El PASO DESTINO 2045 MODEL

MODEL DEVELOPMENT REPORT

prepared for

El Paso Metropolitan Planning Organization

prepared by

Cambridge Systematics, Inc.

with

AECOM Transportation, Inc.

ETC Institute

March 31, 2018

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final report

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prepared by

Cambridge Systematics, Inc.
10415 Morado Circle, Building II, Suite 340
Austin, TX 78759

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1.0 Model Development Plan

This chapter provides a description of the El Paso Metropolitan Planning Organization (MPO) model development plan. It also briefly discusses the data necessary to estimate various model components. This plan was developed and put into place before the model update commenced. As a result, the plan captures the goals, objectives, and ambitions of performing the model update. Later chapters in this report discuss the actual development work and the calibration.

1.1 Preexisting Model Basis and Structure

The preexisting 2007 MPO model was developed using a combination of the 2009 household travel survey and 2006-2010 American Community Survey (ACS) data. The 2009 household survey was conducted to collect information pertaining to travel behavior of residents in El Paso County, Texas and portions of Dona Ana and Otero Counties in New Mexico. The survey also included a stated choice survey to identify preferences on future transportation alternatives. A total of 411 households responded and provided useable information for model development. This survey formed the basis for deriving trip generates rates, trip length frequency distributions, and mode shares. The ACS data were used as a means to cross-check and calibrate some of these model parameters.

The trip generation and distribution models used the Texas TripCal5 and ATOM2 models. Mode shares from the survey were used as a direct input to split person trip tables into different modes and purposes. There was not a mode choice model in the 2007 MPO model. For the external model, the 2002 external travel survey was used as the basis while external station counts were used as a means to calibrate the external model. There were no updates made to the truck trips in the model.

1.2 Model Design Plan

The motivation for developing a new travel demand model was to update the 2007 MPO model to a new base year of 2012, develop input data and execute model runs for several horizon years, and use the forecasts for air quality and conformity analyses. Also, there have been several data collection efforts in the region since the last model update that include household travel surveys, on-board surveys, and commercial vehicle surveys. This project involved using these data to update and/or develop new model parameters to capture the latest travel behavioral characteristics in the region. The following subsections describe the approach to the different model components in the model update plan. Later in the report, separate chapters are presented covering the model development and model calibration/validation activities.

1.2.1 Trip Generation

The model update plan included updating the trip generation models. One aspect of the update was refining the trip purposes. Table 1.1 provides presents the 2007 MPO model trip purposes and the new model trip purposes.

The model update plan called for the update of the trip production model using the 2010/2011 household travel survey. One of the key objectives, in addition to using the latest data, was to incorporate and retain income stratifications throughout the modeling process, all the way from generation through assignment. This is very critical for tolling and environmental justice analysis, and also improves the explanatory power of all models that are dependent upon income based market segments.

In addition to incorporating income group disaggregation, the plan included disaggregating the HBNW (Home-Based Non-Work) purpose into "retail" and "other"; supplementing the NHB (Non-Home Based) purpose with NHB-special generator trips based on special generator surveys; and building a commercial vehicle model based on a commercial vehicle survey and truck counts.

The plan included developing trip attraction models for the same set of trip purposes as the production models, with all these purposes coded and updated inside of TripCal5. In coordination with Texas Department of Transportation (TxDOT)/ Texas A&M Transportation Institute (TTI), the model update plan adopted the use of TexPACK, a modeling system that houses TripCal5 and ATOM2 and integrates it with a new interface inside TransCAD. Chapter 4 discusses the development of the trip generation models and Chapter 12 (Section 12.1) provides an overview of the TexPACK System.

Table 1.1 Trip Generation
Additional Trip Purposes

Prior Model – Base Year 2007		New Model – New Base Year 2012	
Trip Purpose	**Trip Type**	**Trip Purpose**	**Trip Type**
HBW by Income Groups	Person	HBW by Income Groups	Person
HBNW by Income Groups	Person	HBNW – Retail by Income Group	Person
		HBNW – Other by Income Group	Person
		HBNW – ED1 (K-12)	Person
		HBNW – ED2 (College)	Person
NHB by Income Groups	Person	NHB by Income Groups	Person
		NW – Airport	Person
		NHB – Special	Person
Truck – Taxi	Vehicle	Truck Commercial	Vehicle
		Taxi	Vehicle
EXLO Non-Commercial	Vehicle	EXLO Non-Commercial	Vehicle
EXLO Commercial	Vehicle	EXLO Commercial	Vehicle
EXT-Through	Vehicle	EXT-Through	Vehicle

1.2.2 Time of Day Factors

The model update plan retained the approach of applying time of day factors after trip generation to the productions and attractions by purpose. This approach provides the appropriate level of service skims (time, generalized costs) into vehicle availability, trip distribution, and mode choice models based on trip purpose. Peak-period skims are used for home-based work and home-based education trips (ED1 and ED2) while off-peak period skims are used for home-based non-work (retail, other) and non-home based trips (NW-airport, NHB, NHB-special).

The model update plan called for time of day factors used by the existing 2007 MPO model to be examined and updated using the 2010/2011 household travel survey data and appropriate traffic counts. Given the wide variations of temporal distribution of traffic across different areas in the region, analysis for potential geographic market segmentations were also undertaken. In summary, the plan involved reviewing existing time of day factors, analyzing household travel survey data for time of day factors (by mode, purpose and/or market segment), developing capacity factors by time of day (to be input into the volume-delay functions), and developing scripts for implementation.

The work program incorporated four time periods (AM Peak, mid-day, PM Peak, and night) into the assignment procedures, resulting in four different assignment models while also giving the ability to run a 24-hour daily assignment. Chapter 9 discusses the developed time of day factors.

1.2.3 Vehicle Availability Model

The model update plan incorporated a vehicle availability model into the updated model, to be applied before trip distribution. Vehicle availability models are very helpful to mode choice modeling, since they provide a prediction as to the number of vehicles or vehicle sufficiency (vehicles equal to or more than workers per household), important aspects of transit . The 2010/2011 household travel survey and the 2009 National Household Travel Survey were considered as the estimation datasets for this model. Chapter 6 presents the development of the vehicle availability model.

1.2.4 Trip Distribution

The model update plan called for separate gravity models by trip purpose to be developed and implemented within ATOM2. The basic approach was to review the existing procedures for trip distribution and update them based on recent survey data. In consultation with TxDOT Transportation Planning and Programming Division (TPP), TTI and El Paso Metropolitan Planning Organization (EPMPO) staff, ATOM2 was updated and calibrated until the estimated or predicted trip tables closely matched observed targets derived from the 2010/2011 household travel survey. Chapter 5 discusses ATOM2 and the trip distribution model development.

1.2.5 Mode Choice

The preexisting 2007 MPO model did not have a mode choice component; it took observed mode shares and split the person trip tables by person into modal trip tables. The model update plan called for estimating new mode choice models using the 2010/2011 household travel survey and 2012 transit on-board survey data.

A state of the practice mode choice model was desired. Typically, this model would be a nested logit model structure with at least the following choices 1) three auto modes – drive alone, shared-ride 2-persons, and shared-ride 3-or-more-persons, 2) transit mode stratified by mode of access (walk, auto), and 3) nonmotorized mode. The Cambridge Systematics (CS) team reviewed the available data, identified the needs of EPMPO and Sun Metro, and consulted with TxDOT/TPP. These reviews and discussions led to the identification of several desired model capabilities, including: 1) local service versus premium service choice; and 2) kiss and ride (KNR) versus park and ride (PNR) automobile-access-to-transit choice. Chapter 7 discusses the resulting mode choice model development.

1.2.6 Trip Assignment

The preexisting 2007 MPO model highway assignment was multi-class assignment with three classes of vehicles – drive alone (DA), shared ride 2 (SR2), and shared 3+ (SR3+). Trucks and externals are pre-loaded in an all-or-nothing assignment.

For the updated model, the model update plan changed this procedure to include additional vehicle classes as well as to assign trucks along with the auto classes. Specifically, commute trips made by the drive alone mode of travel are stratified by income group and retained as separate vehicle classes in the assignment to allow the model to be sensitive to pricing and tolling scenarios. There are separate tables maintained for all the non-work purposes for the drive alone mode, but for shared ride 2 and 3+, trips are aggregated prior to assignment to permit assignment for all trip purposes together (fewer vehicle classes speeds the process). External autos are added to the auto classes while trucks are assigned in parallel to the auto classes. All of the vehicle classes have separate values of time (VOT) factors so that they react differently to different pricing and tolling options.

The model update plan included reviewing the volume-delay function (VDF) parameters during highway assignment validation for adjustment by facility type to better match the observed traffic counts and VMT. In addition, an appropriate number of feedback loops were included based on the convergence criterion and differences between adjacent assignments. Table 1.2 summarizes and highlights how the model update plan expanded the vehicle classes scheme for improved highway assignment. Section 11.1 discusses the resulting highway assignment development.

Table 1.2 Improvements to Highway Assignment

2007 MPO Model
Vehicle Class
DA
SR2
SR3+
TRUCK-Commercial
EXLO Non-Commercial
EXLO Commercial
EXT-Through

Proposed 2012 MPO Model
Vehicle Class
HBW - DA - Inc 1
HBW - DA - Inc 2
HBW - DA - Inc 3
HBW - DA - Inc 4
HBW - DA - Inc 5
HBNW and NHB - DA
SR2
SR3+
TRUCK (internal + EXT)
Auto (EXT + Through)

The preexisting 2007 MPO model transit assignment assigned transit walk access and drive access trips to the bus network which included local bus and express bus routes. For the model update plan, transit assignment was enhanced to recognize the addition of a mode choice model and to allow additional premium transit sub-modes that could be modeled. The plan called for networks and related attributes for these new modes to be developed mindful of FTA guidelines and for network path building parameters to conform to FTA standards, where certain premium modes (e.g., LRT) could enjoy the benefit of lower perceived travel time. Table 1.3 summarizes and highlights how the model update plan expanded the transit mode scheme for improved transit assignment. Section 11.2 discusses the resulting transit assignment development.

Table 1.3 Improvements to Transit Assignment

2007 MPO Model
Transit Mode
Transit – Walk Access
Transit – Drive Access

Proposed 2012 MPO Model
Transit Mode
Local Bus – Walk access
Local Bus – Drive access
Express Bus – Walk access
Express Bus – Drive access
Street Car – Walk access
Street Car – Drive access
BRT – Walk access
BRT – Drive access
LRT – Walk access
LRT – Drive access

1.3 Model Validation Plan

Model reliability is an ever-important part of model evaluation. Policy tests must produce reasonable results, or the credibility of the model system will be damaged. Travel model validation is a crucial, but often overlooked, part of model development. The summary from the Transportation Research Board (TRB) Special Report 288, *Metropolitan Travel Forecasting, Current Practice and Future Direction* (*SR 288)*[1], clearly outlined model validation issues (*emphasis added*) as an important area of concern:

> **Validation Errors:** Validating the ability of a model to predict future behavior requires comparing its predictions with information other than that used in estimating the model. Perceived problems with model validation include *insufficient emphasis and effort* focused on the validation phase, the *unavailability of accurate and current data* for validation purposes, and the *lack of necessary documentation*. The survey of MPOs conducted for this study found that validation is hampered by a *dearth of independent data sources*.

In alignment with CS' typical practice (and as is also recommended in CS' 2010 update to the TMIP *Travel Model Validation and Reasonableness Checking Manual*), CS developed a model validation plan in conjunction with the composition of the model design plan. The model validation plan considered each model component included in the model design plan, as well as the overall model system. It included data assembly, the validation process, temporal validation and sensitivity testing, and software testing. Chapter 12 discusses the actual model validation performance.

[1] Special Report 288, *Metropolitan Travel Forecasting, Current Practice and Future Direction*, Transportation Research Board (TRB), 2007.

1.4 Summary

The model development plan and its component model design plan and model validation plan informed EPMPO and other stakeholders, such as TxDOT/TPP, City of El Paso, and Sun Metro, of the planned model structure, proposed work program, and means for confirming the model update was successful (i.e., achieving a validated and reasonable model). The opinions and comments of EPMPO and stakeholders were taken into account before finalizing the model development plan components. Local knowledge and experience informed the development, leading to a model system suitable to provide analytical capabilities for the region's planning needs. The process also benefited from understanding how EPMPO, TxDOT/TPP, and TTI staff could best contribute their knowledge and experience to achieve success with the model development plan. The remainder of this report discusses the model development itself, model calibration, and model validation.

2.0 Review and Preparation of Model Data

One of the initial activities in developing the Destino 2045 travel demand model involved compiling necessary data. Data were obtained from several agencies, including the EPMPO, TxDOT TPP, TxDOT El Paso District and New Mexico Department of Transportation (NMDOT). CS reviewed the available survey- and model-related data and summarized descriptive statistics before engaging in model estimation, calibration, or validation.

CS compiled and linked data to build estimation datasets in formats conducive for use in each model component and the software being used for estimation. These data included trip-level data, sociodemographic data, geocoded location data, modal skim data, and observation-specific weights necessary for correcting nonrandom biases. Separate datasets were prepared for estimating each model type, which reduced the burden of dealing with enormous datasets.

The subsections that follow provide summary information regarding the major categories of data which were assembled and reviewed:

- Travel survey data;
- Land use, socioeconomic, and demographic data;
- Highway and transit network data; and
- Traffic counts.

2.1 Travel Surveys

The following surveys were reviewed for their relevance in updating the model:

- **2009 El Paso Household Travel and Stated Choice Survey –** This survey collected demographic and 24-hour travel behavior data from 411 households in El Paso County, Texas, and portions of Dona Ana and Otero Counties in New Mexico, as shown in Table 2.1. The study also included a stated choice survey to identify preferences regarding future transportation alternatives in the region. The results of this survey, presented in Table 2.2, were available to be used to examine the preferences and behavior of residents to future non-existent transportation modes under different conditions.

- **2010/2011 El Paso Household Travel Survey** – The 2010/2011 El Paso household travel survey that was administered by TxDOT TPP/TTI obtained data and information from 3,042 households randomly selected in El Paso County. This data served as the basis for all model estimation in this project including estimating trip generation rates, vehicle availability model, distribution model, mode choice and time of day models. Table 2.3 presents a summary of survey samples by household size, workers and income, while Table 2.4 presents mode shares by trip purpose.

Table 2.1 2009 Household Travel and Stated Choice Survey
Summary by Region

County	Total Households	Percentage of Total Households	Actual Surveys
El Paso, Texas	210,022	94%	389
Dona Ana, New México (Partial)	11,857	5%	19
Otero, New Mexico (Partial)	3,104	1%	3
Total	**224,983**	**100%**	**411**

Table 2.2 2009 Household Travel and Stated Choice Survey

Modal Preferences by Scenario

Scenario 1: Fuel costs do not increase and traffic delays do not increase

Future Alternatives						
Preferences	**Bicycle Paths**	**Bus Rapid Transit (BRT)**	**Bicycle Paths and BRT**	**Car + BRT**	**Toll Lanes**	**No Preference: Keep Current Trip Details the Same**
Will not use this option	3,286	2,867	3,316	2,789	3,364	1,355
First preference	219	404	50	584	98	2,357
Second preference	73	273	199	242	99	-
Third preference	49	143	102	55	90	-
Fourth preference	54	24	42	34	19	-
Fifth preference	31	1	3	8	42	-
Total	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**

Scenario 2: Fuel costs double and traffic delays increase

Future Alternatives									
Preferences	**Bicycle Paths**	**Bus Rapid Transit (BRT)**	**Bicycle Paths and BRT**	**Car + BRT**	**Toll Lanes**	**No Preference: Keep Current Trip Details the Same**	**Preference for Keep Used Mode, But Change Time of Day 1 hour or More to Avoid Congestion**	**Preference for Other (Van Pool/walk)**	**Preference for: to not Make the Trip at All**
Will not use this option	3,228	2,686	3,156	2,712	3,335	1,728	3,217	3,701	3,634
First preference	278	544	67	454	93	1,984	217	6	70
Second preference	76	281	184	355	113	-	91	5	2
Third preference	36	160	120	127	84	-	85	-	2
Fourth preference	48	30	22	49	34	-	61	-	2
Fifth preference	20	11	81	15	37	-	35	-	2
Sixth preference	26	-	82	-	16	-	6	-	-
Total	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**	**3,712**

Table 2.3 2010/2011 El Paso Household Travel Survey
Summary of Household Size, Workers, and Income

	HH Size Category					Total
Zero Workers						
Annual HH Income in 2010$/HH Size	1	2	3	4	5+	Total
$0 to $14,999	45	68	41	21	12	187
$15,000 to $24,999	29	55	32	14	19	149
$25,000 to $39,999	30	59	32	38	17	176
$40,000 to $69,999	34	61	31	33	17	176
$70,000+	30	41	31	24	7	133
Total	168	284	167	130	72	821
One Worker						
Annual HH Income in 2010$/HH Size	1	2	3	4	5+	Total
$0 to $14,999	44	42	62	56	29	233
$15,000 to $24,999	48	69	51	47	53	268
$25,000 to $39,999	58	56	70	57	69	310
$40,000 to $69,999	57	98	57	51	43	306
$70,000+	41	53	36	35	29	194
Total	248	318	276	246	223	1,311
Worker 2+						
Annual HH Income in 2010$/HH Size	1	2	3	4	5+	Total
$0 to $14,999		4	16	15	12	47
$15,000 to $24,999		9	8	28	34	79
$25,000 to $39,999		15	48	53	52	168
$40,000 to $69,999		52	63	72	76	263
$70,000+		81	101	110	59	351
Total		161	236	278	233	908
Total						
Annual HH Income in 2010$/HH Size	1	2	3	4	5+	Total
$0 to $14,999	89	114	119	92	53	467
$15,000 to $24,999	77	133	91	89	106	496
$25,000 to $39,999	88	130	150	148	138	654
$40,000 to $69,999	91	211	151	156	136	745
$70,000+	71	175	168	169	95	678
Total	416	763	679	654	528	3,040

Table 2.4 2010/2011 El Paso Household Travel Survey
Percent of Trips by Purpose and Mode

Mode	Home-Based Work	Home-Based Nonwork	Non-Home-Based	Grand Total
Auto	98.1%	89.3%	92.0%	91.3%
Commercial Vehicle	0.6%	0.1%	1.3%	0.4%
School Bus	0.0%	3.7%	2.6%	2.9%
Bus	0.2%	0.3%	1.4%	0.5%
Walk	0.8%	6.1%	2.5%	4.5%
Bike	0.1%	0.5%	0.0%	0.3%
Other	0.0%	0.0%	0.2%	0.1%
Unknown	0.0%	0.0%	0.0%	0.0%
Grand Total	100.0%	100.0%	100.0%	100.0%

- **2012 On-Board Transit Survey –** The 2012 transit on-board survey data consists of transit travel data from 7,060 riders in the El Paso region. This data helped in enhancing the transit trip sample size for model estimation. The data is merged with the household travel survey data to enhance model estimation datasets for mode choice, and also used in model validation including verification and improvement the transit path-building algorithms.

