ARIZONA DEPARTMENT OF TRANSPORTATION

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TRIP ATTRACTION RATES STUDY

Final Report (Volume I)

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16. Abstract

The objectives of this study, conducted for the Arizona Department of Transportation, were to 1) efficiently collect data on current non-residential trip attraction rates, non-home-based trips and non-home-based (NHB) trip length trip length (duration), 2) analyze these data in order to develop trip attraction rates by major land use type and development category and make recommendations for the revision of trip attraction relationships used by the Tucson area trip generation models, and 3) develop a new NHB trip length distribution for comparison with the current simulation and update the associated model friction factors, if necessary. The study was conducted in two parts, Spring, 1986 and Fall, 1986, and encompassed 45 different sites. The sites represented 6 of the 12 employment categories PAGPTD, the local MPO, uses in its trip generation model. Overall, more NHB travel was observed than was predicted in the model. Community shopping centers (CSC) and other retail (OR) had large increases in their NHB trip rates. Another result was, for some development categories, the observed trip rates were the same as those used in the modelling process. The ONR category is especially sensitive to shifts in the economic makeup of the community, it was suggested that the category be further disaggregated. Another possible change to the model system is the elimination of the CBD as a land use/development category. The results are mixed in attempting to balance the trip production and trip attraction generation models. Home-based other (HBO) trips move in the correct direction (towards productions), while home-based work (HBW), home-based shopping (HBS) and NHB do not.

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1.0 INTRODUCTION

1.1 Background

The trip generation step of the urban travel demand forecasting process is concerned with estimating the number of trips produced and attracted to an area, based on its socio-economic and land use characteristics. In general, trip generation analysis can be separated into two basic components. The first, trip productions, is based on household characteristics, such as household income, household size, and auto ownership. The second component, trip attractions, is based on non-residential characteristics, such as employment, land use type, and area type.

In checking the causal relationships used in trip generation analysis for applicability and stability, much of the previous emphasis has been placed on the trip production component, because it is generally felt that household characteristics more adequately reflect changes in travel behavior. However, it is equally important that the causal relationships used in estimating trip attractions also be checked for applicability and stability. Although the summation of regionwide trip attraction totals may closely balance the trip production totals, examination of trips ends at the small area level, such as the transportation analysis zone, may reveal an under-prediction or over prediction of trip attractions to certain types of non-residential land use activities. This error in the estimation of trip attractions can result in poor traffic assignment results in that subarea.

It is felt that some of the assigned travel volume discrepancies in the Pima Association of Governments, Transportation Planning Division (PAGTPD) travel simulations can be attributed to the procedures used in estimating these trip attractions. Potential problem areas in PAGTPD procedures are insufficient stratification of land use type and area type and the lack of current empirical data on non-residential activity trip attraction rates.

Land use type is stratified by PAGTPD into retail and non-retail. The retail categories are community shopping center, regional shopping center, and other retail. PAGTPD also further disaggregates non-retail by its location in the region and by other categories such as community college and hospitals. An increase in stratification of these land use categories can improve the accuracy of the trip generation model, because there are probably more stratifications of land use type, other than retail and non-retail that exhibit substantially different attraction rates. For example, if manufacturing and office building land use categories do have very different trip attraction rates, then the accuracy of the trip attraction model will likely improve by further stratifying the non-retail employment into these two categories.

The lack of data on non-residential activity can result in inadequate calibration of non-home-based trip distribution parameters. This potentially can lead to poor travel simulation results. Non-home-based trips are estimated to comprise a sizable proportion of regionwide travel. Non-home-based trips are often under reported in household oriented surveys.

Additional data, specifically targeted towards non-residential to non-residential trip types, may be necessary for accurate calibration of the trip distribution parameters for non-home-based travel.

There has been significant work conducted on regionwide, urban area trip attraction analysis and non-home-based trip distribution. Almost every urban area that performs transportation systems planning has conducted analyses in these areas. However, almost all of this work has been based on household oriented surveys, such as the U.S. Census Journey-to-Work data or home interview surveys. There have been few recent origin-destination studies with large enough samples to adequately address stratification of non-residential land use type and area types and non-home-based travel.

Trip attraction rates for specific land use categories have also been reported in numerous studies, including the **Institute of Transportation Engineers (ITE) Trip Generation Manual.** These type of studies do not include information on trip purpose or trip length, and are often not adequate for use in regional transportation modelling efforts.

No recent comprehensive studies of non-residential trip attraction behavior and non-home-based trip distribution were found. There have been numerous small scale surveys, usually for special generators, which have collected this type of information. However, these type of surveys have generally been for only one or two specific sites. No recent comprehensive surveys at the non-residential trip end including data on non-home-based

trip distribution, particularly for areas similar to Tucson were found in the literature.

1.2 Objectives and Methodology

The primary objectives of this study were to: 1) efficiently collect data on current non-residential trip attraction rates, non-home-based trips and non-home-based trip length (duration), 2) analyze these data in order to develop trip attraction rates by major land use type and development category and make recommendations for the revision of trip attraction relationships in the PAGTPD trip generation models, and 3) develop a new non-home-based trip length distribution for comparison with the current PAGTPD simulation and update the associated model friction factors, if necessary.

The secondary objectives of this study included: 1) development of a survey instrument and the establishment of a database for non-residential trip activity, 2) consideration of the availability of forecasts for any new non-residential trip attraction variables, 3) development of recommendations for non-residential trip characteristics requiring further research, and 4) reporting of the observed trip attraction rates in a form suitable for inclusion in the Trip Generation Intensity Factors reports published by the Arizona Department of Transportation.

The method required to gather the data necessary to meet these objectives was a survey that focused on travel to and from non-residential locations. The survey was conducted in two parts, in the spring and fall of 1986, and encompassed 45 differ-

ent sites. These sites represented 6 of the 12 employment categories PAGTPD uses in its trip generation model:

1 - Central Business District (CBD)
2 - Community Shopping Center (CSC)
3 - Regional Shopping Center (RSC)
4 - Other Retail (OR)
5 - Other Non-Retail (ONR)
6 - Davis-Monthan Air Force Base (DMAFB).

DMAFB is one of the six special generator (SG) employment categories that PAGPTD uses in its current model. Revised trip attraction rates for three other SG categories, Tucson International Airport (TIA), University of Arizona (UA), and Pima Community College (PCC), are also proposed in this report. These SG rates were acquired by contacting other MPOs in the country and using their rates for sites comparable to the Tucson sites.

1.3 Report Structure

This report presents the study methodology, analysis, results, and conclusions of the Trip Attraction Rates Study. This chapter describes the objectives and background of the study. Chapter 2 presents the new trip attraction rates derived from this study, along with a discussion of the methodology used to calculate them.

Chapter 3 focuses on the non-home-based trip length distribution developed from this study and how it compares with the one currently used by PAGTPD. Chapter 4 analyzes the results of modelling simulations performed using scenarios proposed by the study team. Also included in this chapter are new development categories proposed by the study team that may help more accurately predict Other Non-Retail (ONR) travel in the

future. Chapter 5 presents the conclusions drawn by the study team and recommendations for further research that PAGTPD may wish to pursue in order to more accurately predict non-residential travel in the Tucson area.

Chapter 6 is a discussion of how the survey was designed and implemented. Included here are problems encountered during the survey process, survey card return rates and sampling rates, and a section on the statistical validity of the survey method and sample collected. Chapter 7 is a detailed description of processes used to edit, compile, analyze, weight and expand the data collected from various sources during the course of the study.

2.0 ANALYSES OF TRIP ATTRACTION RATES

2.1 Introduction

This chapter describes the methodology used to calculate and analyze the trip attraction rates. The rates were derived from the survey card and other data sources discussed in Chapter 5. The theories employed to calculate the rates in each part of the survey and to combine the two parts into final, composite rates are described here. The survey sites were grouped into land use and development categories according to PAGTPD model specifications. Trip attraction rates were developed for these categories so that comparisons could be made with those from the PAGTPD model. Potential new stratifications of trip attractions by land use and development type were proposed, tested, and rates were calculated for them, also.

The term "trip attraction rates" that appears in this report refers to the measure of vehicle person trips per employee. The rates calculated in this study are for vehicle trips only. They do not include walk trips.

2.2 Methodology

The surveys were originally scheduled to begin in October of 1985, with the first half of the surveying to be completed prior to Thanksgiving of that year. The holidays were to have been spent evaluating the first half and recommending modifications for the second half, as well as giving a preliminary analysis of the travel related findings.

The surveys did not actually start until the first week in February. Although the objective then was to survey 45 sites

during the following weeks, in essence doubling the rate at which the surveys were originally intended to be completed, it soon became apparent that this would not be possible. Surveying two sites per day was not feasible when large sites such as regional shopping malls were surveyed, since both field crews were required for this kind of site. Also, some key periods of the day were missed at the majority of the sites, necessitating resurveys. In addition, some of the winter residents of Tucson began to leave as early as March, making results after this date tenuous. These factors led to the decision at the beginning of March to divide the survey into two segments. The first group of surveys were conducted in February and March, 1986, and the second group will be conducted between September and December, 1986.

There are several benefits to this schedule. A survey with equally distributed late and early winter data would be more representative of overall peak season traffic patterns than one with just late winter data. In addition, a mid-course analysis would point out areas needing further investigation which could be followed up in the second half of the survey. Finally, lessons learned from the first half of the survey could be used to make the second half of the survey more efficient and the results more meaningful.

In the the calculation and analysis of trip attraction rates, the differences between the two part of the survey have their most profound effect. The addition of the question in Part Two that asked where the tripmaker was travelling next allowed

the study team to generate more confident attraction rates. It is best to describe the methodology used in each part of the survey separately, and then describe how the rates calculated for each part were combined into one rate.

2.2.1 Derivation of Trip Attraction Rates for Part One

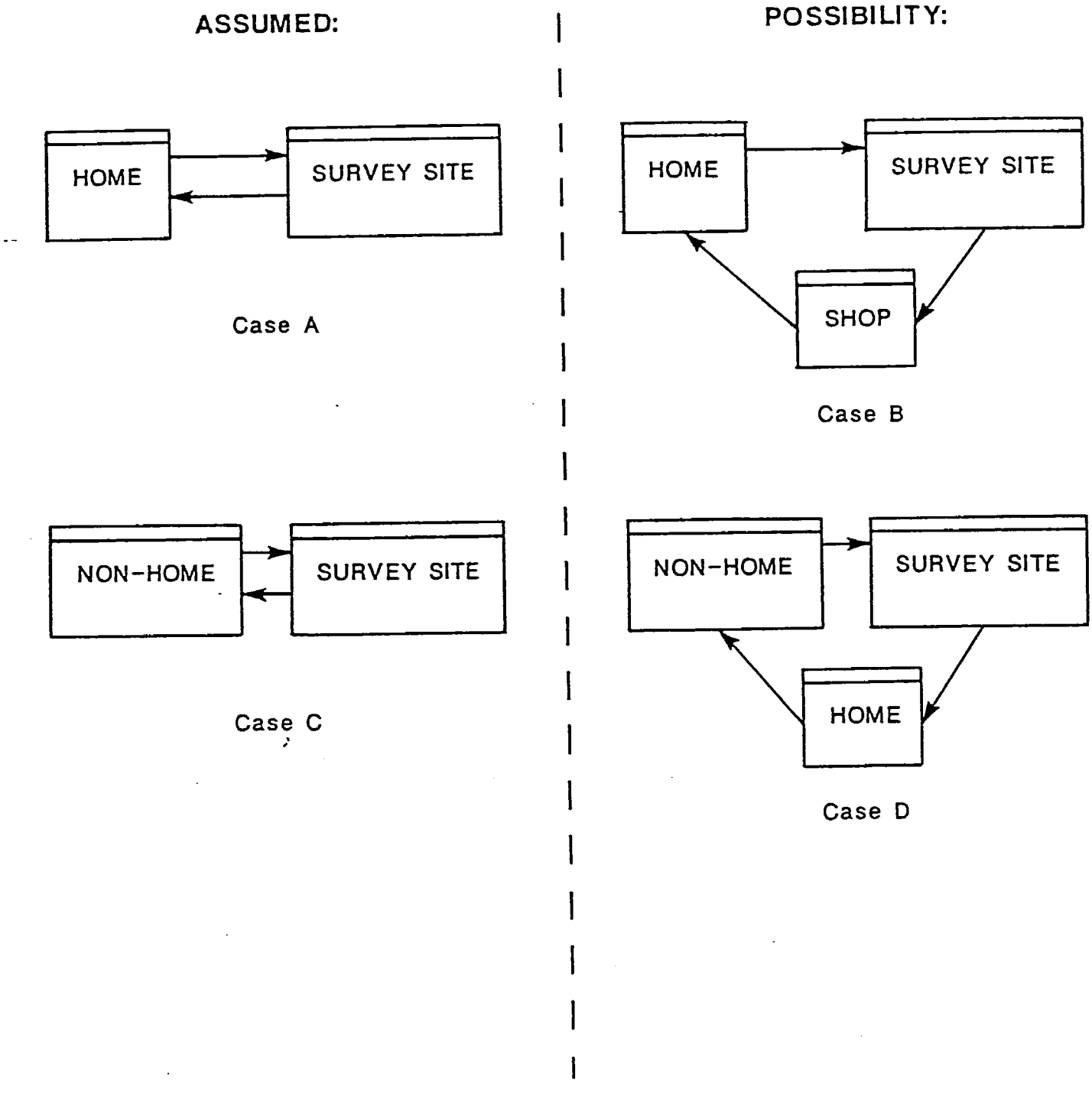
As discussed earlier, for home-based trips, the home end is the production and the non-home end is the attraction. For non-home-based trips, the origin end is the production and the destination is the attraction. Trip attraction rates were calculated in Part One of the survey based upon an assumption of symmetry. For example, if a trip started at home and went to the survey site, it was assumed that the next trip for the respondent was back home. This scenario is shown by Case A in Exhibit 2-1. Using this assumption, the trip would produce two home-based attractions for that site.

For non-home-based trips, it is assumed that the respondent's next trip is to another location other than home. Therefore, this trip would produce one non-home-based attraction and one non-home-based production. This scenario is shown by Case C in Exhibit 2-1. The assumption of symmetry used in Part One assumes that the tripmaker next trip is to the same type of place that he came from, i.e., if he came from home to the survey site, he is going back home upon leaving.

Cases B and D of Exhibit 2-1 show what might actually have occurred. The design of the questionnaire in Part One precludes the study team from determining if these cases actually occurred. In Case B, the tripmaker goes from home to the survey site, and

Exhibit 2-1

DIFFERENT TRIP ATTRACTION SCENARIOS



then to another non-home site. This scenario would produce one home-based attraction and one non-home-based production, instead of the two home-based productions assumed by Case A. In Case D, the tripmaker goes from a non-home location to the survey site, and then home. This would produce one non-home-based attraction and one home-based attraction, instead of one non-home-based attraction and one non-home based production assumed by Case C. Therefore, the assumption of symmetry does have its flaws.

Trip attraction rates, for this study, are the number of vehicle trips attracted to the site per employee working at the site. The rates for the PAGTPD development categories in Part One of the survey are shown in Exhibit 2-2. A table showing the rates for each site in Part One is included in Appendix 1. When computting the home-based rates, the number of vehicle trips is divided by the number of employees and then multiplied by two. They are multiplied by two because of the assumption of symmetry. The rate for non-home-based attractions is simply the number of trips to the site divided by the number of employees working at the site. The number of trips used is the expanded and weighted count of person vehicle trips for the 24-hour period.

