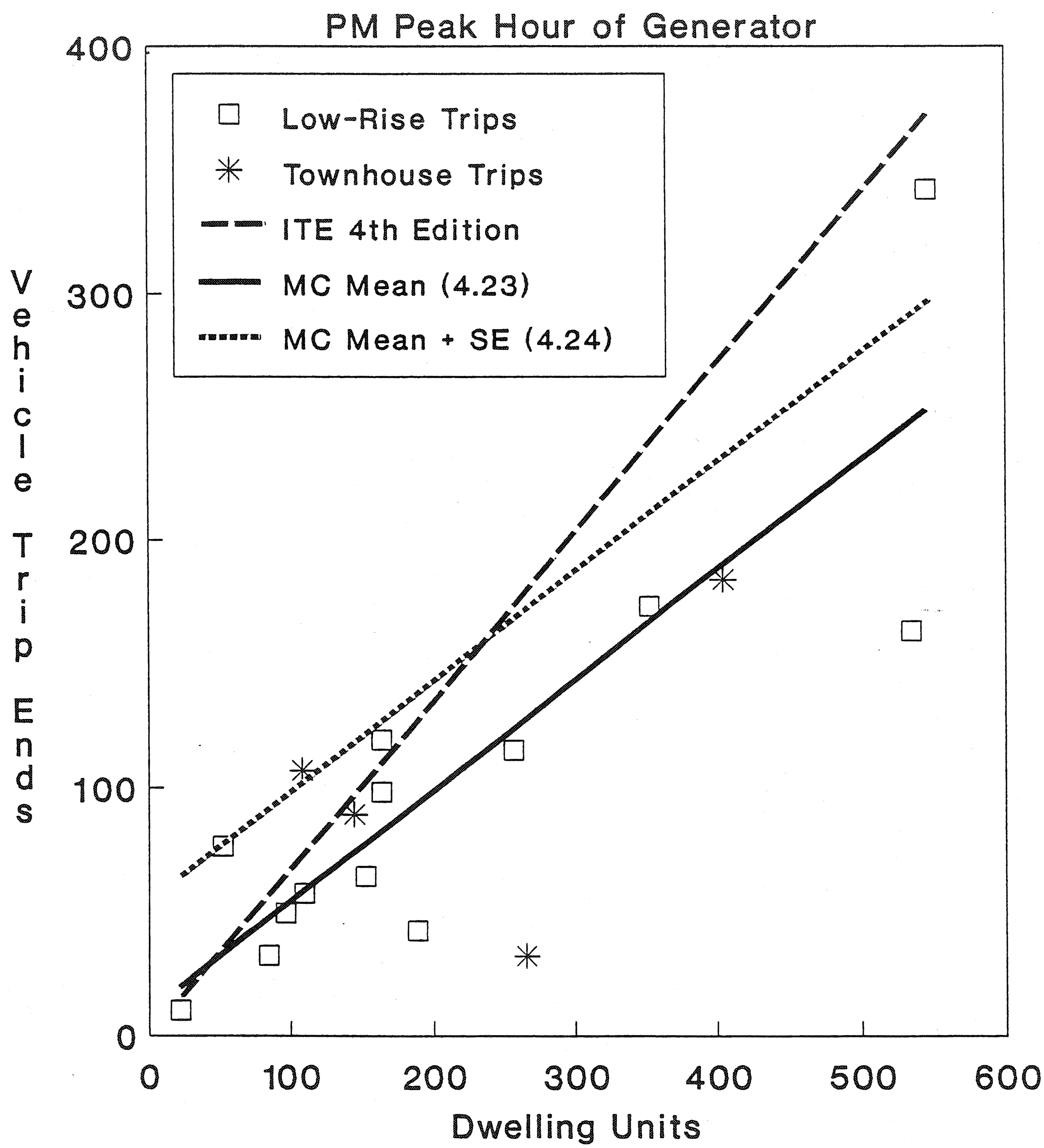
III COMPARISON OF TRIP END ESTIMATES

	Occupied Dwelling Units		
AM Peak Hour Trip Ends	**100**	**250**	**500**
MC Equation (4.19)	43	103	203
ITE 4th Edition	56	141	282
ITE 3rd Edition	60	150	300

	Occupied Dwelling Units		
PM Peak Hour Trip Ends	**100**	**250**	**500**
MC Equation (4.23)	48	119	236
ITE 4th Edition	68	170	341
ITE 3rd Edition	70	175	350

Source Douglas & Douglas, Inc.

Figure 8.5 Suggested Equations for LOW-RISE APARTMENT (ITE 221) TOWNHOUSE (ITE 230)



Source: Douglas & Douglas, Inc.

Table 8.6
Suggested Trip Generation Equations
HIGH-RISE APARTMENT (ITE 222)

I SUGGESTED EQUATIONS (Peak Hour of Generator)

A. AM Peak Hour on a Weekday

(4.27) T=0.29(X)+11 R^2=0.877
In/Out Percentages: 25% Enter, 75% Exit.

PM Peak Hour on a Weekday

(4.31) T=0.34(X)+12 R^2=0.921
In/Out Percentages: 62% Enter, 38% Exit.

B. For Secondary Impact Assessment

AM Peak Hour on a Weekday
(4.28) T=0.29(X)+37

PM Peak Hour on a Weekday

(4.32) T=0.34(X)+37

Where: T = 2-way Trip Ends
X = Number of Occupied Dwelling Units

II ADJUSTMENTS: None.

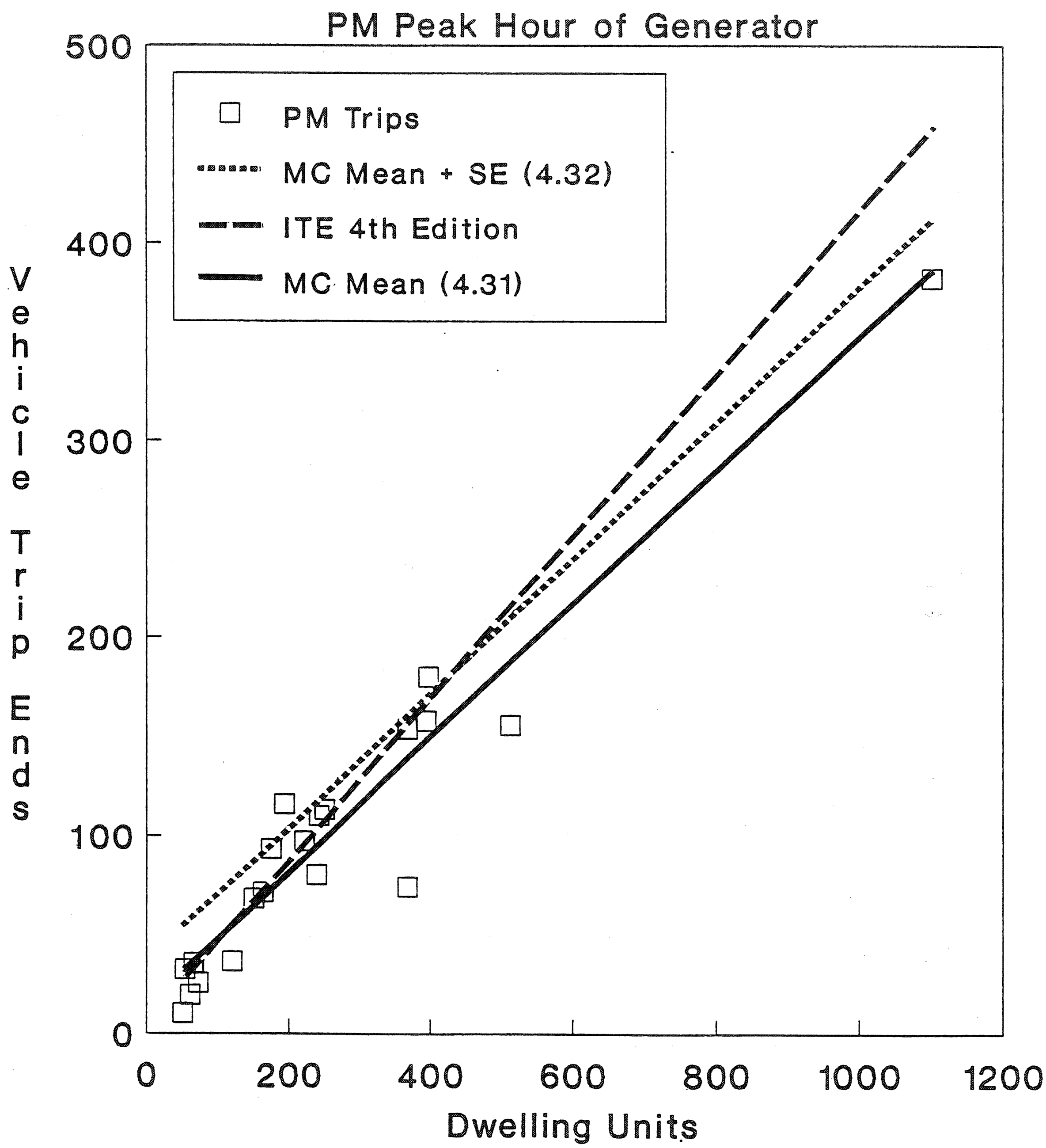
III COMPARISON OF TRIP END ESTIMATES

	Occupied Dwelling Units		
AM Peak Hour Trip Ends	**200**	**500**	**1000**
MC Equation (4.27)	69	156	301
ITE 4th Edition	70	159	274
ITE 3rd Edition	60	150	300

	Occupied Dwelling Units		
PM Peak Hour Trip Ends	**200**	**500**	**1000**
MC Equation (4.31)	80	182	352
ITE 4th Edition	89	212	417
ITE 3rd Edition	80	200	400

Source: Douglas & Douglas, Inc.

Figure 8.6
Suggested Trip Generation Equations for HIGH-RISE APARTMENT (ITE 222)



Source: Douglas & Douglas, Inc.

based linear equations. The data from Montgomery County did not support the non-linear model chosen by ITE (see Figure 7.19b). This led to the choice of the Montgomery County equations as the basis for high-rise apartment trip estimates.

No adjustments to the basic trip end equation results are suggested.

Using Montgomery County equations for the morning peak will give slightly higher trip estimates (by up to 10%) for large complexes than using the ITE 4th Edition equations. In the afternoon peak hour the Montgomery County equations give slightly lower results. Using Montgomery County equations will give slightly lower estimates than will the ITE 4th Edition equations--on the order of 10% to 15% lower (See Figure 8.6). This appears to be in keeping with a trend toward smaller households in multi-family dwelling units.

8.8 CONCLUSIONS

As a result of this study, Montgomery County has a set of trip generation equations which reflect current conditions within it and which thus better serve its land development and transportation planning needs than do the ITE 4th Edition equations. Our data have clearly shown that trips associated with the different land use categories can vary significantly from the national trip estimates as determined by the ITE. Additionally, use of the suggested procedures and equations developed from the Montgomery County data explicitly acknowledges the variation among sites in the same land use category and makes allowances for the risk of underestimating the expected traffic from a particular site through the use of the secondary impact test for large developments.

While we may have pursued a prudent and somewhat conservative course, the results are not uniformly more conservative than using the nationwide ITE rates. Indeed, in many of the land use categories, the rates derived from Montgomery County data result in lower estimates of traffic. In many cases, these lower traffic estimates may be translated into more development being staged at an earlier point in time. At the same time these new equations allocate the responsibility for increased traffic volumes to those land uses which seemingly generate more traffic. As a consequence, we believe these equations and application procedures to be more equitable than those used heretofore and to be necessary elements in the processes of regulating land development and planning for the provision of infrastructure.

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GLOSSARY

ADEQUATE PUBLIC FACILITIES ORDINANCE: In Montgomery County, this is defined as an element of the Subdivision Ordinance which requires the Planning Board to verify that existing or programmed public facilities are adequate before they can approve a preliminary plan of subdivision. Compliance with this ordinance is therefore an integral part of the development review process.

ADJACENT STREET PEAK*: The hour of the highest volume of traffic passing the site on adjacent streets. It is typically between 7 and 9 AM (the morning peak) and between 4 and 6 PM (the afternoon peak).

AVERAGE DAILY TRAFFIC (ADT): The average number of vehicles passing a specific point in a 24-hour period.

AVERAGE TRIP RATE*: A weighted average of the number of trips or trip ends per unit of an appropriate development characteristic (for example, trip ends per dwelling unit or per employee). The average rate is calculated by summing all trips (or trip ends) and all the units of the appropriate development characteristic (dwelling units or employees, say) where paired data are available, and then by dividing the resulting sum of trips by the sum of the characteristics. (This is a weighted average trip rate. An unweighted average trip rate would be calculated by summing the trip rates of all the individual sites and dividing this by the total number of sites.)

CALIBRATION: The procedure used to estimate the parameters of an equation, or to adjust an equation so that it replicates conditions actually measured. The term encompasses any technique which might be used to improve or construct an equation, including trial and error.

CAPACITY: The maximum number of vehicles and/or people that can be carried past a point on a transportation system in a specified time, at a specified level of service. One might express capacity as, for example, vehicles per hour, or vehicles per lane per hour.

CAPACITY ANALYSIS: An analysis to estimate the maximum amount of patronage or use that a point or segment within a transportation system can accommodate over a given period of time and at specific service levels.

CORRELATION: A mutual or reciprocal relationship between two or more variables such that, as one changes, the other(s) changes also in a systematic and predictable fashion. If, as the level of one variable increases (decreases), the level of the other(s) increases (decreases), then we say that there is a positive or direct correlation. If the levels of the variables shift in opposite directions, we can say that there is a negative or inverse correlation.

COUNT: The process of determining traffic volumes by counting vehicles either on a street, or entering and exiting a site. In this study, we counted the total number of vehicles entering and leaving a site in both the morning and the afternoon peak periods of weekdays.

DEPENDENT VARIABLE: Normally represented by the letter "Y," this is a variable whose value is defined as being a function of, or dependent upon, the value of another, independent, variable (commonly represented by "X"). When the dependence of Y upon X is linear, we can write: $\mathbf{Y = a + bX}$ (where "a" is the value of Y when X equals zero and "b" is the effect of a unit of X on Y). In this study, we treated trip generation rates and trip volumes as dependent variables whose value was determined by the characteristics of a site and its tenants and patrons.

DESTINATION: The location of the end of a trip, or the zone in which the trip ends.

DIVERTED TRIPS: Trips between an origin and a destination may include a change in routing to reach one or more intermediate points (for example, stores and restaurants) in a linked trip. From the vantage point of these intermediate sites, such trips are referred to as Diverted Trips. (See also Pass-by Trips and Primary Trips.)

DIVISION (OF MONTGOMERY COUNTY): As part of this study, the territory of Montgomery County was subdivided into four divisions corresponding roughly to the different levels of urbanization and development activity from one part of the County to another. These divisions, which are groupings of Planning Areas, are: Up-County, Mid-County, Down-County, and Eastern Montgomery County.

DWELLING UNIT (DU): A house, apartment, townhouse, mobile home, group of rooms, or single room that is occupied as separate living quarters. Separate living quarters are defined as those in which the occupants live and eat together. These units have direct access from the outside of a building, or through a common hall.

GENERAL OFFICE: This is an office building which houses one or more tenants and is the place where the affairs of a business, commercial or industrial organization, professional person or firm are conducted. If the building contains a mixture of tenants, these may include professional services, insurance companies, investment brokers, company headquarters, banks, and services for the tenants such as retail facilities and a cafeteria. Every office building surveyed as part of this research was a general office building. (The above definition is a paraphrased version of that presented by ITE in the 4th edition of the Trip Generation report.)

GENERATOR (TRAFFIC GENERATOR): Any facility or land use which induces traffic. In this study, each site at which a traffic count was taken constituted a single traffic generator. Thus, we implicitly regarded every shopping center, fast food restaurant, general office site, and residential subdivision surveyed as an individual traffic generator.

GENERATOR PEAK HOUR*: The generator peak hour of a given site is the hour at which the highest volume of traffic enters and exits the site. There are usually two peak hours over the course of a day - one in the morning (AM) and one in the afternoon (PM). The generator peak hour may or may not coincide with the adjacent street peak hour. If it does not, the generator and adjacent street peak hour traffic volumes at a given site will not be equal.

GOODNESS-OF-FIT: This term refers to how well a line generated by least squares methods describes a set of points on a graph. One of the most commonly used measures of goodness-of-fit is the R or "proportion explained" statistic.

GROSS LEASABLE AREA (GLA):** The total floor area of a building designed for tenant occupancy and exclusive use, including any basements, hallways, mezzanines, and upper floors. The GLA is expressed in terms of square feet and is measured from the centerline of joint partitions and from outside wall faces.

HOUSEHOLD: One person or a group of persons occupying a dwelling unit.