Table 2.5 2012 On-Board Transit Survey
Transit Trips by Purpose and Mode

Purpose	Income Level	Local Bus			Express Bus			Total		
		Walk	Drive	Total	Walk	Drive	Total	Walk	Drive	Total
Home Based Work										
	Low	755	68	822	581	116	697	1,336	184	1,520
	Medium	1,453	84	1,538	1,180	180	1,361	2,633	265	2,898
	Total	2,208	152	2,360	1,761	297	2,058	3,969	449	4,418
	Low	3,842	186	4,027	3,062	494	3,556	6,904	679	7,583
Home Based Non-Work										
	Medium	5,452	330	5,782	3,425	492	3,917	8,877	822	9,699
	Total	9,293	516	9,809	6,488	985	7,473	15,781	1,501	17,282
Non-Home Based										
	All Incomes	2,557	170	2,727	1,820	260	2,081	4,377	430	4,808
External										
	All Incomes	1,098	142	1,239	1,644	218	1,862	2,742	359	3,101
Total	**All Incomes**	**15,156**	**980**	**16,136**	**11,713**	**1,760**	**13,473**	**26,870**	**2,739**	**29,609**

- **2010/2011 El Paso Workplace Survey** – The survey collected employment data from 605 work sites. Out of the 605 worksites, interviews were conducted at 300 sites to record travel data at worksites. Table 2.6 shows the total number of sites surveyed and the total number of employees at the sites by employment types. Table 2.7 summarizes the survey samples or people interviewed by trip purposes and by employment types.

Table 2.6 Number of Surveyed Worksites and Total Employment at Surveyed Site

Employment Type	Number of Sites Surveyed	Total Employment
Office (Non-Government)	112	2,547
Retail	150	3,039
Industrial	5	170
Medical	44	2,762
Education (day care/k-12)	96	6,946
Education (college, trade, other)	11	5,875
Gov't/City/County/State/Federal Offices	10	4,762
Convenience Store/Gas Station	28	237
Grocery Store	13	612
Restaurant/Fast Food/Bar & Grill	56	920
Bank/Financial Institution	6	146
Manufacturing	24	804
Wholesale Trade	29	490
Construction	19	412
Other	2	815
Total	**605**	**30,537**

Table 2.7 Number of Samples by Trip Purpose and Employment Type of Work Site

Purpose/Mode	Return Home	Work Related	School Related	Social/ Recreational/Visit	Shop	Eat Out	Personal Business	Pick Up/ Drop Off Passenger	Delivery – Pick Up/ Drop Off	Total
Office (Non-Government)	1	266	2	6	14	–	303	4	2	598
Retail	1	437	1	4	2,660	1	187	19	4	3,314
Industrial	–	7	–	–	–	–	8	–	–	15
Medical	–	102	–	2	–	–	331	17	1	453
Education (day care/k-12)	1	1,235	8	31	–	–	82	443	1	1,801
Education (college, trade, other)	–	45	123	14	–	–	3	6	–	191
Gov't/City/County/ State/Federal Offices	–	44	–	–	–	–	14	–	–	58
Convenience Store/Gas Station	3	36	–	2	636	–	5	6	–	688
Grocery Store	–	37	–	–	515	–	7	–	–	559
Restaurant/Fast Food/Bar & Grill	1	153	–	1	13	653	5	1	–	827
Bank/Financial Institution	–	10	–	–	–	–	18	–	–	28
Manufacturing	–	127	–	4	51	–	14	3	1	200
Wholesale Trade	–	94	–	1	155	–	23	1	–	274
Construction	–	99	–	1	10	–	17	2	–	129
Other	–	15	–	–	–	–	15	–	–	30
Total	**7**	**2,707**	**134**	**66**	**4,054**	**654**	**1,032**	**502**	**9**	**9,165**

- **2010/2011 El Paso Commercial Vehicle Survey (CVS)** – The commercial vehicle survey consists of two types of records: (1) the vehicles that participated in the CVS; and (2) the trips by those vehicles. The two record types can be linked through the use of a common Vehicle ID. The CVS records the classification of the vehicles that participated in the CVS. That classification and a determination of which of these vehicles would be considered to be trucks is shown below.

Table 2.8 Number of Commercial Surveys and Trips

Code	Description	Vehicles	Truck Type	Vehicles	Total Trips	Total Trips per Vehicle
1	Passenger Car	44	Not Trucks	44	236	5.75
2	Pick-up	251	Light trucks	413	1839	4.45
3	Van (Cargo or Mini)	136				
4	Sport Utility Vehicle (SUV)	26				
5	Single Unit 2-axle (6 wheels)	68	Medium trucks	95	450	4.74
6	Single Unit 3-axle (10 wheels)	21				
7	Single Unit 4-axle (14 wheels)	6				
8	Semi (all Tractor-Trailer Combinations)	80	Heavy trucks	80	197	2.46
9	Other	9	#NA		47	1.67

- **2010/2011 El Paso Special Generator Survey** – The special generator survey was conducted at El Paso Airport, University of Texas at El Paso, Fort Bliss, Thomason General Hospital-UMC, and Cielo Vista Mall. Table 2.9 summarizes the total employment and the number of people interviewed at the survey sites. The survey data includes information on travel mode, trip purpose, trip origin, and trip destination. Table 2.10 presents the summaries of samples or people interviewed at El Paso Airport by trip purposes and by arrival modes.

Table 2.9 Total Employment and Number of People Interviewed at Special Generators

Special Generators	Total Employment	Person Interviewed
El Paso Airport	800	676
University of Texas at El Paso	4,000	619
Fort Bliss	2,500	961
Thomason General Hospital-UMC	2,100	639
Cielo Vista Mall	1,200	708

Table 2.10 Summary of People Interviewed by Trip Purposes and by Arrival Mode at El Paso Airport

	Return Home	Work Related	School Related	Social/ Recreational/ Visit	Shop	Eat Out	Personal Business	Pick Up/ Drop Off Passenger	Change Travel Mode	Delivery	Other	Total
Driver (car/truck/van)	1	295	1	3	0	0	8	160	26	0	0	494
Passenger (car/truck/van)	2	25	0	0	0	0	4	20	20	0	0	71
Walk	0	0	0	0	0	0	0	0	0	0	0	0
Bicycle	0	0	0	0	0	0	0	0	0	0	0	0
Transit Bus	0	0	0	0	0	0	1	1	1	0	0	3
School Bus	0	0	0	0	0	0	0	0	0	0	0	0
Taxi/Limo	1	0	0	1	0	0	0	1	2	0	0	5
Commercial Cargo Transport Vehicle	0	0	0	0	0	0	0	0	0	0	0	0
Commercial Service Vehicle	0	0	0	0	0	0	0	0	0	0	0	0
Motorcycle	0	0	0	0	0	0	0	0	0	0	0	0
Airplane	14	17	0	38	0	0	13	0	3	0	0	85
Hotel/Motel Shuttle Bus/Van	5	0	0	0	0	0	0	0	12	0	0	17
Other Parking Shuttle	0	0	0	0	0	0	0	0	1	0	0	1
Other	0	0	0	0	0	0	0	0	0	0	0	0
Total	**23**	**337**	**1**	**42**	**0**	**0**	**26**	**182**	**65**	**0**	**0**	**676**

2.2 Land Use and Socioeconomic Data

Several land use and/or socioeconomic datasets were assembled to support the model update, including:

- Land use data from 2007 El Paso Base Year Model

This section is intended to present summaries of the assembled data for reference. Chapter 3 of this report discusses usage of the data to support the development of the model input data.

2.2.1 Preexisting Model Base Year Land Use Data

Table 2.11 shows socioeconomic data from the 2007 El Paso base year model, as well as projections for several horizon years that were used in previous conformity analyses.

Table 2.11 Land Use Data Coded in El Paso Model TAZ Layers

Land Use Data in El Paso County	Year 2007	Year 2010	Year 2012	Year 2014	Year 2017	Year 2020	Year 2030	Year 2040
Population	723,802	772,767	784,310	803,518	832,034	862,078	947,189	1,017,068
Household	231,189	251,657	257,463	264,868	276,017	287,747	322,999	354,439
Basic Employment	83,296	97,183	100,582	102,325	104,938	107,807	119,383	132,811
Retail Employment	60,303	59,050	59,626	61,338	62,684	64,873	72,682	81,583
Service Employment	108,879	109,524	112,296	115,165	117,698	121,944	138,195	157,599
Education	24,689	25,010	25,010	25,280	25,580	26,170	26,170	26,170
Total Employment	277,167	290,767	297,514	304,108	310,900	320,794	356,430	398,163

Census data and InfoUSA 2007 data were obtained and reviewed to aid in checking the above distributions of socioeconomic data. Tables 2.12 and 2.13 below show employment distribution from the InfoUSA 2007 data and 2010 Census data.

Table 2.12 Employment in El Paso County from InfoUSA 2007 Data

InfoUSA	2007
Basic Employment	72,332
Retail Employment	42,957
Service Employment	134,990
Education	27,826
Total Employment	**278,105**

Table 2.13 Census 2010 Population and Households

Census	2010
Population	800,647
Household	256,557

2007 InfoUSA Check of Preexisting Model 2007 Employment Data

As a reasonableness check, the 2007 model employment data were cross-checked against the 2007 InfoUSA employment data. InfoUSA data were made available in point shapefile format, with each point associated with a specific employer. The signs and magnitudes of the latitudes and longitudes were reviewed and deemed reasonable, but the InfoUSA data were not scrubbed as this comparison was intended as a high-level check rather than undertaken for the purpose of updating the 2007 model employment data to 2012.

The following two figures (Figures 2.1 and 2.2) show the revealed spatial distribution of the 2007 model employment data and 2007 InfoUSA employment data. While for the most part they were deemed similar, the exercise highlighted some TAZs with different distributions of employment. These differences were noted for later review during the preparation of the 2012 base year data.

Figure 2.1 Distribution of 2007 Employment in the 2007 Model

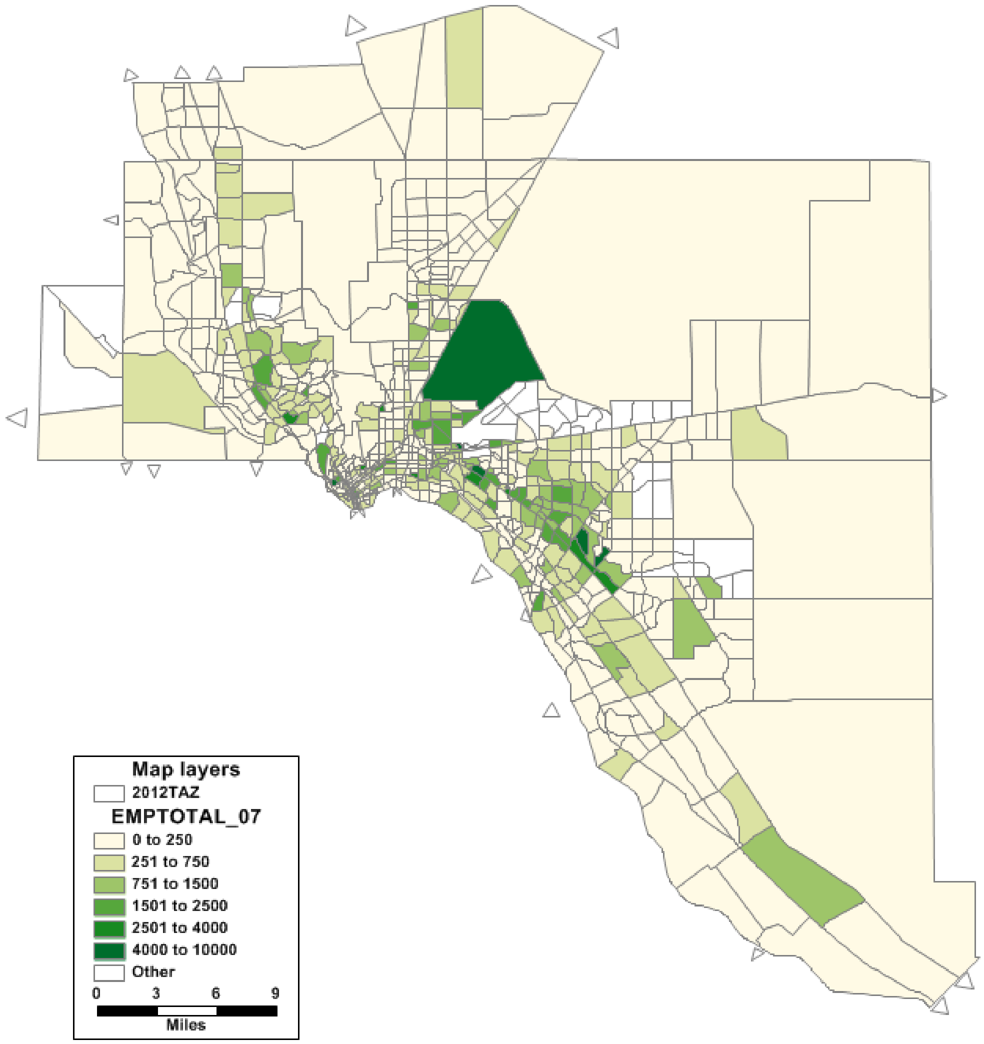
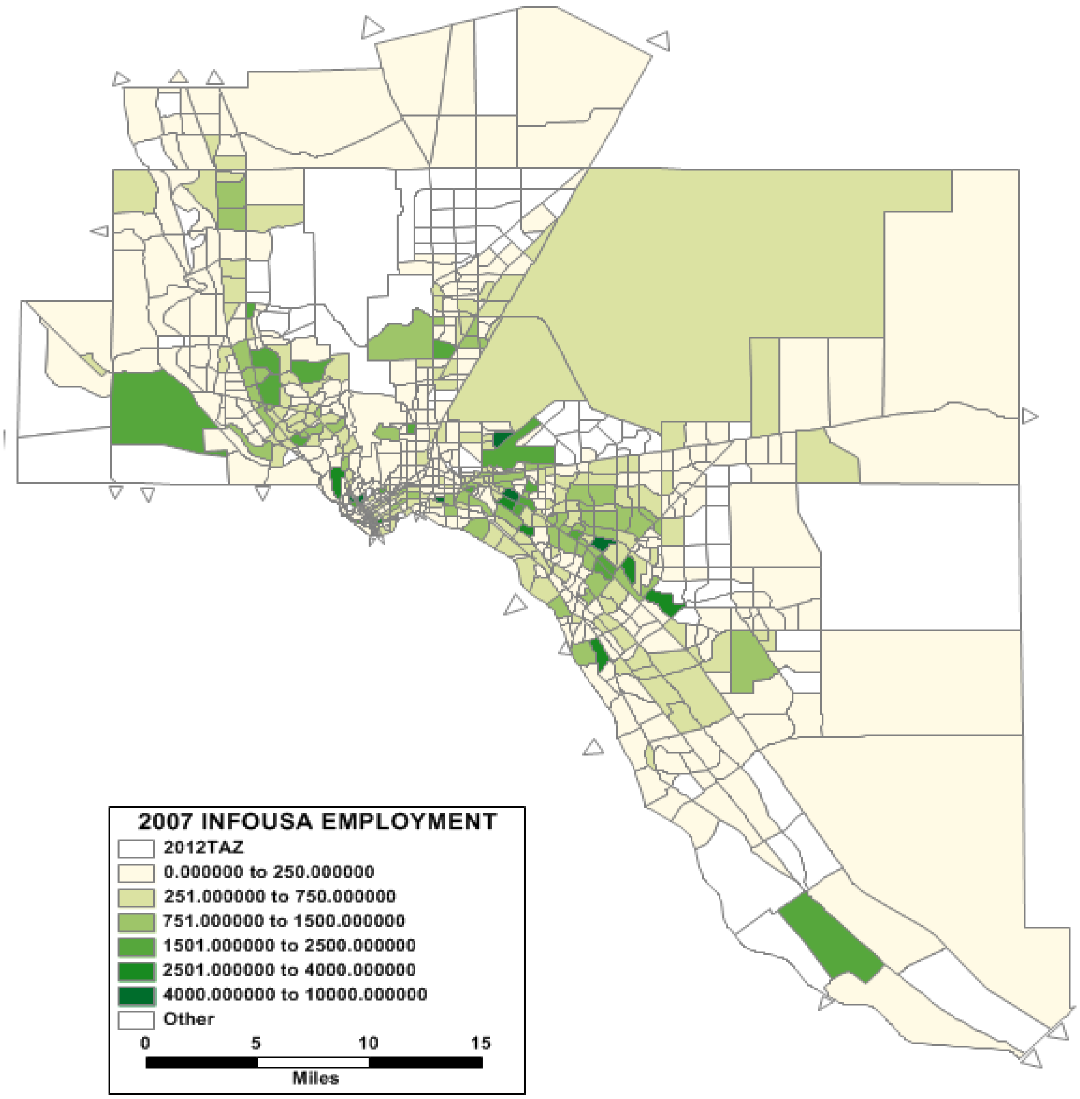