2.2.2 Derivation of Trip Attraction Rates for Part Two

For Part Two of the survey, the assumption of symmetry is no longer necessary because of the additional question that asks the tripmaker where he is going next. Using the response to this question, it was possible to determine which of the four scenarios presented in Exhibit 2-1 actually took place from the survey card data. This led to the addition of a new rate cate-

Exhibit 2-2

PART ONE TRIP ATTRACTION RATES

(Vehicle Trips/Employee)

Central Business District

HBW	2.09
HBS	0.00
HBO	1.08
NHB	0.72
Total	3.89

Community Shopping Center

HBW	1.70
HBS	13.35
HBO	10.76
NHB	10.77
Total	36.58

Other Retail

HBW	1.39
HBS	15.05
HBO	2.98
NHB	10.32
Total	29.74

Other Non-Retail

HBW	1.45
HBS	0.05
HBO	2.13
NHB	1.26
Total	4.89

Exhibit 2-3

PART TWO TRIP ATTRACTION RATES

(Vehicle Trips/Employee)

Central Business District		
HBW	1.73	
HBS	0.00	
HBO	2.96	
NHBA	2.21	
NHBP		2.28
Total	6.90	
Community Shopping Center		
HBW	2.50	
HBS	34.37	
HBO	7.26	
NHBA	18.37	
NHBP		10.10
Total	62.50	
Regional Shopping Center		
HBW	1.77	
HBS	6.68	
HBO	6.56	
NHBA	6.54	
NHBP		4.51
Total	21.54	
Other Retail		
HBW	1.78	
HBS	15.46	
HBO	6.46	
NHBA	13.27	
NHBP		8.78
Total	36.97	
Other Non-Retail		
HBW	1.41	
HBS	0.08	
HBO	2.76	
NHBA	1.84	
NHBP		2.03
Total	6.09	
Davis-Monthan Air Force Base		
HBW	2.19	
HBS	0.88	
HBO	1.17	
NHBA	0.67	
NHBP		0.12
Total	4.91	

gory, non-home-based productions, because they could now be accurately calculated. Exhibit 2-3 presents the trip attraction rates, by PAGTPD development category, for the sites in Part Two of the survey. For all trip purposes, the formula for computing the attraction rate is the number of vehicle trips to the site divided by the number of employees working at the site. The non-home-based production (NHBP) rate is also shown in Exhibit 2-3. However, the NHBP numbers are not included in site totals because they are productions and not attractions. A table showing the rates for all of the sites in Part Two is included in Appendix 1.

2.2.3 Derivation of Combined Trip Attraction Rates

To combine the trip attraction rates derived from the two parts of the survey into one composite rate, it was necessary to calculate rates for Part Two using the same methodology used in Part One. This meant applying the assumption of symmetry to the Part Two data even though it was not necessary because of the additional question. These rates were derived so that a factor could be calculated that would represent the ratio between the two methodologies. The attraction rates for Part Two, using the Part One methodology, are shown in Exhibit 2-4.

The expansion factor calculated was applied to the number of trips in each development category in Part One of the survey and new trip rates were derived, combining the data from both parts of the survey. Exhibit 2-5 shows how the composite rates were calculated for each of the development categories.

The simplest way to explain the combination of the two surveys is "walk through" the procedure using one of the rates in

Exhibit 2-4

PART TWO TRIP ATTRACTION RATES

(Using Part One Methodology)

(Vehicle Trips/Employee)

Central Business District	
HBW	1.74
HBS	0.00
HBO	3.02
NHBA	2.21
Total	6.97

Community Shopping Center	
HBW	2.51
HBS	26.92
HBO	6.45
NHBA	18.37
Total	54.25

Other Retail	
HBW	1.79
HBS	11.28
HBO	6.15
NHBA	13.27
Total	32.49

Other Non-Retail	
HBW	1.40
HBS	0.09
HBO	2.95
NHBA	1.84
Total	6.29

	Part One of Survey						Part Two of Survey				Combined		
	Part 1 Method	Part 2 Method	Expansion Factor	Trips	Adjusted Trips	Emp	Part 1 Method	Part 2 Method	Trips	Emp	Trips	Emp	Rate
	(A)	(B) (E/F)	(C) (H/G)*2	(D)	(E) (C*D)	(F)	(G)	(H)	(I)	(J)	(K) (E+I)	(L) (F+J)	(M) (K/L)
CBD													
HBW	2.09	2.08	1.99	913	1816	874	1.74	1.73	275	159	2091	1033	2.02
HBS	.00	.00	.00	0	0	874	.00	.00	0	159	0	1033	.00
HBO	1.08	1.06	1.96	472	925	874	3.02	2.96	471	159	1396	1033	1.35
NHBA	.72	.72	1.00	633	633	874	2.21	2.21	352	159	985	1033	.95
Total	3.89	3.86		2018	3374	874	6.97	6.90	1098	159	4472	1033	4.33
Community Shopping Center													
HBW	1.70	1.70	1.99	229	456	269	2.51	2.50	671	268	1127	537	2.10
HBS	13.35	17.04	2.55	1795	4584	269	26.92	34.37	9212	268	13796	537	25.69
HBO	10.76	12.11	2.25	1447	3257	269	6.45	7.26	1947	268	5204	537	9.69
NHBA	10.77	10.77	1.00	2898	2898	269	18.37	18.37	4924	268	7822	537	14.57
Total	36.58	41.62		6369	11195	269	54.25	62.50	16754	268	27949	537	52.05
Other Retail													
HBW	1.39	1.38	1.99	275	547	396	1.79	1.78	762	427	1309	823	1.59
HBS	15.05	20.62	2.74	2979	8166	396	11.28	15.46	6601	427	14767	823	17.94
HBO	2.98	3.13	2.10	590	1239	396	6.15	6.46	2757	427	3996	823	4.86
NHBA	10.32	10.32	1.00	4085	4085	396	13.27	13.27	5667	427	9752	823	11.85
Total	29.74	35.45		7929	14037	396	32.49	36.97	15787	427	29824	823	36.24
Other Non-Retail													
HBW	1.45	1.46	2.01	2230	4492	3070	1.40	1.41	1273	906	5765	3976	1.45
HBS	.05	.04	1.78	73	130	3070	.09	.08	75	906	205	3976	.05
HBO	2.13	1.99	1.87	3264	6108	3070	2.95	2.76	2503	906	8611	3976	2.17
NHBA	1.26	1.26	1.00	3862	3862	3070	1.84	1.84	1665	906	5527	3976	1.39
Total	4.89	4.75		9429	14591	3070	6.28	6.09	5516	906	20107	3976	5.06

Exhibit 2-5

Exhibit 2-5. Using the CBD HBW data, the first step is to divide the Part Two rates (H/G*2), to produce the expansion factor (C), 1.99. The number of Part One CBD HBW trips is multiplied by the factor (C*D) to yield the number of expanded trips (E), 1816. These trips are added to the Part Two trips (E+I), giving 2091 total HBW CBD trips. These trips are divided the total number of CBD employees in both parts of the survey (F+J), 1033, to derive the CBD HBW trip attraction rate (K/L), 2.02 trips/employee.

Since the only Regional Shopping Center site and only Special Generator site (Davis-Monthan Air Force Base) were both surveyed in Part Two, there is no need to calculate a composite rate for these two categories.

2.3 Analysis by Development Category

This section is a comparison of the final, composite trip attraction rates derived from the survey data with the rates in PAGTPD travel demand forecasting model. The rates are shown by trip purpose within each development category. The following section (2.4) presents the results of the analysis by trip purpose.

2.3.1 Central Business District (CBD)

Five of the survey sites were located in the CBD (PAGTPD defines the Tucson CBD as TAZs one through eight). The sites were:

8 - General Services Administration
9 - Pioneer Plaza
12 - Tucson Museum of Art
29 - Greyhound Bus Station
42 - Dooley-Jones Engineers.

Sites 8, 9, and 42 are office buildings. As shown in Exhibit 2-6, the CBD attraction rate derived from the study (4.32 trips/employee) is 56 percent lower than the rate currently used by PAGTPD (9.78 trips/employee). None of the survey sites in the CBD were retail stores or shopping centers. The rate shows a home-based shopping (HBS) trip rate of 0.00 trips/employee, compared with the current PAGTPD HBS rate of 1.89 trips/employee, and a NHB trip rate of 0.95 trips/employee compared to 2.46 trips/employee currently used by PAGTPD. The lower HBS and NHB rates are probable attributable to the lack of retail sites surveyed by this study in the CBD. It is recommended that additional CBD sites should be surveyed, particularly retail sites. These additional sites are probable necessary to achieve a more representative rate for comparison with the existing PAGTPD rate.

2.3.2 Community Shopping Centers (CSC)

A previous study conducted for the Arizona Department of Transportation (ADOT) indicated that in the rates currently used by PAGTPD, there might be an underestimating of HBO trips and an underestimating of HBS trips attracted to CSCs. This was one of the hypotheses of the current study. The new rates calculated show a significant increase over the previous rates, but there are mitigating circumstances surrounding this conclusion.

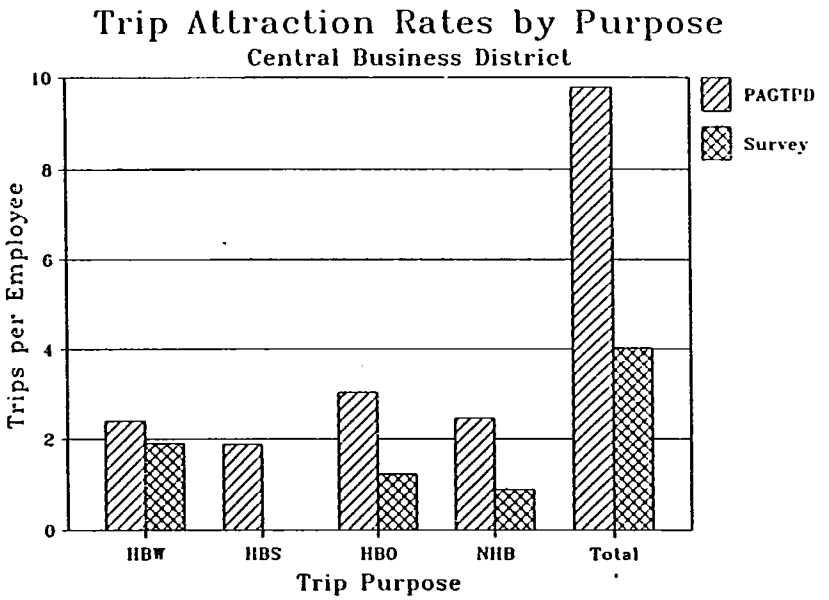
Two rates are presented for CSCs in Exhibit 2-7 because of problems encountered when conducting pedestrian counts at the CSC sites. The higher rate (52.05 trips/employee) is an almost 300 percent increase over the current PAGTPD CSC rate (18.68 trips/

Exhibit 2-6

CENTRAL BUSINESS DISTRICT

(Vehicle Trips/Employee)

	PAGTPD		Survey	
Purpose	Rate	Percent	Rate	Percent
HBW	2.40	25	2.02	47
HBS	1.89	19	0.00	0
HBO	3.04	31	1.35	31
NHB	2.46	25	0.95	22
Total	9.79	100	4.32	100



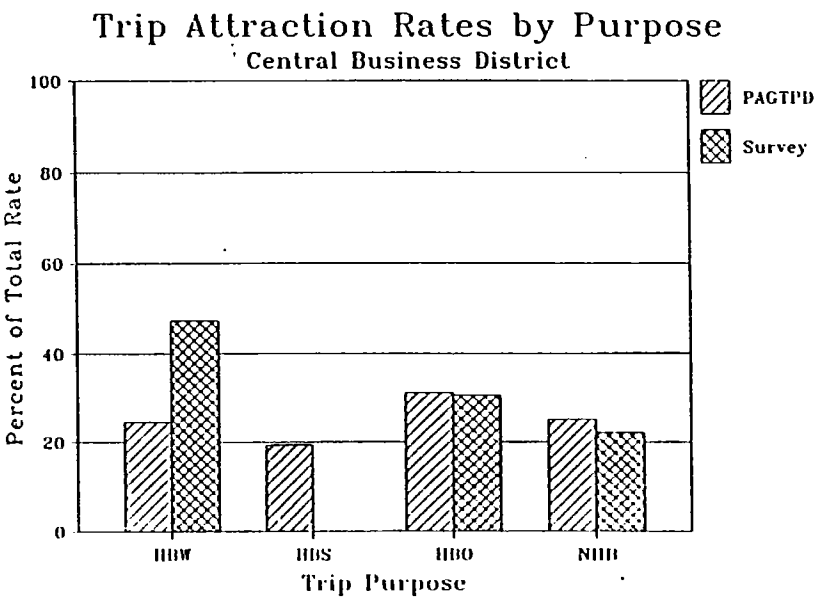
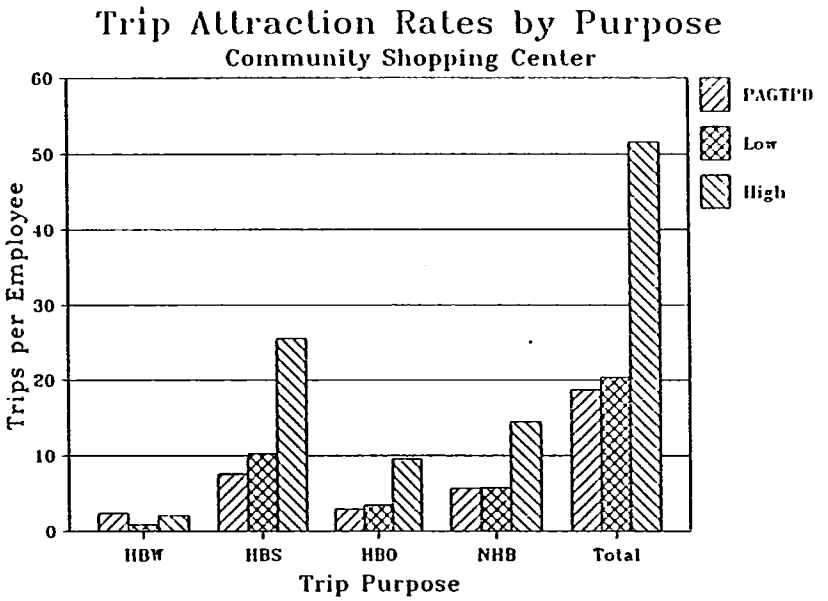


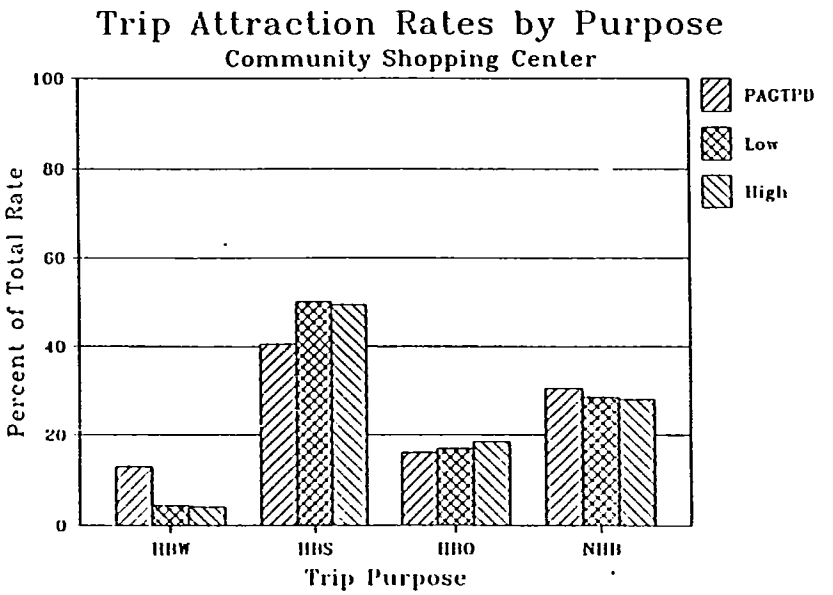
Exhibit 2-7

COMMUNITY SHOPPING CENTER

(Vehicle Trips/Employee)

	PAGTPD		Survey Low		Survey High	
Purpose	Rate	Percent	Rate	Percent	Rate	Percent
HBW	2.41	13	0.89	4	2.10	4
HBS	7.58	41	10.22	50	25.69	49
HBO	2.99	16	3.46	17	9.69	19
NHB	5.70	31	5.81	29	14.57	28
Total	18.68	100	20.38	100	52.05	100





employee). This rate was computed using the pedestrian counts made by the survey crews as the control total to which the surveys were expanded. There is a distinct possibility that the control total is corrupt due to double counting of pedestrians at the site by the survey crew. Pedestrians were counted by one survey crew when they passed them arriving at the CSCs, and then the same pedestrian may have been counted by a different crew as they passed them going between stores in the shopping center.