INDEPENDENT VARIABLE*: A variable (normally represented by X) whose value is held to determine the value of a dependent variable (Y). A linear form of this relationship is written: **Y = a + bX**. In this study, independent variables are defined as the characteristics of sites which are assumed to influence (directly or indirectly) the levels of traffic generated by the sites (the dependent variables). Examples include building floor area, employment levels, restaurant seats, and house values.

ITE--THE INSTITUTE OF TRANSPORTATION ENGINEERS: A national professional organization concerned with transportation planning and engineering. It publishes Trip Generation (the fourth edition was published in 1987), a report which attempts to standardize trip generation rates used nationwide for the purposes of estimating the traffic likely to be induced by new development.

LAND USE: The purpose for which land, or the structures occupying the land, is used. In this study, we are concerned with four land uses: general offices, shopping centers, residential uses, and fast food restaurants.

LEAST SQUARES METHODS: A mathematical tool which allows one to determine the line which best describes a set of data points plotted on a graph. It works by so positioning the line that the sum of the squared deviations of the data points from the line is minimized. The line is normally given in the linear form: **Y = a + bX**, where Y (the dependent variable) and X (the independent variable) are scaled along the two axes of the graph.

MARYLAND-NATIONAL CAPITAL PARK AND PLANNING COMMISSION (M-NCPPC): The sponsors of this study. M-NCPPC has responsibility for area planning and for subdivision approvals connected with new development in Montgomery and Prince George's Counties, Maryland.

MEAN: The sum of a set of measurements (items) divided by the number of measurements in the set. Identical with the term "average," a mean is a number that is taken to be representative of a set of numbers. It is that number for which the sum of squared deviations of the individual measurements about it is minimized.

MEDIAN: The middle measurement in a series of measurements which has been arranged in ascending order. If the number of measurements is even, the median is interpolated between the middle numbers of the set. The median is less sensitive to "outliers" (extremely atypical numbers) in the data set than is the mean, and has the property that the sum of deviations of the individual measurements in the set about it is minimized.

MODAL SPLIT: The division of person trips between the various modes of public and private transportation.

MODE OF TRAVEL: The means of travel between various points. Examples include driving by automobile, being an auto passenger, riding on the mass transit system, being a pedestrian, or riding a bicycle.

NET REGRESSION COEFFICIENT: The 'b' term which appears in the linear equation: $\mathbf{Y = a + bX}$. It indicates the magnitude of a change in Y (in units of Y) that follows from a one unit change in X.

OCCUPIED GROSS SQUARE FEET: This is the gross square footage of a building minus the vacant leasable square footage. Thus, it represents the amount of space in a building that is currently "in use," irrespective of whether it is leasable space or not and includes space let to individual tenants and that used in common by all, such as rest rooms, hallways and entrance foyers. It does not include parking garages or boiler rooms.

ORIGIN: The location of the beginning of a trip, or the zone in which the trip begins.

PASS-BY TRIPS: Trips to a specific site made by vehicles on a longer journey such that had the vehicles not called at the site, they would have nonetheless passed by on the adjacent street or highway. (See also Diverted Trips and Primary Trips.)

PEAK HOUR: The one-hour period during which the maximum amount of travel over some longer time period occurs. It can refer to the hour that sees the maximum level of traffic over a 24-hour period, but usually (as in this study) we are concerned with both a morning and an afternoon peak hour.

PEAK PERIOD: The two (or more) consecutive hours which collectively contain the maximum amount of travel over a longer time period. As is the case with respect to Peak Hours, we normally refer to both a morning (AM) and an afternoon (PM) peak period. In Montgomery County, the peak periods occur on weekdays from 7 AM to 9 AM in the morning and from 4 PM to 6 PM in the afternoon.

PERSON TRIP: A trip made by a person for any purpose and using any mode of transport.

POPULATION: The total set of items or observations from which samples are drawn. In this study, the populations were the total set of office buildings, shopping centers, fast food restaurants, and residential sites in Montgomery County that satisfied the various criteria relating to size and so forth. Thus, any of the items in the population could have been drawn into our sample, though only a certain number were actually picked by the random selection process.

PRIMARY TRIPS: A trip for which the site under consideration is either the origin or the destination.

REGRESSION: A mathematical procedure which utilizes least squares methods to determine the optimal structure of a relationship between one dependent variable (Y) and one or more independent variables (X). This optimal structure is most commonly given in linear form: **Y = a + bX**, in which the values of the parameters "a" and "b" are set so that the expected error involved in estimating the dependent variable given the value of the independent variable is minimized.

R^2 (PROPORTION EXPLAINED): The proportion of the variation in the dependent variable about its mean that can be linked to the variation in the independent variable(s) about its mean by the application of the least squares method. A value of R^2 of 0.9 (or 90 percent) tells us that the variation in the independent variable (X) is an extremely good guide to the variation in the dependent variable (Y). An R^2 value of 0.1 (10 percent), however, indicates that X is a rather weak predictor of Y.

SAMPLE: A subset of items or observations drawn from a larger population of the same items or observations. The process of selecting members of the subset from the larger population is designed so that the mean and distribution of items in the subset are as close as possible to those of the items in the larger population. In this way, conclusions about the behavior and effects of the subset of items can be reliably extrapolated to the level of the larger population. For our research, we took samples (or subsets) of sites (residential, fast food restaurant, etc.) from the larger populations of all such sites in Montgomery County with the expectation that analyses of these subsets would yield conclusions valid even for those sites not surveyed.

STANDARD DEVIATION: A common measure of the variability of a set of numbers about their mean. It is not quite the average deviation from the mean of the set, but is conceptually close to this. It is the square root of the variance of the set; the variance is the average squared deviation from the mean. When the numbers in the set are normally distributed, 68.26 percent of them lie within one standard deviation of the mean

STANDARD ERROR: Conceptually related to the Standard Deviation, this measures the random variation of sample statistics around the parameter for the whole population that they estimate. There are standard errors for means, medians, and net regression coefficients. Generally, the standard error falls as the sample size rises. When there are more than about 25 observations in a sample, there is a 68 percent chance that the sample statistics are within one standard error of the "true" parameter values, and a 95 percent chance that they are within two standard errors.

STANDARD ERROR OF ESTIMATE: As the Standard Deviation describes the variation of a set of observations about their mean, the standard error of the estimate describes the variation of data points on a graph about a line which purports to summarize their distribution. The regression line generated by the Least Squares Method has the property that its standard error of estimate is the lowest of any straight line which may conceivably be drawn to summarize graphed data. The value of the standard error of estimate is based on the differences between the actual and the predicted (by regression techniques) values of the dependent variable for given levels of the independent variable.

STEPWISE REGRESSION: The development of a regression equation by the addition, one at a time, of independent variables. The independent variable selected for inclusion at each iteration is the one that causes the greatest reduction in standard error of estimate within the critical limits specified by the analyst.

STRATIFIED SAMPLE: A sample in which the population from which it is drawn has been divided into groups and in which the sample items have been randomly selected from each group equally. It can be contrasted with a conventional sample which is drawn randomly from the whole population. The value of a stratified sample is that it allows us to weight the composition of our sample toward groups within the population that are of particular interest but which account for only a small proportion of the total population.

TRIP*: A single or one-direction vehicle movement such that either the origin (exit) or the destination (enter) occur at the site under consideration.

TRIP ENDS*: The total number of all trips entering and leaving a site, or land use type, over a given period of time.

TRIP GENERATION: The process of estimating the volume of traffic induced by a site containing a traffic generator.

TRIP PURPOSE: The reason for making a trip. An example might be commuting from home to work.

WALKSHED: The area surrounding a transit station or stop that is within acceptable walking distance of it. The size and shape of the walkshed will vary, obviously, but in this study we defined it as a circular area around the transit facility with a radius of 2500 feet.

VOLUME: The number of vehicles passing a given point per unit of time. It is normally expressed in vehicles per hour (vph).

*Institute of Transportation Engineers (1987): Trip Generation.

**Urban Land Institute (1984): Dollars and Cents of Shopping Centers.

APPENDIX A

DETAILED TRIP GENERATION STUDY STATISTICS

TABLE A.1

LIST OF PLANNING AREAS

PLANNING AREA	NAME
10	BENNETT AND LITTLE BENNETT WATERSHED
11	DAMASCUS & VICINITY
12	LITTLE MONOCACY BASIN/ DICKERSON-BARNESVILLE
13	CLARKSBURG & VICINITY
14	GOSHEN, WOODFIELD, CEDAR GROVE & VICINITY
15	PATUXENT WATERSHED CONSERVATION AREA
16	MARTINSBURG & VICINITY
17	POOLESVILLE & VICINITY
18	LOWER SENECA BASIN - PARTS ONE, TWO, THREE
19	GERMANTOWN & VICINITY
20	GAITHERSBURG VICINITY
21	GAITHERSBURG
22	UPPER ROCK CREEK WATERSHED
23	OLNEY & VICINITY
24	DARNESTOWN & VICINITY
25	TRAVILAH & VICINITY
26	ROCKVILLE
27	ASPEN HILL & VICINITY
28	CLOVERLY/ NORWOOD
29	POTOMAC/ CABIN JOHN & VICINITY
30	NORTH BETHESDA
31	KENSINGTON/ WHEATON
32	KEMP MILL/ FOUR CORNERS & VICINITY
33	COLESVILLE/ WHITE OAK & VICINITY
34	FAIRLAND/ BELTSVILLE & VICINITY
35	BETHESDA/ CHEVY CHASE & VICINITY
36	SILVER SPRING & VICINITY
37	TAKOMA PARK

TABLE A.2

LIST OF OFFICE BUILDING SITES

SITE NO.	PLAN AREA	NAME	NUMBER	STREET NAME	CITY	SURVEYS	NO.	DATE
004	22	METRO PARK NORTH I A-D&H		STANDISH PLACE	ROCKVILLE	1	33	06-Nov-86
008	34	THE HARKINS GROUP	12301	OLD COLUMBIA	SILVER SPRING	1	126	27-May-87
010	21	DANAC OFFICE PARK I # 2	2098	GAITHER RD.	ROCKVILLE	1	42	18-Nov-86
012	20	CESSNA AVE IND PARK	7821	CESSNA AVE. (7821-7865)	GAITHERSBURG	1	89	05-May-87
015	21	AVENEL BUSINESS PK PH II	209	PERRY PKWY (-213)	GAITHERSBURG	1	37	13-Nov-86
016	33	ADVENTIST HOME CARE BLDG	10800	LOCKWOOD DR.	SILVER SPRING	1	118	21-May-87
021	26	TWELVE OAKS OFF PK BLDG C	1450	RESEARCH BLVD.	ROCKVILLE	1	70	10-Dec-86
028	21	LADDS CO. BLDG	9121-5	GAITHER RD	GAITHERSBURG	1	132	28-May-87
029	34	TECH PARK 29	12144	TECH RD.	SILVER SPRING	1	129	27-May-87
030	21	DANAC OFFICE PARK I # 1	2092	GAITHER RD.	ROCKVILLE	1	42	18-Nov-86
031	20	RIDDLE AIRPARK CENTER	7618	AIRPARK RD	GAITHERSBURG	1	78	28-Apr-87
033	31	KENSINGTON PROF. CENTER	3750	UNIVERSITY BLVD.	KENSINGTON	1	101	12-May-87
038	26	RESEARCH I	2401	RESEARCH BLVD.	ROCKVILLE	1	96	07-May-87
040	22	METRO PARK NORTH II B & C	7500	-STANDISH PLACE (7690)	ROCKVILLE	1	33	06-Nov-86
045	21	IBM	15	FIRSTFIELD RD	GAITHERSBURG	1	51	01-Dec-86
053	22	METRO PK. N. II A&D		STANDISH PLACE	ROCKVILLE	1	33	06-Nov-86
061	22	METRO PK. N. I E-G, I-J		STANDISH PLACE	ROCKVILLE	1	33	06-Nov-86
062	21	DANAC OFFICE PARK I # 3	2096	GAITHER RD.	ROCKVILLE	1	42	18-Nov-86
103	21	AVENEL BUSINESS PK PH I	201	PERRY PKWY (-207)	GAITHERSBURG	1	37	13-Nov-86
107	26	TWELVE OAKS OFF PK BLDG B	1500	RESEARCH BLVD.	ROCKVILLE	1	70	10-Dec-86
127	26	TWELVE OAKS OFF PK BLDG A	1550	RESEARCH BLVD.	ROCKVILLE	1	70	10-Dec-86
202	20	SHADY GROVE WEST	15200	SHADY GROVE RD.	ROCKVILLE	1	71	11-Dec-86
203	26	GENERAL MOTORS	1395	PICCARD DRIVE	ROCKVILLE	1	40	17-Nov-86
204	20	OAKMONT CENTER	?	OAKMONT AVE	GAITHERSBURG	1	133	28-May-87
205	19	CENTURY 21 COMPLEX	20010	CENTURY BLVD. (-30)	GERMANTOWN	1	86	30-Apr-87
207	26	HARRIS BLDG.	1370	PICCARD DRIVE	ROCKVILLE	3	1	30-Sep-86
							4	08-Oct-86
							27	03-Nov-86
208	26	BANNER LIFE BLDG.	1701	RESEARCH BLVD.	ROCKVILLE	1	64	09-Dec-86
210	26	E G & G	1396	PICCARD DRIVE	ROCKVILLE	1	97	07-May-87
211	33	BEST WESTERN	10770	COLUMBIA PIKE	SILVER SPRING	1	25	29-Oct-86
217	21	SENECA ONE	200	PROFESSIONAL DR.	GAITHERSBURG	1	90	06-May-87
218	22	WEST GUDE-BLDG. 3	2040	W. GUDE DR.	ROCKVILLE	1	134	28-May-87
219	21	SPACECOM BUILDING	1300	QUINCE ORCHARD BLVD.	GAITHERSBURG	1	49	24-Nov-86
220	33	QUALITY INN INT.	10750	COLUMBIA PIKE	SILVER SPRING	1	25	29-Oct-86
221	26	NCR	2301	RESEARCH BLVD.	ROCKVILLE	1	46	25-Nov-86
224	29	PHILLIPS PUBLISHING BLDG	7811	MONTROSE ROAD	ROCKVILLE	1	139	03-Jun-87
225	21	TECH PARK 270 PH. II	900	CLOPPER RD.	GAITHERSBURG	1	45	24-Nov-86
230	20	BNA	9401	DECOVERLY HALL RD.	GAITHERSBURG	2	141	03-Jun-87
							144	09-Jun-87
235	26	WARD BLDG.	1300	PICCARD DRIVE	ROCKVILLE	1	28	03-Oct-86
241	26	TRACOR	1601	RESEARCH BLVD.	ROCKVILLE	1	65	09-Dec-86
248	21	WATKINS-JOHNSON	704	QUINCE ORCHARD RD.	GAITHERSBURG	2	3	02-Oct-86
							50	02-Dec-86
253	33	NO NAME	10720	COLUMBIA PIKE	SILVER SPRING	1	25	29-Oct-86
275	20	OAK GROVE CENTER	15825	SHADY GROVE RD.	ROCKVILLE	1	12	09-Oct-86
277	26	FOUR RESEARCH PLACE	4	RESEARCH PLACE	ROCKVILLE	1	47	25-Nov-86

TABLE A.2 (CONT.)