Figure 2.2 Distribution of 2007 Employment from 2007 InfoUSA



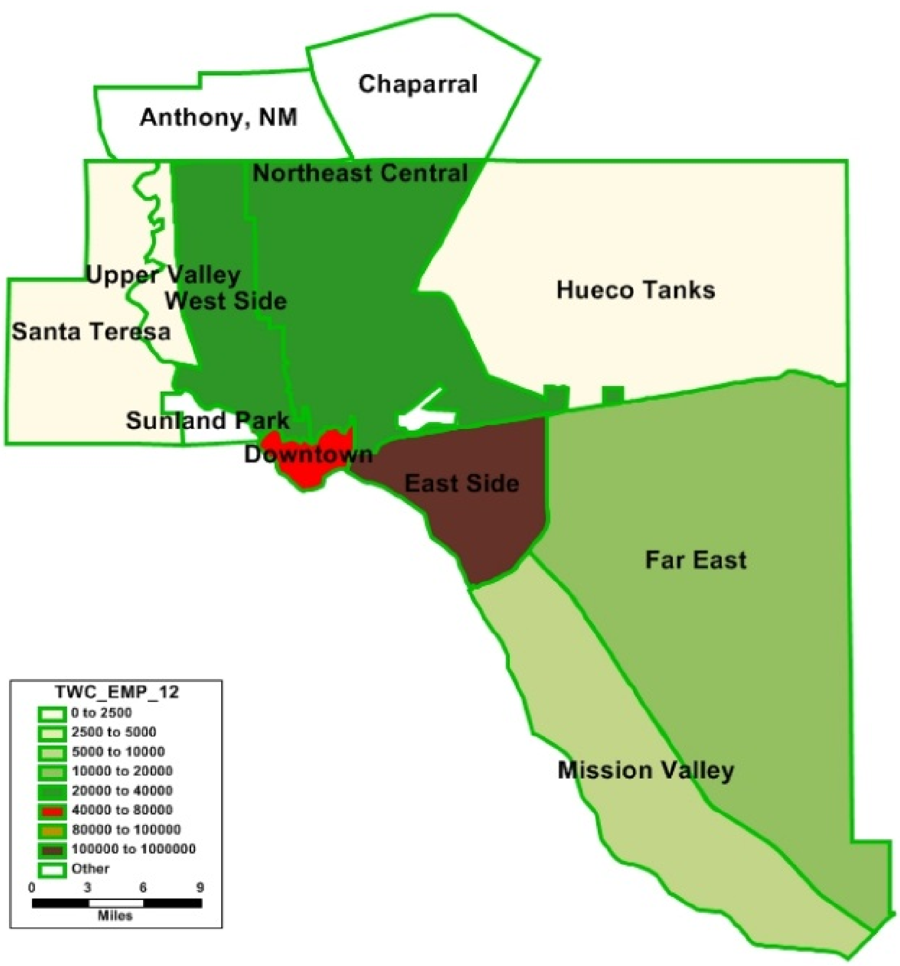
2.2.2 Texas Workforce Commission Data

The Texas Workforce Commission (TWC) is the state agency charged with overseeing and providing workforce development services to employers and job seekers of Texas. TWC maintains and updates the number of jobs by industry sector at a very disaggregate level in the state of Texas. These data were deemed an excellent source for deriving employment data at the TAZ level for the base year 2012. Chapter 3 discusses this work (and presents graphics at the TAZ level). Table 2.14 shows a summary of TWC employment data by districts. Figure 2.3 shows a summary distribution of total employment by districts.

Table 2.14 Summary of TWC Data by Industry Type

District	Basic	Educational	Retail	Service	Total Employment
Downtown	7,111	4,525	6,828	26,313	44,777
East Side	23,066	9,165	28,655	42,027	102,913
Far East	3,145	5,442	3,594	1,626	13,807
Hueco Tanks	577	14	1,014	736	2,341
Mission Valley	4,038	207	1,984	2,326	8,555
Northeast Central	8,977	632	8,881	16,528	35,018
Santa Teresa	2	–	9	17	28
Upper Valley	1,031	40	729	576	2,376
West Side	6,864	372	14,141	13,285	34,662
Total	**54,811**	**20,397**	**65,835**	**103,434**	**244,477**

Figure 2.3 Distribution of Total Employment in TWC Data by District



2.2.3 School Enrollment Data

The location of schools were obtained from the Texas Educational Agency (TEA) website. Schools located in El Paso County were extracted from this list. The Texas Education Agency's Academic Excellence Indicator System (AEIS) reports for 2012 were used to derive data for student enrollment and the number of professional staff at each campus.

2.2.4 Special Generator Data

There are several special generators in the region for which data were obtained, reviewed, and updated. These included hospitals, colleges and universities, shopping malls, and military bases. Information on the development of special generator models is presented in Section 4.3.

2.3 Model Data

Highway and transit networks serve as the primary source of level-of-service data used in distribution and mode choice models. The CS team conducted quality assurance checks on highway and transit networks before using the data for estimation purposes. This included reviewing the networks, updating the skipping and path-building procedures, and validating the times and speeds resulting in the updated networks.

The following sections describe the work done to perform highway and transit networks checks and to develop skims for input to mode choice model estimation.

2.3.1 Highway and Transit Network Checks

A master highway network was provided by the El Paso MPO for use in the model development. The network contained links for all model years and year-specific fields used to extract networks for desired model years. For example, FUNCL_12 had functional class information for year 2012. Eight functional classifications were defined (freeway, expressway, principal arterial, minor arterial, collectors and frontage, local streets, ramps, and centroid connectors).

For the purpose of base year model development, the year 2012 network was checked. In addition to connectivity, attribute data were checked to make sure all the necessary data exists. Data were added where missing. For example, functional class attributes were added to centroid connectors to TAZs 855 and 860. Area type was also found missing for several links across the network. Figure 2.4 shows a plot of functional classes in the highway network.

Unlike the highway network, only part of the transit network was provided by the MPO. The network had the routes coded, but did not have any stops or attributes coded. Given data availability and lack of major changes, schedules from March 2013 (closest to 2012) were used to code the missing route and stop information. Peak and off-peak headways, service type (local, express), and park and ride lots were also coded. Figure 2.5 shows the plot of transit routes by service type. Table 2.15 shows the list of routes, service types, and headways. Table 2.16 shows the park and ride lots coded in the model. Similar to highway network checks, transit coding was also checked for connectivity.

Figure 2.4 Year 2012 Highway Network – Functional Classification

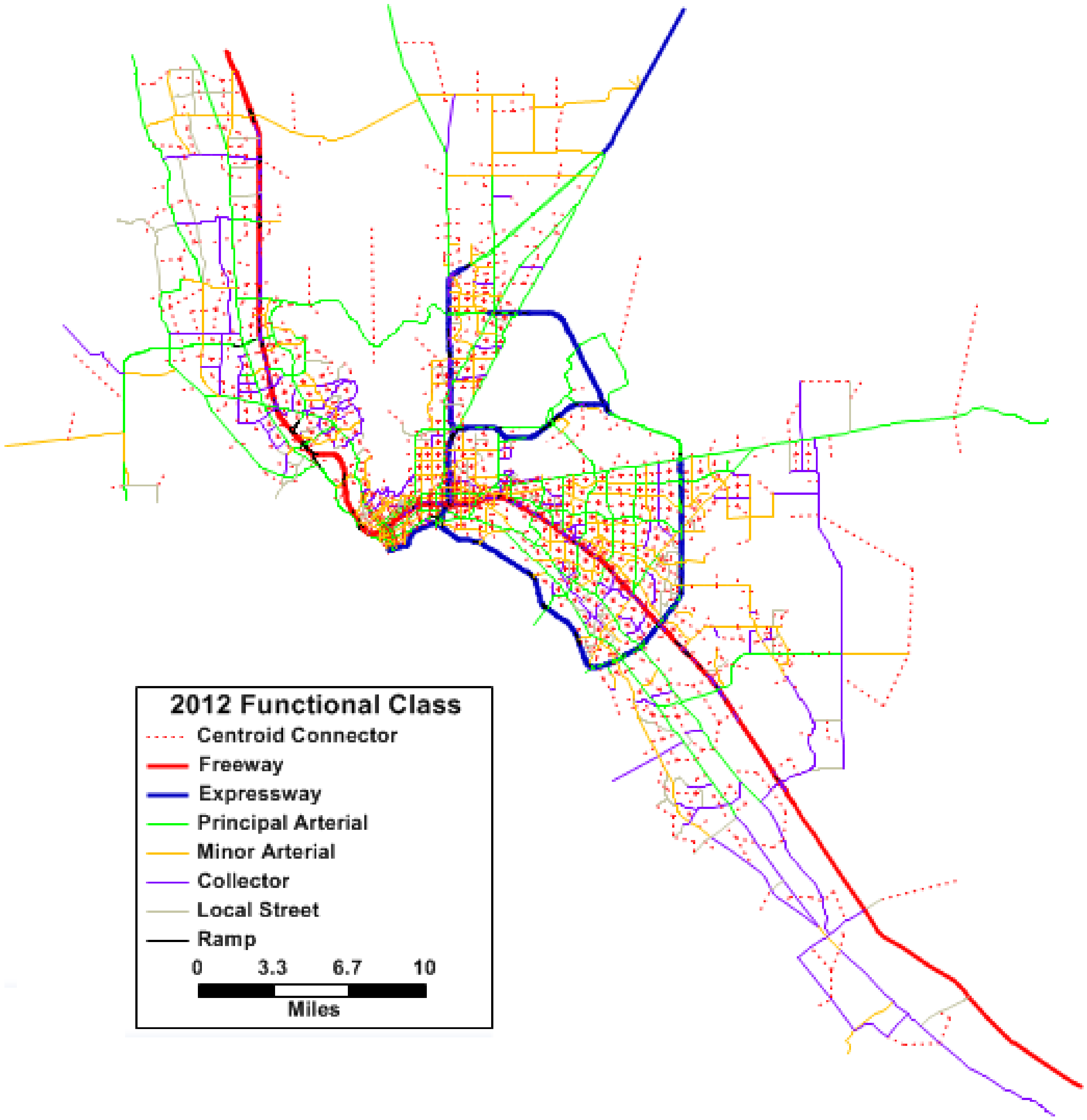


Figure 2.5 Year 2012 Transit Network – Service Type

Table 2.15 Summary of Transit Routes

Route Name	Mode	Schedule Runtime		Headway	
		PK	OP	PK	OP
4 - Union Plaza Circulator	Circulator	58	58	20	20
8 - Court District Circulator	Circulator	-	-	25	25
9 - Downtown Shopping District	Circulator	-	-	25	25
1-Eastside Express	Express	136	-	60	-
3 - Ysleta Express	Express	35	35	25	25
7 Northeast/Mission Valley	Express	200	200	55	55
18 - Westside Express	Express	49	49	18	18
42 - Northeast Connector	Express	61	61	22	22
59 - Eastside Connector	Express	51	51	14	14
70 - University Express	Express	60	60	30	30
83 - NM Sunland Park via McNutt	Express	85	85	90	90
84 - EPCC MDP via Clint/Socorro	Express	90	90	90	90
50 - Mesquite Hills - PA50	Express	35	35	40	40
10 - Sunset Heights/UTEP	Local	45	45	25	25
11 - Mesita via Kern Place	Local	60	60	65	65
12 - Doniphan Circulator	Local	41	41	45	45
13 - Coronado Hills Circulator	Local	109	109	55	55

Route Name	Mode	Schedule Runtime		Headway	
		PK	OP	PK	OP
14 - Westwind	Local	135	135	35	35
15 - Mesa	Local	100	100	30	30
16 - Upper Valley Circulator	Local	60	60	65	65
17- Three Hills NW EPCC	Local	90	90	95	95
19 - Resler Circulator	Local	41	41	45	45
20 - Sunland Park Circulator	Local	56	56	60	60
21 - Chelmont via Raynolds	Local	95	95	65	65
22 - Chelmont via Chelsea	Local	90	90	65	65
23 - Paisano via Fox Plaza	Local	76	76	100	100
24 - Delta via Second Ward	Local	71	71	75	75
25 - University Medical Center	Local	116	116	60	60
30 - Fort Bliss via Pleasanton	Local	55	55	60	60
31 - Fort Bliss/Eastside Connect	Local	110	110	60	60
32 - Logan Heights via Piedras	Local	45	45	50	50
33 - Government Hill via Bassett	Local	85	85	45	45
34 - Medical Center via Cliff	Local	85	85	45	45
35 - Northgate via Dyer	Local	146	146	30	30
36 - Beaumont via Highland	Local	105	105	55	55
40 - North Hills via Rushing	Local	65	65	70	70
41 - Northgate via Piedras	Local	135	135	70	70
43 - Shearman Park via Dyer	Local	60	60	60	60
44 - Sean Haggerty via McCombs	Local	77	77	20	20
45 - TransMountain EPCC Circulator	Local	45	45	50	50
46 - Northeast Circulator	Local	60	60	60	60
50 - Montana	Local	145	145	60	60
51 - Edgemere	Local	55	55	60	60
52 - Pebble Hills	Local	110	110	60	60
53 - Montwood	Local	95	95	50	50
55 - Eastside Terminal	Local	125	125	65	65
58 - Montana/Turner	Local	66	66	70	70
60 - Zaragoza Bridge Circulator	Local	51	51	24	24
61 - Ysleta via Alameda	Local	145	145	50	50
62 - Pasodal via Lakeside	Local	170	170	60	60
63 - Loma Terrace via Zaragoza	Local	116	116	60	60
65 - Hacienda via Carolina	Local	145	145	60	60
66 - Lancaster via North Loop	Local	145	145	60	60

Route Name	Mode	Schedule Runtime PK	Schedule Runtime OP	Headway PK	Headway OP
67 - Yarbrough/Lee Trevino	Local	100	100	80	80
69 - George Dieter	Local	105	105	55	55
71 - Trawood	Local	85	85	90	90
72 - Vista Del Sol	Local	85	85	90	90
73 - Pellicano	Local	100	100	55	55
74 - Rojas	Local	85	85	65	65
204 - Glory Rd/UMC Express	Local	64	64	60	60

Table 2.16 Park and Ride Lots

Name
West Side P&R
Glory Road TC & P&R
Union Plaza Transit Terminal
Northeast P&R
East Side P&R
Vista Hills P&R
RC Poe P&R
Mission Valley P&R
Downtown Transfer Center

2.3.2 Highway and Transit Skims Development

Input Travel Times Comparison

The first step in generating the skims using the checked networks for model estimation was to make sure the travel times in the networks were reasonable. Highway and transit travel times from the model were compared with year 2014 INRIX data (closest to 2012 available) and transit schedules, respectively.