The second rate presented was developed after the potential problems with the pedestrian counts were discovered. This rate is based upon using the number of survey cards passed out as the control total for the number of trips to the site on the survey day. This assumes a survey card pass out rate of 100 percent, which is probably unlikely. The lower rate shown (20.38 trips/employee) reflects a 9 percent increase over the current rate. It is our hypothesis that the actual rate is probably between the two rates presented here. It is recommended that ADOT conduct carefully designed traffic counts at the CSC sites for this survey so that an accurate control can be developed, to which the survey data can be reweighted.

2.3.3 Regional Shopping Center (RSC)

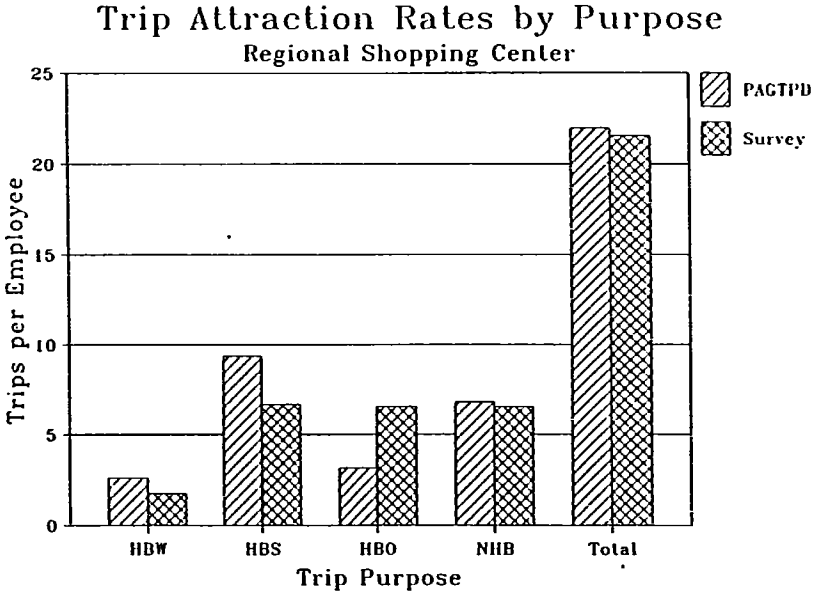
Park Mall was the only Regional Shopping Center (RSC) in the survey. The RSC rate of 21.55 trips/employee is very close to the currently used PAGPTD rate of 21.98 trips/employee. The change here occurred within the distribution of trips by purpose. The home-based work (HBW) rate has decreased by approximately one third, from 2.63 to 1.77 trips/employee. Trips have shifted from

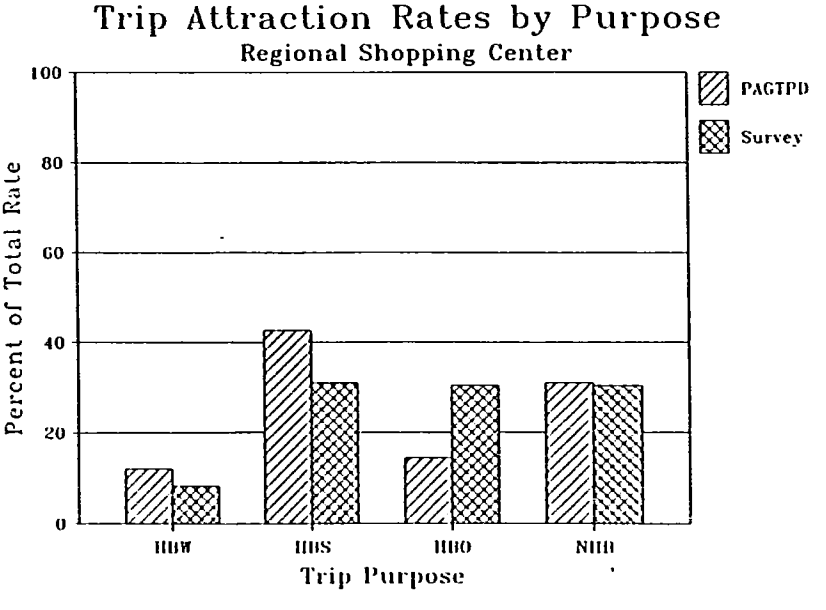
Exhibit 2-8

REGIONAL SHOPPING CENTER

(Vehicle Trips/Employee)

	PAGTPD		Survey	
Purpose	Rate	Percent	Rate	Percent
HBW	2.63	12	1.77	8
HBS	9.38	43	6.68	31
HBO	3.16	14	6.56	31
NHB	6.81	31	6.54	30
Total	21.98	100	21.55	100





a HBS rate of 9.38 to 6.68, to HBO, where the rate changes from 3.16 to 6.56 trips/employee. The percentages of trips by purpose can be seen in Exhibit 2-8, which also shows the increase in proportion of HBO trips and the decrease in the proportion of HBS trips. This reduction in HBS trips and increase in HBO trips is consistent with observed overestimation of HBS trips and underestimation of HBO trips predicted by the PAGTPD trip attraction models when compared to trip production models.

2.3.4 Other Retail (OR)

The Other Retail category consisted of 13 different retail sites. The types of stores ranged from a car dealership to a grocery store to a fast food restaurant. The OR rate, as can be seen in Exhibit 2-9, changed from the currently used rate of 25.25 trips/employee to 36.24 trips/employee, an increase of 44 percent. As with CSC, the largest increases were with HBS and NHB trips. A shift occurred from HBW trips, 11 percent to 4 percent of total rate, to HBS trips, 44 percent to 50 percent of total rate.

2.3.5 Other Non-Retail (ONR)

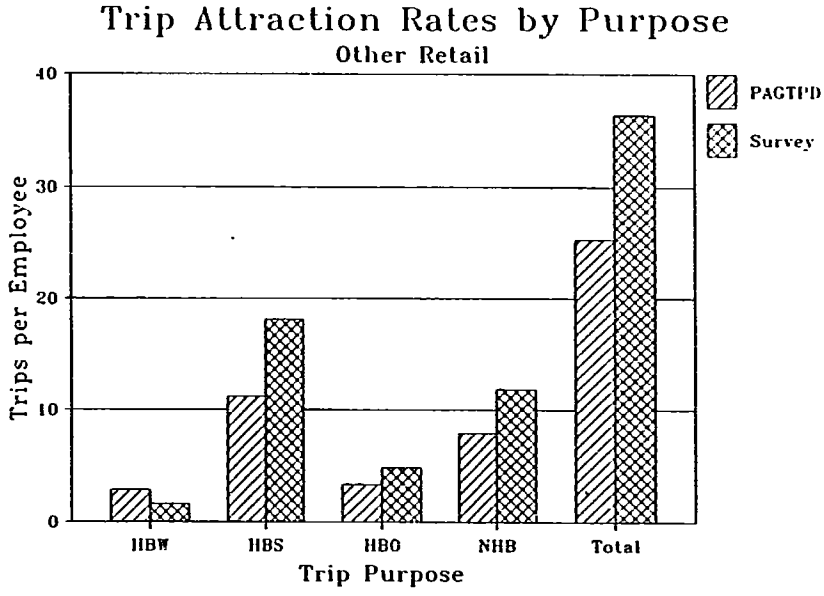
The ONR category was the most diverse in its content of site types. In all there were 19 different sites in ONR, ranging from office buildings to manufacturing plants to hotels to amusement parks. The new ONR rate of 5.06 trips/employee is a slight decrease (13 percent) from the currently used rate of 5.81 trips/employee. The distributions of trips by purpose for the two rates are almost identical.

Exhibit 2-9

OTHER RETAIL

(Vehicle Trips/Employee)

	PAGTPD		Survey	
Purpose	Rate	Percent	Rate	Percent
HBW	2.84	11	1.59	4
HBS	11.17	44	17.94	50
HBO	3.33	13	4.86	13
NHB	7.91	31	11.85	33
Total	25.25	100	36.24	100



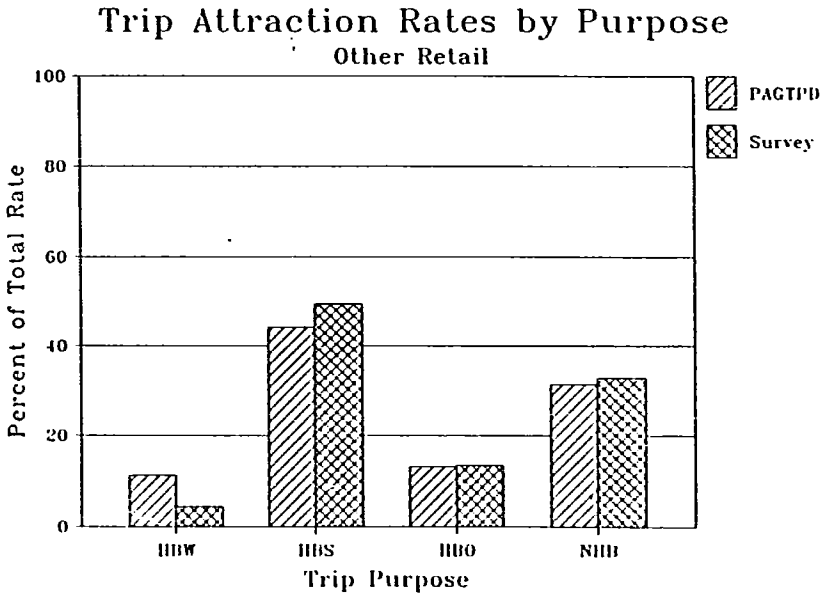
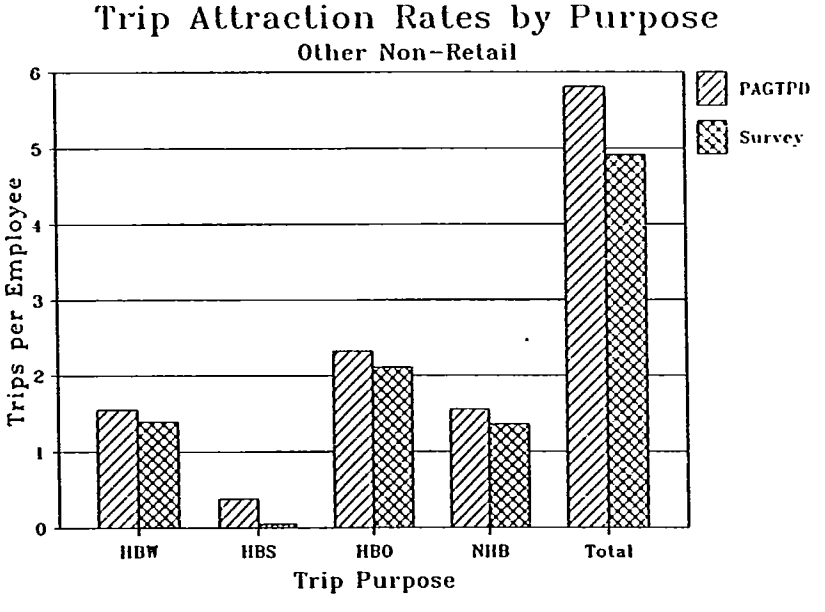


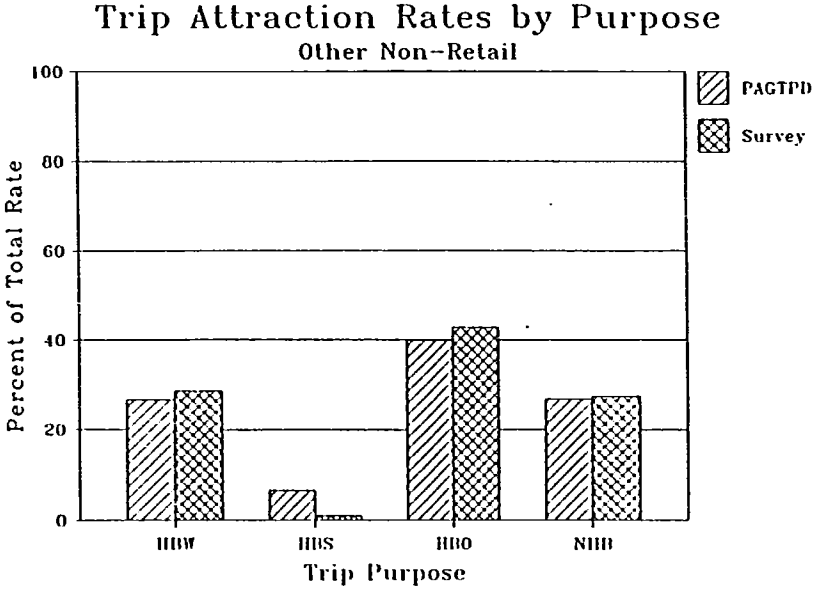
Exhibit 2-10

OTHER NON-RETAIL

(Vehicle Trips/Employee)

	PAGTPD		Survey	
Purpose	Rate	Percent	Rate	Percent
HBW	1.55	27	1.45	29
HBS	0.38	7	0.05	1
HBO	2.32	40	2.17	43
NHB	1.56	27	1.39	27
Total	5.81	100	5.06	100





2.3.6 Special Generator

There was only one special generator site in the survey, Davis-Monthan Air Force Base (DMAFB). The DMAFB rate of 4.91 trips/employee reflects an increase of 75 percent over the current PAGTPD rate of 2.80 trips/employee. The largest increases occur in HBW trips, which rise from 0.60 trips/employee to 2.19 trips/employee. The reason for this increase could be that a larger number of employees now live off-base than in the past. Currently, 2645 of the 6989 employees live off-base. According to the PAGTPD, only 21 percent of trips to the base should be HBW, while the observed data shows that 45 percent of the trips are HBW, more than twice as many as believed. The comparative rates and percentages for DMAFB can be seen in Exhibit 2-11.

2.4 Analysis by Trip Purpose

This section presents the new rates by trip purpose--HBW, HBS, HBO, and NHB. Analysis by trip purpose attempts to explain why changes in the trip attraction rates have occurred.