LIST OF OFFICE BUILDING SITES

SITE NO.	PLAN AREA	NAME	NUMBER	STREET NAME	CITY	SURVEYS	NO.	DATE
278	21	DANAC OFFICE PARK I # 4	2094	GAITHER RD.	ROCKVILLE	1	42	18-Nov-86
302	26	AMERICAN SATELLITE	1801	RESEARCH BLVD. (-03)	ROCKVILLE	1	61	09-Dec-86
304	30	ENERGY BLDG.	6011	EXECUTIVE BLVD.	ROCKVILLE	1	138	03-Jun-87
305	26	JEFFERSON PLAZA I	600	E. JEFFERSON ST.	ROCKVILLE	1	143	04-Jun-87
306	26	STSC INC.	2115	E. JEFFERSON ST.	NORTH BETHESDA	1	30	05-Nov-86
307	30	WILLCO BLDG.	6000	EXECUTIVE BLVD.	NORTH BETHESDA	1	26	30-Oct-86
308	26	RESEARCH BLVD. CENTER II	1803	RESEARCH BLVD.	ROCKVILLE	1	61	09-Dec-86
310	30	N.O.A.A.	6001	EXECUTIVE BLVD. (6015)	ROCKVILLE	1	138	03-Jun-87
311	26	COMMERCE CTR 270	1700	RESEARCH BLVD.	ROCKVILLE	1	63	09-Dec-86
312	21	NUS CORPORATION	910	CLOPPER RD.	GAITHERSBURG	1	45	24-Nov-86
313	30	CONTROL DATA BLDG.	6003	EXECUTIVE BLVD.	ROCKVILLE	1	138	03-Jun-87
314	20	RESEARCH OFFICE CTR. I	2277	RESEARCH BLVD.	ROCKVILLE	1	69	11-Dec-86
315	35	CHEVY CHASE LAKE BLDG	8401	CONNECTICUT AVE	CHEVY CHASE	2	115	14-May-87
							155	13-May-87
317	30	ADP CORP.	6006	EXECUTIVE BLVD.	ROCKVILLE	1	147	09-Jun-87
318	30	IBM	6600	ROCKLEDGE DR.	BETHESDA	1	7	02-Oct-86
320	22	METRO PARK NORTH	7501-	STANDISH PLACE (7684)	ROCKVILLE	1	32	06-Nov-86
321	26	WEST-X	1375	PICCARD DRIVE	ROCKVILLE	1	98	07-May-87
327	21	MONTGOMERY EXECUTIVE CTR.	6	MONTGOMERY VILLAGE AVE	GAITHERSBURG	1	93	06-May-87
328	26	CDSI BLDG.	1	CURIE COURT	ROCKVILLE	1	41	13-Nov-86
329	26	WILMOTT BOWER	1350	PICCARD DRIVE	ROCKVILLE	1	14	16-Oct-86
330	19	FAIRCHILD INDUS.	20301	CENTURY BLVD	GERMANTOWN	1	85	30-Apr-87
334	26	PLAZA 270 OFF. CTR.	1600	RESEARCH BLVD. (-50)	ROCKVILLE	1	62	09-Dec-86
335	26	GILLETTE RESEARCH	1413	RESEARCH BLVD.	ROCKVILLE	1	145	09-Jun-87
349	30	ROCKLEDGE EXEC. PLAZA II	6610	ROCKLEDGE DR.	NORTH BETHESDA	1	7	02-Oct-86
352	30	(VACANT)	6009	EXECUTIVE BLVD	ROCKVILLE	1	138	03-Jun-87
401	27	VITRO LABS	13900	CONNECTICUT AVE.	SILVER SPRING	1	24	30-Oct-86
402	19	M/A COM-DCC - CALL DDI	11717	EXPLORATION LANE	GERMANTOWN	1	34	12-Nov-86
403	30	DEMOCRACY CENTER I	6901	ROCKLEDGE DR.	NORTH BETHESDA	1	72	22-Apr-87
405	21	IBM BUILDING	18100	FREDERICK AVE.	GAITHERSBURG	1	39	12-Nov-86
406	30	IBM BUILDING	10401	FERNWOOD RD.	BETHESDA	1	55	04-Dec-86
407	30	DEMOCRACY CENTER II	6903	ROCKLEDGE DR.	NORTH BETHESDA	1	72	22-Apr-87
408	30	EXECUTIVE PLAZA SOUTH	6120	EXECUTIVE BLVD.	NORTH BETHESDA	1	148	09-Jun-87
410	30	MARRIOT BUILDING	10400	FERNWOOD ROAD	BETHESDA	1	146	09-Jun-87
411	34	C & P BUILDING	11920	TECH ROAD	SILVER SPRING	1	43	19-Nov-86
412	30	MARTIN MARIETTA	6801	ROCKLEDGE DR.	BETHESDA	1	56	04-Dec-86
413	30	ONE & TWO ROCKLEDGE CTR.	6701-5	ROCKLEDGE DR.	NORTH BETHESDA	1	73	22-Apr-87

TABLE A.3

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY FOR AM & PM PEAK HOUR ON ADJACENT STREET
GROUPED BY SIZE OF SITE

					AM					PM				
SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. IN	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
UNDER 100,000 G.S.F.				ITE CODE 711										
101	13500	100.0	93	27	0730	0.52	0.37	0.89	1.29	1700	0.59	1.26	1.85	1.29
78	16500	97.0	64	52	0730	1.94	1.50	3.44	1.13	1645	0.88	1.56	2.44	1.36
118	20000	50.0	71	106	0700	1.40	0.10	1.50	1.00	1700	1.40	3.00	4.40	1.10
51	29159	100.0	0	101	0730	1.89	0.27	2.16	1.05	1630	0.17	1.82	1.99	1.04
126	36000	100.0	146	139	0700	1.08	0.28	1.36	1.08	1630	2.50	2.75	5.25	1.09
132	39725	81.9	108	212	N/A	N/A	N/A	N/A	N/A	1630	1.05	1.60	2.64	1.25
97	48000	100.0	195	178	0800	1.65	0.25	1.90	1.05	1630	0.52	1.79	2.31	1.19
147	48000	100.0	380	257	0800	2.50	0.31	2.81	1.10	1730	0.46	2.04	2.50	1.05
40	54162	100.0	187	200	0800	0.55	0.17	0.72	1.10	1630	0.13	1.33	1.46	1.15
89	60000	100.0	113	130	0730	0.98	0.67	1.65	1.17	1645	0.28	0.52	0.80	1.35
90	60000	100.0	215	225	0715	1.90	0.15	2.05	1.10	1700	0.13	1.80	1.93	1.09
134	65000	100.0	205	215	0800	1.91	0.82	2.72	1.09	1700	0.97	1.85	2.82	1.12
49	77939	100.0	200	208	0730	1.87	0.08	1.95	1.03	1630	0.15	1.45	1.60	1.03
47	78786	100.0	207	266	0730	1.70	0.18	1.88	1.24	1630	0.25	1.16	1.41	1.03
133	79800	100.0	131	148	0800	0.55	0.23	0.78	1.16	1700	0.21	0.71	0.93	1.28
12	80025	100.0	291	343	0730	1.07	0.14	1.21	1.17	1630	0.27	1.15	1.42	1.15
28	97262	100.0	298	272	0800	1.15	0.28	1.43	1.06	1630	0.10	0.90	1.01	1.06
139	98618	94.3	309	323	0800	1.11	0.06	1.17	1.06	1645	0.11	1.01	1.12	1.22
AVERAGE	55693	97.7				1.37	0.28	1.65	1.10		0.41	1.35	1.76	1.13
100,000 - 199,999 G.S.F.				ITE CODE 712										
63	102940	100.0	443	353	0730	1.59	0.13	1.72	1.14	1700	0.05	1.28	1.33	1.11
64	105760	100.0	240	420	0730	1.41	0.10	1.51	1.12	1700	0.19	1.37	1.56	1.17
14	107000	100.0	186	332	0800	0.96	0.11	1.07	1.04	1630	0.43	0.46	0.89	1.16
141	110000	54.5	180	238	0730	1.88	0.48	2.37	1.18	N/A	N/A	N/A	N/A	N/A
144	110000	54.5	180	238	0730	2.08	0.68	2.77	1.18	1700	0.05	0.72	0.77	1.09
98	112800	100.0	400	405	0800	0.81	0.12	0.92	1.07	1630	0.32	0.74	1.05	1.23
1	113482	96.7	288	266	0800	1.32	0.13	1.45	1.01	1630	0.32	0.99	1.31	1.08
4	113482	96.7	288	266	0800	1.33	0.14	1.47	1.05	1630	0.32	0.80	1.12	1.22
27	113482	96.7	300	266	0800	1.04	0.13	1.17	1.07	1630	0.35	1.08	1.43	1.18
93	120000	100.0	710	401	0745	2.45	0.20	2.65	1.09	1700	0.79	1.98	2.77	1.11
26	124431	100.0	299	364	0800	1.11	0.15	1.26	1.09	1700	0.20	0.97	1.17	1.13
70	128211	100.0	460	445	0730	1.81	0.16	1.97	1.09	1700	0.16	1.19	1.35	1.07
41	130260	100.0	300	436	0800	1.25	0.19	1.44	1.08	1630	0.45	1.21	1.65	1.20
30	148000	70.0	208	600	0730	0.54	0.08	0.62	1.05	1630	0.13	0.42	0.55	1.09
69	150000	100.0	450	503	0730	0.66	0.09	0.75	1.06	1700	0.05	0.84	0.89	1.11
62	160000	100.0	750	620	0730	1.28	0.09	1.37	1.05	1700	0.36	2.33	2.68	1.15
115	162568	100.0	473	212	0800	0.87	0.12	1.00	1.09	1700	0.20	0.72	0.92	1.11
155	162568	100.0	473	212	0800	1.02	0.14	1.16	1.08	N/A	N/A	N/A	N/A	N/A
3	165000	100.0	696	623	0730	0.62	0.04	0.66	1.06	1630	0.13	1.10	1.24	1.17
50	165000	100.0	696	623	0730	0.88	0.08	0.96	1.16	1630	0.12	0.92	1.03	1.08

TABLE A.3

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY FOR AM & PM PEAK HOUR ON ADJACENT STREET
GROUPED BY SIZE OF SITE

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
65	174000	100.0	650	800	0730	1.03	0.12	1.15	1.08	1700	0.06	0.84	0.90	1.05
86	175000	92.0	674	700	0800	1.70	0.23	1.93	1.16	1700	0.24	1.25	1.48	1.14
129	175600	100.0	314	409	0700	0.68	0.07	0.75	1.12	1630	0.17	0.55	0.72	1.09
AVERAGE	136069	94.6				1.17	0.14	1.31	1.09		0.24	1.05	1.28	1.13
200,000 G.S.F. AND OVER				ITE CODE 713										
46	200000	100.0	205	342	0730	0.69	0.08	0.77	1.09	1630	0.18	0.55	0.73	1.11
37	206120	96.1	0	824	0800	1.56	0.24	1.80	1.10	1700	0.14	1.45	1.59	1.15
42	214840	47.5	292	700	0700	1.65	0.15	1.79	1.10	1630	0.38	1.85	2.23	1.18
25	234850	85.2	600	509	0730	1.32	0.07	1.39	1.15	1700	0.17	1.68	1.85	1.17
61	255174	100.0	1000	1200	0730	1.29	0.12	1.40	1.09	1700	0.21	1.31	1.52	1.05
55	256000	100.0	600	1031	0730	1.14	0.12	1.25	1.10	1700	0.15	0.64	0.79	1.09
56	262000	100.0	550	524	0730	1.32	0.10	1.42	1.15	1700	0.31	0.44	0.75	1.15
45	263740	100.0	936	767	0700	0.77	0.06	0.83	1.12	1700	0.13	1.41	1.54	1.11
34	281000	78.0	838	984	0800	1.64	0.07	1.71	1.09	1700	0.10	1.49	1.59	1.12
7	333000	100.0	0	962	0730	1.11	0.15	1.26	1.08	1700	0.11	0.78	0.89	1.10
148	341278	39.9	546	1156	0800	1.30	0.06	1.36	1.08	1730	0.13	0.93	1.06	1.07
85	350000	100.0	1220	1350	0800	0.44	0.07	0.51	1.05	1700	0.07	0.53	0.60	1.09
138	420268	98.5	0	1100	0800	0.66	0.10	0.77	1.05	1700	0.07	0.58	0.65	1.12
32	449586	95.0	1144	1675	0730	1.07	0.22	1.28	1.13	1700	0.18	1.09	1.28	1.10
72	485000	98.8	816	1550	0730	0.70	0.02	0.72	1.06	1700	0.03	0.80	0.82	1.07
73	500984	94.2	1564	1750	0730	0.84	0.07	0.91	1.08	1700	0.10	0.86	0.96	1.09
39	508996	100.0	1900	1935	0745	1.25	0.19	1.44	1.06	1700	0.19	1.03	1.22	1.06
146	549000	100.0	3130	2500	0730	1.89	0.14	2.04	1.11	1630	0.25	1.33	1.58	1.13
43	730000	60.3	2000	1700	0730	2.43	0.15	2.57	1.12	1700	0.14	0.93	1.07	1.11
24	752000	78.0	2344	2100	0800	0.32	0.13	0.45	1.18	1700	0.09	0.58	0.67	1.02
AVERAGE	379692	87.6				1.13	0.12	1.25	1.10		0.14	0.95	1.09	1.10

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.4

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY FOR GENERATED AM & PM PEAK HOUR
GROUPED BY SIZE OF SITE

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL- OYEES	PARKING SPACES	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
UNDER 100,000 G.S.F.				ITE CODE 711										
101	13500	100.0	93	27	0830	1.85	0.15	2.00	1.24	1530	0.89	1.78	2.67	1.25
78	16500	97.0	64	52	0815	2.81	1.81	4.62	1.16	1600	1.31	2.44	3.75	1.13
118	20000	50.0	71	106	0800	3.20	0.80	4.00	1.09	1700	1.40	3.00	4.40	1.10
51	29159	100.0	0	101	0745	1.92	0.34	2.26	1.12	1615	0.14	2.06	2.19	1.10
126	36000	100.0	146	139	0830	1.94	0.69	2.64	1.14	1600	3.67	2.36	6.03	1.16
132	39725	81.9	108	212	0830	1.01	0.65	1.66	1.24	1600	1.05	1.66	2.71	1.17
97	48000	100.0	195	178	0745	2.02	0.27	2.29	1.09	1645	0.46	2.04	2.50	1.14
147	48000	100.0	380	257	0800	2.50	0.31	2.81	1.10	1700	0.48	2.40	2.88	1.04
40	54162	100.0	187	200	0715	1.53	0.15	1.68	1.10	1600	0.30	1.27	1.57	1.17
89	60000	100.0	113	130	0730	0.98	0.67	1.65	1.17	1600	0.52	0.55	1.07	1.24
90	60000	100.0	215	225	0730	2.23	0.13	2.37	1.09	1630	0.20	3.73	3.93	1.10
134	65000	100.0	205	215	0800	1.91	0.82	2.72	1.09	1700	0.97	1.85	2.82	1.12
49	77939	100.0	200	208	0730	1.87	0.08	1.95	1.03	1645	0.15	1.58	1.73	1.02
47	78786	100.0	207	266	0730	1.70	0.18	1.88	1.24	1545	0.51	1.62	2.13	1.07
133	79800	100.0	131	148	0830	0.54	0.30	0.84	1.16	1615	0.38	0.70	1.08	1.18
12	80025	100.0	291	343	0815	1.71	0.19	1.90	1.09	1645	0.26	1.44	1.70	1.15
28	97262	100.0	298	272	0745	1.13	0.37	1.50	1.11	1615	0.13	0.93	1.06	1.03
139	98618	94.3	309	323	0830	1.70	0.15	1.85	1.06	1715	0.15	1.19	1.34	1.19
AVERAGE	55693	97.7				1.64	0.35	1.99	1.11		0.52	1.61	2.13	1.11
100,000 - 199,999 G.S.F.				ITE CODE 712										
63	102940	100.0	443	353	0800	1.95	0.23	2.19	1.12	1630	0.08	1.55	1.63	1.12
64	105760	100.0	240	420	0730	1.41	0.10	1.51	1.12	1630	0.28	1.66	1.95	1.11
14	107000	100.0	186	332	0800	0.96	0.11	1.07	1.04	1700	0.48	0.50	0.97	1.09
141	110000	54.5	180	238	0745	1.92	0.48	2.40	1.17	N/A	N/A	N/A	N/A	N/A
144	110000	54.5	180	238	0730	2.08	0.68	2.77	1.18	1545	0.33	1.25	1.58	1.33
98	112800	100.0	400	405	0815	0.87	0.13	1.00	1.17	1630	0.32	0.74	1.05	1.23
1	113482	96.7	288	266	0800	1.32	0.13	1.45	1.01	1645	0.30	1.05	1.35	1.10
4	113482	96.7	288	266	0800	1.33	0.14	1.47	1.05	1630	0.32	0.80	1.12	1.22
27	113482	96.7	300	266	0745	1.21	0.15	1.37	1.07	1645	0.34	1.28	1.61	1.15
93	120000	100.0	710	401	0800	2.67	0.23	2.90	1.08	1700	0.79	1.98	2.77	1.11
26	124431	100.0	299	364	0815	1.22	0.17	1.39	1.10	1630	0.27	1.09	1.37	1.10
70	128211	100.0	460	445	0745	1.82	0.16	1.98	1.09	1630	0.25	1.61	1.86	1.12
41	130260	100.0	300	436	0745	1.46	0.16	1.62	1.07	1630	0.45	1.21	1.65	1.20
30	148000	70.0	208	600	0815	0.88	0.14	1.02	1.05	1715	0.08	0.69	0.77	1.08
69	150000	100.0	450	503	0830	0.95	0.19	1.14	1.04	1630	0.16	0.94	1.10	1.13
62	160000	100.0	750	620	0800	2.01	0.21	2.22	1.07	1700	0.36	2.33	2.68	1.15
115	162568	100.0	473	212	0830	1.25	0.28	1.53	1.08	1630	0.29	0.92	1.21	1.17
155	162568	100.0	473	212	0830	1.26	0.29	1.55	1.09	N/A	N/A	N/A	N/A	N/A
3	165000	100.0	696	623	0700	1.32	0.04	1.36	1.10	1600	0.19	1.45	1.65	1.20
50	165000	100.0	696	623	0630	1.26	0.12	1.38	1.15	1600	0.18	1.70	1.88	1.11