Loaded travel times from the model were compared with INRIX data for I-10 Eastbound and Gateway Boulevard Westbound segments. Figure 2.6 shows plots of the two segments. Table 2.17 shows statistics for preliminary modeled, as well as INRIX travel times, on the segments. As can be seen from Table 2.17, loaded times from the model did not demonstrate valid goodness-of-fit statistics. As a workaround, we used INRIX speeds where available to generate highway skims. It should be emphasized that this was done only to generate skims for mode choice model estimation. Travel times were checked again during model validation once procedures to generate more meaningful loaded travel times were in place (see Chapter 12).

Figure 2.6 Highway Travel Times Comparison – Selected Segments

Table 2.17 Highway Travel Times Comparison – Statistics

Section and Time Period	Observations	RMSE	RelRMSE	Sum of INRIX IT	Sum of Model IT	Percentage Model/INRIX
IH10EFrwyWtInrix_AM	64	0.76	125.92	38.86	64.72	66.54
IH10EFrwyWtInrix_MD	64	0.2	32.18	38.90	38.29	-1.56
GatewayWest_Inrix_AM	64	0.3	149.58	12.75	22.71	78.13
GatewayWest_Inrix_MD	64	0.12	54.67	13.73	15.4	12.22

Transit times were compared with scheduled times from March 2013 (closest to 2012 available). Since there was not a transit component in the preexisting model, all transit procedures were developed from scratch. In order to capture delays associated with transit such as deceleration/ acceleration before and after stopping, passenger boarding/alighting, etc., we developed a relationship to calculate transit times as a function of highway travel time:

Transit Time = Highway Time + Transit Delay + Dwell Time

Where:

Transit Delay is a per-mile delay calibrated by area type and functional class and *Dwell Time* is a fixed delay time for each transit stop.

Figure 2.7 shows the comparison of modeled transit time and scheduled transit time before and after calibrating the transit delays and dwell times. The overall R^2 values for peak and off-peak were both 0.89. Table 2.18 shows the per-mile transit delays in minutes used to generate the travel times seen in Figure 2.7. The relationship was calibrated for each area type and functional class for local and express routes separately to enable calculation of reasonable transit travel times.

Figure 2.7 Scheduled versus Modeled Transit Runtimes Comparison

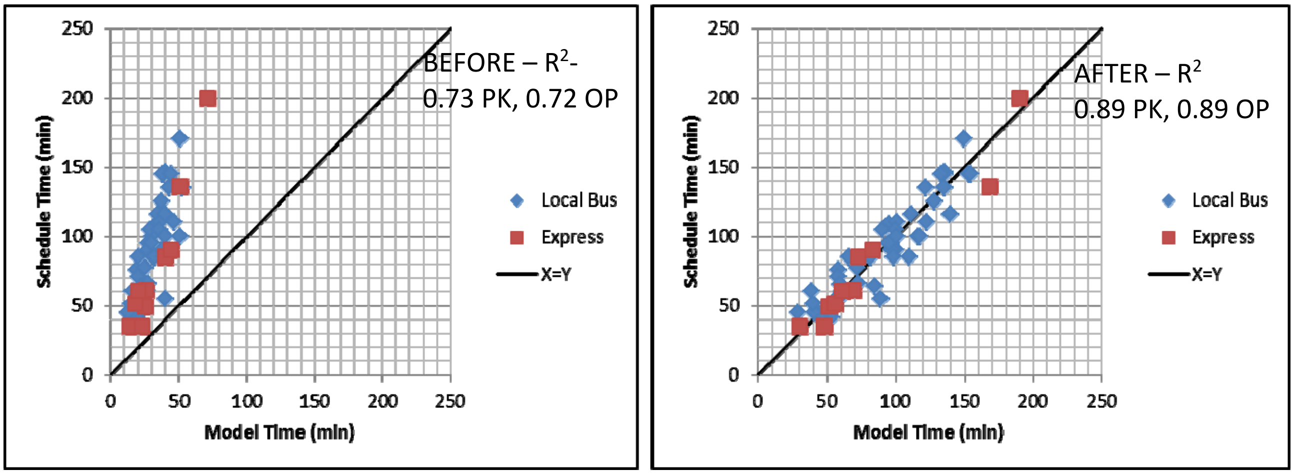


Table 2.18 Transit Delays (in minutes per mile)

	CBD	Urban Intense	Urban Central	Suburban	Rural		CBD	Urban Intense	Urban Central	Suburban	Rural
Local Routes – Peak						**Express Routes - Peak**					
Interstate	0.0	0.0	0.0	0.0	0.0	Interstate	0.0	0.0	0.0	0.0	0.0
Expressway	0.0	0.0	0.0	0.0	0.0	Expressway	0.0	0.0	0.0	0.0	0.0
Principal Arterial	1.0	0.8	0.7	0.7	0.7	Principal Arterial	0.5	0.1	0.1	0.0	0.0
Minor Arterial	0.5	0.2	0.5	0.1	0.0	Minor Arterial	2.5	2.5	2.5	0.0	0.0
Collector	0.5	0.2	0.1	0.1	0.1	Collector	0.1	0.1	0.1	0.1	0.0
Local Street	0.5	0.3	0.3	0.3	0.3	Local Street	0.5	0.1	0.5	0.0	0.0
Ramp	0.0	0.0	0.0	0.0	0.0	Ramp	0.0	0.0	0.0	0.0	0.0
Local Routes – Off-peak						**Express Routes – Off-peak**					
Interstate	0.0	0.0	0.0	0.0	0.0	Interstate	0.0	0.0	0.0	0.0	0.0
Expressway	0.0	0.0	0.0	0.0	0.0	Expressway	0.0	0.0	0.0	0.0	0.0
Principal Arterial	1.0	1.0	1.0	0.2	0.2	Principal Arterial	0.5	0.1	0.1	0.0	0.0
Minor Arterial	0.5	0.5	0.5	0.1	0.0	Minor Arterial	2.5	2.5	2.5	0.0	0.0
Collector	0.5	0.5	0.1	0.1	0.1	Collector	0.1	0.1	0.1	0.1	0.0
Local Street	0.5	0.5	0.3	0.1	0.1	Local Street	0.5	0.1	0.5	0.0	0.0
Ramp	0.0	0.0	0.0	0.0	0.0	Ramp	0.0	0.0	0.0	0.0	0.0

These transit travel times were used to support the model estimation. Later in the model development process, as is described in Chapter 12, the travel time relationships were checked again to make sure the highway and transit travel time relationships continued to generate reasonable transit times.

Skim Generation

Returning to the pre-model estimation discussion, once the highway and transit travel times were checked, skims were generated for use in model estimation. The highway skim procedure from the preexisting Horizon model was used as a starting point to develop highway skims. Three sets of skims were generated (peak, off-peak, and free flow) with the following tables:

- Congested Time (min);
- Length (mi);
- HOV1 Toll Cost (cents);
- HOV2 Toll Cost (cents);
- HOV3 Toll Cost (cents); and
- Truck Toll Cost (cents).

In order to generate transit skims, the transit path parameters were calibrated. This process involved preparing survey trip tables from 2012 El Paso's On-board survey and assigning them using the transit assignment procedures developed for this project. The model parameters were refined in an iterative fashion. After each assignment, parameters were checked and revised until the resulting modeled boardings reasonably replicated the observed survey transit boardings.

Initial assignments showed more than 10 percent of unassigned trips. After checking the survey records, the geocoding for many of those trips was found to be inaccurate. Such records were excluded and the survey was reweighted to make sure the totals matched the previous survey expansion targets.

Table 2.19 shows the initial summary of survey trip table assignments. Table 2.20 shows the summary after the adjustments.

Table 2.19 Survey versus Modeled Boardings – Initial Summary

	2012 Survey Linked Trips			Survey Boardings			Survey Transfer Ratio		
Path	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**
Walk to Transit	12,623	14,751	27,374	18,343	21,302	39,645	1.45	1.44	1.45
Drive to Transit	957	933	1,890	1,399	1,333	2,732	1.46	1.43	1.45
Total	13,580	15,684	29,264	19,742	22,635	42,377	1.45	1.44	1.45

	2012 Survey Linked Trips			Unassigned Trips			Intrazonal Trips			Survey Assignment Boardings			Transfer Ratio		
Path	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**
Walk to Transit	12,623	14,751	27,374	1,580	1,348	2,928	268	313	582	22,093	25,036	47,129	2.05	1.91	1.97
Drive to Transit	957	933	1,890	121	151	272	11	43	54	1,077	944	2,021	1.31	1.28	1.29
Total	13,580	15,684	29,264	1,701	1,499	3,200	279	356	636	23,170	25,980	49,149	2.00	1.88	1.93
						10.9%									

Mode	2012 Survey Unlinked Trips			Survey TT Assignment		
	Peak	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**
Local	14,407	16,263	30,669	16,099	18,536	34,635
Express	5,336	6,372	11,708	7,071	7,443	14,514
TOTAL	19,742	22,635	42,377	23,170	25,980	49,149

Table 2.20 Survey versus Modeled Boardings – Following Adjustment

Path	2012 Survey Linked Trips			Survey Boardings			Survey Transfer Ratio		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
Walk to Transit	12,400	14,542	26,942	18,314	21,364	39,677	1.48	1.47	1.47
Drive to Transit	951	864	1,816	1,429	1,271	2,700	1.50	1.47	1.49
Total	13,351	15,407	28,758	19,742	22,635	42,377	1.48	1.47	1.47

Path	2012 Survey Linked Trips			Unassigned Trips			Intrazonal Trips			Survey Assignment Boardings			Transfer Ratio		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
Walk to Transit	12,400	14,542	26,942	61	106	167	302	335	636	22,446	25,123	47,569	1.86	1.78	1.82
Drive to Transit	951	864	1,816	0	0	0	14	46	60	1,106	1,043	2,149	1.18	1.27	1.22
Total	13,351	15,407	28,758	61	106	167	315	381	696	23,552	26,167	49,718	1.82	1.75	1.78
						0.6%									

Mode	2012 Survey Unlinked Trips			Survey TT Assignment		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total
Local	14,407	16,263	30,669	16,046	18,756	34,802
Express	5,336	6,372	11,708	7,505	7,411	14,916
TOTAL	19,742	22,635	42,377	23,552	26,167	49,718

Table 2.21 summarizes the transit path parameters used to generate results in Table 2.20. While the number of unassigned trips reduced significantly after excluding incorrectly geocoded records, the assigned-to-the-network survey showed a higher number of transfer than recorded in the actual survey.

Table 2.21 Recommended Transit Path Parameters

	Peak		Off-Peak	
	Walk – Transit	Drive – Transit	Walk – Transit	Drive – Transit
Local IVT Weight	1.0	1.0	1.0	1.0
Express Buses IVT Weight	1.0	1.0	1.3	1.0
Walk/Transfer Weight	2.5	2.5	2.5	2.5
Drive Access weight	-	1.0	-	1.0
Out-of-Vehicle Time Weight	2.5	2.5	2.5	2.5
Boarding Penalty (min)	-	-	-	-
Path Threshold	0.15	0.15	0.15	0.15
Transfer Penalty (min) Local	2.0	2.0	2.0	2.0
Transfer Penalty (min) Express	5.0	5.0	5.0	5.0
Maximum Walk Access/Egress (min)	30	30	30	30

A set of four transit skims were developed – peak/off-peak walk/drive to transit, each with the following tables:

- Generalized Cost;
- Fare;
- In-Vehicle Time;
- Initial Wait Time;
- Transfer Wait Time;
- Transfer Penalty Time;
- Transfer Walk Time;
- Access Walk Time;
- Egress Walk Time;
- Dwelling Time;
- Number of Transfers;
- In-Vehicle Distance; and
- Access Drive Distance (Only in Drive Skims).

2.4 Traffic Counts

Existing and new traffic counts were assembled to support model development and validation activities. Traffic Counts for this project are discussed in more detail in Chapter 10 of this report.

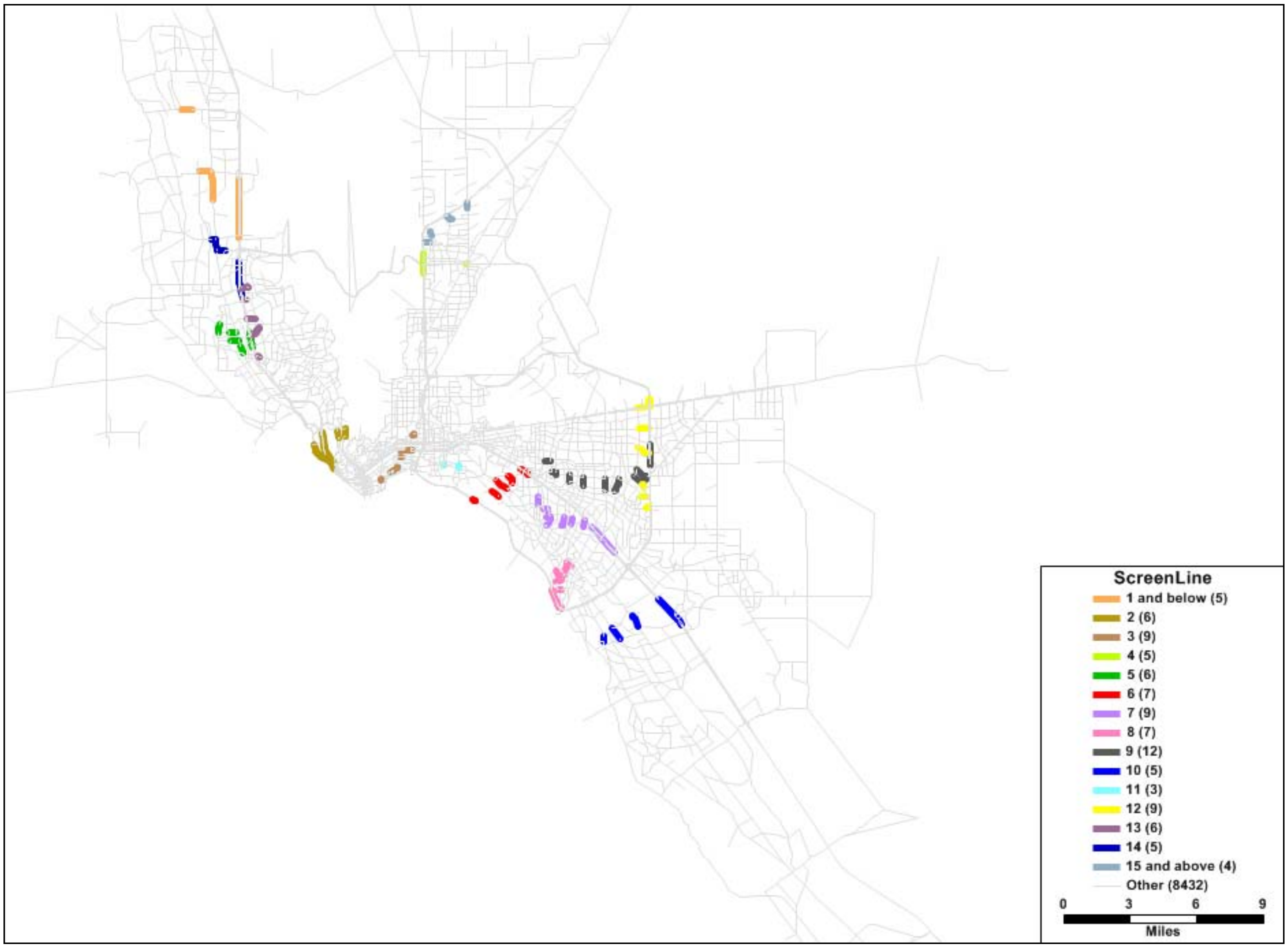
As part of this project, new counts were collected on the New Mexico side of the MPO region. CS team member ETC planned for and collected daily traffic counts, including vehicle classification (passenger cars, mid-sized trucks, and heavy trucks) from 71 locations on the New Mexico side of the EPMPO boundary.

In addition, on the Texas side of the MPO region, the El Paso District collected saturation counts at 15-minute intervals for a 48-hour period. This data collection was done at the same time as the New Mexico data collection. Figure 2.8 shows the spread of the available counts on the network (highlighted in red).

Figure 2.8 Traffic Count Locations

Figure 2.9 depicts the screenlines across the region showing locations of counts along each screenline.