2.4.1 Home-Based Work (HBW)

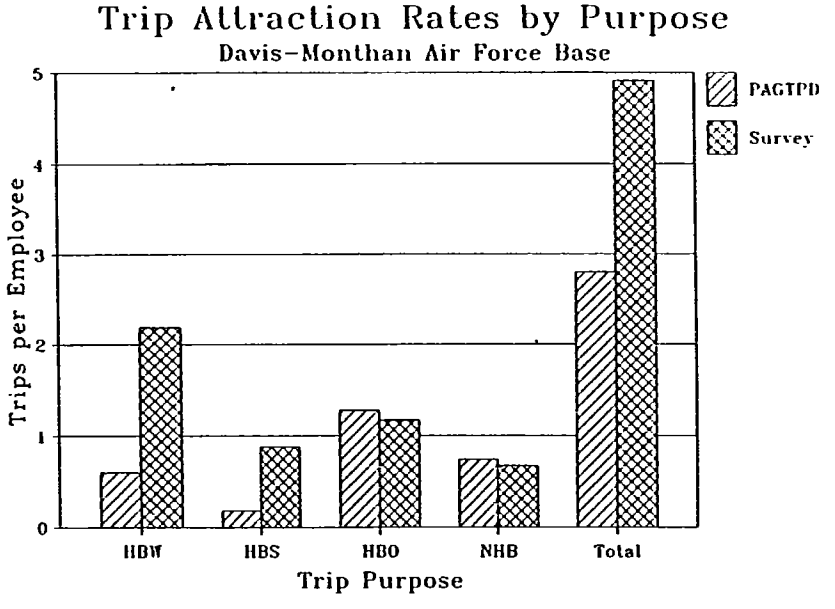
Exhibit 2-12 shows that the HBW rates decreased for all development categories except for DMAFB. An explanation for the increase in the HBW rate for DMAFB was offered earlier. The decreases in HBW rates for other categories may be attributable to more part time employees and longer work weeks. There has been a shift recently, especially in retail sales, towards hiring a large number of part time personnel instead of full time. Part time employees are generally paid less and do not collect the

Exhibit 2-11

DAVIS-MONTHAN AIR FORCE BASE

(Vehicle Trips/Employee)

	PAGTPD		Survey	
Purpose	Rate	Percent	Rate	Percent
HBW	0.60	21	2.19	45
HBS	0.18	6	0.88	18
HBO	1.28	46	1.17	23
NHB	0.74	26	0.67	14
Total	2.80	100	4.91	100



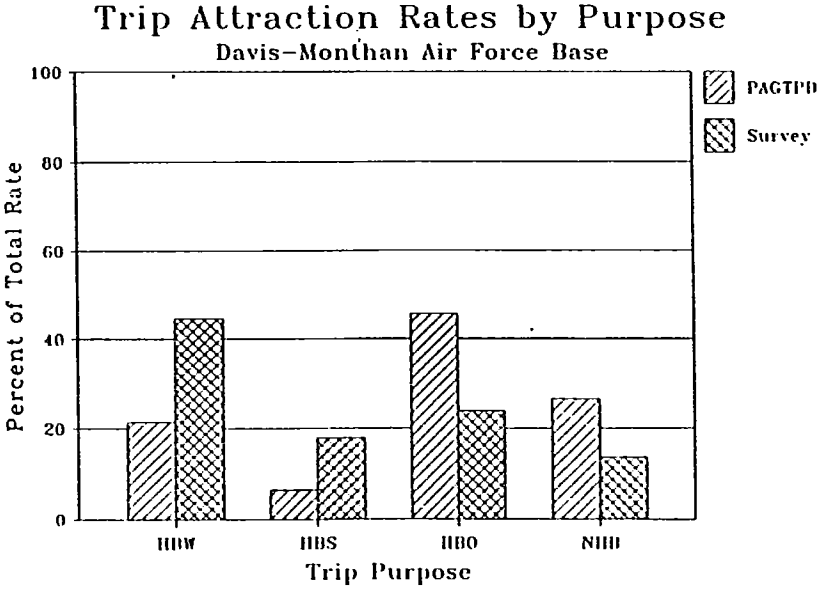


Exhibit 2-12

HOME-BASED WORK

(Vehicle Trips/Employee)

Development Category	PAGTPD	Survey
CBD	2.40	2.02
CSC	2.41	2.10 (0.89)*
RSC	2.63	1.77
OR	2.84	1.59
ONR	1.55	1.45
DMAFB	0.60	2.19

* Rate assuming control total of surveys distributed.

benefits of a full time employee. Also, many retail sites are now open seven days a week, instead of five. So, on any given day, only 1/7th of the total work force is present, instead of 1/5th as in the past. These two factors mean that there are more employees overall, but not all working everyday. This results in more employees with the same number of trips as the past. This leads to the lower HBW trip rates as shown by the survey data.

2.4.2 Home-Based Shopping (HBS)

According to the findings of this survey, as shown in Exhibit 2-13, PAGTPD models have been under reporting HBS trips in the past. Regional shopping center HBS attractions decreased by nearly 30%, while the combined RSC rate for all purposes changed very little (4 percent). The reason for the shift from HBS to HBO for regional shopping centers may be the increase of other services (restaurants, banking and financial services, etc.) being offered by malls and larger shopping centers.

The largest increases in HBS trip rates occurred in the CSC and OR categories. For CSC, the rate went from 7.58 trips/employee to between 10.22 and 25.69 trips/employee, the possibility of an almost 300 percent increase. For OR, the increase was not as dramatic, going from 11.17 trips/employee to 17.94 trips/employee, but still, a rise of 60 percent.

The HBS rate also increased for DMAFB, from 0.18 to 0.88 trips/employee. This, too, could be due to the increasing number of persons living off-base, but travelling to the base to use its services, such as the exchange and commissary. There could also

Exhibit 2-13

HOME-BASED SHOPPING

(Vehicle Trips/Employee)

Development Category	PAGTPD	Survey
CBD	1.89	0.00
CSC	7.58	25.69 (10.22)*
RSC	9.38	6.68
OR	11.17	17.94
ONR	0.38	0.05
DMAFB	0.18	0.88

* Rate assuming control total of surveys distributed.

be a number of NHB shopping trips that are internal and not reported here. That is, a person may travel to the base for work, but visit stores and other services on the base during the day. These trips are internal, and therefore are not counted in the trip attraction rate for DMAFB.

As mentioned earlier, the HBS rate for CBD sites was 0.00 trips/employee due to the fact that no CBD retail sites were surveyed. Therefore, it is difficult to draw any definitive conclusions concerning the validity of the currently used rate of 1.89 trips/employee.

2.4.3 Home-Based Other (HBO)

As can be seen in Exhibit 2-14, there was a great deal of variation between the observed HBO rates and those currently being used by PAGTPD. For ONR and DMAFB, the HBO rates decreased very little, from 2.32 to 2.17 trips/employee for the former and from 1.28 to 1.17 trips/employee for the latter.

The largest decrease in HBO trip rates was for CBD sites. There, the rate went from 3.04 to 1.38 trips/employee. Of the five CBD survey sites, three were office buildings and the other two were the Tucson Museum of Art and the Greyhound Bus Station. The majority of attractions to the office building were HBW, while attractions to the other sites were, for the large part, HBO and NHB. The number of employees, however, at the museum and bus station were 24 and 8, respectively. Therefore, their high HBO and NHB rates were diluted by the large number of employees at the three office building sites. It is recommended that more sites be surveyed in the CBD to get a more representative sample

Exhibit 2-14

HOME-BASED OTHER

(Vehicle Trips/Employee)

Development Category	PAGTPD	Survey
CBD	3.04	1.35
CSC	2.99	9.69 (3.46)*
RSC	3.16	6.56
OR	3.33	4.86
ONR	2.32	2.17
DMAFB	1.28	1.17

* Rate assuming control total of surveys distributed.

of the variety of development. Unlike other trip purposes, CBD rates are very dependent on the distribution of site types in the category.

The categories that showed increases in their HBO trip rate were CSC and RSC. This could be seen as a shift from HBS to HBO, as stated earlier, because of the larger variety of services being offered by shopping centers and malls and the increased use of shopping centers as destinations for social-recreational purposes.

2.4.4 Non-Home-Based (NHB)

The observed NHB trip rates followed the same pattern as the HBO rates when compared to the rates from the PAGTPD model. For DMAFB, RSC, and ONR, the rates decreased only slightly, while the CBD rate had the largest drop, from 2.46 to 1.10 trips/employee.

Of the three retail categories, two, CSC and OR, had large increases in their NHB trip rates. Part of this rise may be due to the greater number of women in the work force, who may have to incorporate their shopping trips into their work days, or consolidate visiting two or three different retail locations into one trip, due to a lack of time. Exhibit 2-15 presents the PAGTPD and survey NHB rates and percentages.

2.5 New Trip Attraction Rates for Special Generators

PAGTPD divides the region into the following 11 employment categories:

1 - Central Business District
2 - Regional Shopping Center
3 - Community Shopping Center
4 - Other Retail
5 - Other Non-Retail

Exhibit 2-15

NON-HOME-BASED

(Vehicle Trips/Employee)

Development Category	PAGTPD	Survey
CBD	2.46	0.95
CSC	5.70	14.57 (5.81)*
RSC	6.81	6.54
OR	7.91	11.85
ONR	1.56	1.39
DMAFB	0.74	0.67

* Rate assuming control total of surveys distributed.

6 - Davis-Monthan Air Force Base
7 - Tucson International Airport
8 - University of Arizona
9 - Pima Community College
10 - Hospital
11 - Dwelling Unit.

Categories 7 through 11 are special generators. This survey included only one special generator, Davis-Monthan Air Force Base (DMAFB). The research team decided, in conjunction with PAGTPD, to propose trip attraction rates for Tucson International Airport (TIA), University of Arizona (UA), and Pima Commmunity College (PCC) based upon rates for similar special generators (SG) in other parts of the country.

The North Central Texas Council of Governments (NCTCOG) recently completed a study of special generators in the Dallas-Fort Worth area of Texas. Included in that study were three airports, two community colleges, and two four-year universities (with dormitories).

In an attempt to collect a broad sample of SG rates, the research team contacted transportation related organizations around the country. Over 15 different MPOs, universities, and transportation research centers were contacted concerning trip attraction rates. Other than NCTCOG, the only other source with any SG rates was the Maricopa Association of Governments Transportation Planning Division (MAGTPD). MAGTPD did have an overall rate for Arizona State University of 0.83 trips per student. They did not, however, express much confidence in this rate. The majority of organizations indicated that they used the Trip Generation Manual published by the Institute of Transportation Engineers (ITE). A technical memorandum

containing a detailed account of the research team's search for SG trip rates is included as an appendix to this report.

2.5.1 Airport

Exhibit 2-16 shows the current PAGTPD rates for TIA and the rates NCTCOG supplied. The airports in the Dallas-Fort Worth area are:

1 - Dallas/Fort Worth Airport
2 - Love Field, Dallas
3 - Meacham Field, Fort Worth.

The NCTCOG rates for the three airports were combined into one rate using a weighted average. The NCTCOG rate is 14 percent lower than PAGTPD's, with the decrease being in the HBO purpose. NHB trips are slightly higher for the Texas airports and the HBW trip rates are almost identical. The ITE rate for airports is 16.82 trips per employee, which is very close to the PAGTPD rate.

2.5.2 Community Colleges

NCTCOG supplied trip attraction rates for two community colleges in Dallas, Brookhaven and Eastfield. Like the airport rates, the NCTCOG community college rates for the two schools were combined into one using a weighted average. Exhibit 2-17 shows the NCTCOG rates compared with the rates currently used by PAGTPD for Pima Community College. The overall rate for the Texas colleges (18.63 trips/employee) is almost eight times the PAGTPD rate (2.39 trips/employee). The NCTCOG rate is based upon 1673 employees, 15,260 students, and 31,174 person trips/day.

The extremely low PAGTPD rate is a mystery, unless it is trips/student, not trips/employee. If that were the case, the

Exhibit 2-16

AIRPORT

(Vehicle Trips/Employee)

	PAGTPD		NCTCOG	
Purpose	Rate	Percent	Rate	Percent
HBW	2.11	13	2.14	15
HBS	0.00	0	0.00	0
HBO	9.23	56	6.42	46
NHB	4.98	31	5.44	39
Total	16.32	100	14.00	100

Exhibit 2-17

COMMUNITY COLLEGE

(Vehicle Trips/Employee)

	PAGTPD		NCTCOG	
Purpose	Rate	Percent	Rate	Percent*
HBW	0.92	38	--	-
HBS	0.14	6	--	-
HBO	0.84	35	--	-
NHB	0.49	21	--	-
Total	2.39	100	18.63	100

* NCTCOG did not have the trip rate by purpose at this time.

NCTCOG rate would by 1.70 trips/student. The ITE trip generation rate for community colleges is 1.55 trips/student, so the PAGTPD rate makes sense if it is trips/student. However, the PAGTPD rate for UA is very close to the NCTCOG rate for a four-year university, and the NCTCOG rate is trips/employee. The UA trip rate is discussed in the next section.

2.5.3 Four-Year University

NCTCOG had two four-year universities in their study of special generators, Texas Christian University (TCU), located in Fort Worth, and Southern Methodist University (SMU), located in Dallas. Like UA, TCU and SMU are four-year schools with dormitories, but both are private schools. UA is a public school with a larger enrollment than both TCU and SMU.

The PAGTPD and NCTCOG trip attraction rates are shown in Exhibit 2-18. Overall, there is very little difference between the rates. The distributions by purpose within the rates, however, show quite a bit of difference. The NCTCOG HBW rate is much higher than UA's. NCTCOG did not disaggregate HBS trips from HBO, so, for comparison, the PAGTPD HBO rate should be 2.61 trips/employee (2.23 + 0.38), which represents 46 percent of the total trip rate. The ITE trip rate for universities is 2.41 trips per student. This rate is not comparable to PAGTPD's, as it is based on students, not employees.

2.6 Mode Choice

Exhibit 2-19 shows the weighted distribution of all survey trips by site, category, and travel mode. As expected, auto driver and auto passenger were the two most frequently chosen

Exhibit 2-18

FOUR-YEAR UNIVERSITY

(Vehicle Trips/Employee)

	PAGTPD		NCTCOG	
Purpose	Rate	Percent	Rate	Percent
HBW	1.55	27	2.26	40
HBS	0.38	7	--	--
HBO	2.23	39	2.21	39
NHB	1.56	27	1.22	21
Total	5.72	100	5.69	100

TUCSON TRIP ATTRACTION RATES STUDY
DISTRIBUTION OF TRIPS BY SITE AND TRAVEL MODE
(PARTS ONE AND TWO - WEIGHTED)

14:00 WEDNESDAY, NOVEMBER 18, 1987

TABLE OF SITETYPE BY MODE

SITETYPE SITE CLASSIFICATION MODE TRAVEL MODE

FREQUENCY PERCENT ROW PCT COL PCT	BIKE	BUS	WALK	VEH DRIVER	VEH PASSENGER	TRUCK	TAXI	TOTAL
CSC	164 0.10 0.67 12.93	142 0.09 0.58 7.62	371 0.23 1.51 23.55	15084 9.23 61.28 14.22	8695 5.32 35.33 16.92	151 0.09 0.61 14.41	6 0.00 0.03 5.21	24614 15.07
OR	477 0.29 1.71 37.54	331 0.20 1.19 17.71	523 0.32 1.88 33.25	17458 10.69 62.77 16.45	8782 5.38 31.58 17.09	238 0.15 0.86 22.75	4 0.00 0.01 3.08	27812 17.02
ONR	229 0.14 0.98 18.05	178 0.11 0.76 9.55	196 0.12 0.84 12.45	17670 10.82 75.40 16.65	4980 3.05 21.25 9.69	163 0.10 0.70 15.57	19 0.01 0.08 14.97	23434 14.34
RSC	234 0.14 0.53 18.45	783 0.48 1.79 41.95	271 0.17 0.62 17.21	24744 15.14 56.41 23.32	17567 10.75 40.05 34.18	203 0.12 0.46 19.45	63 0.04 0.14 50.60	43865 26.85
SG	115 0.07 0.29 9.03	231 0.14 0.58 12.36	0 0.00 0.00 0.00	28922 17.70 72.39 27.26	10476 6.41 26.22 20.38	211 0.13 0.53 20.14	0 0.00 0.00 0.00	39954 24.45
CBD	51 0.03 1.37 4.00	202 0.12 5.45 10.81	213 0.13 5.76 13.54	2226 1.36 60.16 2.10	896 0.55 24.21 1.74	80 0.05 2.17 7.67	32 0.02 0.88 26.13	3700 2.26
TOTAL	1270 0.78	1866 1.14	1574 0.96	106104 64.94	51395 31.46	1046 0.64	124 0.08	163379 100.00

Exhibit 2-19

modes, 65 percent and 31 percent, respectively. Bus riders made up only slightly more than 1 percent, with the largest shares in the CBD and RSC. Exhibit 2-20 shows the mode split of the observed survey trips by area type (CBD vs. non-CBD). There were fewer private vehicle trips to the CBD than to non-CBD sites. Bus trips were five times more frequent and walk trips were six times more frequent in the CBD compared to non-CBD sites. It is important to remember, however, that the trip attractions are comprised of only vehicle trips; they do not include walk trips. Trips to DMAFB, and ONR sites had the largest shares of auto driver trips. These two site categories also had a large percentage of HBW trips, indicating that most people drive to work alone.

This can easily be seen in Exhibit 2-21, the weighted distribution of trips by travel mode and purpose. Auto driver trips make up 83 percent of all HBW trips, while auto passenger is only 14 percent, indicating an HBW auto occupancy of approximately 1.2 persons/auto. Bus travel is evenly divided between the purposes, with HBO having the largest share (31 percent). The majority of walk trips are HBS (39 percent) and NHB (23 percent), which was expected.