TABLE A.4

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY FOR GENERATED AM & PM PEAK HOUR
GROUPED BY SIZE OF SITE

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
65	174000	100.0	650	800	0730	1.03	0.12	1.15	1.08	1615	0.12	1.37	1.49	1.03
86	175000	92.0	674	700	0745	1.84	0.21	2.06	1.18	1630	0.26	1.42	1.68	1.16
129	175600	100.0	314	409	0745	0.62	0.14	0.76	1.13	1700	0.16	0.67	0.83	1.23
AVERAGE	136069	94.6				1.38	0.18	1.56	1.10		0.28	1.27	1.54	1.14
200,000 G.S.F. AND OVER				ITE CODE 713										
46	200000	100.0	205	342	0800	0.65	0.17	0.82	1.07	1645	0.15	0.64	0.79	1.09
37	206120	96.1	0	824	0745	1.65	0.18	1.83	1.09	1645	0.16	1.52	1.69	1.13
42	214840	47.5	292	700	0715	2.11	0.21	2.31	1.11	1630	0.38	1.85	2.23	1.18
25	234850	85.2	600	509	0800	1.62	0.14	1.76	1.11	1645	0.23	1.69	1.91	1.16
61	255174	100.0	1000	1200	0745	1.39	0.13	1.52	1.11	1645	0.24	1.29	1.52	1.06
55	256000	100.0	600	1031	0730	1.14	0.12	1.25	1.10	1600	0.08	1.08	1.16	1.12
56	262000	100.0	550	524	0715	1.44	0.09	1.53	1.14	1630	0.20	0.96	1.16	1.10
45	263740	100.0	936	767	0745	1.57	0.08	1.65	1.07	1700	0.13	1.41	1.54	1.11
34	281000	78.0	838	984	0745	1.75	0.08	1.83	1.11	1645	0.11	1.59	1.70	1.10
7	333000	100.0	0	962	0745	1.19	0.15	1.35	1.06	1630	0.18	0.93	1.11	1.10
148	341278	39.9	546	1156	0830	1.71	0.08	1.79	1.05	1630	0.33	0.97	1.30	1.16
85	350000	100.0	1220	1350	0645	1.45	0.07	1.52	1.19	1545	0.20	1.46	1.66	1.30
138	420268	98.5	0	1100	0745	0.69	0.08	0.77	1.06	1630	0.10	0.86	0.96	1.16
32	449586	95.0	1144	1675	0745	1.20	0.22	1.42	1.11	1645	0.21	1.08	1.29	1.11
72	485000	98.8	816	1550	0815	0.87	0.08	0.96	1.05	1630	0.04	0.90	0.94	1.05
73	500984	94.2	1564	1750	0800	1.21	0.09	1.31	1.07	1715	0.09	0.87	0.96	1.09
39	508996	100.0	1900	1935	0700	1.72	0.15	1.87	1.07	1630	0.31	1.53	1.85	1.04
146	549000	100.0	3130	2500	0730	1.89	0.14	2.04	1.11	1630	0.25	1.33	1.58	1.13
43	730000	60.3	2000	1700	0730	2.43	0.15	2.57	1.12	1600	0.14	2.13	2.27	1.15
24	752000	78.0	2344	2100	0700	2.26	0.16	2.42	1.28	1615	0.12	1.80	1.92	1.10
AVERAGE	379692	87.6				1.51	0.13	1.64	1.12		0.17	1.30	1.47	1.12

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.5

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	ADJACENT STREET PEAK AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
PLANNING AREA - 19														
86	175000	92.0	674	700	0800	1.70	0.23	1.93	1.16	1700	0.24	1.25	1.48	1.14
34	281000	78.0	838	984	0800	1.64	0.07	1.71	1.09	1700	0.10	1.49	1.59	1.12
85	350000	100.0	1220	1350	0800	0.44	0.07	0.51	1.05	1700	0.07	0.53	0.60	1.09
AVERAGE	268667	90.6				1.08	0.10	1.18	1.10		0.12	0.98	1.09	1.12
PLANNING AREA - 20														
78	16500	97.0	64	52	0730	1.94	1.50	3.44	1.13	1645	0.88	1.56	2.44	1.36
89	60000	100.0	113	130	0730	0.98	0.67	1.65	1.17	1645	0.28	0.52	0.80	1.35
133	79800	100.0	131	148	0800	0.55	0.23	0.78	1.16	1700	0.21	0.71	0.93	1.28
12	80025	100.0	291	343	0730	1.07	0.14	1.21	1.17	1630	0.27	1.15	1.42	1.15
141	110000	54.5	180	238	0730	1.88	0.48	2.37	1.18	N/A	N/A	N/A	N/A	N/A
144	110000	54.5	180	238	0730	2.08	0.68	2.77	1.18	1700	0.05	0.72	0.77	1.09
69	150000	100.0	450	503	0730	0.66	0.09	0.75	1.06	1700	0.05	0.84	0.89	1.11
AVERAGE	86618	83.4				1.10	0.35	1.45	1.15		0.18	0.84	1.02	1.18
PLANNING AREA - 21														
51	29159	100.0	0	101	0730	1.89	0.27	2.16	1.05	1630	0.17	1.82	1.99	1.04
132	39725	81.9	108	212	N/A	N/A	N/A	N/A	N/A	1630	1.05	1.60	2.64	1.25
90	60000	100.0	215	225	0715	1.90	0.15	2.05	1.10	1700	0.13	1.80	1.93	1.09
49	77939	100.0	200	208	0730	1.87	0.08	1.95	1.03	1630	0.15	1.45	1.60	1.03
93	120000	100.0	710	401	0745	2.45	0.20	2.65	1.09	1700	0.79	1.98	2.77	1.11
3	165000	100.0	696	623	0730	0.62	0.04	0.66	1.06	1630	0.13	1.10	1.24	1.17
50	165000	100.0	696	623	0730	0.88	0.08	0.96	1.16	1630	0.12	0.92	1.03	1.08
37	206120	96.1	0	824	0800	1.56	0.24	1.80	1.10	1700	0.14	1.45	1.59	1.15
42	214840	47.5	292	700	0700	1.65	0.15	1.79	1.10	1630	0.38	1.85	2.23	1.18
45	263740	100.0	936	767	0700	0.77	0.06	0.83	1.12	1700	0.13	1.41	1.54	1.11
39	508996	100.0	1900	1935	0745	1.25	0.19	1.44	1.06	1700	0.19	1.03	1.22	1.06
AVERAGE	168229	93.1				1.29	0.14	1.43	1.09		0.23	1.32	1.55	1.11
PLANNING AREA - 22														
134	65000	100.0	205	215	0800	1.91	0.82	2.72	1.09	1700	0.97	1.85	2.82	1.12
32	449586	95.0	1144	1675	0730	1.07	0.22	1.28	1.13	1700	0.18	1.09	1.28	1.10
AVERAGE	257293	95.6				1.18	0.29	1.47	1.12		0.29	1.19	1.48	1.10

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.5

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

					ADJACENT STREET PEAK									
					AM					PM				
SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. IN	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
				PLANNING AREA - 26										
97	48000	100.0	195	178	0800	1.65	0.25	1.90	1.05	1630	0.52	1.79	2.31	1.19
40	54162	100.0	187	200	0800	0.55	0.17	0.72	1.10	1630	0.13	1.33	1.46	1.15
47	78786	100.0	207	266	0730	1.70	0.18	1.88	1.24	1630	0.25	1.16	1.41	1.03
28	97262	100.0	298	272	0800	1.15	0.28	1.43	1.06	1630	0.10	0.90	1.01	1.06
63	102940	100.0	443	353	0730	1.59	0.13	1.72	1.14	1700	0.05	1.28	1.33	1.11
64	105760	100.0	240	420	0730	1.41	0.10	1.51	1.12	1700	0.19	1.37	1.56	1.17
14	107000	100.0	186	332	0800	0.96	0.11	1.07	1.04	1630	0.43	0.46	0.89	1.16
98	112800	100.0	400	405	0800	0.81	0.12	0.92	1.07	1630	0.32	0.74	1.05	1.23
1	113482	96.7	288	266	0800	1.32	0.13	1.45	1.01	1630	0.32	0.99	1.31	1.08
4	113482	96.7	288	266	0800	1.33	0.14	1.47	1.05	1630	0.32	0.80	1.12	1.22
27	113482	96.7	300	266	0800	1.04	0.13	1.17	1.07	1630	0.35	1.08	1.43	1.18
70	128211	100.0	460	445	0730	1.81	0.16	1.97	1.09	1700	0.16	1.19	1.35	1.07
41	130260	100.0	300	436	0800	1.25	0.19	1.44	1.08	1630	0.45	1.21	1.65	1.20
30	148000	70.0	208	600	0730	0.54	0.08	0.62	1.05	1630	0.13	0.42	0.55	1.09
62	160000	100.0	750	620	0730	1.28	0.09	1.37	1.05	1700	0.36	2.33	2.68	1.15
65	174000	100.0	650	800	0730	1.03	0.12	1.15	1.08	1700	0.06	0.84	0.90	1.05
46	200000	100.0	205	342	0730	0.69	0.08	0.77	1.09	1630	0.18	0.55	0.73	1.11
61	255174	100.0	1000	1200	0730	1.29	0.12	1.40	1.09	1700	0.21	1.31	1.52	1.05
AVERAGE	124600	97.5				1.17	0.13	1.31	1.08		0.24	1.09	1.33	1.12
				PLANNING AREA - 27										
24	752000	78.0	2344	2100	0800	0.32	0.13	0.45	1.18	1700	0.09	0.58	0.67	1.02
AVERAGE	752000	78.0				0.32	0.13	0.45	1.18		0.09	0.58	0.67	1.02
				PLANNING AREA - 29										
139	98618	94.3	309	323	0800	1.11	0.06	1.17	1.06	1645	0.11	1.01	1.12	1.22
AVERAGE	98618	94.3				1.11	0.06	1.17	1.06		0.11	1.01	1.12	1.22
				PLANNING AREA - 30										
147	48000	100.0	380	257	0800	2.50	0.31	2.81	1.10	1730	0.46	2.04	2.50	1.05
26	124431	100.0	299	364	0800	1.11	0.15	1.26	1.09	1700	0.20	0.97	1.17	1.13
55	256000	100.0	600	1031	0730	1.14	0.12	1.25	1.10	1700	0.15	0.64	0.79	1.09
56	262000	100.0	550	524	0730	1.32	0.10	1.42	1.15	1700	0.31	0.44	0.75	1.15
7	333000	100.0	0	962	0730	1.11	0.15	1.26	1.08	1700	0.11	0.78	0.89	1.10
148	341278	39.9	546	1156	0800	1.30	0.06	1.36	1.08	1730	0.13	0.93	1.06	1.07
138	420268	98.5	0	1100	0800	0.66	0.10	0.77	1.05	1700	0.07	0.58	0.65	1.12
72	485000	98.8	816	1550	0730	0.70	0.02	0.72	1.06	1700	0.03	0.80	0.82	1.07

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.5

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	ADJACENT STREET PEAK — AM — PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM — PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
73	500984	94.2	1564	1750	0730	0.84	0.07	0.91	1.08	1700	0.10	0.86	0.96	1.09
146	549000	100.0	3130	2500	0730	1.89	0.14	2.04	1.11	1630	0.25	1.33	1.58	1.13
AVERAGE	331996	92.6				1.14	0.10	1.24	1.10		0.15	0.86	1.00	1.10
PLANNING AREA - 31														
101	13500	100.0	93	27	0730	0.52	0.37	0.89	1.29	1700	0.59	1.26	1.85	1.29
AVERAGE	13500	100.0				0.52	0.37	0.89	1.29		0.59	1.26	1.85	1.29
PLANNING AREA - 33														
118	20000	50.0	71	106	0700	1.40	0.10	1.50	1.00	1700	1.40	3.00	4.40	1.10
25	234850	85.2	600	509	0730	1.32	0.07	1.39	1.15	1700	0.17	1.68	1.85	1.17
AVERAGE	127425	82.4				1.33	0.07	1.40	1.15		0.23	1.74	1.97	1.16
PLANNING AREA - 34														
126	36000	100.0	146	139	0700	1.08	0.28	1.36	1.08	1630	2.50	2.75	5.25	1.09
129	175600	100.0	314	409	0700	0.68	0.07	0.75	1.12	1630	0.17	0.55	0.72	1.09
43	730000	60.3	2000	1700	0730	2.43	0.15	2.57	1.12	1700	0.14	0.93	1.07	1.11
AVERAGE	313867	69.2				1.88	0.14	2.02	1.12		0.27	0.93	1.20	1.10
PLANNING AREA - 35														
115	162568	100.0	473	212	0800	0.87	0.12	1.00	1.09	1700	0.20	0.72	0.92	1.11
155	162568	100.0	473	212	0800	1.02	0.14	1.16	1.08	N/A	N/A	N/A	N/A	N/A
AVERAGE	162568	100.0				0.95	0.13	1.08	1.09		0.20	0.72	0.92	1.11

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.6

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

					SITE GENERATED PEAK									
					AM					PM				
SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. IN	PEAK HOUR START	TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
PLANNING AREA - 19														
86	175000	92.0	674	700	0745	1.84	0.21	2.06	1.18	1630	0.26	1.42	1.68	1.16
34	281000	78.0	838	984	0745	1.75	0.08	1.83	1.11	1645	0.11	1.59	1.70	1.10
85	350000	100.0	1220	1350	0645	1.45	0.07	1.52	1.19	1545	0.20	1.46	1.66	1.30
AVERAGE	268667	90.6				1.62	0.11	1.73	1.16		0.18	1.49	1.67	1.21
PLANNING AREA - 20														
78	16500	97.0	64	52	0815	2.81	1.81	4.62	1.16	1600	1.31	2.44	3.75	1.13
89	60000	100.0	113	130	0730	0.98	0.67	1.65	1.17	1600	0.52	0.55	1.07	1.24
133	79800	100.0	131	148	0830	0.54	0.30	0.84	1.16	1615	0.38	0.70	1.08	1.18
12	80025	100.0	291	343	0815	1.71	0.19	1.90	1.09	1645	0.26	1.44	1.70	1.15
141	110000	54.5	180	238	0745	1.92	0.48	2.40	1.17	N/A	N/A	N/A	N/A	N/A
144	110000	54.5	180	238	0730	2.08	0.68	2.77	1.18	1545	0.33	1.25	1.58	1.33
69	150000	100.0	450	503	0830	0.95	0.19	1.14	1.04	1630	0.16	0.94	1.10	1.13
AVERAGE	86618	83.4				1.32	0.41	1.73	1.13		0.33	1.03	1.36	1.18
PLANNING AREA - 21														
51	29159	100.0	0	101	0745	1.92	0.34	2.26	1.12	1615	0.14	2.06	2.19	1.10
132	39725	81.9	108	212	0830	1.01	0.65	1.66	1.24	1600	1.05	1.66	2.71	1.17
90	60000	100.0	215	225	0730	2.23	0.13	2.37	1.09	1630	0.20	3.73	3.93	1.10
49	77939	100.0	200	208	0730	1.87	0.08	1.95	1.03	1645	0.15	1.58	1.73	1.02
93	120000	100.0	710	401	0800	2.67	0.23	2.90	1.08	1700	0.79	1.98	2.77	1.11
3	165000	100.0	696	623	0700	1.32	0.04	1.36	1.10	1600	0.19	1.45	1.65	1.20
50	165000	100.0	696	623	0630	1.26	0.12	1.38	1.15	1600	0.18	1.70	1.88	1.11
37	206120	96.1	0	824	0745	1.65	0.18	1.83	1.09	1645	0.16	1.52	1.69	1.13
42	214840	47.5	292	700	0715	2.11	0.21	2.31	1.11	1630	0.38	1.85	2.23	1.18
45	263740	100.0	936	767	0745	1.57	0.08	1.65	1.07	1700	0.13	1.41	1.54	1.11
39	508996	100.0	1900	1935	0700	1.72	0.15	1.87	1.07	1630	0.31	1.53	1.85	1.04
AVERAGE	168229	93.1				1.71	0.15	1.86	1.09		0.28	1.66	1.94	1.10
PLANNING AREA - 22														
134	65000	100.0	205	215	0800	1.91	0.82	2.72	1.09	1700	0.97	1.85	2.82	1.12
32	449586	95.0	1144	1675	0745	1.20	0.22	1.42	1.11	1645	0.21	1.08	1.29	1.11
AVERAGE	257293	95.6				1.29	0.30	1.59	1.11		0.31	1.18	1.49	1.11