Figure 2.9 Location of Screenlines



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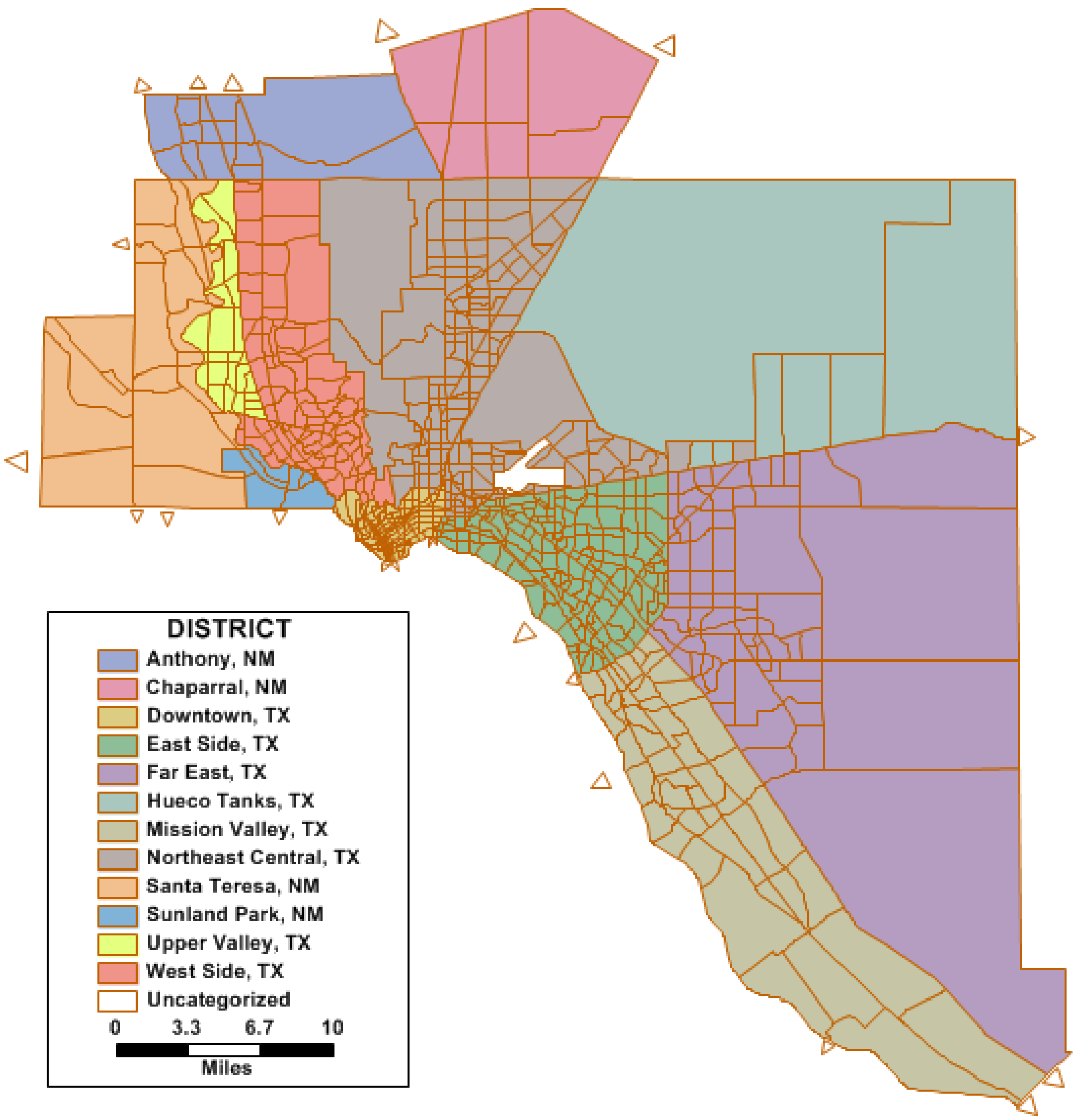
3.0 Socioeconomic Data

This chapter provides a review of the EPMPO base year 2012 socioeconomic data (SED) and discusses the data used in the updated 2012 travel demand model. As part of the review, the 2012 Texas Workforce Commission data were also summarized.

3.1 Study Area

The study area includes El Paso County and areas within four districts in New Mexico: Anthony, Chaparral, Santa Teresa and Sunland Park. Figure 3.1 shows the 12 districts defined in the MPO area and used in the analysis.

Figure 3.1 El Paso MPO Districts



3.2 MPO 2012 Socioeconomic Data Summary

Table 3.1 shows a summary comparison of the MPOs socioeconomic data across three time points – 2007, 2010 and 2012.

Table 3.1 2007-2012 MPO Socioeconomic Data Summary
Employment [a], Population, Households

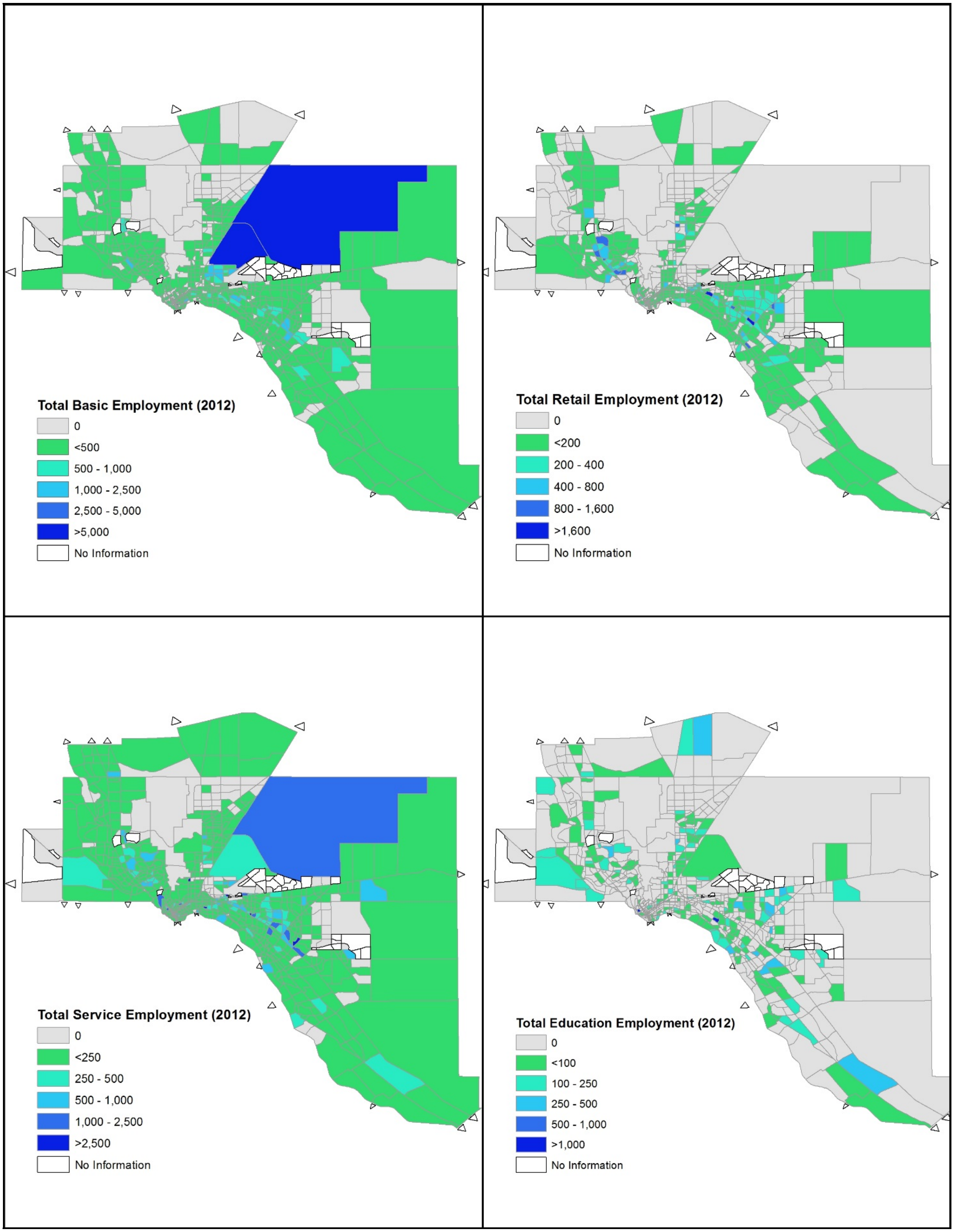
	2007 MPO Data	2010 MPO Data	2012 MPO Data
El Paso County Population (including GQ pop.)	735,562	785,835	804,276
New Mexico Districts Population (including GQ pop.)	49,491	52,356	54,414
Total Study Area Population	**785,053**	**838,191**	**858,690**
El Paso County Households	231,189	251,657	257,463
New Mexico Districts Households	15,134	15,946	16,638
Total Study Area Households	**246,323**	**267,603**	**274,101**
El Paso County Basic Employment	83,296	97,183	100,582
New Mexico Districts Basic Employment	519	695	723
Total Study Area Basic Employment	**83,815**	**97,878**	**101,305**
El Paso County Retail Employment	60,303	59,050	59,626
New Mexico Districts Retail Employment	708	708	722
Total Study Area Retail Employment	**61,011**	**59,758**	**60,348**
El Paso County Service Employment	108,879	109,524	112,296
New Mexico Districts Service Employment	1,602	2,181	2,347
Total Study Area Service Employment	**110,481**	**111,705**	**114,643**
El Paso County Education Employment	24,689	25,010	25,010
New Mexico Districts Education Employment	1,428	1,653	1,653
Total Study Area Education Employment	**26,117**	**26,663**	**26,663**
Total El Paso County Employment	277,167	290,767	297,514
Total New Mexico Districts Employment	4,257	5,291	5,445
Total Study Area Employment	**281,424**	**296,058**	**302,959**

[a] "Basic" employment figures include the special generator employment.

Figure 3.2 maps the spatial distribution of the 2012 MPO employment data by type across the study area geography. The data include special generator employment, including El Paso Community College and Fort Bliss.

The tabular review indicated a logical progression of most of the key SED variables across the three time points. The progression of retail employment in El Paso County was the only exception. The 2010 and 2012 retail employment were less than that of year 2007. The spatial analysis of 2012 data showed basic, retail, and service employment spread across the region, with the exception of in the Fort Bliss area. This area has the highest distribution of basic and service employment but was coded with no retail employment. Since this was deemed one of the reasons for the drop in retail employment in the region, it was flagged for correction.

Figure 3.2 Spatial Distribution of 2012 Employment by Type



3.3 2010 Census Analysis

Table 3.2 compares employment, population, and households between Census and MPO socioeconomic data for years 2010 and 2012 for El Paso County. While there was a consistent increase in population, households, and employment from 2010 to 2012, the MPO model data appeared lower than observed Census estimates. This led to the examination of the data at the Census block level to see which areas of the MPO region have lesser SED compared to the Census data.

Table 3.2 El Paso County Comparison
Employment, Population, Households

	2010	2012
Population, *Census*	800,647	831,864
Population, *Model*	785,835	804,276
Households, *Census*	256,557	252,426 [b]
Households, *Model*	251,657	257,463
Employment, Bureau of Labor Statistics [a]	313,932	320,286
Employment, *Model*	290,767	297,514

[a] Employment figures are as of April of that year.
[b] Household number for 2012 is from the 2008-2012 American Community Survey Five-Year Estimates.

Although the census block boundaries did not align perfectly with those of the TAZs in the New Mexico side of the MPO, the populations between the two data sources were similar, as shown in Table 3.3.

Table 3.3 Census Comparison for New Mexico TAZs
Population, Households

	2010 Census	2010 MPO	Difference (Percentage)
Population	51,136	52,356	2.4%
Households	15,708	15,946	1.5%

3.4 BBER Comparison

The University of New Mexico Bureau of Business and Economic Research (BBER) database contained information on the New Mexico districts included in the study area: Anthony, Chaparral, Santa Teresa, and Sunland Park. Table 3.4 compares the BBER data to the MPO data for these districts. Since land areas are different between the two sources, the populations were not directly comparable. However, given the magnitude of differences between the land areas, the MPO data seemed to be consistent with the BBER data.

Table 3.4 New Mexico Districts BBER Comparison
Population

	BBER Census Place (2010)	MPO District (2010)	MPO District (2012)	% Difference between 2010 BBER and 2010 MPO Data	Census Place Area (Square Miles)	District Area (Square Miles)
Anthony	9,360	14,736	14,989	57.4%	3.95	52.97
Chaparral	14,631	15,681	15,935	7.2%	59.23	78.15
Santa Teresa	4,258	9,346	10,228	119.5%	11.00	69.83
Sunland Park	14,106	12,531	13,200	-11.2%	11.40	8.53
Total	**42,355**	**52,294**	**54,352**	**23.5%**	**85.58**	**209.48**

3.5 2012 Texas Workforce Commission Data Summary

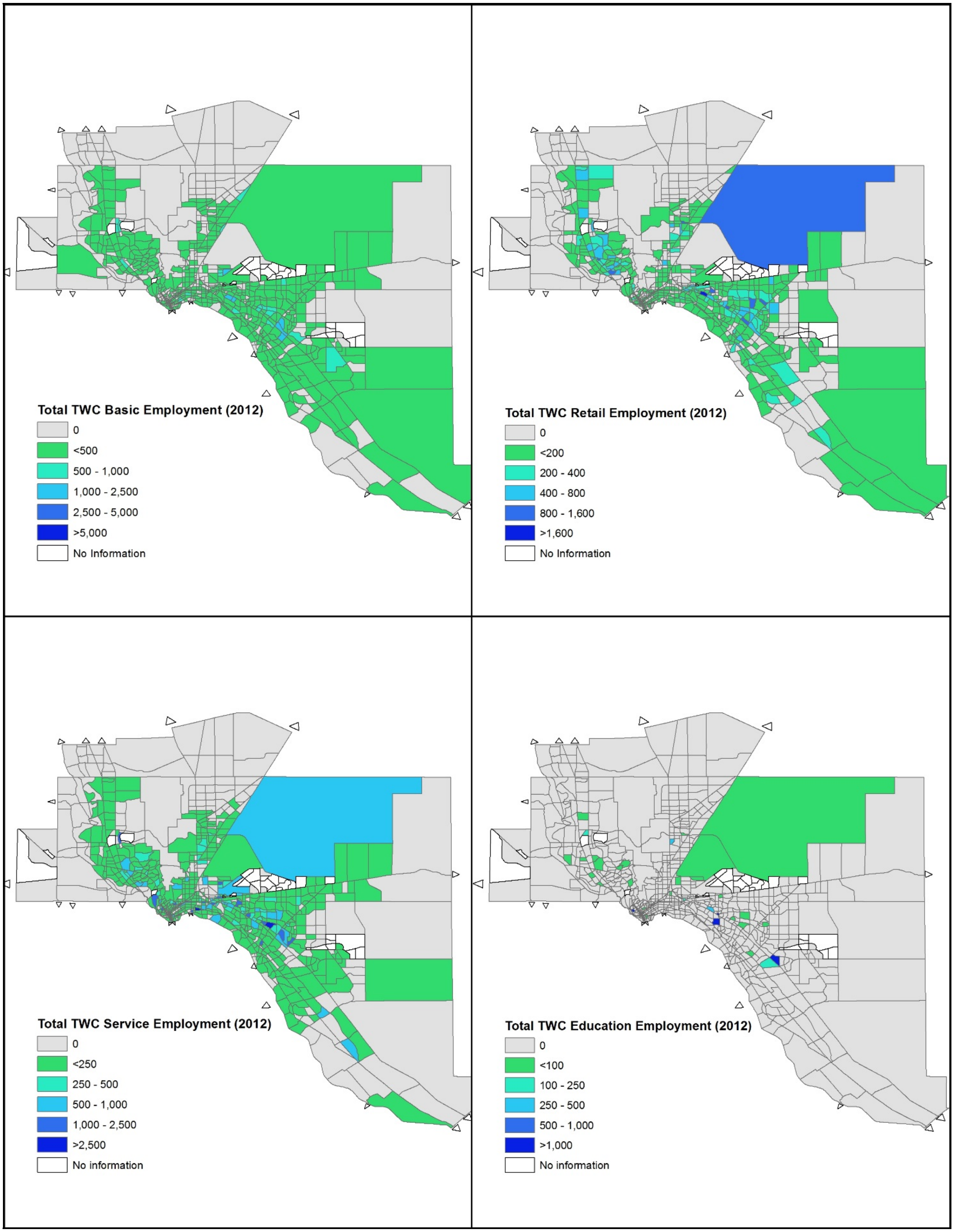
Employment information for employers within the State of Texas for base year 2012 was obtained from the TWC. The establishments were geocoded and assigned to TAZs according to their geographical locations. Table 3.5 shows the aggregated employment by type and by district.

Table 3.5 2012 TWC Summary
Employment

	Basic	Retail	Service	Education	Total Employment
Downtown	7,111	6,828	26,313	4,525	44,777
East Side	23,066	28,655	42,027	9,165	102,913
Far East	3,145	3,594	1,626	5,442	13,807
Hueco Tanks	577	1,014	736	14	2,341
Mission Valley	4,038	1,984	2,326	207	8,555
Northeast Central	8,977	8,881	16,528	632	35,018
Santa Teresa	2	9	17	0	28
Upper Valley	1,031	729	576	40	2,376
West Side	6,864	14,141	13,285	372	34,662
Uncategorized	389	178	792	0	1,359
Total	**55,200**	**66,013**	**104,226**	**20,397**	**245,836**

Figure 3.3 presents the spatial distribution of the 2012 TWC employment data by type across the study area geography. The classifications for each employment type were kept the same as those of the MPO to facilitate comparison between the two data sources. This analysis showed consistency among basic, retail and service employment across the region, unlike the 2012 MPO data as depicted in Figure 3.2. This is discussed further in the next section.