Exhibit 2-20

MODE CHOICE BY AREA TYPE

	CBD	Non-CBD	All
Vehicle Driver	60.2%	65.1%	64.9%
Vehicle Passenger	24.2	31.6	31.5
Bus	5.5	1.0	1.1
Truck	2.2	0.6	0.6
Taxi	0.9	0.1	0.1
Bike	1.4	0.8	0.8
Walk	5.8	0.9	1.0
Total	100.0%	100.0%	100.0%

TUCSON TRIP ATTRACTION RATES STUDY
DISTRIBUTION OF TRIPS BY TRAVEL MODE AND PURPOSE
(SURVEY PARTS ONE AND TWO - WEIGHTED)

13:06 TUESDAY, AUGUST 4, 1987

TABLE OF MODE BY OD_PURP

MODE TRAVEL MODE OD_PURP ORIGIN/DESTINATION PURPOSE

FREQUENCY PERCENT ROW PCT COL PCT	HBW	HBS	HBO	NHBA	NHBP	TOTAL
BIKE	123 0.08 9.68 0.38	342 0.21 26.91 0.90	305 0.19 24.01 0.95	320 0.20 25.19 0.82	180 0.11 14.21 0.81	1270 0.78
BUS	380 0.23 20.38 1.18	381 0.23 20.43 1.00	570 0.35 30.54 1.78	396 0.24 21.20 1.02	139 0.09 7.45 0.62	1866 1.14
WALK	174 0.11 11.04 0.54	615 0.38 39.11 1.62	333 0.20 21.16 1.04	357 0.22 22.66 0.92	95 0.06 6.02 0.43	1573 0.96
VEH DRIVER	26711 16.35 25.18 82.95	22718 13.91 21.41 59.79	18339 11.23 17.29 57.13	24322 14.89 22.93 62.70	14000 8.57 13.20 62.86	106089 64.94
VEH PASS	4772 2.92 9.29 14.82	13889 8.50 27.03 36.55	12434 7.61 24.19 38.73	12804 7.84 24.91 33.01	7492 4.59 14.58 33.64	51391 31.46
TRUCK	27 0.02 2.59 0.08	26 0.02 2.50 0.07	111 0.07 10.58 0.34	547 0.33 52.25 1.41	336 0.21 32.08 1.51	1046 0.64
TAXI	14 0.01 11.34 0.04	25 0.02 20.02 0.07	11 0.01 8.46 0.03	44 0.03 35.12 0.11	31 0.02 25.06 0.14	124 0.08
TOTAL	32201 19.71	37997 23.26	32101 19.65	38788 23.74	22272 13.63	163360 100.00

Exhibit 2-21

3.0 NON-HOME-BASED TRIP LENGTH DISTRIBUTION

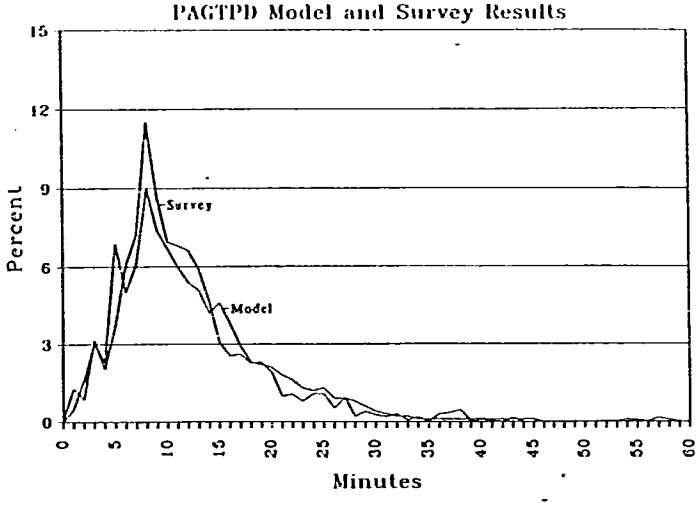
The purpose of geocoding the origin end of NHB trips and appending highway time skims was to develop a new NHB trip length distribution. This distribution, when compared with the one currently used by PAGTPD, would indicate whether there was a statistically significant difference between the two. If there was, then the respective friction factors would have been iteratively adjusted to produce a satisfactory calibration.

The observed distribution can be seen compared graphically to the existing PAGTPD distribution in Exhibit 3-1. Exhibit 3-1 also shows the differences between the two distributions and the cumulative distributions together for comparison. It is evident from these graphs that the currently used PAGTPD model needs no adjustment. A table in Appendix shows the actual counts and percentages associated with the observed NHB trip length distribution.

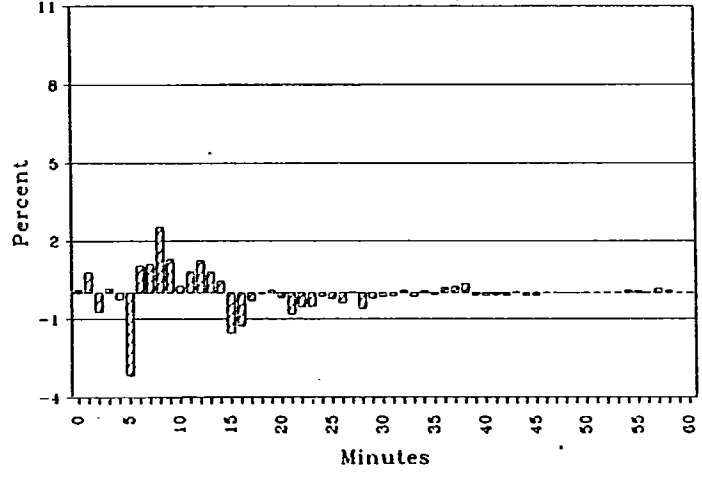
The mean NHB trip length for the PAGTPD model is 12.28 minutes, while to mean of the observed data, using highway skim times, is 11.85 minutes. The mean of the times reported by the tripmakers in the survey is 11.76 minutes. The only major differences between the two distributions are at the five- and eight-minute marks. At five minutes, the PAGTPD model has approximately 3 percent more trips than the observed distribution. At the eight-minute level, the observed distribution consists of slightly more 2 percent more trips than the current model. These differences were not judged significant enough to justify adjusting the current model.

Exhibit 3-1

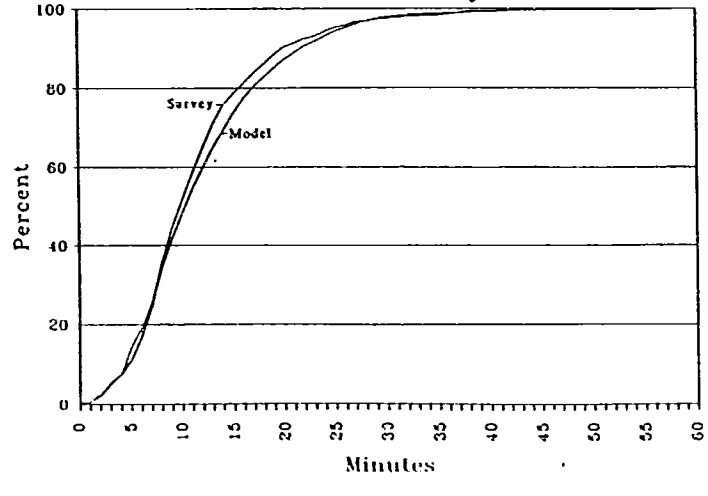
NHB Trip Length Distribution
PAGTPD Model and Survey Results



NHB Trip Length Distribution
Difference Between Survey and Model



Cumulative NHB Trip Length Distributions
PAGTPD Model and Survey Results



4.0 APPLICATION OF REVISED TRIP ATTRACTION RATES

4.1 Introduction

The research team proposed two different test trip attraction rates scenarios for PAGTPD to use as inputs to the modelling process. The first of these scenarios (shown as "Revised with CBD" in the exhibits in this chapter) replaced the current PAGTPD rates with the survey results. For the Community Shopping Center (CSC) category, the lower rate was used. The second scenario proposed was the same as the first, except for elimination of the CBD as one of the categories. Employment in the CBD was distributed amongst the other retail (OR) and other non-retail (ONR) development categories. (The second scenario is shown as "Revised No CBD" in the exhibits accompanying this chapter.)

Further scenarios are proposed later in this chapter (beginning with Section 4.5). Modelling runs using these scenarios are not feasible at this time due to a lack of detailed data. They may, however, lead to further research that will improve the modelling process in the future.

4.2 Total Regionwide Attractions

Exhibit 4-1 shows the application of the trip attraction rates derived from the study to the regionwide trip attraction model. The tables compare, by trip purpose, the 1980 base model regionwide attractions using existing trip attraction rates with the two scenarios proposed by the research team. Also shown are trip end summaries (attractions) for the CBD and DMAFB. As expected the number of trips for all purposes except HBW

Exhibit 4-1

Total Regionwide Attractions

Home Based Work Attractions

	1980 Base	Revised with CBD	% Diff	Revised No CBD	% Diff
CBD	30,321	31,242	3.0%	23,292	-23.2%
DMAFB	10,148	16,995	67.5%	17,425	71.7%
All TAZs	326,823	303,346	-7.2%	295,944	-9.4%

Home Based Shop Attractions

	1980 Base	Revised with CBD	% Diff	Revised No CBD	% Diff
CBD	9,551	7,518	-21.3%	7,095	-25.7%
DMAFB	695	1,684	142.3%	1,698	144.3%
All TAZs	474,785	640,188	34.8%	638,699	34.5%

Home Based Other Attractions

	1980 Base	Revised with CBD	% Diff	Revised No CBD	% Diff
CBD	29,727	13,824	-53.5%	23,113	-22.2%
DMAFB	8,361	7,192	-14.0%	7,064	-15.5%
All TAZs	679,728	748,351	10.1%	762,705	12.2%

Non-Home Based Attractions

	1980 Base	Revised with CBD	% Diff	Revised No CBD	% Diff
CBD	20,633	7,847	-62.0%	18,139	-12.1%
DMAFB	3,737	2,764	-26.0%	2,669	-28.6%
All TAZs	544,069	634,971	16.7%	654,226	20.2%

increased, with the largest gain in HBS. This is due to the higher OR and CSC rates. (Even though the lower of the two CSC survey rates were used in these runs, they are still higher than the currently used rates.)

The elimination of the CBD as a separate category had a profound effect on the number of attractions to the CBD, especially for HBW, HBO, and NHB trips. For HBW and HBS, there were more CBD attractions in the first scenario (with CBD category) than the second scenario (without CBD category). The opposite was true for HBO and NHB trips.

The number of attractions to DMAFB increased dramatically from the 1980 base in both scenarios for HBW and HBS. (For DMAFB, the two trip attraction scenarios can be thought of as one because the difference of the CBD category does not have much effect on DMAFB.) The number of HBO and NHB attractions decreased when the revised trip rates were used.

4.3 Screenline Analysis

As part of the modelling runs using the two proposed scenarios, six screenlines were defined and analyzed. The locations of the screenlines are shown in Exhibit 4-2. Exhibit 4-3 compares the observed ground counts for those screenline locations with the 1980 base model and the two trip attraction scenarios. For screenlines 3 through 6, all model runs are over-predicting trips, while all models are under-predicting trips at screenline 2. The three model runs for screenline 1 are very close to the observed count. This table shows that the different model scenarios do not have a significant effect on the

Exhibit 4-2

SCREENLINE LOCATIONS

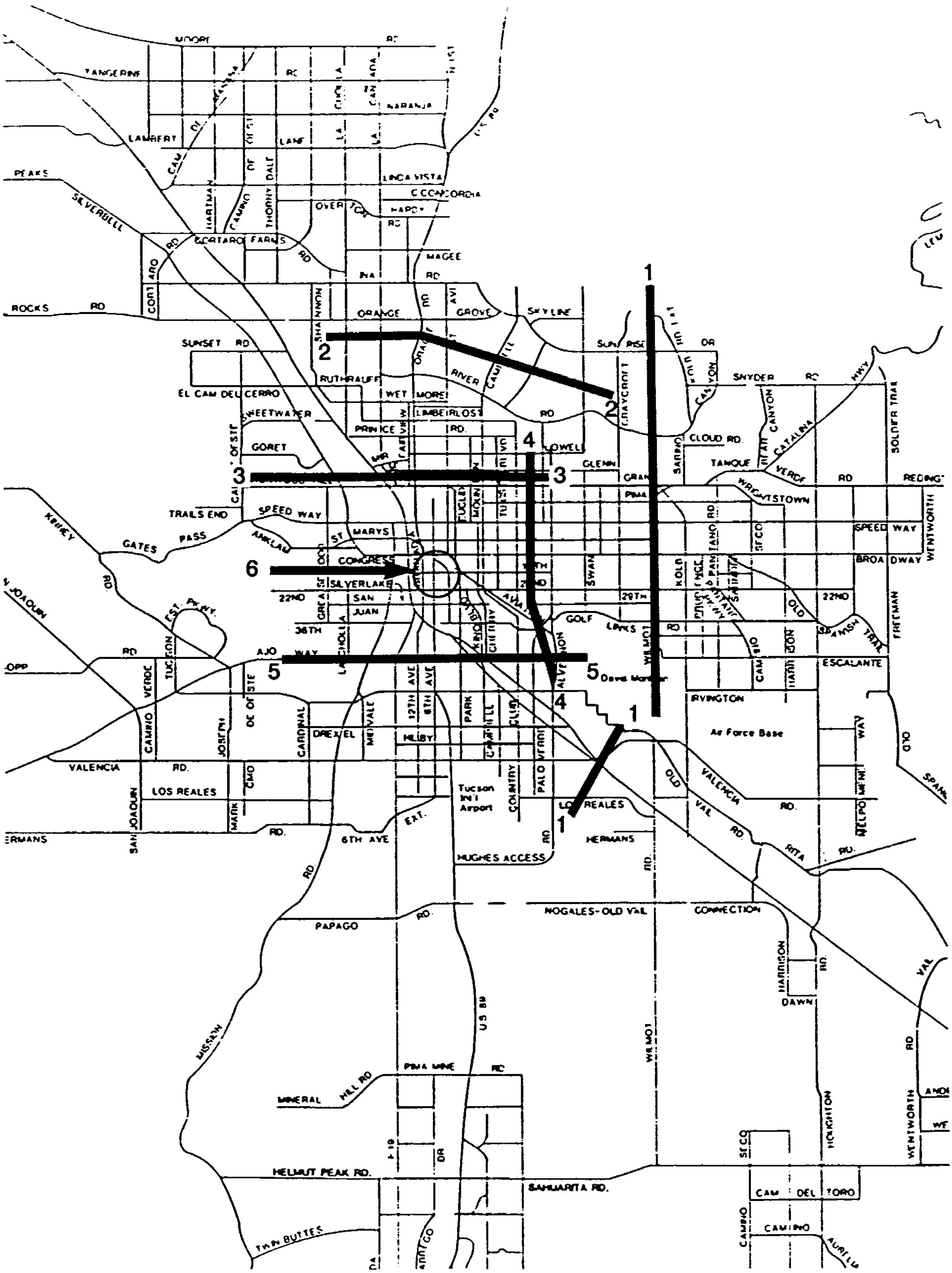


Exhibit 4-3

Screenline Analysis

Screenline	Observed	1980 Base	% Diff from Obs	Revised With CBD	% Diff from Obs	Revised No CBD	% Diff from Obs
1	198,700	199,268	.3%	199,002	.2%	198,413	-.1%
2	67,300	60,605	-9.9%	60,398	-10.3%	60,348	-10.3%
3	174,000	181,645	4.4%	181,369	4.2%	182,408	4.8%
4	234,800	257,519	9.7%	257,814	9.8%	259,051	10.3%
5	184,400	200,525	8.7%	202,403	9.8%	203,225	10.2%
6 (CBD)	59,600	64,788	8.7%	60,867	2.1%	64,893	8.9%
DMAFB	28,922			32,091	11.0%		

screenlines. It appears that the revised rates generated by this study are having only a minor effect on the total number of trips by purpose generated by the modelling process.

4.4 Zonal Analysis

The revised trip attraction rates, however, are having a significant effect on the distribution of attractions by zone. Four zones (247,251,257,258), were used to demonstrate the effect of the revised trip generation rates on the final trip attractions simulated for each zone. The employment characteristics of each zone are shown in Exhibit 4-4. These four zones represent areas with employment primarily at communtiy shopping centers, other non-retail, and a regional shopping center. One zone primarily has non-retail employment with a significant amount of retail employment.