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.6

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	SITE GENERATED PEAK — AM — PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM — PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
PLANNING AREA - 26														
97	48000	100.0	195	178	0745	2.02	0.27	2.29	1.09	1645	0.46	2.04	2.50	1.14
40	54162	100.0	187	200	0715	1.53	0.15	1.68	1.10	1600	0.30	1.27	1.57	1.17
47	78786	100.0	207	266	0730	1.70	0.18	1.88	1.24	1545	0.51	1.62	2.13	1.07
28	97262	100.0	298	272	0745	1.13	0.37	1.50	1.11	1615	0.13	0.93	1.06	1.03
63	102940	100.0	443	353	0800	1.95	0.23	2.19	1.12	1630	0.08	1.55	1.63	1.12
64	105760	100.0	240	420	0730	1.41	0.10	1.51	1.12	1630	0.28	1.66	1.95	1.11
14	107000	100.0	186	332	0800	0.96	0.11	1.07	1.04	1700	0.48	0.50	0.97	1.09
98	112800	100.0	400	405	0815	0.87	0.13	1.00	1.17	1630	0.32	0.74	1.05	1.23
1	113482	96.7	288	266	0800	1.32	0.13	1.45	1.01	1645	0.30	1.05	1.35	1.10
4	113482	96.7	288	266	0800	1.33	0.14	1.47	1.05	1630	0.32	0.80	1.12	1.22
27	113482	96.7	300	266	0745	1.21	0.15	1.37	1.07	1645	0.34	1.28	1.61	1.15
70	128211	100.0	460	445	0745	1.82	0.16	1.98	1.09	1630	0.25	1.61	1.86	1.12
41	130260	100.0	300	436	0745	1.46	0.16	1.62	1.07	1630	0.45	1.21	1.65	1.20
30	148000	70.0	208	600	0815	0.88	0.14	1.02	1.05	1715	0.08	0.69	0.77	1.08
62	160000	100.0	750	620	0800	2.01	0.21	2.22	1.07	1700	0.36	2.33	2.68	1.15
65	174000	100.0	650	800	0730	1.03	0.12	1.15	1.08	1615	0.12	1.37	1.49	1.03
46	200000	100.0	205	342	0800	0.65	0.17	0.82	1.07	1645	0.15	0.64	0.79	1.09
61	255174	100.0	1000	1200	0745	1.39	0.13	1.52	1.11	1645	0.24	1.29	1.52	1.06
AVERAGE	124600	97.5				1.32	0.16	1.49	1.09		0.27	1.23	1.50	1.11
PLANNING AREA - 27														
24	752000	78.0	2344	2100	0700	2.26	0.16	2.42	1.28	1615	0.12	1.80	1.92	1.10
AVERAGE	752000	78.0				2.26	0.16	2.42	1.28		0.12	1.80	1.92	1.10
PLANNING AREA - 29														
139	98618	94.3	309	323	0830	1.70	0.15	1.85	1.06	1715	0.15	1.19	1.34	1.19
AVERAGE	98618	94.3				1.70	0.15	1.85	1.06		0.15	1.19	1.34	1.19
PLANNING AREA - 30														
147	48000	100.0	380	257	0800	2.50	0.31	2.81	1.10	1700	0.48	2.40	2.88	1.04
26	124431	100.0	299	364	0815	1.22	0.17	1.39	1.10	1630	0.27	1.09	1.37	1.10
55	256000	100.0	600	1031	0730	1.14	0.12	1.25	1.10	1600	0.08	1.08	1.16	1.12
56	262000	100.0	550	524	0715	1.44	0.09	1.53	1.14	1630	0.20	0.96	1.16	1.10
7	333000	100.0	0	962	0745	1.19	0.15	1.35	1.06	1630	0.18	0.93	1.11	1.10
148	341278	39.9	546	1156	0830	1.71	0.08	1.79	1.05	1630	0.33	0.97	1.30	1.16
138	420268	98.5	0	1100	0745	0.69	0.08	0.77	1.06	1630	0.10	0.86	0.96	1.16
72	485000	98.8	816	1550	0815	0.87	0.08	0.96	1.05	1630	0.04	0.90	0.94	1.05

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.6

TRIP GENERATION STUDY

GENERAL OFFICE SITE TRIP RATE SUMMARY BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	EMPL-OYEES	PARKING SPACES	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
73	500984	94.2	1564	1750	0800	1.21	0.09	1.31	1.07	1715	0.09	0.87	0.96	1.09
146	549000	100.0	3130	2500	0730	1.89	0.14	2.04	1.11	1630	0.25	1.33	1.58	1.13
AVERAGE	331996	92.6				1.26	0.11	1.38	1.09		0.16	1.02	1.18	1.11
PLANNING AREA - 31														
101	13500	100.0	93	27	0830	1.85	0.15	2.00	1.24	1530	0.89	1.78	2.67	1.25
AVERAGE	13500	100.0				1.85	0.15	2.00	1.24		0.89	1.78	2.67	1.25
PLANNING AREA - 33														
118	20000	50.0	71	106	0800	3.20	0.80	4.00	1.09	1700	1.40	3.00	4.40	1.10
25	234850	85.2	600	509	0800	1.62	0.14	1.76	1.11	1645	0.23	1.69	1.91	1.16
AVERAGE	127425	82.4				1.70	0.17	1.87	1.11		0.28	1.75	2.03	1.16
PLANNING AREA - 34														
126	36000	100.0	146	139	0830	1.94	0.69	2.64	1.14	1600	3.67	2.36	6.03	1.16
129	175600	100.0	314	409	0745	0.62	0.14	0.76	1.13	1700	0.16	0.67	0.83	1.23
43	730000	60.3	2000	1700	0730	2.43	0.15	2.57	1.12	1600	0.14	2.13	2.27	1.15
AVERAGE	313867	69.2				1.91	0.17	2.09	1.12		0.34	1.75	2.09	1.16
PLANNING AREA - 35														
115	162568	100.0	473	212	0830	1.25	0.28	1.53	1.08	1630	0.29	0.92	1.21	1.17
155	162568	100.0	473	212	0830	1.26	0.29	1.55	1.09	N/A	N/A	N/A	N/A	N/A
AVERAGE	162568	100.0				1.25	0.28	1.54	1.09		0.29	0.92	1.21	1.17

SOURCE: DOUGLAS & DOUGLAS, INC.

TABLE A.7

LIST OF SHOPPING CENTERS

SITE NO.	PLAN AREA	NAME	SURVEY NO.	DATE
501	19	GERMANTOWN COMMONS SHOP. CTR. MIDDLEBROOK RD. GERMANTOWN, MD. 20874	044	20-Nov-86
502	27	LAYHILL SHOP. CTR. LAYHILL RD. LAYHILL, MD. 20906	015	22-Oct-86
503	34	BRIGGS CHANEY PLAZA COLUMBIA PIKE (RT 29) COLUMBIA, MD 20904	130	27-May-87
511	27	ASPEN HILL SHOP. CTR. CONNECTICUT AVE ASPEN HILL	029	05-Nov-86
512	20	MONTGOMERY VILLAGE CENTER II LOST KNIFE RD. (OFF PRICE CTR) GAITHERSBURG, MD. 20879	135	28-May-87
513	20	MONTGOMERY VILLAGE CENTER LOST KNIFE & ODENTHAL RDS. GAITHERSBURG, MD. 20879	140	03-Jun-87
515	26	WINTER GREEN PLAZA ROCKVILLE PIKE ROCKVILLE	149	10-Jun-87
516	21	QUINCE ORCHARD PLAZA QUINCE ORCHARD RD. GAITHERSBURG, MD. 20878	006	01-Oct-86
553	21	THE SUMMIT SHOP. CTR. N. SUMMIT AVE. GAITHERSBURG, MD. 20877	019	23-Oct-86
554	23	OLNEY SHOP. CTR. GEORGIA AVE. OLNEY, MD 20832	010	15-Oct-86
558	21	DIAMOND SQUARE SHOP. CTR. QUINCE ORCH. & CLOPPER GAITHERSBURG, MD. 20878	009	09-Oct-86
559	26	SEVEN LOCKS PLAZA SEVEN LOCKS RD. ROCKVILLE, MD. 20854	022	28-Oct-86
560	26	COLLEGE PLAZA FREDERICK RD. N. ROCKVILLE, MD. 20850	031	06-Nov-86
561	15	BURTONSVILLE SHOP. CTR. COLUMBIA PIKE BURTONSVILLE, MD 20866	023	29-Oct-86
569	33	COLESVILLE CTR. SHOP. CTR. RANDOLPH RD. COLESVILLE, MD 20904	017	21-Oct-86

TABLE A.8

TRIP GENERATION STUDY

RETAIL SITE TRIP RATE SUMMARY FOR ADJACENT STREET PEAK HOUR

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
22	50000	100.0	340	6.8	1630	6.84	4.52	11.36	1.65
23	50000	100.0	365	7.3	1700	4.68	3.88	8.56	1.21
AVERAGE	50000	100.0				5.76	4.20	9.96	1.45
10	53500	96.4	241	4.5	1700	6.34	5.68	12.02	1.38
19	55250	100.0	312	5.6	1700	6.06	5.45	11.51	1.38
15	56184	100.0	431	7.7	1700	4.75	4.57	9.33	1.40
9	76500	100.0	403	5.3	1700	6.33	5.70	12.03	1.29
17	80000	100.0	512	6.4	1700	4.17	3.56	7.74	1.24
31	94000	100.0	502	5.3	1700	6.16	6.22	12.38	1.23
AVERAGE	69239	99.5				5.62	5.22	10.84	1.30
135	105797	100.0	462	4.4	1700	2.02	1.57	3.59	1.43
140	116110	100.0	684	5.9	1700	2.76	2.21	4.97	1.40
6	125000	100.0	785	6.3	1700	3.82	3.71	7.53	1.56
29	132000	100.0	893	6.8	1700	4.05	3.49	7.55	1.21
44	135498	78.2	1192	8.8	1700	5.28	4.02	9.31	1.27
149	144881	77.1	606	4.2	1700	3.39	2.82	6.22	1.27
130	192125	100.0	1044	5.4	1730	4.72	4.33	9.05	1.39
AVERAGE	135916	96.5				3.86	3.31	7.17	1.36

TABLE A.9

TRIP GENERATION STUDY

RETAIL SITE TRIP RATE SUMMARY FOR GENERATOR PEAK HOURS

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. OUT	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
22	50000	100.0	340	6.8	1215	232	237	469	1.21	1545	298	339	637	1.64
23	50000	100.0	365	7.3	1300	199	203	402	1.52	1745	250	245	495	1.36
AVERAGE	50000	100.0				4.31	4.40	8.71	1.35		5.48	5.84	11.32	1.52
10	53500	96.4	241	4.5	1200	211	194	405	1.34	1700	327	293	620	1.38
19	55250	100.0	312	5.6	1130	188	195	383	1.34	1915	307	389	696	1.48
15	56184	100.0	431	7.7	1130	237	203	440	1.37	1800	302	296	598	1.38
9	76500	100.0	403	5.3	1145	490	465	955	1.44	1730	561	537	1098	1.40
17	80000	100.0	512	6.4	1130	334	260	594	1.29	1830	371	286	657	1.30
31	94000	100.0	502	5.3	1130	1118	910	2028	1.34	1715	591	625	1216	1.28
AVERAGE	69239	99.5				6.23	5.39	11.62	1.35		5.95	5.87	11.81	1.36
135	105797	100.0	462	4.4	N/A	N/A	N/A	N/A	N/A	1800	301	247	548	1.37
140	116110	100.0	684	5.9	N/A	N/A	N/A	N/A	N/A	1745	354	246	600	1.39
6	125000	100.0	785	6.3	1200	581	493	1074	1.29	1800	606	555	1161	1.44
29	132000	100.0	893	6.8	1130	537	336	873	1.13	1645	530	499	1029	1.28
44	135498	78.2	1192	8.8	1130	657	621	1278	1.36	1715	760	576	1336	1.29
149	144881	77.1	606	4.2	N/A	N/A	N/A	N/A	N/A	1745	462	305	767	1.35
130	192125	100.0	1044	5.4	N/A	N/A	N/A	N/A	N/A	1800	950	932	1882	1.39
AVERAGE	135916	96.5				4.52	3.69	8.22	1.27		4.32	3.66	7.98	1.36

TABLE A.10

TRIP GENERATION STUDY

RETAIL SITE TRIP RATE SUMMARY FOR ADJACENT STREET PM PEAK HOUR BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	OUT	TOTAL	PM AUTO OCC. OUT
	PLANNING AREA - 15								
23	50000	100.0	365	7.3	1700	4.68	3.88	8.56	1.21
AVERAGE	50000	100.0				4.68	3.88	8.56	1.21
	PLANNING AREA - 19								
44	135498	78.2	1192	8.8	1700	5.28	4.02	9.31	1.27
AVERAGE	135498	100.0				5.28	4.02	9.31	1.27
	PLANNING AREA - 20								
135	105797	100.0	462	4.4	1700	2.02	1.57	3.59	1.43
140	116110	100.0	684	5.9	1700	2.76	2.21	4.97	1.40
AVERAGE	110954	100.0				2.41	1.91	4.31	1.41
	PLANNING AREA - 21								
19	55250	100.0	312	5.6	1700	6.06	5.45	11.51	1.38
9	76500	100.0	403	5.3	1700	6.33	5.70	12.03	1.29
6	125000	100.0	785	6.3	1700	3.82	3.71	7.53	1.56
AVERAGE	85583	100.0				5.05	4.68	9.73	1.42
	PLANNING AREA - 23								
10	53500	96.4	241	4.5	1700	6.34	5.68	12.02	1.38
AVERAGE	53500	96.4				6.34	5.68	12.02	1.38
	PLANNING AREA - 26								
31	94000	100.0	502	5.3	1700	6.16	6.22	12.38	1.23
149	144881	77.1	606	4.2	1700	3.39	2.82	6.22	1.27
AVERAGE	119440	86.1				4.66	4.38	9.03	1.24
	PLANNING AREA - 27								
15	56184	100.0	431	7.7	1700	4.75	4.57	9.33	1.40
29	132000	100.0	893	6.8	1700	4.05	3.49	7.55	1.21
AVERAGE	94092	100.0				4.26	3.82	8.08	1.28
	PLANNING AREA - 29								
22	50000	100.0	340	6.8	1630	6.84	4.52	11.36	1.65
AVERAGE	50000	100.0				6.84	4.52	11.36	1.65
	PLANNING AREA - 33								
17	80000	100.0	512	6.4	1700	4.17	3.56	7.74	1.24
AVERAGE	80000	100.0				4.17	3.56	7.74	1.24
	PLANNING AREA - 34								
130	192125	100.0	1044	5.4	1730	4.72	4.33	9.05	1.39
AVERAGE	192125	100.0				4.72	4.33	9.05	1.39

TABLE A.11

TRIP GENERATION STUDY

RETAIL SITE RATE TRIP SUMMARY FOR GENERATED PEAK HOURS BY PLANNING AREA

SURVEY NO.	GROSS SQ.FT.	PCNT. OCC.	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	AM PEAK HOUR START	AM TRIPS/1,000 OCC. GROSS SQ. FT. IN	AM OUT	AM TOTAL	AM AUTO OCC. IN	PM PEAK HOUR START	PM TRIPS/1,000 OCC. GROSS SQ. FT. IN	PM OUT	PM TOTAL	PM AUTO OCC. OUT
			PLANNING AREA - 15											
23	50000	100.0	365	7.3	1300	3.98	4.06	8.04	1.52	1745	5.00	4.90	9.90	1.36
AVERAGE	50000	100.0				3.98	4.06	8.04	1.52		5.00	4.90	9.90	1.36
			PLANNING AREA - 19											
44	135498	78.2	1192	8.8	1130	4.85	4.58	9.43	1.36	1715	5.61	4.25	9.86	1.29
AVERAGE	135498	100.0				4.85	4.58	9.43	1.36		5.61	4.25	9.86	1.29
			PLANNING AREA - 20											
135	105797	100.0	462	4.4	N/A	N/A	N/A	N/A	N/A	1800	2.85	2.33	5.18	1.37
140	116110	100.0	684	5.9	N/A	N/A	N/A	N/A	N/A	1745	3.05	2.12	5.17	1.39
AVERAGE	110954	100.0			N/A	N/A	N/A	N/A	N/A		2.95	2.22	5.17	1.38
			PLANNING AREA - 21											
19	55250	100.0	312	5.6	1130	3.40	3.53	6.93	1.34	1915	5.56	7.04	12.60	1.48
9	76500	100.0	403	5.3	1145	6.41	6.08	12.48	1.44	1730	7.33	7.02	14.35	1.40
6	125000	100.0	785	6.3	1200	4.65	3.94	8.59	1.29	1800	4.85	4.44	9.29	1.44
AVERAGE	85583	100.0				4.90	4.49	9.39	1.35		5.74	5.77	11.51	1.44
			PLANNING AREA - 23											
10	53500	96.4	241	4.5	1200	4.09	3.76	7.85	1.34	1700	6.34	5.68	12.02	1.38
AVERAGE	53500	96.4				4.09	3.76	7.85	1.34		6.34	5.68	12.02	1.38
			PLANNING AREA - 26											
31	94000	100.0	502	5.3	1130	11.89	9.68	21.57	1.34	1715	6.29	6.65	12.94	1.28
149	144881	77.1	606	4.2	N/A	N/A	N/A	N/A	N/A	1745	4.14	2.73	6.87	1.35
AVERAGE	119440	86.1				11.89	9.68	21.57	1.34		5.12	4.52	9.64	1.30
			PLANNING AREA - 27											
15	56184	100.0	431	7.7	1130	4.22	3.61	7.83	1.37	1800	5.38	5.27	10.64	1.38
29	132000	100.0	893	6.8	1130	4.07	2.55	6.61	1.13	1645	4.02	3.78	7.80	1.28
AVERAGE	94092	100.0				4.11	2.86	6.98	1.20		4.42	4.22	8.65	1.32
			PLANNING AREA - 29											
22	50000	100.0	340	6.8	1215	4.64	4.74	9.38	1.21	1545	5.96	6.78	12.74	1.64
AVERAGE	50000	100.0				4.64	4.74	9.38	1.21		5.96	6.78	12.74	1.64
			PLANNING AREA - 33											
17	80000	100.0	512	6.4	1130	4.17	3.25	7.42	1.29	1830	4.64	3.58	8.21	1.30
AVERAGE	80000	100.0				4.17	3.25	7.42	1.29		4.64	3.58	8.21	1.30
			PLANNING AREA - 34											
130	192125	100.0	1044	5.4	N/A	N/A	N/A	N/A	N/A	1800	4.94	4.85	9.80	1.39
AVERAGE	192125	100.0			N/A	N/A	N/A	N/A	N/A		4.94	4.85	9.80	1.39