Figure 3.3 Spatial Distribution of 2012 TWC Data by Employment Type



3.6 Comparison of MPO 2012 and TWC 2012

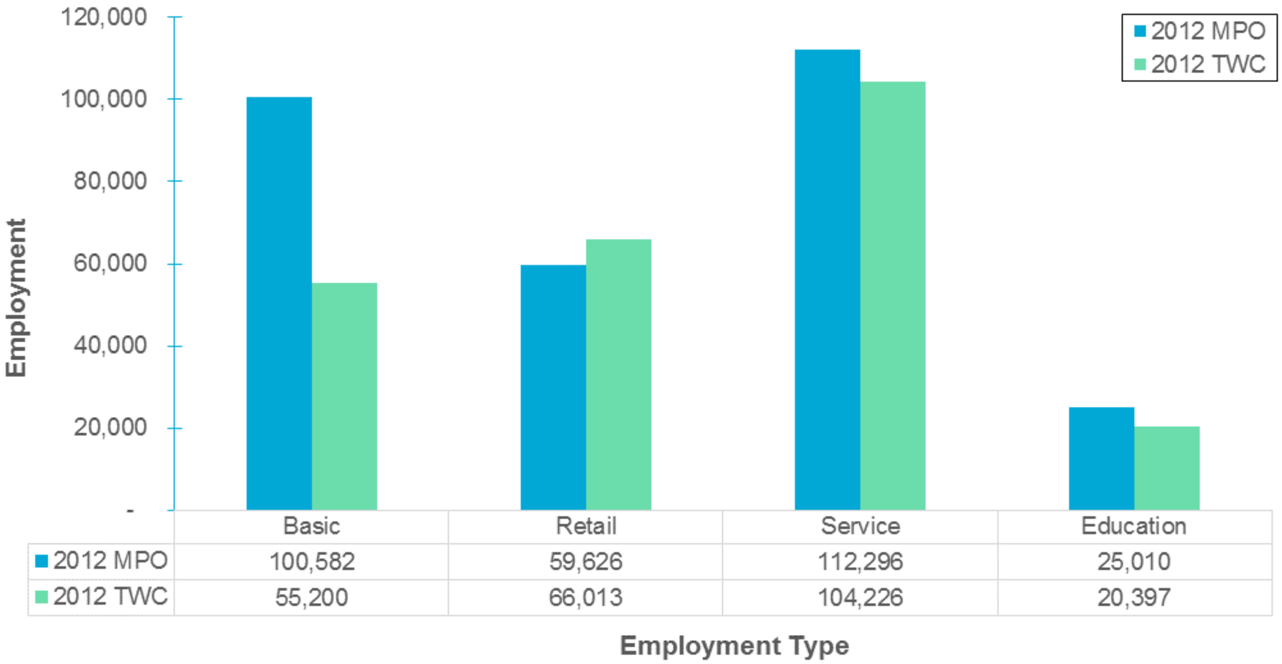
Table 3.6 provides a comparison between the MPO 2012 total employment and the TWC 2012 total employment by district. Anthony, Chaparral, Santa Teresa, and Sunland Park have little or no information in the TWC data because they belong to the New Mexico side of the MPO and the TWC data is limited to the State of Texas. So this comparison was limited to El Paso County districts only. Overall, MPO and TWC employment figures were similar except for Northeast Central and Hueco Tanks. This same difference was also evident in comparing Figure 3.2 and Figure 3.3. The area of difference is where Fort Bliss, El Paso International Airport, and Biggs Army Airfield are located. These issues were flagged for correction. Section 3.12 discusses the updated MPO dataset.

Table 3.6 Comparison of 2012 MPO SED versus 2012 TWC Data

	TWC Total Employment	Model Total Employment
Downtown	44,777	48,694
East Side	102,913	104,329
Far East	13,807	13,939
Hueco Tanks	2,341	7,544
Mission Valley	8,555	11,211
Northeast Central	35,018	72,800
Santa Teresa	28	1,816
Upper Valley	2,376	2,056
West Side	34,662	36,941
Total	**244,477**	**299,330**

Figure 3.4 presents a comparison between 2012 MPO employment data for El Paso County and 2012 TWC data by employment type. Minor differences among employment categories were to be expected due to potentially different category definitions across the datasets. In aggregate, total retail, service, and education employment were within reasonable differences between the two data sources, but there was a big difference in the reported “basic employment.” The main reason for this difference was that special generator employment data was included in the MPO data, while the TWC data does not include special generator employment data. For example, the MPO basic employment figures for the TAZs comprising Biggs Army Airfield include about 25,000 in special generator basic employment. This issue was noted and addressed as further work was performed. Section 3.12 discusses the updated MPO dataset.

Figure 3.4 Comparison of 2012 Employment versus 2012 TWC Data by Employment Type



3.7 TWC Employment Historic Growth

In order to forecast employment data for the years following the base year, the growth in employment from 2002 to 2012 TWC data were observed, as shown in Table 3.7. Table 3.8 shows similar comparison of growth in employment from 2007 to 2012 using the MPO data.

Table 3.7 TWC Employment Growth

Employment Type	2002 TWC	2007 TWC	2012 TWC	% Growth between 2007 and 2012
Basic Employment	56,027	58,049	55,200	-4.9%
Retail Employment	48,474	58,259	66,013	+13.3%
Service Employment	64,921	90,946	104,226	+14.6%
Education Employment	18,275	20,630	20,397	-1.1%
Total Employment	187,697	227,884	245,836	+7.9%

Table 3.8 MPO Data Employment Growth
El Paso County

Employment Type	2007 MPO Data	2012 MPO Data	% Growth between 2007 and 2012
Basic Employment (no SG)	63,846	64,764	+1.4%
Retail Employment (no SG)	55,566	55,695	+0.2%
Service Employment (no SG)	94,919	96,861	+2.0%
Total Employment	239,020	242,330	+1.4%
SG Basic Employment	19,450	35,818	+84.2%
SG Retail Employment	4,737	3,931	-17.0%
SG Service Employment	13,960	15,435	+10.6%
SG Education Employment	24,689	25,010	+1.3%
Total Basic Employment	**83,296**	**100,582**	**+20.8%**
Total Retail Employment	**60,303**	**59,626**	**-1.1%**
Total Service Employment	**108,879**	**112,296**	**+3.1%**
Total Education Employment	**24,689**	**25,010**	**+1.3%**
Total Employment with SG	**277,167**	**297,514**	**+7.3%**

Comparing Table 3.7 and Table 3.8, it can be noted that the growth patterns for the TWC data and the MPO data do not fully align. While 2007 and 2012 MPO employment data excluding special generator data is more comparable in magnitude to the 2007 and 2012 TWC data, respectively, the percent growth for basic, retail and service employment in the MPO data are smaller than those in the TWC data. For basic employment, the MPO data shows a positive growth, whereas the TWC data shows a negative growth.

The comparison of TWC employment data to MPO employment data, including special generator employment, showed larger discrepancies between the two datasets. However, the growth is positive and logical for all employment types with the exception of retail. Retail was deducted from Table 3.1 and Figure 3.2. This warranted adjustments to be made to the retail employment in the 2012 MPO data. The growth in total employment, however, seems to be comparable between the two datasets (7.9 percent growth between 2007 TWC and 2012 TWC versus 7.3 percent growth between 2007 MPO data and 2012 MPO data).

The comparisons between the starting-point MPO data and the TWC data were useful for identifying desirable refinements in the SED prior to model building. Section 3.12 discusses the updated MPO data.

3.8 Area Type

An area type factor for each TAZ was calculated according to the following formula:

$$AT_i = \frac{Population_i + \left(\frac{Regional\ Population}{Regional\ Employment}\right) \times Employment_i}{Acres_i}$$

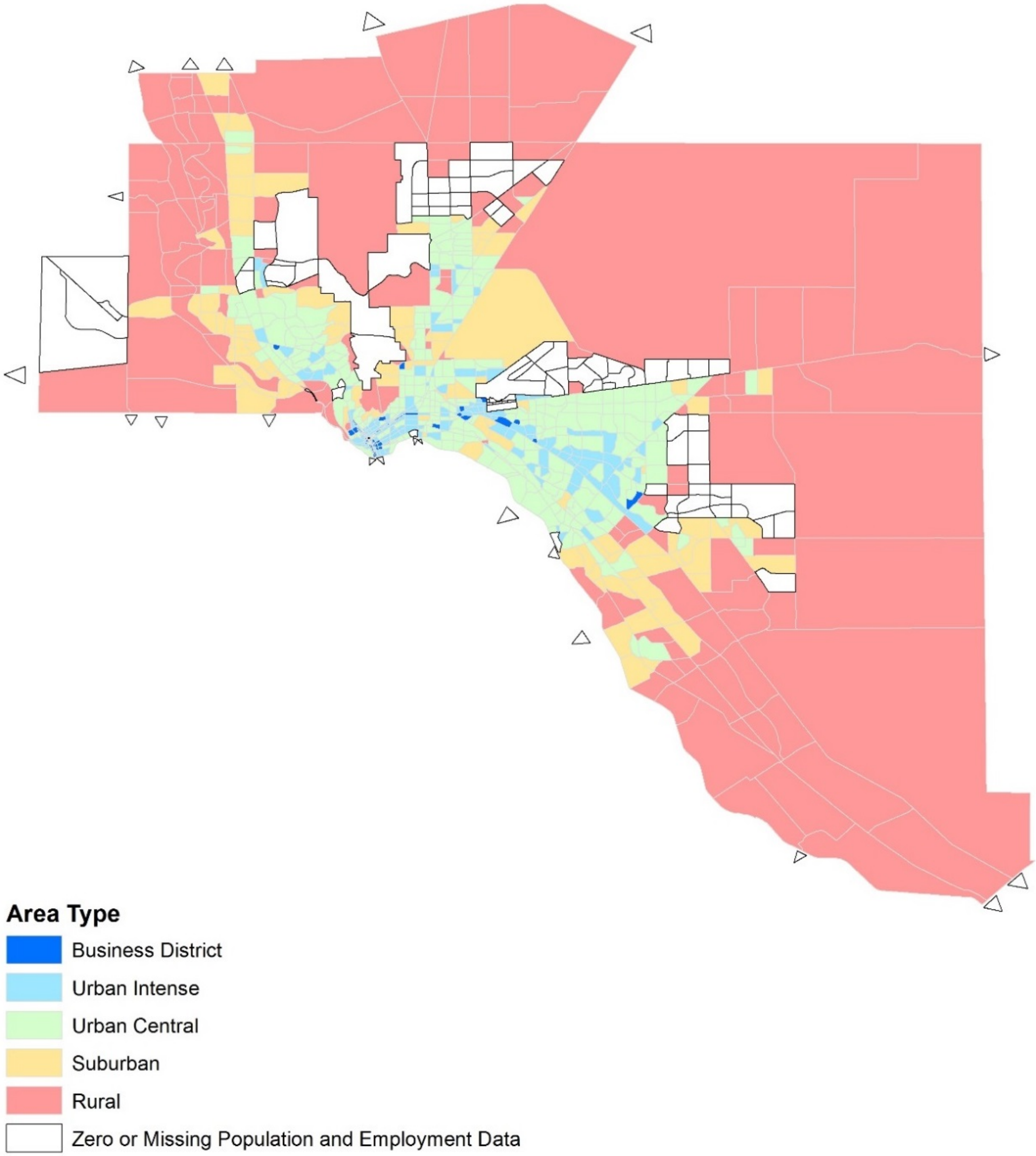
These area type factors were then classified, according to Table 3.9, to produce five area types: Business District, Urban Intense, Urban Central, Suburban and Rural. This is consistent with the MPO's 2007 base year model. Figure 3.5 maps these five area types onto the study area geography. The area types shown seemed reasonable except for those TAZs that have zero population and employment data (which is also seen in Figure 3.5). Area types for TAZs with no population and employment were assumed to be rural. Area types were computed for the TAZ layer for every forecast year and then tagged onto the corresponding forecast year network.

The preliminary review of area types was deemed successful. Following refinement of the MPO data for next steps in the model development, area types were updated and Section 3.12 reports the updated MPO data by area type.

Table 3.9 Area Type Ranges

Area Type	Area Type Name	Area Type Factor Ranges
1	Business District	AT ≥ 54
2	Urban Intense	54 > AT ≥ 18
3	Urban Central	18 > AT ≥ 6
4	Suburban	6 > AT ≥ 2
5	Rural	AT < 2

Figure 3.5 Area Types Map



3.9 Employment-to-Population Ratios

This section discusses the preliminary review of demographic data and demographic data by area type, with an emphasis on employment-to-population concentrations and ratios. Section 3.12 address some of the same metrics with the refined demographic data.

Table 3.10 shows a breakdown of population, households, and employment by calculated area type in this round of review. Around 60 percent of population and households are located in area type Urban Central, where around 28 percent of employment is situated. These figures seemed reasonable, but were subject to change through subsequent revision of the MPO data.

Table 3.10 Area Type Summary
2012 MPO Population, Households, Employment

Area Type Name	Pop	HH	Total Emp	Basic Emp	Retail Emp	Service Emp	Education Emp	Emp-to-Pop Ratio
Business District	7,414	2,598	58,266	8,024	8,018	37,766	4,458	7.86
Urban Intense	121,642	42,333	99,095	29,704	27,450	37,851	4,090	0.81
Urban Central	506,558	166,777	86,050	27,072	20,852	25,612	12,514	0.17
Suburban	139,894	38,860	41,720	27,665	2,935	7,725	3,395	0.30
Rural	83,182	23,533	17,828	8,840	1,093	5,689	2,206	0.21
Total	**858,690**	**274,101**	**302,959**	**101,305**	**60,348**	**114,643**	**26,663**	**0.35**

About eight percent of basic employment was in the business district area type, 29 percent in the urban intense area type, 27 percent in the urban central area type, 27 percent in the suburban area type, and nine percent in the rural area type.

The retail employment was spread in a similar manner with the exception of suburban area where it is very low. That is, about 13 percent occurs in the business district, 45 percent in urban intense areas, 35 percent in urban central areas, a low five percent in suburban areas and two percent in rural areas.

As expected, there was a lot of service employment, up to 33 percent in the business district and 33 percent in urban intense areas, where there is a lot of employment. It was about 22 percent in urban central areas, 7 percent in suburban areas, and five percent in rural areas.

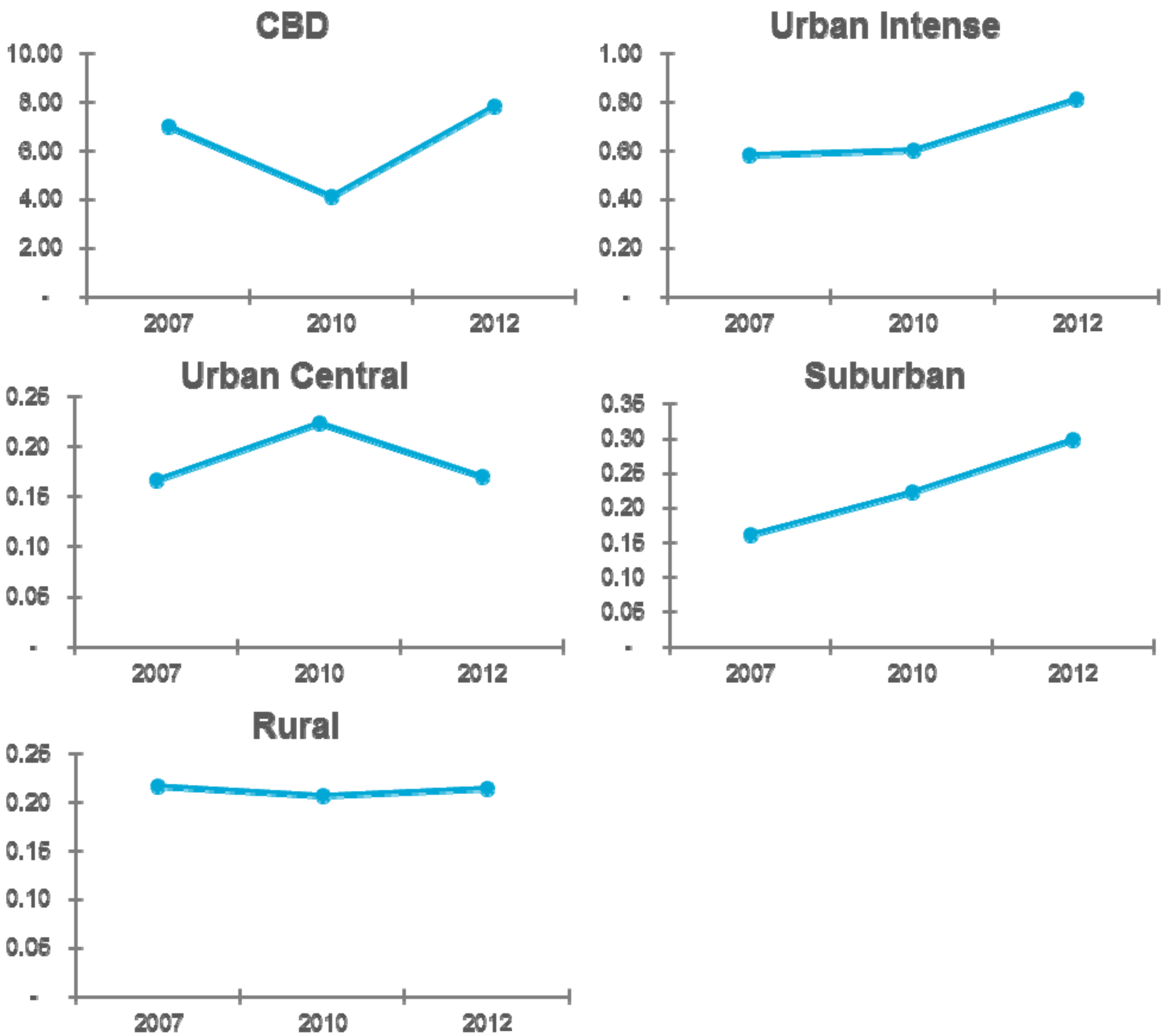
The employment-to-population ratio was calculated by dividing the total employment in the area type by the total population in that area type. The business district had the highest employment-to-population ratio as it contained around 18 percent of the total regional employment and less than one percent of the total regional population. Overall, these ratios made sense – declining from business district to more peripheral areas like suburban and rural.