Exhibits 4-5 through 4-8 demonstrate the difference in total trip attractions by purpose for each of the trip attraction rate scenarios. The attractions shown in these tables reflect the attractions for each zone after total attractions are balanced to total productions (total regional attractions by purpose are normalized to total productions). As can be seen in Exhibit 4-5 the total home based work attractions are significantly reduced for zones with retail employment, while the zone with primarily ONR employment is not significantly affected.

Home-based shop attractions (Exhibit 4-6) are not significantly changed for zones with ONR and CSC employment, but there is a 40% reduction in final shopping attractions for the zone with the regional shopping center. In contrast to that, home-

Exhibit 4-4

TAZ'S USED IN ZONAL ANALYSIS

TAZ	Employment Description
247	86% Community Shopping Center
251	82% Other Non-Retail
257	62% ONR, 28% CSC, 10% OR
258	90% Regional Shopping Center (Park Mall)

Exhibit 4-5

HOME BASED WORK ZONAL ATTRACTIONS

TAZ	1980 Base	Revised with CBD	Revised no CBD
247	450	219	238
251	270	249	257
257	2579	2252	2329
258	5511	4577	4674

Exhibit 4-6

HOME BASED SHOP ZONAL ATTRACTIONS

TAZ	1980 Base	Revised with CBD	Revised no CBD
247	561	589	585
251	123	140	142
257	1612	1647	1663
258	7259	4292	4307

Exhibit 4-7

HOME BASED OTHER ZONAL ATTRACTIONS

TAZ	1980 Base	Revised with CBD	Revised no CBD
247	553	619	596
251	545	558	529
257	3172	3235	3187
258	4939	9389	9201

Exhibit 4-8

NON-HOME BASED ZONAL ATTRACTIONS

TAZ	1980 Base	Revised with CBD	Revised no CBD
247	722	690	679
251	279	298	304
257	2837	2815	2734
258	8932	8017	7782

based other trips (Exhibit 4-7) are approximately the same for all zones except zone 258 (zone containing the Park Mall) where there are nearly twice as many home-based other attractions than are simulated by the existing model. The number of non-home based attractions does not differ much between any of the trip attraction models.

These revised distributions of attractions are due to the considerable difference in attractions for the same purpose between the existing PAGTPD model and the results of this study. For example for home based shop trips, using the existing PAGTPD model, regional shopping center trips per employee are 24% higher than community shopping center trips, and this study found that community shopping center trips per employee are at least 50% higher than for regional shopping centers. The net effect of this difference is that when the trip attractions are balanced to productions the new rates force more of the community shopping center trips to be over-represented relative to the regional shopping center trips.

4.5 Proposed Analysis by New Development Categories

4.5.1 Introduction

The current PAGTPD model stratifies land use and development into the following categories:

- o Central Business District (CBD)
- o Community Shopping Centers (CSC)
- o Regional Shopping Centers (RSC)
- o Other Retail (OR)
- o Other Non-Retail (ONR)
- o Special Generators (SG).

Aside from the CBD and SG stratifications, these categories are basically retail and non-retail. This could lead to inaccuracy in predicting non-retail trips due to the variety of development types encompassed by non-retail. Office buildings have different trip generation characteristics than amusement parks and hotels, but they are placed in the same category for analysis. If the mix of ONR employment shifts, over time, from manufacturing to office, for example, the existing trip attraction model cannot capture that change. Therefore, the study team proposed five new stratifications of ONR and CBD sites:

- o Office Buildings (CBD)
- o Office Buildings (Non-CBD)
- o Manufacturing-Industrial
- o Other Non-Retail (CBD)
- o Other Non-Retail (Non-CBD).

Trip attraction rates were calculated for these five new stratifications and were compared to each other and current PAGTPD rates. The same methodology was used to calculate the trip attraction rates for these new categories as was employed before. Tables is Appendix 1 show how the trip rates for the new categories were derived.

4.5.2 Office Buildings

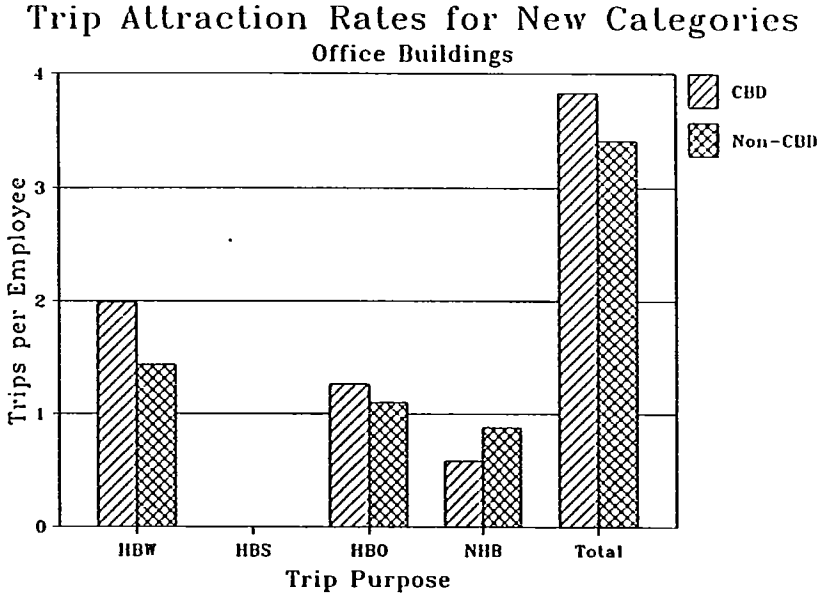
The CBD office building category consisted of three survey sites, while the non-CBD office building category consisted of five sites. The CBD sites had a higher trip rate (3.83 trips/ employee) than non-CBD sites (3.45 trips/employee), however, they are very close to each other. Both rates are lower than the PAGTPD (5.81 trips/employee) and observed ONR rates (5.06 trips/

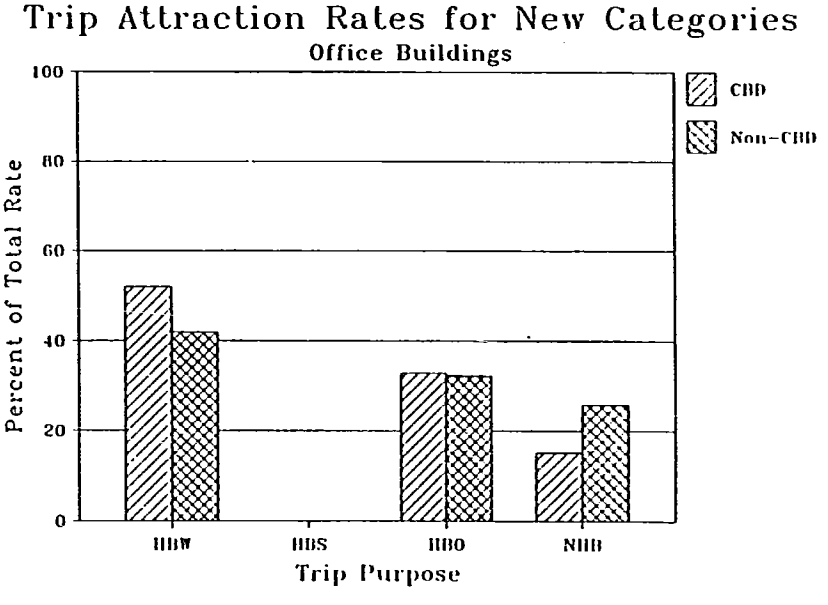
Exhibit 4-9

OFFICE BUILDINGS

(Vehicle Trips/Employee)

Purpose	CBD Rate	CBD Percent	Non-CBD Rate	Non-CBD Percent
HBW	1.99	52	1.43	42
HBS	0.00	0	0.00	0
HBO	1.26	33	1.10	32
NHB	0.58	15	0.88	26
Total	3.83	100	3.41	100





employee). The majority of the rates are made up of HBW trips (52 percent for CBD and 42 percent for non-CBD), while only 29 percent of the existing ONR rate was comprised of HBW trips.

As can be seen in Exhibit 4-9, the overall rates for the two office building categories were very close, while the distribution by purpose is not as similar, but still close. As a consideration, PAGTPD may want to categorized only by office building, and aggregate by CBD and non-CBD area type.

4.5.3 Manufacturing-Industrial

The Manufacturing-Industrial (M-I) category consisted of five survey sites. The rates and percent distribution by purpose can be seen in Exhibit 4-10. The M-I trip attraction rate of 2.36 trips/employee is approximately half of both the PAGTPD and observed ONR rates. Also, 89 percent of the rate is composed of HBW trips, compared to 29 percent for the observed ONR rate, three times as much.

4.5.4 Other Non-Retail

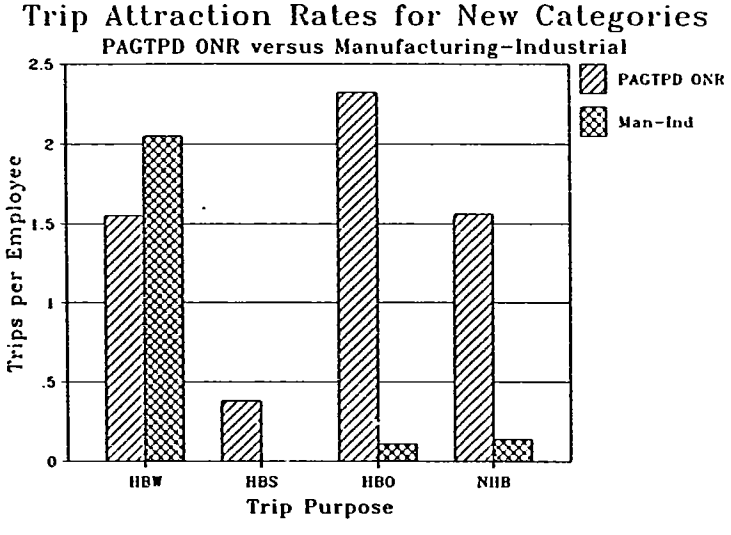
The CBD ONR category consisted of only two sites, while the non-CBD ONR category was made up of 9 sites. The CBD rate of 38.10 trips/employee is suspect because of the small sample size. Both of the sites had relatively few employees and a large number of trips. The non-CBD rate of 10.49 is approximately twice the PAGTPD and observed ONR rates. Like those rates, the CBD and non-CBD ONR rates are comprised mainly of HBO and NHB trips. Even though there is a large disparity in the overall trip attraction rate between CBD and non-CBD, the distribution of

Exhibit 4-10

MANUFACTURING-INDUSTRIAL vs. PAGTPD ONR

(Vehicle Trips/Employee)

	PAGTPD ONR		Manufacturing-Industrial	
Purpose	Rate	Percent	Rate	Percent
HBW	1.45	29	2.05	89
HBS	0.05	1	0.00	0
HBO	2.17	43	0.11	5
NHB	1.39	27	0.14	6
Total	5.06	100	2.30	100



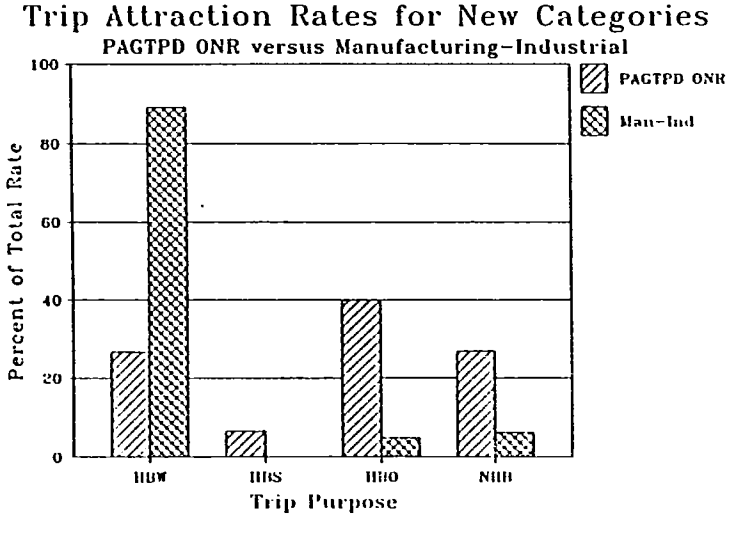
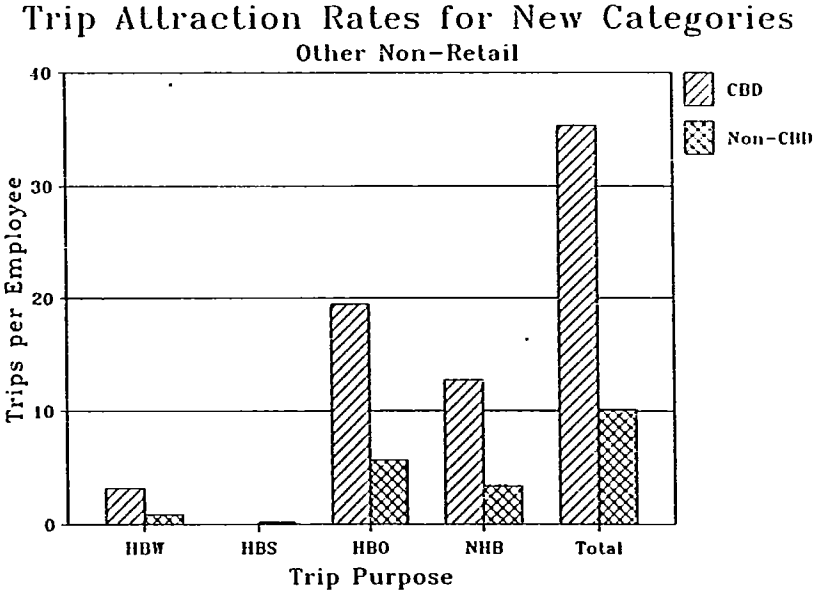


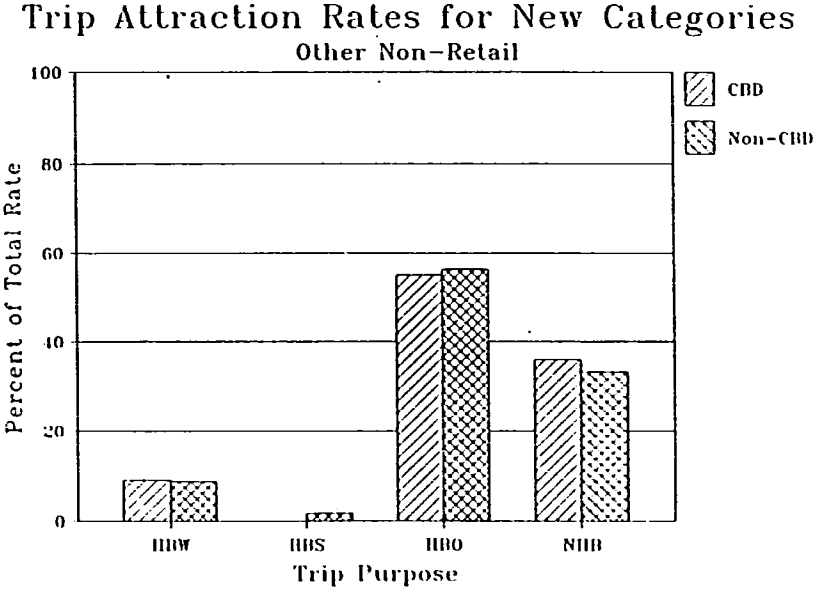
Exhibit 4-11

OTHER NON-RETAIL

(Vehicle Trips/Employee)

	CBD		Non-CBD	
Purpose	Rate	Percent	Rate	Percent
HBW	3.55	9	0.92	9
HBS	0.00	0	0.18	2
HBO	20.27	53	5.92	56
NHB	14.28	37	3.47	33
Total	38.10	100	10.49	100





trips by purpose within the rates are very similar. The trip rates and purpose distribution for the two new ONR categories are presented in Exhibit 4-11.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Previous chapters have presented the results of this research project. This chapter will offer conclusions and some areas that may need further analysis.