TABLE A.12

LIST OF FAST FOOD RESTAURANTS

SITE NO.	PLAN AREA	NAME/ ADDRESS	SURVEY NO.	SURVEY DATE
453	31	ROY ROGERS 12135 VIERS MILL RD. WHEATON, MD.	021	28-Oct-86
454	31	McDONALDS 12312 GEORGIA AVE. SILVER SPRING, MD.	116	20-May-87
455	26	McDONALDS 1390 ROCKVILLE PIKE ROCKVILLE, MD.	136	02-Jun-87
456	11	McDONALDS 26429 RIDGE RD. DAMASCUS, MD.	456	11-Jun-87
459	20	BURGER KING 16004 SHADY GROVE RD. GAITHERSBURG, MD.	002	30-Sep-86
461	19	HARDEES 12982 MIDDLEBROOK RD. GERMANTOWN, MD.	008	08-Oct-86
464	23	ROY ROGERS 17901 GEORGIA AVE. OLNEY, MD.	117	20-May-87
465	19	BURGER KING SUGERLOAF CENTER GERMANTOWN, MD.	011	14-Oct-86
469	21	ROY ROGERS 465 N. FREDERICK AVE. GAITHERSBURG, MD.	013	16-Oct-86

TABLE A.13a

TRIP GENERATION STUDY

FAST FOOD SITE TRIP RATE SUMMARY - ADJACENT STREET PEAK

					AM					PM				
SURVEY NO.	GROSS SQ.FT.	DRIVE THRU?	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	PEAK HOUR START	TRIPS/1,000 GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. IN	PEAK HOUR START	TRIPS/1,000 GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
2	3058	Y	67	21.9	0800	29.10	29.43	58.53	1.22	1700	28.12	24.20	52.32	1.80
8	3200	Y	45	14.1	0730	20.94	21.88	42.81	1.21	1700	6.56	6.25	12.81	1.45
11	2500	Y	25	10.0	0730	6.00	4.40	10.40	1.53	1700	11.60	8.00	19.60	1.40
13	3200	Y	50	15.6	0745	9.69	4.38	14.06	1.19	1700	23.75	20.00	43.75	1.34
21	3000	Y	46	15.3	0800	16.67	15.00	31.67	1.16	1700	21.33	17.33	38.67	1.77
116	3000	N	40	13.3	0730	26.00	16.00	42.00	1.33	1700	21.33	14.67	36.00	1.73
117	2912	Y	38	13.0	0800	15.80	12.36	28.16	1.13	1700	23.01	13.39	36.40	1.62
136	3520	N	0	0.0	0800	26.70	18.75	45.45	1.18	1700	14.20	22.16	36.36	1.42
150	3000	Y	70	23.3	0700	20.67	16.33	37.00	1.37	1600	15.67	15.00	30.67	1.62
AVERAGE	3043					19.42	15.66	35.09	1.24		18.40	15.92	34.32	1.58

TABLE A.13b

TRIP GENERATION STUDY

FAST FOOD SITE TRIP RATE SUMMARY - SITE GENERATED PEAK

					AM					PM				
SURVEY NO.	GROSS SQ.FT.	DRIVE THRU?	PARKING SPACES	PK.SPCS./ 1,000 GROSS SQ. FT.	PEAK HOUR START	TRIPS/1,000 GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. IN	PEAK HOUR START	TRIPS/1,000 GROSS SQ. FT. IN	OUT	TOTAL	AUTO OCC. OUT
2	3058	Y	67	21.9	0800	29.10	29.43	58.53	1.22	1745	30.41	30.74	61.15	1.56
8	3200	Y	45	14.1	0730	20.94	21.88	42.81	1.21	1530	11.56	11.56	23.12	1.16
11	2500	Y	25	10.0	0715	7.20	7.20	14.40	1.94	1545	12.80	16.40	29.20	1.76
13	3200	Y	50	15.6	0830	15.31	6.56	21.88	1.18	1745	30.31	21.88	52.19	1.27
21	3000	Y	46	15.3	0800	16.67	15.00	31.67	1.16	1800	37.33	15.33	52.67	1.80
116	3000	N	40	13.3	0900	35.67	32.67	68.33	1.36	1800	31.00	22.00	53.00	1.48
117	2912	Y	38	13.0	0900	17.51	16.83	34.34	1.33	1800	31.25	20.26	51.51	1.36
136	3520	N	0	0.0	0930	30.68	28.69	59.38	1.38	1730	23.58	23.86	47.44	1.65
150	3000	Y	70	23.3	0715	23.33	18.33	41.67	1.44	1800	37.67	21.67	59.33	1.94
AVERAGE	3043					22.23	19.97	42.21	1.32		27.42	20.52	47.94	1.56

TABLE A.14

LIST OF RESIDENTIAL SITES

SITE NO.	PLAN AREA	NAME	SURVEY NO.	SURVEY DATE
601	20	HUNTERS WOODS # 2 OFF SNOUFFER SCHOOL RD.	020	23-Oct-86
602	34	TOWNES OF GLOUCESTER RTE. 29 BEFORE RTE. 198	018	21-Oct-86
603	19	MEADOWBROOK ESTATES OFF RTE. 118 NEAR RTS. 270-355	035	12-Nov-86
604	27	NORWOOD VILLAGE RTE. 28 & RTE. 182	016	22-Oct-86
605	19	WATERS LANDING	036	12-Nov-86
606	20	WILLOW RIDGE I COPEN MEADOW DR & RT 28	094	07-May-87
608	14	WOODFIELD OFF RTE. 124/NEAR SENECA CK.	079	28-Apr-87
616	34	PERRYWOOD ESTATES	076	23-Apr-87
617	31	CONNECTICUT AVENUE GARDENS CONN AVE & ADAMS DR	099	21-May-87
618	20	HUNTERS WOODS #1 GREEN RUN & GOSHEN RD	092	06-May-87
621	11	CHESNEY & GREENHILLS OFF RTE. 27	142	04-Jun-87
622	28	FAIRLAND ACRES HOLLY SPRINGS DR	110	14-May-87
624	28	PEACH ORCHARD HEIGHTS SEIBEL & PEACH ORCHARD ROAD	077	23-Apr-87
626	30	GARRETT PARK II KENILWORTH AVE & WAVERLY AVE	153	12-May-87
628	23	GRIFFITH PARK GRIFFITH RD. & RTES. 108-650	080	24-Jun-87
630	20	QUINCE ORCHARD VALLEY PARK QUINCE ORCHARD RD & RTE 28	095	07-May-87
646	20	PARKRIDGE RTE. 124	038 048	12-Nov-86 24-Nov-86

TABLE A.14 (CONT.)

LIST OF RESIDENTIAL SITES

SITE NO.	PLAN AREA	NAME	SURVEY NO.	SURVEY DATE
652	33	BURNT MILLS VILLAGE	082	29-Apr-87
		COLUMBIA PIKE & OAK LEAF DR	123	21-May-87
664	32	SPRINGBROOK FORREST STONINGTON & KEMP MILL	107	13-May-87
681	14	GOSHEN ESTATES	091	06-May-87
690	22	GRANBY WOODS GRANBY RD	131	28-May-87
691	29	GREAT FALLS ESTATES BURBANK DR & FALLS RD	154	10-Jun-87
693	30	MONTROSE WOODS MONTROSE RD & HITCHING POST LN	137	02-Jun-87
703	34	WOODS AT KNIGHTS BRIDGE ASTON MANOR DR & ROBY RD SILVER SPRING, MD. 20904	074	23-Apr-87
704	34	WOODLAKE APTS. 14175 CASTLE BLVD. SILVER SPRING, MD. 20904	075	23-Apr-87
732	33	WHITE OAK GARDENS 11600 LOCKWOOD DRIVE SILVER SPRING, MD. 20904	121	21-May-87
746	34	MARYLAND FARMS 11386 CHERRY HILL ROAD BELTSVILLE, MD. 20705	119	21-May-87
752	27	ASPEN CROSSING 14114 GRAND PRE ROAD SILVER SPRING, MD. 20906	113	14-May-87
767	33	WHITE OAK PARK 11431 LOCKWOOD DRIVE SILVER SPRING, MD. 20904	081	29-Apr-87
789	31	VILLAGE SQUARE WHEATON 12011 VEIRS MILL RD. SILVER SPRING, MD. 20902	100	12-May-87
795	33	HOLLY HALL 10110 N.H. AVE EXT HILLANDALE	127	27-May-87
830	33	VILLANOVA LOCKWOOD DR WHITE OAK	125	21-May-87
845	19	GUNNERS VIEW CONDOMINIUM HICKORY TREE WAY GERMANTOWN, MD. 20874	087	30-Apr-87
846	31	KENSINGTON TERRACE CONDOMINIUM 3404 UNIVERSITY BLVD. KENSINGTON, MD. 20895	054	03-Dec-86

TABLE A.14 (CONT.)

LIST OF RESIDENTIAL SITES

SITE NO.	PLAN AREA	NAME	SURVEY NO.	DATE
852	31	MONTGOMERY CENTURY CONDOMINIUM 3141 UNIVERSITY BLVD WHEATON, MD	128	27-May-87
868	36	FRIENDLY GARDENS 2423 LYTTONSVILLE RD. SILVER SPRING, MD. 20910	104	13-May-87
901	33	WHITE OAK TOWERS 11700 OLD COLUMBIA PIKE SILVER SPRING, MD. 20904	083 120	29-Apr-87 21-May-87
902	33	THE POINT 11215 OAKLEAF DRIVE SILVER SPRING, MD. 20901	122	21-May-87
903	32	WAYNE-MANCHESTER TOWERS 25 & EAST WAYNE AVE. (75) SILVER SPRING, MD. 20901	059	08-Dec-86
904	37	CHATEAU 9727 MOUNT PISGAH RD. SILVER SPRING, MD. 20903	124	21-May-87
906	32	THE WARWICK APTS. 1131 UNIVERSITY BLVD. W SILVER SPRING, MD. 20902	111	14-May-87
911	32	UNIVERSITY TOWERS CONDOMINIUM 1111 UNIVERSITY BLVD. W. SILVER SPRING, MD. 20902	108	13-May-87
912	35	KENWOOD CONDOMINIUM 5101 RIVER ROAD BETHESDA, MD. 20816	102	13-May-87
921	32	FOREST PARK APTS.J 9306 PINEY BRANCH RD. SILVER SPRING, MD. 20903	068	10-Dec-86
922	36	CLARIDGE HOUSE 2445 LYTTONSVILLE RD. SILVER SPRING, MD. 20910	105	03-Dec-86
923	31	WINEXBURG MANOR 2301 GLENALLEN AVE. SILVER SPRING, MD. 20906	053	03-Dec-86
924	37	MAPLE VIEW APTS. (TPC) 7710 MAPLE AVE. TAKOMA PARK, MD. 20912	067	10-Dec-86
936	32	PARKSIDE PLAZA CONDOMINIUM 9039 SILGO CREEK PKY SILVER SPRING, MD. 20901	057	08-Dec-86
939	29	CHELSEA TOWERS 7401 WESTLAKE TERRACE BETHESDA, MD. 20817	052	02-Dec-86
946	31	WATERFORD CONDOMINIUM 3333 UNIVERSITY BLVD. W. KENSINGTON, MD. 20895	151	12-May-87
951	37	SEVENTY-SIX ELEVEN MAPLE 1 7611 MAPLE AVE. (TCP) TAKOMA PARK, MD. 20912	066	10-Dec-86

TABLE A.14 (CONT.)

LIST OF RESIDENTIAL SITES

SITE NO.	PLAN AREA	NAME	SURVEY NO.	SURVEY DATE
953	36	MONTGOMERY TOWERS 415 SILVER SPRING AVE. SILVER SPRING, MD. 20910	106	13-May-87
954	32	KEN MIL 9119 MANCHESTER ROAD SILVER SPRING, MD. 20901	058	08-Dec-86
955	32	MANCHESTER MANOR 8401 MANCHESTER RD. SILVER SPRING, MD. 20901	060	08-Dec-86
968	35	SUSSEX HOUSE 4970 BATTERY LANE BETHESDA, MD. 20814	103	13-May-87
976	19	FIELDSTONE AT BRANDERMILL 11401 HEREFORDSHIRE WAY GERMANTOWN, MD. 20874	088	30-Apr-87
981	28	GREAT HOPE HOMES 900- GOOD HOPE DR. (1191) SILVER SPRING, MD. 20904	112	14-May-87
982	27	THE OVERLOOK 1 3968 CHESTERWOOD DR. SILVER SPRING, MD. 20906	152	12-May-87
991	23	CHERRYWOOD MOSS SIDE LANE OLNEY 20832 (OLD BALTIMORE RD)	114	14-May-87

TABLE A.15

TRIP GENERATION STUDY

RESIDENT SITE TRIP RATE SUMMARY BY TYPE - ADJACENT STREET PEAK

SURVEY NO.	DWELLING UNITS	AM PEAK HOUR START	AM TRIPS/DWELLING UNIT IN	AM TRIPS/DWELLING UNIT OUT	AM TRIPS/DWELLING UNIT TOTAL	AM AUTO OCC. OUT	PM PEAK HOUR START	PM TRIPS/DWELLING UNIT IN	PM TRIPS/DWELLING UNIT OUT	PM TRIPS/DWELLING UNIT TOTAL	PM AUTO OCC. IN
		SINGLE FAMILY DETACHED HOMES									
79	52	0700	0.10	0.73	0.83	1.16	1700	0.52	0.23	0.75	1.30
35	61	0730	0.20	0.38	0.57	1.17	1700	0.36	0.10	0.46	1.00
38	77	0700	0.12	0.57	0.69	1.27	1700	0.64	0.36	1.00	1.08
48	77	0700	0.13	0.65	0.78	1.38	1700	0.52	0.19	0.71	1.27
80	78	0700	0.27	0.88	1.15	1.49	1700	0.77	0.49	1.26	1.60
91	87	0700	0.49	0.74	1.23	1.58	1645	0.62	0.52	1.14	1.52
92	89	0700	0.15	0.42	0.56	1.14	1630	0.47	0.24	0.71	1.40
16	90	0700	0.19	0.71	0.90	1.45	1700	0.92	0.63	1.56	1.48
94	97	0730	0.23	0.33	0.56	1.34	1700	0.65	0.37	1.02	1.49
107	120	0745	0.18	0.54	0.72	1.45	1645	0.38	0.25	0.63	1.48
110	128	0700	0.12	0.62	0.75	1.52	1630	0.40	0.19	0.59	1.29
77	133	0700	0.11	0.57	0.68	1.39	1630	0.42	0.32	0.74	1.36
95	149	0800	0.09	0.34	0.42	1.28	1700	0.64	0.38	1.02	1.33
76	157	0800	0.15	0.52	0.67	1.33	1700	0.82	0.39	1.22	1.36
142	159	0700	0.12	0.50	0.62	1.23	1600	0.30	0.14	0.44	1.31
20	175	0730	0.12	0.43	0.55	1.47	1645	0.49	0.25	0.74	1.33
99	221	0730	0.14	0.48	0.62	1.35	1645	0.46	0.28	0.74	1.39
154	268	0745	0.35	0.69	1.04	1.42	1700	0.70	0.57	1.27	1.30
36	437	0715	0.14	0.42	0.57	1.29	1700	0.49	0.26	0.74	1.27
AVERAGE	140		0.18	0.53	0.71	1.37		0.55	0.33	0.87	1.35
		GARDEN APARTMENTS									
125	22	0800	0.09	0.27	0.36	1.00	1700	0.27	0.09	0.36	1.00
104	84	0730	0.38	0.54	0.92	1.93	1700	0.24	0.14	0.38	1.75
87	96	0715	0.02	0.30	0.32	1.14	1630	0.26	0.08	0.34	1.24
81	111	0800	0.06	0.26	0.32	1.59	1700	0.23	0.14	0.36	1.32
152	152	0730	0.03	0.16	0.20	1.00	1730	0.24	0.10	0.34	1.28
100	163	0730	0.20	0.37	0.56	1.37	1700	0.43	0.30	0.73	1.17
128	163	0800	0.07	0.29	0.37	1.19	1700	0.37	0.21	0.59	1.25
113	192	0800	0.02	0.10	0.11	1.16	1630	0.09	0.03	0.12	1.17
74	256	0730	0.08	0.39	0.47	1.17	1715	0.31	0.14	0.45	1.32
121	352	0800	0.12	0.25	0.37	1.48	1700	0.22	0.13	0.34	1.33
75	534	0730	0.07	0.25	0.32	1.31	1715	0.19	0.09	0.28	1.45
119	545	0800	0.11	0.25	0.36	1.31	1700	0.36	0.27	0.63	1.36
AVERAGE	222		0.10	0.27	0.37	1.33		0.27	0.16	0.42	1.33