Using area types for 2007 and 2010 embedded in the dataset, employment-to-population ratios were calculated for years 2007 and 2010, and compared to year 2012 as shown in Table 3.11. These were then plotted in Figure 3.6 to complete the preliminary review.

Table 3.11 Employment-to-Population Ratios by Area Type
Employment

Area Type Name	2007 MPO	2010 MPO	2012 MPO
Business District	7.00	4.11	7.86
Urban Intense	0.58	0.60	0.81
Urban Central	0.17	0.22	0.17
Suburban	0.16	0.22	0.30
Rural	0.22	0.21	0.21
Total	**0.36**	**0.35**	**0.35**

Figure 3.6 Employment-to-Population Ratios by Area Type



3.10 Findings

Based on the analyses presented above, the following were the key findings:

- Retail employment is declining, going down from year 2007 to 2010 to 2012 in the MPO SED.
- The initial retail employment coded in the Fort Bliss area was zero.
- The initial MPO population figures did not line up with Census figures for year 2010 and 2012, especially in those census blocks where the MPO SED “missing” population. That is, there are several TAZs with zero employment and population, even though Census data indicates otherwise.
- A comparison of MPO 2012 and TWC 2012 data highlighted potential issues with the employment distributions.
- Although, in aggregate, retail employment was similar across datasets, the initial spatial distribution is off, requiring adjustments.
- A difference in basic employment was observed due to the fact that TWC 2012 data does not include any special generator employment (e.g., Biggs Army Field).
- The employment growth from 2007 to 2012 revealed issues with retail employment, where it was on a decline.
- The area type summaries indicated low retail employment allocated to suburban areas (e.g., Fort Bliss).
- The employment-to-population ratios seemed normal for 2007 and 2012. For 2010, the ratios seemed indicative of it being a Great Recession year.

3.11 Recommendations

The above-listed findings led to the following recommendations:

- **Confirm Findings Meet Expectations –** The findings were first reviewed with the MPO and stakeholders to confirm that the differences were as expected and that the figures are valid.
- **Increase Retail Employment –** Based on the findings of this review, it was recommended that the 2012 MPO retail employment data be increased by a similar growth as observed in the TWC data. This helped reflect TWC 2012 data and maintained consistent distribution of retail employment. Table 3.7 shows a growth of about 13.3 percent between 2007 and 2012 TWC data. So when this growth is applied to 2007 MPO retail employment of 55,566, the 2012 retail employment is 62,956, which is 7,261 more retail jobs. These jobs were added to the Fort Bliss area which is currently zero in the 2012 MPO SED.
- **Adjust Zero-Population TAZs –** The TAZs that had no population and households in the 2012 MPO data were replaced by the 2012 Census estimates. This added about 8,000 in population to the MPO data.

- **Reexamine Key Metrics after Adjustments –** After the above adjustments were made, key metrics like area types, employment distributions, and employment-to-population ratios by area type were computed again.

3.12 Updated 2012 Base Year Socioeconomic Data

Based on the recommendations above, along with comments received from TxDOT TPP and CDM Smith, various steps were undertaken to bring the 2012 base year socioeconomic data in El Paso County closer to observed (independent) data. No changes were made to the New Mexico side of the MPO due to lack of observed data.

3.12.1 Population

There were several stages to the update of the 2012 population data. In the first stage, there was an effort to update and adjust the 2010 MPO population using 2010 census block population data, as follows:

- Where the boundaries of a census block, or a cluster of census blocks, coincided with TAZ boundaries, 2010 MPO population was replaced with 2010 census data.
- Where 2010 MPO TAZ population was zero, but a census block or a cluster of census blocks with non-zero population was contained within it, the 2010 MPO TAZ value was replaced with census data.
- Where 2010 MPO TAZ population was smaller than the aggregated population of a census block or a cluster of census blocks contained within it, the 2010 MPO TAZ value was replaced with census data.
- Where 2010 MPO TAZ population was larger than the population of a census block in which it was contained, the 2010 MPO TAZ value was replaced with census data.

In the second stage, the individual TAZ-specific growth rates between years 2010 and 2012 from the MPO were then applied to 2010 MPO population data to obtain 2012 MPO population data. An average growth factor (2.4%) was applied to TAZs that originally had zero populations in 2010 (and were replaced with non-zero populations from the census block data) to get the 2012 populations. This affected nine TAZs in total. Population in these TAZs were designated as GQ population to avoid impacting household size or number of households data.

The individual TAZ populations in El Paso County were then scaled according to Texas Populations Estimates and Projection Programs (TPEPP) 2012 control total (see Figure 3.7). The TPEPP population growth rate for El Paso County was applied for the New Mexico side of the MPO in order to obtained control totals for the TAZs falling outside El Paso County. The growth rates were checked against the growth rates of Doña Ana County, and the growth patterns are similar (see Figure 3.8). The 2012 control total was then used to proportionally scale the base year population. Evidently, there is a significant forecasted increase in MPO population between 2017 and 2020 resulting from anticipated development in the Fort Bliss and Airport areas.

Figure 3.7 El Paso MPO Projections by Migration Scenario

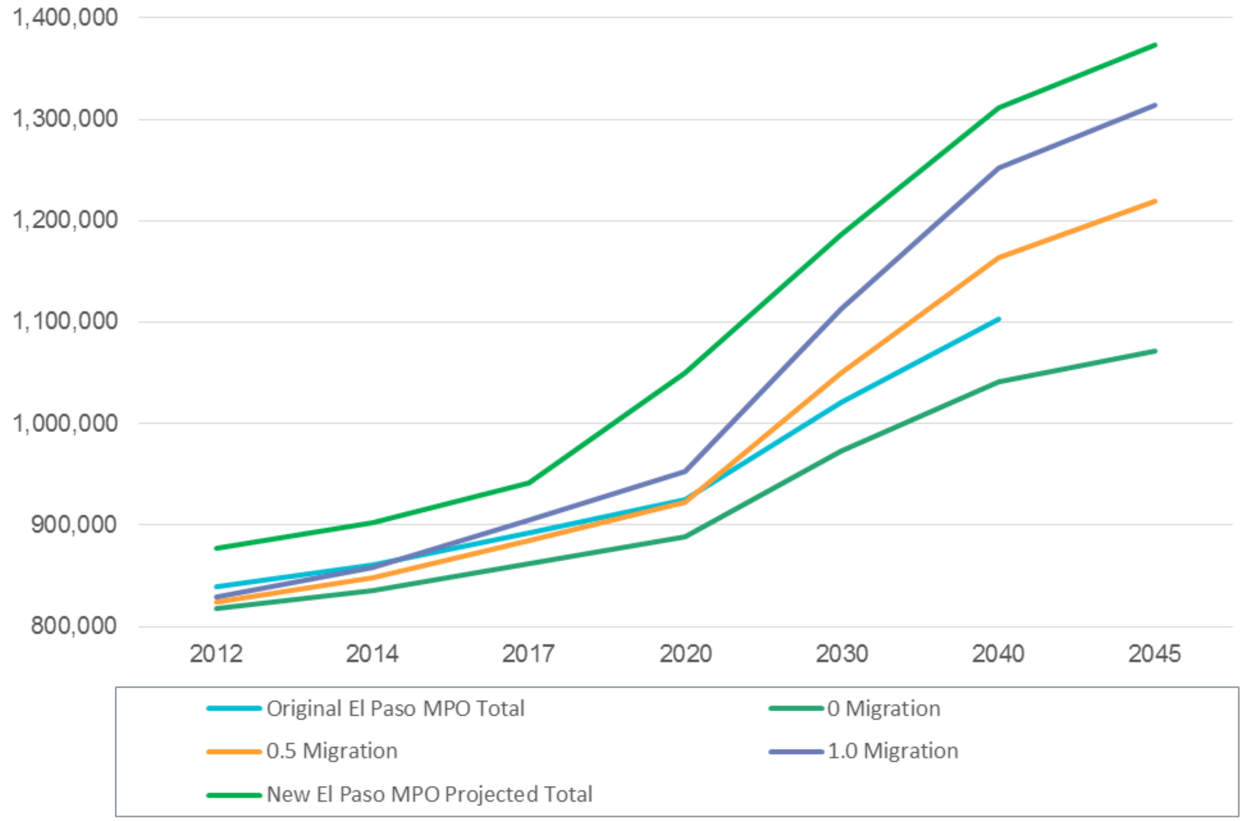
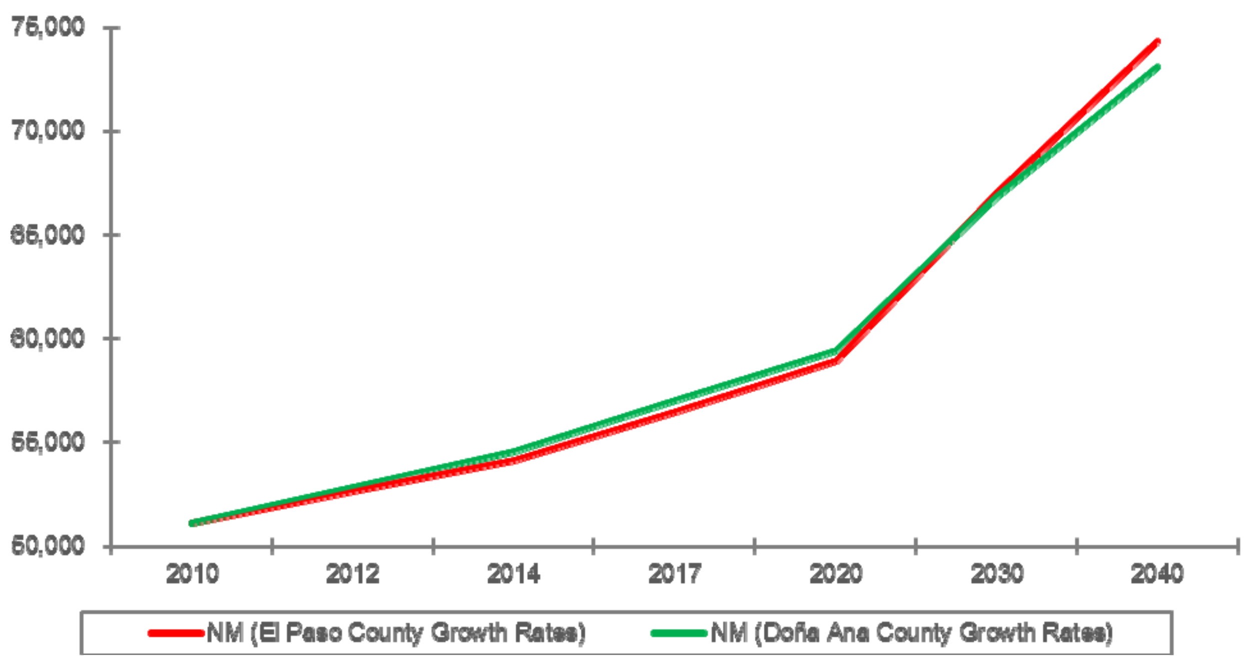


Figure 3.8 Population Estimates for the New Mexico TAZs



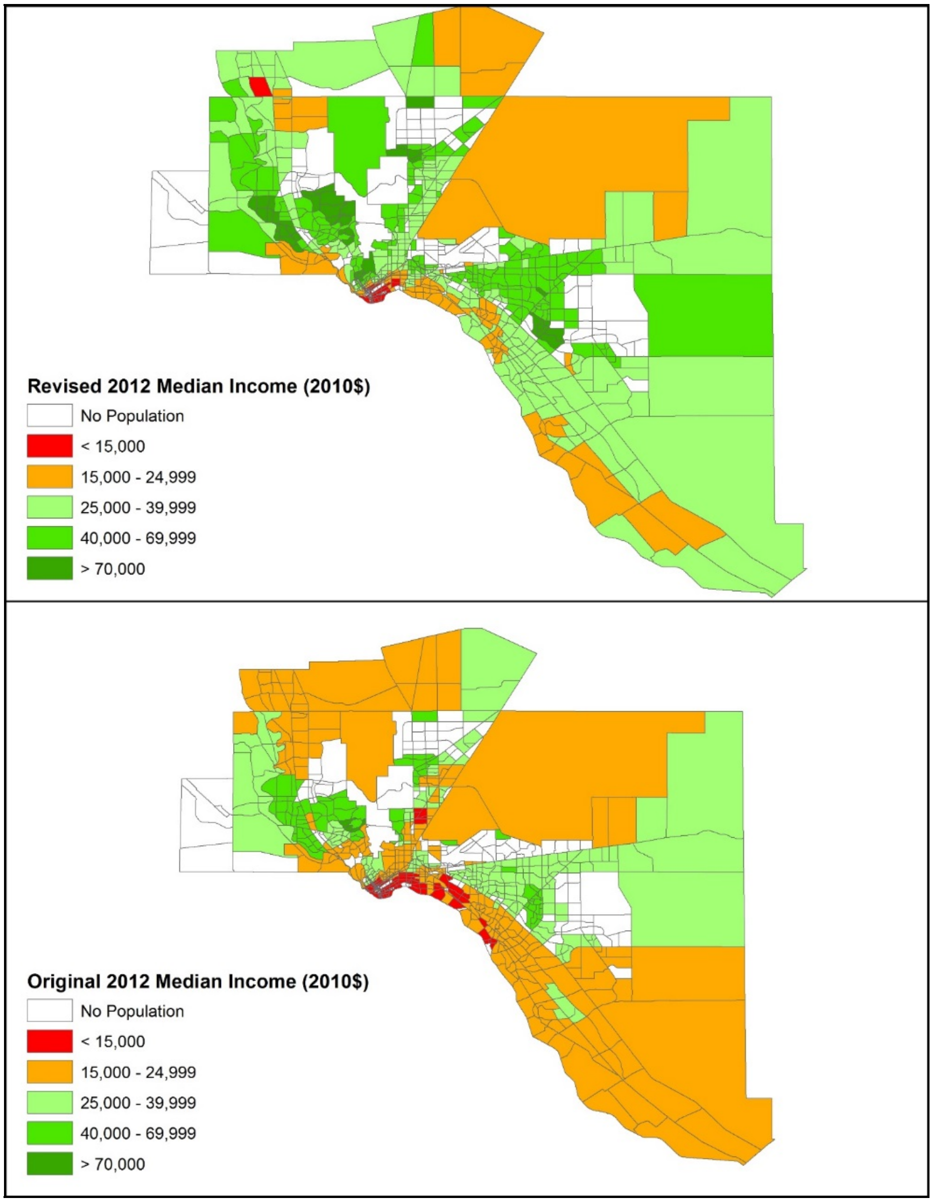
3.12.2 Households

Updating population required updating the number of households at the TAZ-level as well. TAZ-specific average household sizes were computed by dividing the original 2012 MPO population by the original 2012 MPO number of households. The updated 2012 MPO population was then divided by the calculated average household size to obtain the new number of households in each TAZ. Household size ranges from 1 to 6 in the updated dataset, with a simple mean of 3.02.

3.12.3 Median Income

The 2013 five-year ACS block group median incomes were used to update the median income for the updated TAZs. Income is reported in 2010 dollars. The resulting median income distribution is mapped in Figure 3.9 and compared to the median income in the original model data (which was a forecast based on 2007 income data).

Figure 3.9 Comparison between Original and Revised 2012 Median Incomes



3.12.4 Employment

The originally-supplied 2012 MPO employment was a result of a projection using the previous year's employment trends. This was created before TWC 2012 data were available. In order to represent actual employment as much as possible, the basic, retail, and service employment were derived directly from 2012 TWC data for El Paso County.

In TAZs where TWC indicated zero employment, and aerial imagery showed otherwise, the 2012 MPO employment data were retained where available. This was done to offset some missing TWC employment that was not assigned to any of the TAZs in the study area due to missing geographic information.