5.1 Central Business District

The observed CBD trip rate shows an over-reporting of trips by the current model. One contributing factor is that there were no retail CBD sites in the survey, thus producing a HBS rate of 0.00 trips/employee. Any additional analysis of CBD sites must include retail sites. Also, more non-office building ONR sites are probably needed to produce a representative sample of all the different CBD attractions.

The CBD category may not be necessary if the other non-retail employment category is further stratified. If separate rates are applied for office employment and retail employment, attractions to the CBD may be properly estimated. Special CBD rates may be necessary if it is found that a considerable number of retail trips are made by pedestrians not using vehicles.

5.2 Community Shopping Center

Further surveying of CSC sites is needed to acquire accurate counts of the total number of person trips. The survey crews encountered trouble counting pedestrians travelling between stores once they had arrived at the site. Carefully constructed and controlled traffic counts are needed to accurately estimate the number of trips.

Although the higher observed rates are probably corrupt, the lower rates indicate that the PAGTPD model is under reporting HBS

trips to CSCs. One area that needs investigating is how the original PAGTPD rates were determined. One problem may be that the number of employees per square foot that the model is based upon may be too high, thus making the trip attraction rate too low. A thorough analysis of how the employee estimates used in the modeling process are derived may also be appropriate to determine if the employee estimates for this category are accurate. If not, the rates may be higher, but the employees in the category lower, yielding fewer overall trips for this category.

Another interesting result for CSC is related to the size of the shopping center. For shopping centers with 75 or fewer employees (Sites 37 and 43), the trip rates were more than twice the rates for shopping centers with more than 75 employees. More data collection may be needed, with CSCs stratified by size. Finally, even though the observed rates are likely to be too high, the distribution of trips by purpose is very similar to that currently being used by PAGTPD.

5.3 Regional Shopping Center

The overall rate for RSC changed very little from the PAGTPD rate. The distribution of trips by purpose within the rate, however, shifted significantly. HBS trips decreased while HBO trips increased, indicating that, we suspect, people are visiting RSCs for purposes other than shopping. RSCs now also serve as "meeting places" for social and recreational purposes, thus shifting more trips away from HBS and into HBO.

5.4 Other Retail

Like CSC, the observed OR rate showed a significant increase in HBS and NHB trips. The probability of double counting of pedestrians at OR sites is very small due to the fact that most of the sites were stand-alone stores, which made it easier to count people entering the site. There was also a significant decrease in the HBW rate for OR sites, from 2.84 to 1.57 trips/employee.

5.5 Other Non-Retail

The observed ONR rate matched up extremely well with the currently used rate. The overall rates were very close and the distributions by purpose were also very similar. The ONR part of the model should probably be revised to further stratify the employment categories. This is discussed later in this section. This category, like the CBD, is dependent upon the mix of different land uses in the sample and model applications.

The CBD and other non-retail are the only categories which are made up of many different site types. Therefore, they are especially sensitive to shifts in the economy. Exhibit 5-1 is a hypothetical example for 1,000 employees of what could happen if there was a shift from a manufacturing economy in 1960 to a service economy in 1987. As can be seen, even though the trip rates and number of employees remained constant, the total number of attractions increased from 4,162 to 5,399, an increase of 30 percent. If an average rate for other non-retail employment were used, no difference in attraction would be captured. Furthermore, the trip purpose split for the trips made to these trip

Exhibit 5-1

HYPOTHETICAL SHIFT IN ONR EMPLOYMENT
BY LAND USE TYPE
1,000 EMPLOYEES

Category	Rate	No. of Employees 1960	Trips	No. of Employees 1987	Trips
Office	3.83	200	766	500	1915
Manufacturing	2.30	600	1380	200	460
Other Non-Retail	10.08	200	2016	300	3024
Total			4162		5399

attractions would change, creating more home-based other trips per employee. Therefore, without more accurate stratification, the model may incorrectly predict attractions, even though the overall rates and employees have not changed.

5.6 Davis-Monthan Air Force Base

The changing nature of DMAFB may have lead to changes in the rate of this special generator. As mentioned previously, the increase in employees living off base leads to a larger number of attractions. The increase in the DMAFB rate was mainly due to HBW trips. The HBW rate rose by more than 300 percent. Currently, 5289 of the 6989 DMAFB employees are active duty military, and 50 percent of those live off base. No historical data was available to show what percentage of the work force lived off base in the past.

5.7 New Development Categories

The trip attraction rates derived for the new development categories indicate that there is a need for further stratification. The PAGTPD and observed ONR rates were very similar, between five and six trips/employee. However, the new categories produced rates ranging from 2.43 trips/employee for Manufacturing-Industrial to 38.10 trips/employee for CBD ONR. Of course, the CBD ONR category is not a very representative sample, but the other stratifications--CBD and non-CBD Office Buildings, Manufacturing-Industrial, and non-CBD Other Non-Retail--had good sample sizes. The new stratifications will allow PAGTPD to more accurately model trip generation because they are not dependent on the mix of different kinds of land uses but more accurately

represent the trip attractions created by two large employment categories, manufacturing and office employment.

5.8 Non-Home-Based Trip Length Distribution

As seen previously, the current PAGTPD model accurately predicts the NHB trip length distribution. The three means calculated--PAGTPD model, highway skim time, and reported time--were all very close. Therefore, in our judgment, no adjustments in the friction factors of the model need be made.

5.9 Application of Revised Trip Attraction Rates

When the revised trip attraction rates were applied in the regional modelling process, the total number of regional attractions did not change much, but the distribution of trip attractions by purpose changed drastically by zone. PAGTPD may want to analyze the 1980 base model output and the revised model output and decide which of the zonal distributions of attractions by purpose more accurately reflects the current situation in the Tucson area.

At the same time, PAGTPD may also want to investigate the 1980 employment estimates. Inaccuracy in those data may be causing a dramatic overestimation of total attractions before they are balanced with productions. If one employment category is significantly overestimated, the trip attractions for other land uses could be significantly reduced by the balancing process.

6.0 SURVEY METHODOLOGY AND IMPLEMENTATION

6.1 Introduction

The methodology of the survey was described in the **Task 1 - Working Paper**, which is included in Appendix A. The working paper contains complete information on survey purpose, design, and implementation procedures. This section of the report will discuss the execution of the survey, including problems, methodology changes, and return and sampling rates.

Surveys were conducted in two parts, Part One in February and March of 1986 and Part Two from October 1986 to January 1987. A total of 45 sites were surveyed, 22 in the first part and 23 in the second.

The survey procedure consisted of three basic steps: 1) reconnaissance, 2) organization, and 3) execution. Approximately every two weeks, PAGPTD would notify the Study Team with a list of survey sites that had given preliminary approval to conduct a survey. For each of these sites, a member of the Study Team would contact the site manager to schedule a date for the survey. During this telephone call, the name of the survey supervisor and details of the survey were relayed to the site manager. In the reconnaissance phase, the survey supervisor would visit the site a few days in advance of the survey. The purpose of this visit was to further coordinate with the site management and to draw up a site plan.

During the organization phase, the supervisor set up the logistics of the survey, such as the positioning of each surveyor using the site plan, scheduling the hours of survey operation, and assembling the required equipment.

After the reconnaissance and organization phases, the actual survey was conducted. In most cases the surveys proceeded smoothly. A key to the success of the survey was the assistance of the site managers. The procedure was for surveyors to pass out survey cards to as many pedestrians as possible. The pedestrians would fill out the card and either hand it back to the surveyor, drop it in boxes around the site, or mail it to the study team. The survey cards had a mail-back option on the reverse side.

An example of the survey card is shown in Exhibit 6-1. The tripmakers were asked what there purpose for coming to site was, where they were before they came, and what mode of travel they used. If the person drove to the site, the occupancy of the vehicle was requested. The address of the place where the person came from was also asked. This was later used to geocode non-home-based trips. In Part Two, respondents were also asked where they were going next.

While the survey crews were passing out survey cards, they were also conducting counts of all pedestrians entering the site. The potential double counting of pedestrians at some sites led to problems later in weighting and expanding the data. Details of and problems encountered with each part of the survey are discussed in the following sections.

6.2 Part One Survey

Only two significant problems occurred in the first phase of the survey. There were problems with pedestrian counts at Community Shopping Centers (CSC) and with the traffic counts.

Exhibit 6-1

SURVEY CARD

TUCSON AREA TRAVEL SURVEY
ARIZONA DEPARTMENT OF TRANSPORTATION

Please take just a few seconds and fill out this short questionnaire. This information is needed to plan for the transportation needs of the Tucson area.

1. How did you travel to this place today? PLEASE CHECK ONE

   1. ☐ bicycle
   2. ☐ bus
   3. ☐ walked
   4. ☐ drove a car, van, pickup truck, or RV
   5. ☐ passenger in car, van, pickup truck, or RV
   6. ☐ commercial or delivery truck
   7. ☐ taxicab

2. If you came by car, van, truck, or RV, how many other persons traveled here with you, not including yourself? PLEASE CIRCLE ONE.

   I traveled here alone: ☐ 0

   Number others along: 1 2 3 4 5 6 7+

3. About what time did you arrive here today? ____:____ (write-in) AM 1. PM 2.

4. What is the purpose of your trip to this place? PLEASE CHECK ONE.

   1. ☐ I regularly work here
   2. ☐ Job related (delivery, client, etc.)
   3. ☐ Visit relative or friend
   4. ☐ Entertainment
   5. ☐ Personal business (doctor, dentist, bank, etc.)
   6. ☐ Shop
   7. ☐ Eat Meal
   8. ☐ School
   9. ☐ Other: _____

5. Which establishment are you going (did you go) to first?

   PLEASE WRITE IN: _____ (name of store, office, bank, etc.)

6. Where were you just before coming to this place?
   The place you last got into a vehicle before arriving here.

   A. PLEASE CHECK ONE
   1. ☐ My home
   2. ☐ Place of employment
   3. ☐ Shopping
   4. ☐ Personal business
   5. ☐ Restaurant
   6. ☐ School
   7. ☐ Other place: _____

   B. PLEASE WRITE IN the location of that place:

   APPROXIMATE STREET ADDRESS

   _____ (number) _____ (street name) _____ (town)

   OR, THE NEAREST STREET INTERSECTION of that place:

   _____ (st., ave., etc.) and _____ (st., ave., etc.) _____ (town)

7. How long did it take you to travel here from there? _____ minutes (write in)

8. When you get back in your vehicle to leave this place, where will you be going?

   1. ☐ My home
   2. ☐ Other place

THANK YOU VERY MUCH FOR YOUR HELP!!

PLEASE RETURN THIS FORM TO EITHER THE PERSON WHO HANDED IT TO YOU, OR PLACE IT IN ONE OF THE RETURN BOXES LOCATED ABOUT THIS PLACE MARKED "RETURN SURVEYS HERE." THANKS AGAIN.

6.2.1 Pedestrian Counts

As mentioned earlier, the survey crew was responsible for counting all pedestrians entering the survey site. This count would indicate the total number of person trips to the site during the survey period. At most sites, there were a limited number of entrances, which made it easy to conduct the pedestrian counts. At the two CSC sites, Monterey Village and Southgate Shopping Center, however, double counting of pedestrians may have occurred. The way that this probably happened is that one surveyor counted a pedestrian as they entered one part of the CSC and another surveyor, located at a different part of the site, counted the pedestrian as he went to another store in the shopping center.

6.2.2 Traffic Counts

The purpose of the traffic counts conducted by ADOT was to establish a reference total to which the survey results could be factored. Their usefulness was limited, however, due to various factors. During the first week of the survey, traffic counts included both entering and exiting vehicles. Thus, over a 24 hour period, the counts were usable, because the total could be divided by two. This theory assumes that the parking lot was empty at the beginning and ending of the day. For sites where traffic counts were not done for a 24-hour period, this does not work. For a shorter time period, depending upon the time of day, 75 percent of the vehicles may entering the lot or 75 percent of the vehicles may be exiting the lot. Therefore, dividing the total count by two would not produce an accurate entering count.

During the last three weeks of the survey, the counts were taken in the inbound direction only and, theoretically, represent the number of vehicle trips to the site.

Another possible source of discrepancies with the traffic counts was that ADOT was not able to conduct the counts on the same day the site was being surveyed. Therefore, if traffic conditions were different than those on the survey day, the traffic counts were of limited use.

Subsequent analysis brought out significant differences between the traffic counts and the pedestrian counts at a majority of the sites. Of particular concern are cases where the number of survey cards distributed exceeded the number of vehicles counted. Since the survey card pass out rates at all sites was less than 75 percent, there should not have been more cards distributed than vehicles counted. At other sites, the number of vehicles counted entering the site exceeded the number of pedestrians counted entering the site by a factor of two or more.

6.3 Part Two Survey

During the second phase of the survey, the pedestrian counts conducted at CSCs were again a problem. Three of the sites also posed individual logistics problems, which are discussed below. Traffic counts were not a factor in Part Two. Traffic counts were taken at only four sites instead of all 23. They were needed at the four sites because it was believed that there would be traffic entering the sites before and after the survey hours.

A further explanation is offered in the section of this report discussing the weighting and expanding of the survey data.

6.3.1 Pedestrian Counts

In the second phase of the survey, there were three CSC sites, Kolb and Golf Links, Oracle and McGee, and Swan and Sunrise. The same problem that occurred in Part One with the double counting, happened in Part Two. Possible solutions to the double counting situation at CSCs are offered in the section of this report devoted to analysis of the trip attraction rates.

6.3.2 Burr-Brown

The survey crew encountered problems at site 25, a manufacturing site known as Burr-Brown. They were only able to survey for five of the scheduled eight hours. This was because the workers' union at the site had not been advised of the survey and did not understand what was taking place. The survey was stopped at approximately 11:00 a.m. Therefore, Burr-Brown was categorized as a "Problem Site" during the analysis phase, and was not a part of the other non-retail trip attraction rate.

6.3.3 Park Mall

Site 40, Park Mall, was the only Regional Shopping Center (RSC) in either part of the survey. It was also the largest site in terms of manpower needed. In order to coordinate the 12 surveyors, a packet was made for each one, showing a map of the mall, the surveyor's location for each of the time periods during the survey hours. Two survey supervisors were required for this site to check on the surveyors and relieve them for breaks.

6.3.4 Davis-Monthan Air Force Base

Davis-Monthan Air Force Base (DMAFB), site 41, was the only special generator in either part of the survey. Because of military procedures, a number of advance preparations were required. JHK, the subcontractor overseeing the survey, had to submit a Certificate of Insurance and a list of the surveyors to the base security office beforehand.

This was the only site where surveys were handed out to people in vehicles, by the survey crews. The day before, the crew placed signs by all the gates stating "ADOT SURVEY TOMORROW." Once started the survey went smoothly with the exception of a surveyor who became ill. Fortunately, traffic volume in another part of the base was reduced enough that a surveyor from there could take over for the ill surveyor.

6.4 Analysis of Return and Sampling Rates

Exhibit 6-2 shows the distribution rates, return rates, usable survey rates, and sampling rates for the six different development categories. A complete table showing these rates for each site is included in Appendix B.

6.4.1 Surveys Distributed

The distribution rate is the number of survey cards passed out at each of the sites in the category, divided by the control total for that category. The count of cards passed out is based upon the site logs the surveyors kept indicating which cards were passed during each half hour. The control totals used for all rates calculated vary from site to site, depending on which part

Exhibit 6-2

	Control Total	Surveys Distrib	Distrib Rate	Surveys Returned	Return Rate	Sampling Rate	Usable Surveys	Usable Rate	Sampling Rate
Central Business District	3050	1934	63%	1207	62%	40%	1096	91%	36%
Community Shopping Center	16653	7173	43%	4085	57%	25%	3577	88%	21%
Regional Shopping Center	21157	3407	16%	1562	46%	7%	1428	91%	7%
Other Retail	17859	8740	49%	4948	57%	28%	4396	89%	25%
Other Non-Retail	17545	8829	50%	5323	60%	30%	4651	87%	27%
Special Generator	19699	1825	9%	516	28%	3%	488	95%	2%
Total	95963	31908	33%	17641	55%	18%	15636	89%	16%

of the survey the site is from. For sites from Part One, the control total is the weighted, expanded number of trips to site for the day, based on vehicle and pedestrian counts. For sites in Part Two where vehicle counts were conducted, the control total is the vehicle count for the day. For sites in Part Two without vehicle counts, the control total is the pedestrian count for the site. A description of how the different control totals were calculated is given in the section of this report concerning weighting and expansion of the survey data.