TABLE A.15

TRIP GENERATION STUDY

RESIDENT SITE TRIP RATE SUMMARY BY TYPE - ADJACENT STREET PEAK

SURVEY NO.	DWELLING UNITS	AM PEAK HOUR START	AM TRIPS/DWELLING UNIT IN	AM TRIPS/DWELLING UNIT OUT	AM TRIPS/DWELLING UNIT TOTAL	AM AUTO OCC. OUT	PM PEAK HOUR START	PM TRIPS/DWELLING UNIT IN	PM TRIPS/DWELLING UNIT OUT	PM TRIPS/DWELLING UNIT TOTAL	PM AUTO OCC. IN
		HIGH-RISE MULTI-FAMILY									
103	54	0800	0.11	0.20	0.31	1.09	1700	0.26	0.22	0.48	1.50
67	120	0730	0.07	0.12	0.19	1.21	1700	0.17	0.07	0.24	1.24
151	150	0800	0.06	0.21	0.27	1.13	1700	0.25	0.11	0.36	1.26
102	174	0730	0.15	0.33	0.48	1.18	1730	0.33	0.20	0.53	1.21
52	238	0730	0.04	0.28	0.32	1.18	1700	0.18	0.07	0.24	1.02
57	249	0730	0.16	0.32	0.47	1.47	1700	0.29	0.10	0.39	1.45
111	393	0730	0.03	0.20	0.23	1.10	1630	0.15	0.16	0.32	1.52
124	400	0730	0.05	0.24	0.29	1.22	1600	0.23	0.10	0.33	1.18
83	410	0800	0.06	0.12	0.18	1.33	N/A	N/A	N/A	N/A	N/A
120	410	0800	0.16	0.17	0.34	1.39	1700	0.25	0.11	0.36	1.31
108	532	0730	0.04	0.14	0.18	1.24	1630	0.16	0.12	0.28	1.40
122	1100	0800	0.05	0.19	0.25	1.18	1700	0.20	0.13	0.32	1.23
AVERAGE	352		0.07	0.20	0.27	1.23		0.21	0.12	0.33	1.29
		MID-RISE MULTI-FAMILY									
60	53	0800	0.02	0.04	0.06	1.50	1700	0.11	0.04	0.15	1.17
106	61	0730	0.02	0.21	0.23	1.15	1700	0.15	0.07	0.21	1.11
58	66	0800	0.27	0.12	0.39	1.00	1700	0.27	0.21	0.48	1.33
66	74	0730	0.01	0.12	0.14	1.44	1700	0.11	0.23	0.34	1.00
53	169	0730	0.10	0.13	0.23	1.18	1700	0.22	0.15	0.38	1.16
68	193	0730	0.11	0.35	0.46	1.78	1700	0.32	0.22	0.53	1.49
59	226	0800	0.09	0.23	0.32	1.46	1700	0.23	0.15	0.38	1.24
AVERAGE	120		0.10	0.21	0.30	1.50		0.23	0.17	0.39	1.29
		SPECIAL TOWN HOUSE									
112	103	0715	0.23	0.47	0.70	2.15	1700	0.37	0.35	0.72	1.74
AVERAGE	103		0.23	0.47	0.70	2.15		0.37	0.35	0.72	1.74
		TOWN HOUSES									
123	108	0800	0.15	0.44	0.59	1.17	1700	0.57	0.33	0.91	1.48
114	144	0800	0.10	0.44	0.54	1.24	1700	0.45	0.15	0.60	1.12
88	265	0730	0.01	0.03	0.04	1.33	1700	0.06	0.03	0.09	1.12
18	404	0700	0.09	0.54	0.63	1.27	1700	0.31	0.12	0.44	1.20
AVERAGE	230		0.07	0.37	0.44	1.25		0.29	0.12	0.42	1.24

TABLE A.16

TRIP GENERATION STUDY

RESIDENT SITE TRIP RATE SUMMARY BY TYPE - SITE GENERATED PEAK

SURVEY NO.	DWELLING UNITS	AM PEAK HOUR START	AM TRIPS/DWELLING UNIT IN	AM TRIPS/DWELLING UNIT OUT	AM TRIPS/DWELLING UNIT TOTAL	AM AUTO OCC. OUT	PM PEAK HOUR START	PM TRIPS/DWELLING UNIT IN	PM TRIPS/DWELLING UNIT OUT	PM TRIPS/DWELLING UNIT TOTAL	PM AUTO OCC. IN
		SINGLE FAMILY DETACHED HOMES									
79	52	0700	0.10	0.73	0.83	1.16	1615	0.56	0.25	0.81	1.34
35	61	0745	0.21	0.38	0.59	1.17	1600	0.44	0.16	0.61	1.07
38	77	0700	0.12	0.57	0.69	1.27	1700	0.64	0.36	1.00	1.08
48	77	0700	0.13	0.65	0.78	1.38	1715	0.45	0.27	0.73	1.23
80	78	0700	0.27	0.88	1.15	1.49	1700	0.77	0.49	1.26	1.60
91	87	0700	0.49	0.74	1.23	1.58	1700	0.72	0.51	1.23	1.51
92	89	0800	0.22	0.55	0.78	1.47	1730	0.76	0.30	1.07	1.51
16	90	0730	0.28	0.86	1.13	1.34	1645	0.98	0.61	1.59	1.50
94	97	0630	0.45	0.69	1.14	1.16	1715	0.71	0.32	1.03	1.58
107	120	0800	0.25	0.52	0.77	1.65	1730	0.57	0.42	0.99	1.41
110	128	0700	0.12	0.62	0.75	1.52	1715	0.56	0.26	0.82	1.38
77	133	0745	0.20	0.77	0.97	1.56	1600	0.68	0.38	1.06	1.52
95	149	0715	0.13	0.52	0.65	1.23	1745	0.66	0.40	1.05	1.30
76	157	0730	0.17	0.63	0.80	1.26	1700	0.82	0.39	1.22	1.36
142	159	0700	0.12	0.50	0.62	1.23	1730	0.47	0.19	0.67	1.16
20	175	0730	0.12	0.43	0.55	1.47	1715	0.54	0.21	0.74	1.18
99	221	0715	0.15	0.58	0.74	1.43	1715	0.52	0.29	0.81	1.40
154	268	0800	0.41	0.72	1.14	1.38	1600	0.73	0.63	1.36	1.45
36	437	0715	0.14	0.42	0.57	1.29	1700	0.49	0.26	0.74	1.27
AVERAGE	140		0.21	0.59	0.80	1.38		0.62	0.35	0.97	1.37
		GARDEN APARTMENTS									
125	22	0800	0.09	0.27	0.36	1.00	1600	0.32	0.14	0.45	1.29
104	84	0700	0.38	0.62	1.00	1.87	1700	0.24	0.14	0.38	1.75
87	96	0645	0.05	0.30	0.35	1.24	1715	0.36	0.15	0.51	1.29
81	111	0715	0.12	0.32	0.43	1.51	1800	0.23	0.28	0.51	1.35
152	152	0800	0.05	0.18	0.24	1.21	1700	0.23	0.19	0.42	1.23
100	163	0715	0.20	0.40	0.60	1.38	1700	0.43	0.30	0.73	1.17
128	163	0715	0.06	0.33	0.39	1.22	1715	0.37	0.23	0.60	1.20
113	192	0645	0.02	0.17	0.18	1.31	1745	0.15	0.07	0.22	1.17
74	256	0730	0.08	0.39	0.47	1.17	1715	0.31	0.14	0.45	1.32
121	352	0800	0.12	0.25	0.37	1.48	1745	0.26	0.23	0.49	1.42
75	534	0730	0.07	0.25	0.32	1.31	1745	0.19	0.11	0.31	1.33
119	545	0700	0.11	0.40	0.51	1.37	1700	0.36	0.27	0.63	1.36
AVERAGE	222		0.10	0.31	0.41	1.36		0.28	0.19	0.47	1.32

TABLE A.16

TRIP GENERATION STUDY

RESIDENT SITE TRIP RATE SUMMARY BY TYPE - SITE GENERATED PEAK

SURVEY NO.	DWELLING UNITS	AM PEAK HOUR START	AM TRIPS/DWELLING UNIT IN	AM TRIPS/DWELLING UNIT OUT	AM TRIPS/DWELLING UNIT TOTAL	AM AUTO OCC. OUT	PM PEAK HOUR START	PM TRIPS/DWELLING UNIT IN	PM TRIPS/DWELLING UNIT OUT	PM TRIPS/DWELLING UNIT TOTAL	PM AUTO OCC. IN
		HIGH-RISE MULTI-FAMILY									
103	54	0730	0.13	0.33	0.46	1.22	1730	0.33	0.26	0.59	1.39
67	120	0815	0.10	0.15	0.25	1.44	1715	0.22	0.08	0.30	1.35
151	150	0715	0.06	0.27	0.33	1.17	1730	0.30	0.15	0.45	1.31
102	174	0745	0.16	0.39	0.55	1.21	1730	0.33	0.20	0.53	1.21
52	238	0800	0.06	0.32	0.38	1.11	1730	0.24	0.09	0.34	1.03
57	249	0745	0.14	0.34	0.48	1.49	1630	0.30	0.15	0.45	1.55
111	393	0715	0.03	0.20	0.23	1.09	1745	0.24	0.16	0.40	1.33
124	400	0745	0.05	0.27	0.32	1.15	1800	0.26	0.19	0.45	1.20
83	410	0715	0.07	0.15	0.22	1.62	N/A	N/A	N/A	N/A	N/A
120	410	0730	0.17	0.26	0.42	1.29	1715	0.25	0.13	0.38	1.28
108	532	0800	0.07	0.14	0.21	1.23	1645	0.16	0.13	0.29	1.39
122	1100	0715	0.05	0.25	0.30	1.16	1800	0.22	0.13	0.35	1.25
AVERAGE	352		0.08	0.24	0.32	1.23		0.24	0.14	0.38	1.29
		MID-RISE MULTI-FAMILY									
60	53	0630	0.02	0.19	0.21	1.00	1715	0.11	0.08	0.19	1.17
106	61	0730	0.02	0.21	0.23	1.15	1800	0.16	0.15	0.31	1.00
58	66	0800	0.27	0.12	0.39	1.00	1715	0.32	0.21	0.53	1.33
66	74	0700	0.04	0.15	0.19	1.36	1700	0.11	0.23	0.34	1.00
53	169	0700	0.10	0.17	0.27	1.00	1715	0.27	0.15	0.42	1.20
68	193	0700	0.12	0.35	0.47	1.62	1630	0.39	0.21	0.60	1.49
59	226	0700	0.10	0.30	0.40	1.53	1645	0.23	0.19	0.43	1.25
AVERAGE	120		0.10	0.24	0.35	1.41		0.26	0.18	0.44	1.31
		SPECIAL TOWN HOUSE									
112	103	0730	0.25	0.48	0.73	2.35	1645	0.40	0.33	0.73	1.56
AVERAGE	103		0.25	0.48	0.73	2.35		0.40	0.33	0.73	1.56
		TOWN HOUSES									
123	108	0730	0.14	0.61	0.75	1.44	1630	0.65	0.34	0.99	1.40
114	144	0745	0.09	0.47	0.56	1.25	1715	0.45	0.17	0.62	1.12
88	265	0745	0.03	0.06	0.08	1.33	1800	0.08	0.04	0.12	1.48
18	404	0715	0.09	0.56	0.66	1.25	1730	0.33	0.13	0.46	1.19
AVERAGE	230		0.08	0.41	0.49	1.29		0.31	0.13	0.45	1.25

APPENDIX B

TRIP GENERATION RATE STUDY METHODS

APPENDIX B

TRIP GENERATION RATE STUDY METHODS

B.1 OVERVIEW OF STUDY PROCESS

The technical methods used in the trip generation rate study were designed to respond to questions and criticisms currently being directed at trip generation rates in Montgomery County. The viewpoints of neighborhood groups, commercial developers and the providers of transportation facilities all constitute important perspectives on the subject. Consequently, every effort was made to incorporate concerns expressed by these groups into the framework of the research and analysis.

Briefly, the steps in the process were as follows:

1. Focus Group Meetings - Representatives from all stakeholder groups were invited to attend a series of meetings to discuss issues of credibility, development impacts, and applications. These meetings resulted in revisions to the original work plan which increased the value of the research. Several members of the focus groups were then incorporated into a Study Advisory Committee to assist M-NCPPC in reviewing the results.

2. Fall, 1986: Initial Data Collection - Complete inventories of candidate sites containing general offices, shopping centers, fast food restaurants or residential units were compiled. Stratified samples were then drawn to obtain the required number of sites for field data collection. The field data collected included driveway counts of vehicles leaving and entering a site and the number of occupants in each vehicle. The type of business plus the number and type of employees was ascertained for each office tenant through a questionnaire administered to tenants. The number of parking spaces on site was counted. At shopping centers and fast food restaurants, trip origins were determined through a short interview of patrons. (In this way, the number of pass-by trips was ascertained.) These data were supplemented by information on the physical characteristics of the sites and the demographic characteristics of residential areas which was drawn from secondary sources.

3. Interim Report - Following data collection in the Fall of 1986, an interim analysis was performed. This computed trip generation rates and presented tentative comparisons of these with ITE rates and those from other sources. The results of these analyses were used to confirm or modify the direction of the research and to set the sampling methods and sample sizes to be used for the Spring, 1987 data collection.

4. Spring, 1987: Final Data Collection - Based on reviews of the data collected in the Fall of 1986 and the analysis of these data by the Study Advisory Committee, a decision was made that the Spring, 1987 data collection should concentrate on office, shopping center, residential and fast food sites. (Originally, we also were to survey hotels and housing for the elderly in the Spring.) In addition, the Spring sampling was modified slightly to add sites for which historical data were available to serve as points of comparison. The modification in the sampling did not bias the results since many of the sites were already included in the statistically drawn random sample, and the few that were not were added to a group already large enough for purposes of statistical reliability.

5. Analysis and Recommendations - The final phase of the project was a comparison of the rates empirically derived from the field work with rates published in other sources and an analysis of differences between them. The trip rates recommended by this study reflect both the statistical distribution of the rates measured and the sources of variation identified by the analysis.

B.2 SAMPLE SELECTION

The objectives of the sample selection process were to identify a sufficient number of sites for a statistically reliable sample and to eliminate bias in the resulting trip generation rates where possible. Thus, all possible sites in Montgomery County were inventoried as the first step in the selection process.

B.2.1 Site Inventory

Office buildings were initially identified from lists prepared by Black's Office Leasing Guide: Washington-Baltimore Metro Area: Spring 1986 Update, Spaulding & Slye's "Washington Suburban Report" (July 1986) and a list from the Montgomery County Department of Economic Development. Multi-family residential sites were identified from a Montgomery County Office of Landlord-Tenant Affairs publication, Apartment Directory: Guide to Rental Facilities in Montgomery County, MD. Shopping centers were identified from a list presented by the Alexandria Drafting Company in their Montgomery County, Maryland Street Map (1986). This was augmented by the C & P Telephone "Yellow Pages" and by the personal knowledge of the Douglas & Douglas staff. Single family dwelling units were identified from real estate lists and the Alexandria Drafting Company's Montgomery County maps. Fast food restaurants were located through the "Yellow Pages" and by consulting the fast food chains' regional offices.

B.2.2 Preliminary Screening

Preliminary screening excluded all sites within 2,500 feet of a Metrorail station since the Metrorail walksheds were surveyed as part of the M-NCPPC Post Metro Transportation

Characteristics Study. The preliminary screening process also eliminated sites containing structures in the final phases of construction or not occupied.