As can be seen from Exhibit 6-2, CBD sites had the highest distribution rate (63%), while DMAFB had the lowest (9%). The low rate for DMAFB is due to the fact that there is traffic in and out of the base 24 hours a day and surveyors were handing cards to the drivers of the vehicles. The total pass out rate was 33 percent for the entire survey.

6.4.2 Surveys Returned

The survey return rate is the actual number of survey cards returned divided by the number of surveys distributed. The sampling rate is the number of cards returned divided by the control total. This indicates how much of the population was actually surveyed.

The return rates for all categories were very good, usually between 50 and 60 percent. The overall return rate of 55 percent was much higher than anticipated. The sampling rates varied from category to category depending on what the control total is based. The sites with vehicle counts, such as Park Mall and

DMAFB generally have much lower sampling rates than those that used pedestrian counts.

6.4.3 Usable Surveys

Usable surveys are those survey cards in which enough information was completed so that the card could be used in calculating trip attraction rates. For the first phase of the survey, the critical responses were the purpose of the visit to the site and the purpose at the location the tripmaker came from. For the second phase, the important responses were those two and where the tripmaker was going next. The usable rate is the number of usable survey cards divided by the number of survey cards returned. The usable sampling rate is the number of usable survey cards divided by the control.

The usable rate was very high for all categories, ranging from 87 to 91 percent. Overall, the usable rate was 89 percent. The number of usable trips was 15,636 which represents a sampling rate of 16 percent.

7.0 EDIT, COMPILE, AND ANALYZE DATA

7.1 Introduction

The purpose of this chapter is to document the procedures used in the editing, compiling, and analyzing of the data collected during the Trip Attraction Rates Study. This memorandum contains information concerning data sources, file formats, dataset development and structure, and weighting and expansion methodology.

The survey was conducted in two parts, Part One in the spring of 1986 and Part Two in the fall of 1986. The differences between the two parts of the survey were an additional question in Part One and the more prominent use of vehicle counts in weighting and expanding Part One survey card data. Although the data development and processing for the two parts of the survey were conducted separately, the same basic procedure was followed both times. Therefore, this chapter will describe the procedures as if both parts of the survey were processed as a whole. Differences between the two parts, however, will be highlighted.

7.2 Data Compilation, Editing, and Processing

This section discusses the processes used to combine the many different data sources into one file that was used to calculate trip attraction rates and non-home-based trip lengths.

7.2.1 Data Sources

The data used in the calculation of new trip attraction rates for the Tucson area came primarily from the survey conducted by COMSIS and JHK. The two sources of data were the survey cards that were distributed to pedestrians at the survey

sites, and the site logs that the surveyors completed during the course of the survey.

The survey cards contained information such as trip purpose, travel mode, address of origin of trip, and reported travel time. The site logs consisted of information concerning which survey cards were distributed at each site during each hour of the survey and counts of all pedestrians entering the site by hour during the survey period.

A data source that was derived from the survey card data was the addresses of the origins of the non-home-based trips in the survey. A list of the addresses was geocoded and the geocoded information was later added to the survey card information in the survey file.

Another source of data was PAGTPD. They provided COMSIS with highway skim times derived from their forecasting model. The skim times were from the traffic analysis zones (TAZ) of the survey sites to all other zones in the network. The skims were used in the derivation of non-home-based trip length distribution.

The final data source was the employers and management of the survey sites. They supplied the number of part time and full time employees working at the sites and the total floor area (in square feet) of the sites.

7.2.2 Data Entry

The survey cards and site logs were collected and compiled by the study team and forwarded to the Arizona Department of Transportation (ADOT) for keying. ADOT then forwarded data tapes

to COMSIS with files containing survey card information and files containing site log information. The original survey cards and site logs were also returned.

During the second half of the survey, problems were encountered with the keying of the site log data. Many of the site logs were rekeyed to ensure that accurate pedestrian counts and serial number ranges were in the data file. The extra effort exerted rekeying data and writing special programs to produce a correct site log file was necessary because the logs are one of the most important data sources. Without correct site log information, it would be impossible to identify which surveys were passed out at each site. The site logs also contained the pedestrian counts that were used in weighting and expanding the data. As a result, 98 percent of the survey card serial numbers were found in the site logs.

7.2.3 Geocoding and Highway Skims

After the survey card data had been received, non-home-based trips were selected for geocoding. A list of the survey card serial number and trip origin address was compiled, sorted by address and geocoded.

The TAZ that corresponded with the origin of each trip on the list was appended based upon the address. The list was then forwarded to ADOT for keying. ADOT entered the survey card serial number and the TAZ and forwarded the file to COMSIS.

PAGTPD supplied COMSIS with a file containing the necessary highway skim times. The PAGTPD file consisted of a matrix output from UTPS that was not easily merged with the survey card data,

thus the skims were reformatted. The reformatted file consisted of a record for each unique i-j pair and the associated travel time.

7.2.4 File Structure, Editing, and Processing

After the four necessary data files--survey card data, site log data, geocode data, and highway skim data--were entered, formatted, and verified, the data processing and compiling began. (The file formats are shown in Appendix A.) The data processing was done using FORTRAN, the Statistical Analysis System (SAS) and the Statistical Package for the Social Sciences (SPSS).

Each of the files contained unique identifiers that made merging and appending data possible. For the survey card file, the unique key was the survey card serial number (SERIALNO). For the site log file, the unique keys were the survey site (SITE) and survey hour (BEG_HR). The geocode file also used the serial number of the survey card (SERIALNO) for its identifier. The highway skim file had a record for each unique i-j pair (SITE_TAZ and TAZ). FORTRAN programs were used to append information from the site log file to the survey card file. The survey card file was then read into a SAS dataset. The geocode data and highway skims were also read into SAS datasets and merged with the survey card file.

At this point, the SAS dataset was a compilation of the four original data files. More site information, such as site type, number of employees, and square footage, and traffic counts were then appended to the file.

The next step in processing was to edit the data to ensure their integrity. Each of the variables was checked, using SAS, for missing data and data out of range. If an observation had a response to a question that was not valid, the response was changed to missing value. Preliminary, unweighted cross tabulations were run to get an idea of the sampling rate and how well the survey would reflect the entire population when expanded. The preliminary cross tabulations are included in Appendix B.

7.2.5 Creation of New Variables

The only new variable created from the data was the origin-destination purpose (OD_PURP). This variable is a combination of two other survey responses, trip purpose at the survey site (PURPOSE), and where the respondent was prior to coming to the site (OPURP). The valid responses to these two variables were:

PURPOSE:
- 1 - Work
- 2 - Job-related
- 3 - Visit relative or friend
- 4 - Entertainment
- 5 - Personal business
- 6 - Shop
- 7 - Eat meal
- 8 - School
- 9 - Other

OPURP:
- 1 - Home
- 2 - Place of employment
- 3 - Shopping
- 4 - Personal business
- 5 - Restaurant
- 6 - School
- 7 - Other place.

OD_PURP was identified using a combination of these two variables. The origin-destination purposes and the origin and

destination purposes associated with each are described in Exhibit 7-1.

Because of the additional question in Part Two asking the respondent where he was going next (WHERE), it was possible to calculate an OD_PURP variable for the respondent's next trip. The valid responses to WHERE were:

WHERE:
1 - My home
2 - Other place.

The OD_PURP variable for the respondent's next trip was identified using a combination of PURPOSE and WHERE as shown in Exhibit 7-2.

The definition of home-based work purpose (HBW) used in this study assumes that all work trips are home-based. Any intermediate trips, such as serving passenger or dropping off children at school, are not counted. This sometimes leads to the categorization of some NHB trips as HBW. Of the 3,574 HBW trips in the unweighted data, 700 (20 percent) begin at a place other than home. If these trips were recoded as NHB, the HBW trip rate would decrease slightly, and the NHB rate would increase slightly. The trip rates derived from the survey presented in Chapter 2 already produce 12 percent fewer HBW attractions. Further reduction of the HBW rate by recategorizing work trips that did not begin at home would reduce total regionwide attractions even more.

7.3 Survey Weighting and Expansion

The next step in data processing and analysis was weighting and expansion of the survey data to the total population. At

Exhibit 7-1

PURPOSE DEFINITIONS
(Parts One and Two)

PURPOSE	OPURP	OD_PURP
1	-	1 - Home-based work
6	1	2 - Home-based shopping
1-5,7-9	1	3 - Home-based other
2-9	2-7	4 - Non-home-based.

Exhibit 7-2

PURPOSE DEFINITIONS
(Part Two--Additional Question)

PURPOSE	WHERE	OD_PURP
1	-	1 - Home-based work
6	1	2 - Home-based shopping
1-5,7-9	1	3 - Home-based other
2-9	2	4 - Non-home-based.

this point, the two parts of the survey will be discussed separately because the differences between them affected the way they were weighted.

For the second half of the survey, an additional question was added to the survey questionnaire. The people were asked where they were going next, after their current trip. The responses were either home or somewhere else (not home). This allows for the calculation of attraction rates for trips both coming and going from the survey site. For home-based trips, the home end is always the production, regardless of whether it is the origin or destination. For non-home-based trips, the origin end of the trip is always the production and the destination is always the attraction. With the additional survey question, a more valid calculation of trip attraction rates can be made.

7.3.1 Weighting and Expanding Part One Survey Data

In order to avoid the possibility of double counting when both passengers and drivers from the same vehicle responded to a survey card, only driver response records were used in establishing trips by purpose per hour. Auto passengers were factored into the count of trips by creating a new record for each passenger that the driver reported. The new passenger records contained the same information as the driver record with the exception of mode chosen. The control totals for expanding Part One sites are the pedestrian counts, so the new passenger records are created before expansion.

In addition to having one fewer question than the second half survey, the first half also made use of both vehicle and

pedestrian counts in the expansion procedure. Pedestrian counts were made on an hourly basis at each site during the actual survey period. Vehicle counts were also taken hourly, but for the entire 24-hour period, but not necessarily on the same day the survey was conducted. The easiest way to explain weighting and expansion procedures is to "walk" through an example using the sample data shown in Exhibit 7-3.

The formula for calculating the expansion factor for 8 AM survey hour for Site 1 is:

$$\begin{aligned} \text{Expansion Factor} &= A/B \\ &= 75/52 \\ &= 1.44 \end{aligned}$$

When this expansion factor is applied to the survey card data for that site and hour and all trips made that hour are summed, the resulting number of trips equals the number of person trips made to the site during that hour. The expanded trips made to each were then summed by site. This sum of person trips then had to be expanded to reflect the number of trips made to the site for a 24-hour period. Since only vehicle count information was collected, a ratio of vehicle counts was used to weight the survey period pedestrian counts to a 24-hour count:

$$\begin{aligned} \text{Weight Factor} &= (C+D)/C \\ &= 423/317 \\ &= 1.33 \end{aligned}$$

Thus, multiplying the expanded count of survey period trips by the weight factor (1.33) will produce the count of trips for the 24-hour period for each site (based upon a combination of pedestrian and vehicle counts).

Exhibit 7-3

PART ONE SAMPLE DATA

Site	Hour	Ped Count (A)	Survey Cards (B)	24 Hour Veh Count (C+D)	Survey Veh Count (C)	Non-Survey Veh Count (D)
1	8 AM	75	52	423	317	106
1	9 AM	56	40	423	317	106
1	10 AM	52	41	423	317	106
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1	6 PM	23	14	423	317	106
1	7 PM	18	11	423	317	106

7.3.2 Weighting and Expanding Part Two Survey Data

The expansion procedure for Part One data made use of vehicle count data at every site. In Part Two, only certain sites used vehicle count data in expansion:

25 - Burr-Brown
30 - Safeway
40 - Park Mall
41 - Davis-Monthan Air Force Base.

The reason 24-hour vehicle counts were conducted at only these four sites is that they are only ones which were expected to have regular travel during the hours outside the survey period. For the other 19 sites in Part Two, the survey was conducted for the entire time that the sites were open. Therefore, theoretically, all pedestrians visiting the sites during a 24-hour period would have been counted by the surveyors during the survey period.

Because of the differences between the sites, the weighting and expansion of sites with vehicle count will be discussed separately from those with only pedestrian counts.

7.3.2.1 Sites With Vehicle Counts

The four sites where vehicle counts were conducted employed the same methodology concerning auto driver and passenger records as Part One site and the other 19 Part Two site with one key difference. Because only vehicle counts are available for these four sites, a slightly different procedure was used. First, the passenger records were deleted, then the trips were expanded up to the vehicle counts, and then the new passenger records were created from the driver records. Since the control total is the number of vehicles entering the site during the survey period,

the count of drivers is expanded first. New passenger records are created from driver records after the expansion. Passenger records have the same expansion factor as the driver records.

The procedure used for expanding and weighting the survey card data from these four sites can best be shown using the sample data in Exhibit 7-4.

The formula for computing the factor to expand driver survey card records for 9 AM at Site 30 up to hourly vehicle counts is:

$$\begin{aligned} \text{Expansion Factor} &= A/B \\ &= 132/81 \\ &= 1.63 \end{aligned}$$

When this factor is applied to the driver and new passenger survey records, the resulting count of trips is the total number of person trips made to the site during the survey hour (based upon vehicle counts). The expanded trips for each site are summed to yield a count of person trips made to the site during the survey period.

The expanded count of person trips is for the survey period only. It still must be weighted up to the total 24-hour person trips. This is done by using a weighting factor based upon a ratio of survey hour vehicle counts and non-survey hour vehicle counts:

$$\begin{aligned} \text{Weight Factor} &= (C+D)/C \\ &= 335/708 \\ &= 1.47 \end{aligned}$$

Multiplying the expanded count of survey hour person trips by the weight factor yields the count of person trips for the 24-hour period (based upon vehicle counts). Trips made using modes

Exhibit 7-4

PART TWO SAMPLE DATA
(Site with Vehicle Counts)

Site	Hour	Veh Count (A)	Driver Survey Cards (B)	24 Hour Veh Count (C+D)	Survey Veh Count (C)	Non-Survey Veh Count (D)
30	9 AM	132	81	1043	708	335
30	10 AM	118	71	1043	708	335
30	11 AM	82	45	1043	708	335
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
30	8 PM	44	28	1043	708	335
30	9 PM	84	63	1043	708	335

other than vehicle driver and vehicle passenger were given the given the same weight and expansion factor. This assumes that the same ratio exist between vehicle trips and other modes.

7.3.2.2 Sites Without Vehicle Counts

As with Part One, to avoid double counting when both passengers and drivers from the same vehicle responded to a survey card, all passenger records were deleted, leaving only driver records. Auto passenger records were created and factored into the count of trips using the number of passengers reported by the driver. The new passenger records contained the exact same responses as the driver records they were created from, with the exception of mode chosen.

The survey card data from the 19 sites that did not have vehicle counts taken were expanded using the pedestrian counts made by the surveyors during the survey period. The expansion procedure will be explained using the sample data shown in Exhibit 7-5.

The formula for calculating the expansion factor for 7 AM at Site 27 is:

$$\begin{aligned} \text{Expansion Factor} &= A/B \\ &= 133/102 \\ &= 1.30 \end{aligned}$$

When this expansion factor is applied to each record on the survey card data, the result is the total number of person trips made to the site during the survey hour. When the expanded trips are summed for each site, the result is the number of person trips made to the site during the survey period and, theoretically, the 24-hour period.

Exhibit 7-5

PART TWO SAMPLE DATA
(Sites Without Vehicle Counts)

Site	Hour (A)	Ped Count (B)	Survey Cards
27	7 AM	133	102
27	8 AM	125	90
27	9 AM	130	95
.	.	.	.
.	.	.	.
.	.	.	.
27	8 PM	54	31
27	9 PM	63	48