Following preliminary screening, the full inventory of approximately 1,000 sites was then tested against three criteria to develop a list of acceptable candidates. The three tests were:

1. Homogeneity of land use - Only sites with a single land use were studied in this research. Although there is a great interest in mixed land uses, the Advisory Committee and M-NCPPC staff agreed that basic research was needed more for single land uses, in order to provide the proper foundation for assessing development proposals. Mixing of land uses and the possible impacts on trip generation rates represent possible avenues for future research.

   Shopping centers which contained fast food restaurants, either within the main building of the center, or on an out-parcel, were surveyed as single retail sites. The volume of trips recorded at these sites therefore includes some trips which were generated by fast food restaurants.

   However, fast food restaurants located within the structure of a shopping center (and thus having only pedestrian access) were excluded from consideration when it came to drawing a sample of these restaurants for purposes of performing traffic counts. Also excluded were fast food restaurants located on an outparcel adjacent to a shopping center for which it was difficult to restrict counting of vehicles to those actually patronizing the restaurant. Only where the restaurant patronage was clearly differentiable from shopping center traffic was an out-parcel fast food restaurant included in the population from which our sample was drawn.

2. Reasonable Occupancy Rate - Sites which had low occupancy rates were excluded from the study. This was because not only is traffic lower than it would be with full occupancy in such cases, but where construction is taking place there is a considerable amount of construction traffic, which distorts the trip generation data. For example, housing projects under construction have a lot of construction traffic and frequently have homes that are sold but not occupied. In several cases, retail centers with high occupancy rates were undergoing major renovation or revitalization and were therefore excluded from the study. Office buildings in their initial leasing period or, in a few cases, undergoing major renovation, were also rejected. In each of these cases the decision was prompted by a desire to avoid abnormal conditions.

3. Field Test Acceptability - The owner/manager of each site that was randomly selected for survey was contacted for permission to enter the site and interview tenants or customers. Six sites were rejected after the owner's refusal to participate in the project. These were all less than 100,000 square feet in size. Most were owned by banks and had parking problems.

Sites for which permission to survey was granted by the owner were also checked for access control (that is whether the vehicles entering and leaving the survey site could be distinguished from other vehicular traffic). In several cases we combined buildings of a similar size and character into a single survey because they had shared parking facilities. Two buildings were removed from the sample because they lacked onsite parking, and off-site parking was dispersed among enough locations to render observation impossible. Finally, field checks were made of entrance and exit driveways for shopping centers and fast food restaurants to determine the size of the crew needed for surveying.

B.2.3 Stratified Random Sample Selection

In random sampling all members of a population have an equal chance of being selected. But of all the sites in Montgomery County from which we wished to draw samples, only a few had certain characteristics of particular interest in this study, such that had a truly random sample been drawn, we would have taken statistically unreliable numbers of such sites. For example, among existing office buildings in Montgomery County, 40% are under 50,000 square feet in size, and only 7% of the buildings are larger than 200,000 square feet in size. But because buildings over 200,000 square feet represent the apparent trend in applications for new development in the County and because they have a much larger impact on traffic per site than small buildings, we would like them to represent rather more than 7% of our sample and this way produce more statistically meaningful results about them. In cases such as this, we can stratify our sample. This entails decomposing the population of sites into groups defined by a specific characteristic - in this case, office building size - and then, when drawing the sample, picking from each group equally. In this way, a statistically significant sample can be drawn from each size group using a random process. Stratification based on size was used for both offices and shopping centers. Residential sites were stratified by both type and size since previous experience has shown that trip rates for single-family dwelling units are quite different from trip rates for multi-family units. The characteristics used for stratification purposes and the sample sizes are given in the chapters for each land use.

B.3 TRIP END DATA COLLECTION

Driveway counts of vehicles entering and leaving the selected sites represent the primary trip end data collected for this study. Counts were made manually and recorded according to vehicle occupancy rates over fifteen-minute intervals. Arrival and/or departure by means other than automobile was so rare (1%-2%) that it was deemed to be outside the concern of this study. (Pedestrians were recorded but not reported--they were assumed to be either transit riders, carpool dropoffs or all-walk commuters. This extremely low level of traffic by non-auto modes was primarily due to the location of the sites selected in areas with limited or no transit service.

Each site was identified with a unique number and the geographic area of its location, and the day of the week and date on which field surveys were done were noted for every site. Field surveys were conducted between September 30, 1986 and December 11, 1986 and between April 22, 1987 and June 11, 1987. The collection periods were organized to capture typical weekday traffic during periods when public schools were in session. Weekdays which fell on either side of a major holiday were excluded from study.

The hours over which traffic counts took place varied by land use and are listed in Table B.1. They were selected to cover the hours of maximum traffic on Montgomery County roads. This generally occurs during the morning and afternoon rush hours or peak periods. Data collection was, in most cases, limited to Tuesday through Thursday with adjustments for holidays so that the data would most closely approximate typical weekday traffic. In a few instances, counts were taken on Monday (comparisons with Tuesday through Thursday data showed hardly perceptible variation). At fast food restaurants and retail centers, data were also collected during off-peak hours in order to determine the diurnal distribution of the trips generated by these land uses and also to provide more comprehensive data on pass-by and diverted trips. Tenant and customer surveys were conducted on the same day as the traffic counts.

Machine counts using pneumatic tube counters were conducted during the first month of the survey. Their use was discontinued after tube count data and manual count data were compared. As has often been found in earlier applications, tube counters frequently do not produce accurate results in driveways where traffic moves at low speeds. In most cases, tube count data are factored based on a short manual count. Our experience with this approach was that the inaccuracies were non-uniform and that any expansion or contraction of the data based on a short manual count produced unreliable results. Consequently, all data presented in this report represent carefully controlled manual counts made by people observing entrances and exits.

B.4 LAND USE AND TRAVEL DATA COLLECTION

The prediction of trip generation rates for buildings in advance of their construction depends on there being a known relationship between vehicular trips and some predictable and measurable characteristic of the proposed development. It is here that the needs of long range planning and development approval activities diverge. In long range planning one can presuppose an income or an auto ownership level for future generations. But these projections are of little value in the development approval process. To illustrate, it would be inappropriate and unacceptable to assess the development impact fees to be met by a home builder on the basis of the number of automobiles his clients are expected to own since this is outside his control. However, it would be acceptable to assess fees on the basis of housing cost or housing size (number of rooms, number of bedrooms, etc.) because these <u>are</u> under the control of the developer. It becomes

TABLE B.1

TRIP GENERATION RATE SURVEY PERIODS

LAND USE	TRAFFIC COUNT PERIODS	OTHER SURVEYS
OFFICE	7:00 AM - 9:30 AM 4:00 PM - 6:30 PM	Tenant Surveys
RETAIL (Shopping Centers)	10:00 AM - 10:00 PM	Shopper Survey
RESIDENTIAL	7:00 AM - 9:30 AM 4:00 PM - 6:30 PM	No Other Survey
FAST FOOD RESTAURANT	7:00 AM - 7:00 PM	Customer Survey

necessary, then, to derive some statistically significant relationship between traffic generation and an alterable land use characteristic. The intention is that this relationship be used to predict the traffic generated by developments in advance of their construction.

A set of independent variables was selected for each land use type. These were characteristics of the land use believed to influence the number of trips generated. The objective was to isolate those variables which were highly correlated with trip rates as well as being measurable and predictable. Table B.2 lists the variables selected for this study. We can divide them into two groups. Primary variables are those which could perhaps be used to predict trip generation levels during the planning, zoning and subdivision approval processes. Secondary variables are those which are interesting because they may help to explain variations in trip generation rates between sites.

Primary variables can themselves be decomposed into two basic categories. The first category, which includes occupied floor area, number of dwelling units, presence of a drive-through facility, etc., consists of variables which can be used to estimate future traffic directly. The second category, which includes transportation systems management (TSM) incentives used, parking costs, and the availability of public transit services, consists of variables which can be used to adjust the basic trip generation rate. For example, in a zoning application for a new development, the impact fees assessment could be based on the trip rate linked to the relevant category of land use. But based on either the location of the site within the County or some

TABLE B.2

MONTGOMERY COUNTY TRIP GENERATION RATE STUDY: INDEPENDENT VARIABLES DESCRIBING LAND USE CHARACTERISTICS

PRIMARY VARIABLES	SECONDARY VARIABLES
OFFICE BUILDINGS	
Floor Area (Occ. Gross Sq. Ft)	Number of Tenants
Number of Employees	Business of Tenants
Office Hours	No. Pking Spaces Provided
No. Employees Present on Day of Survey	No. Employees in Each Job Category
Number of Floors	Average Tenant Size
TSM Incentives Used	Year Built
Parking Costs/Conditions	
Metro/Ride-on Services Available	
RETAIL SHOPPING CENTERS	
Floor Area (Occ.Gr.Leasable Sq.Ft)	Number of Parking Spaces
Patron's Trip Type (Pass-by, Primary, Diverted)	Number of Stores
Public Transportation Availability	Types of Stores
	Major Tenants
FAST FOOD RESTAURANTS	
Floor Area (Gross Sq. Ft)	Number of Parking Spaces
Drive-Through Facilities	
Number of Seats	
Number of Cash Registers	
RESIDENCES	
Number of Dwelling Units	Number of Parking Spaces
Type of Dwellings	1980 Populn/Dwelling Unit
Building Height (No.Floors)	1980 Median Income
Median Value of Units	
Median Rent (1986)	

agreement by the developer to implement measures which have been shown to reduce peak hour traffic, an adjustment to the estimated trip generation rate might be made.

Secondary variables, such as the future number and mix of tenants in an office building or stores in a retail center, are currently outside the control of the developer and are not regulated by the zoning process. But even though they are not readily usable in the assessment of development applications, they can help us to understand trip rate differences between sites.

B.4.1 Site Data

In the preceding section, we classified our data according to its potential value in the development review process. At this point, it is convenient to decompose this same independent variable data into three groups corresponding to their source: site data, tenant information, and trip characteristic information. Principal building or site characteristics were determined either through discussion with building owners and managers or through physical observation. Initial estimates of gross floor area were drawn from the various publications cited earlier and were later verified by building owners and managers. Field surveys included collection of data such as the number of parking spaces by type, the number of floors, and the number of tenants.

The time span of the "adjacent street peak hour" was determined from traffic counts performed by the State Highway Administration and the Montgomery County DOT during 1986 and 1987. We selected the nearest major arterial as the "adjacent street." (We did not use the peak hour count for the street serving the site driveway as it is often only representative of the site being surveyed, plus one or two neighbors.) Frequently, the adjacent street peak hour counts reflected the traffic at the nearest major signalized intersection.

Other data collected by observation included the number and names of tenants at both office and retail sites and the physical characteristics of fast food restaurants such as the presence of a drive-through facility and the numbers of seats and cash registers, etc.

In some cases, trip generation rates expressed in terms of crude site or tenant characteristics may be more reliable than those expressed in terms of variables which, a priori, are more closely linked to trip generation but which are much more difficult to measure accurately in the field. To illustrate, note that, in this research, we computed office trip generation rates with respect to the Occupied Gross Square Footage as opposed to the Occupied Leasable Square Footage of a building. It might be thought that the latter is a more desirable base for trip rates because it excludes such things as hallways, washrooms, janitorial closets, and the building lobby which do not generate traffic independent of the tenants around them and which account for different proportions of the gross square footage in different buildings. The problem is that, unlike gross area, there is no obvious and universally recognized measure of leasable area in a building. Indeed it is not uncommon for building managers and researchers to simply estimate the leasable area as some percentage of the gross. Further, any measure of leasable area can be more or less reliable depending on the number of tenants (if any) that occupy whole floors of a building.

Thus, since gross square footage can at least be determined accurately from building plans, it was used as the basis for our trip generation rates. However, when a significant proportion (i.e., more than 20%) of an office building was devoted to non-office use, either as a conference center or as an open atrium, this space was deducted from the gross square footage before trip rates were computed.

Similar difficulties arise in fast food restaurants when using the number of cash registers or the number of seats to determine the amount of traffic. For example, the number of cash registers may actually be a function of the sales methods used (so that Wendys will use one cash register where McDonalds will use eight or ten).

B.4.2 Tenant Information

Much of the trip generation analysis was a test of various hypotheses. One hypothesis was that the gross size of an office building affected the trip generation rate. A second hypothesis was that the characteristics of the tenants in an office complex or shopping center will have an impact on trip generation rates such that information about these characteristics should help to explain variations in trip rates. Data were collected to allow these hypotheses to be tested.

Tenants of office buildings were interviewed on the day of the driveway count using the interview form shown in Figure B.1.

Three main types of data were collected from tenants:

- Nature of business - the type of business pursued by the firm (as stated in the interview) and the types of employees - management, sales, clerical, and so forth - who work there;

- Size of the tenant - the number of square feet occupied by the tenant and the number of employees (both total and the number present on the day of the survey). From this information, we determined the occupancy rates of the building and the employment densities in general and on the day of the survey;

- Transportation environment - the employer's level of support for various transportation systems management (TSM) measures such as flex-time, vanpools/carpools, and/or some form of transit promotion such as Fareshare. At the time of the surveys, a county-wide carpool program was in place, but formal Transportation Management Associations (TMA's) were in their infancy.

Tenants at retail centers were listed by name and by type of business. There was no direct contact with the managers of the tenant stores to obtain information. The remainder of the information on retail sites was gathered from the owner or manager of the center rather than from individual tenants.

FIGURE B.1

MONTGOMERY COUNTY TRIP GENERATION RATE STUDY
OFFICE TENANT FACT SHEET

A. Site Number: ______________________

B. Building Name/Address: ______________________
C. Company Name: ______________________
D. Suite Number: ______________________
E. Person Interviewed: ______________________
(Name, Title, and Telephone Number) ______________________

F. Nature of Business ______________________

G. Square Feet of Area Leased ______________Square Feet

H. Number of Employees at this Location ______________Employees

I. What are the Occupations of the People Working Here?

Occupation	Number of Employees
Managers and Professionals	________
Sales	________
Service	________
Clerical	________
Manufacturing	________
Other (specify)	________
TOTAL	________

J. Number of Employees Present on Day of Survey? __________Employees

K. Is this a Typical Day at This Office? _____Yes _____No
If not, explain:

L. Does your office have any programs or incentives to encourage:

	Yes	No
Carpools	____	____
Vanpools	____	____
Flex-time	____	____
Use of Pub. Trans.	____	____
Other (Specify)	____	____

Fast food restaurants were surveyed for a number of physical attributes such as the numbers of seats, cash registers, drive-through windows, etc. The manager of each fast food survey was interviewed to provide information on the number of employees. (All this data was collected on the day of the traffic count.)

There was almost no contact with the tenants of residential sites. The managers of multi-family sites were contacted on the day of the survey to determine the number of occupied units. Unit occupancy in projects with single-family dwelling units was done by inspection on the day traffic counts were made.

B.5 INTERVIEW DATA

An important issue with respect to trip generation rates at retail centers and fast food restaurants is whether the trip was made specifically to travel to that location. Thus, customers at retail and fast food sites were interviewed to determine if their trip was a primary trip, or one either diverted from a nearby road or captured from the roadway immediately adjacent to the site. Two interview forms were tested, leading to the development of the final form of the questionnaire, which is shown in Figure B.2. This questionnaire was used at both shopping centers and fast food restaurants with equally successful results.

B.6 ANALYSIS OF TRIP GENERATION RATE DATA

Analysis of the trip generation rate data focuses on what rates are observed in Montgomery County today and how these rates compare with those reported from other parts of the country by ITE. We also examined a number of independent variables to suggest why the rates varied from site to site when there were no apparent differences between them in terms of the more commonly-used independent variables such as occupied floor space.

Variations in trip rates from one site to another occur for all of land use types examined in this study. But of course the causes of this variation for one land use need not affect trip rates for other land uses in the same way - if indeed they have any influence at all. For example, the variation in PM peak hour traffic at fast food restaurants of equivalent size, brand name, and service is highly correlated with the adjacent street traffic volumes. We did not find this same relationship between adjacent street traffic volumes and trip rates for any other land use in the study.

While the data for each land use were analyzed using similar techniques and methods of comparison, later stages of the analysis sought to investigate possible relationships between travel and site characteristics that were unique to each land use. We have summarized these analyses and our observations in chapters 3 through 7 of this report.

FIGURE B.2

MONTGOMERY COUNTY TRIP GENERATION RATE STUDY: PASS-BY AND DIVERTED TRIP QUESTIONNAIRE

Good morning/afternoon, my name is __(Your Name)_____. I am conducting a traffic study for the Maryland-National Capital Park and Planning Commission and I would like to ask you a few brief questions. (If they do not wish to answer, end the interview - otherwise proceed.)

Note the time: _______AM/PM

1. Where did you come from before you made this stop at (Name of restaurant or shopping center)?

(Home, work, shopping, other)

2. Are you going back there after you leave this (restaurant or shopping center)?

NO_____
If No,
3. Would you have driven by (this location) anyway, if you had not made this stop?
Yes_________
No_________
Thank you!

YES________
If yes,
Thank you!