As the 2012 TWC data did not have any special generator employment, 2012 MPO special generator basic employment in Fort Bliss was derived from a 2012 study that summarized population and employment for proposed development in the Fort Bliss area.

The TWC employment data were used to derive the 2012 MPO education employment data where major discrepancies were found. However, the TWC data lumps all public school employment at the independent school district, not individual schools, clustering the employment in a handful of TAZs rather than spreading it out in the study area. Hence, the individual school employment was kept as is and education employment was updated based on TWC control totals.

3.13 Updated MPO 2012 SED Summary

The original 2012 data were forecast from 2007. Table 3.12 provides a summary of the socioeconomic data for the updated 2012 base year using more recent and reliable data from the 2013 ACS.

Table 3.12 2007-2012 Updated MPO SED Summary
Employment [a], Population, Households

	2007 MPO Data	2010 MPO Data	2012 Updated MPO Data
El Paso County Population (including GQ pop.)	735,562	785,835	824,017
New Mexico Districts Population (including GQ pop.)	49,491	52,356	52,629
Total Study Area Population	785,053	838,191	876,646
El Paso County Households	231,189	251,657	274,513
New Mexico Districts Households	15,134	15,946	16,115
Total Study Area Households	246,323	267,603	290,628
El Paso County Basic Employment	83,296	97,183	96,415
New Mexico Districts Basic Employment	519	695	1,353
Total Study Area Basic Employment	83,815	97,878	97,768
El Paso County Retail Employment	60,303	59,050	68,276
New Mexico Districts Retail Employment	708	708	737
Total Study Area Retail Employment	61,011	59,758	69,013
El Paso County Service Employment	108,879	109,524	110,573
New Mexico Districts Service Employment	1,602	2,181	2,400
Total Study Area Service Employment	110,481	111,705	112,973
El Paso County Education Employment	24,689	25,010	25,946
New Mexico Districts Education Employment	1,428	1,653	1,668
Total Study Area Education Employment	26,117	26,663	27,614
Total El Paso County Employment	**277,167**	**290,767**	**301,210**
Total New Mexico Districts Employment	**4,257**	**5,291**	**6,158**
Total Study Area Employment	**281,424**	**296,058**	**307,368**

[a] Special generator employment is included within the reported figures.

3.14 Revised Employment-to-Population Ratios

Table 3.13 shows a breakdown of population, households, and employment by area type. The Business District area type is historically designated, whereas the rest of the area types are calculated according to the updates outlined above. Around 52 percent of population and households are located in area type Urban Central, where about 25 percent of employment is situated.

Table 3.13 Area Type Summary
Revised 2012 MPO Population, Households, Employment

Area Type Name	Pop	HH	Total Emp	Basic Emp	Retail Emp	Service Emp	Education Emp	Emp-to-Pop Ratio
Business District	3,292	1,351	14,827	5,519	2,871	6,315	122	4.50
Urban Intense	137,328	50,734	146,548	33,340	32,503	71,798	8,907	1.07
Urban Central	460,211	156,701	77,256	18,127	24,761	22,323	12,045	0.17
Suburban	194,236	57,259	48,485	30,446	5,993	7,886	4160	0.25
Rural	81,579	24,583	20,252	10,336	2,885	4,651	2,380	0.25
Total	**876,646**	**290,628**	**307,368**	**97,768**	**69,013**	**112,973**	**27,614**	**0.35**

About 6 percent of basic employment is in the business district area type, 34 percent in the urban intense area type, 18 percent in the urban central area type, 31 percent in the suburban area type, and 11 percent in the rural area type.

About 4 percent of retail employment occurs in the business district, 47 percent in urban intense areas, 36 percent in urban central areas, 9 percent in suburban areas, and 4 percent in rural areas.

About 5 percent of service employment are in the business district and 64 percent in urban intense areas, where there is a lot of employment. It is about 20 percent in urban central areas, 7 percent in suburban areas, and 4 percent in rural areas.

3.15 Forecast Year Updates

3.15.1 Population

The growth rates embedded in the original MPO dataset were applied to grow the 2012 population over the forecast years. The TPEPP control totals were then applied to adjust the population estimates. For 2045, the 2040 population distribution was kept the same and scaled to match the 2045 control total. Moreover, the Fort Bliss population estimates from C&M Associates' technical memorandum were added to year 2020 data onwards.

3.15.2 Employment

The growth rates from the original MPO dataset were applied to each of the employment types separately in order to grow the employment from the base to the forecast years. In 2016, a project was completed that replaces the Beaumont Army Medical Center at North Piedras St with a hospital at Fort Bliss. Consequently, employment figures for the two TAZs affected by this project were updated for 2017 and all the following forecast years. Moreover, the Fort Bliss employment estimates from C&M Associates' technical memorandum were added to year 2020 data onwards. This is evident in Table 3.14, which represents a summary of the base and forecast year socioeconomic data, and where there is a significant increase in special generator employment.

Table 3.14 Base and Forecast Year Summaries

	2012	2014	2017	2020	2030	2040	2045
MPO Total Population	876,646	901,907	941,124	1,050,416	1,186,027	1,311,439	1,373,481
Group Quarter Population	15,515	15,519	15,525	15,531	15,547	15,559	15,564
Households	290,628	298,384	311,359	348,043	394,069	436,295	457,170
Median Income	$41,551	$41,307	$41,847	$42,275	$42,220	$42,210	$42,213
Basic Employment	61,595	63,503	66,831	69,814	83,377	97,420	104,400
Retail Employment	65,499	67,126	69,496	72,229	83,494	94,496	99,944
Service Employment	100,176	103,782	108,093	113,278	132,986	150,031	158,468
Special Generator – Education	27,614	27,858	28,101	28,486	28,964	29,187	29,376
Special Generator – Basic	36,173	36,370	36,824	45,976	46,745	46,984	47,099
Special Generator – Retail	3,514	4,361	4,436	8,548	8,845	8,890	8,912
Special Generator – Service	12,797	13,079	16,045	29,855	31,382	33,397	34,385
Total Employment	307,368	316,079	329,826	368,186	415,793	460,405	482,584
Employment to Population Ratio	0.35	0.35	0.35	0.35	0.35	0.35	0.35

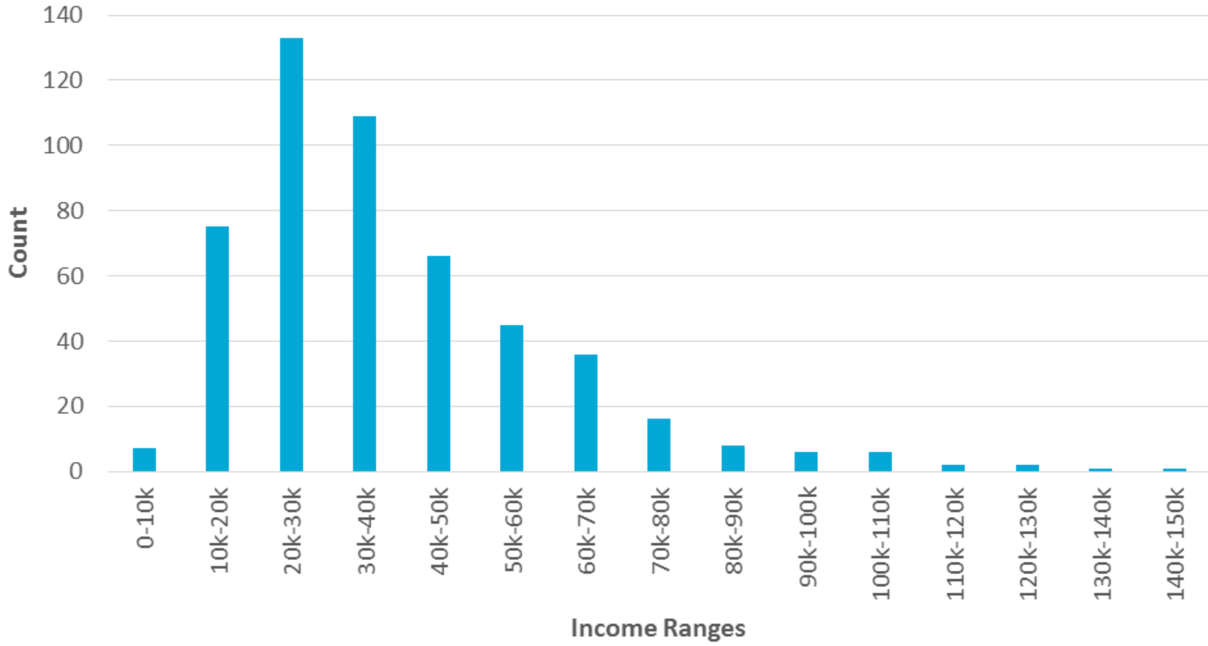
3.15.3 Households

The number of households for each of the forecast years was determined by dividing the forecast year TAZ population by the household size from the original horizon data for the corresponding TAZ and forecast year. Moreover, the Fort Bliss household estimates from C&M Associates' technical memorandum were added to year 2020 data onwards.

3.15.4 Median Income

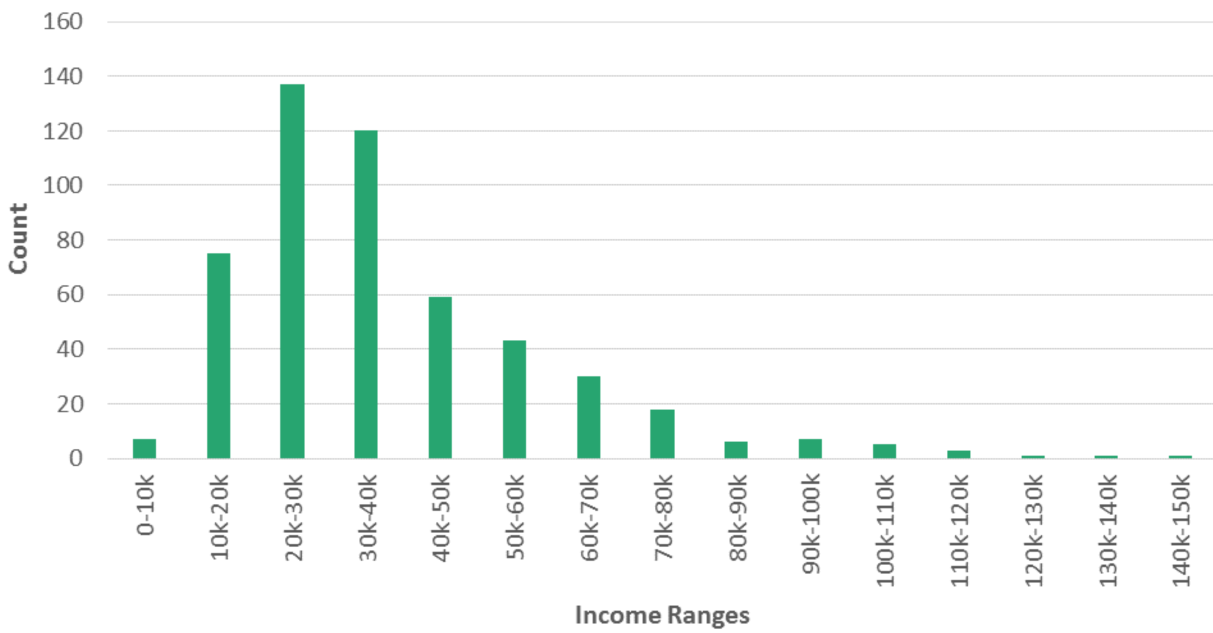
Median income is kept constant across the years with the assumption that the only variable is inflation. This is because the comparison of the 2013 and 2014 ACS median incomes, adjusted for inflation, yielded little differences (see Figure 3.10 and Figure 3.11). All median incomes are reported in 2010 dollars.

Figure 3.10 Adjusted 2013 Median Income
2010 Dollars



Source: American Community Survey, 2013.

Figure 3.11 Adjusted 2014 Median Income
2010 Dollars



Source: American Community Survey, 2014.

4.0 Trip Generation

This chapter describes the trip generation model of the Destino 2045 travel demand model. Different survey datasets were used in the development of trip production rates and attraction rates. Separate rates for special generators, external trips, and commercial vehicles were also estimated using different datasets. All the rates are applied within the TexPACK's TripCal5 procedures as described here. This chapter also discusses the various surveys, expansion procedures, development of rates, comparison of rates against other sources, recommended rates for the Destino 2045 travel demand model, and a summary of trip generation (productions and attractions) by income, area type and districts.

4.1 Trip Production Model

4.1.1 Survey Data Processing

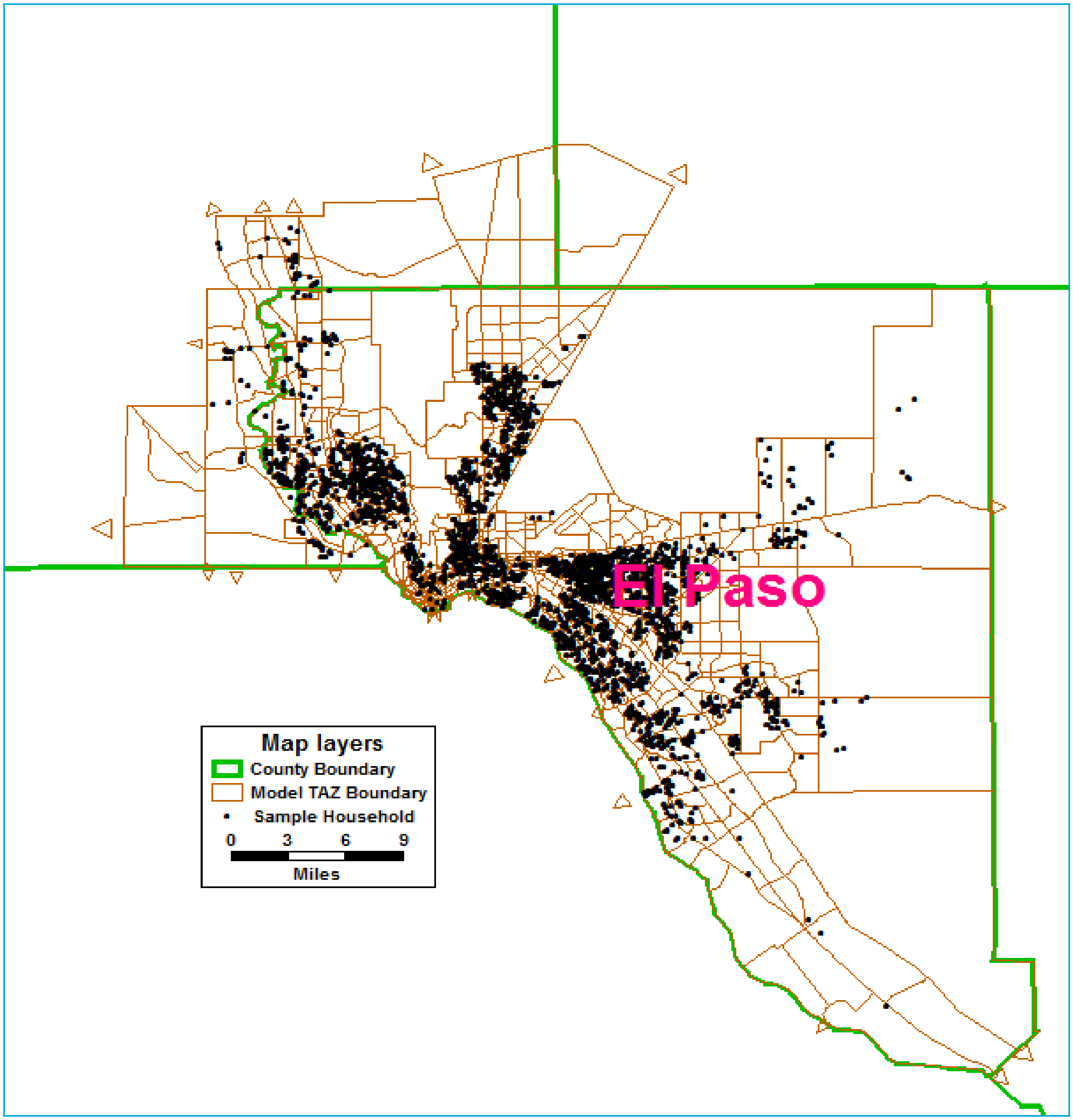
The 2010/2011 El Paso household survey data were used in the development of the trip production model. The survey includes 3,042 randomly selected household samples, out of which only 83 household samples were collected from the districts of Anthony, Santa Teresa and Sunland Park in New Mexico. The rest of the household samples are from El Paso County. The survey includes four types of data: household, person, vehicle and travel data. Table 4.1 shows the summary of survey samples by household sizes, income levels, and number of workers in household, while Figure 4.1 depicts the location of these households. It shows a fairly good coverage within the region.

Table 4.1 2010/2011 El Paso Household Travel Survey – Summary of Household Size, Workers, and Income

Annual HH Income in 2010$ / HH Size	1	2	3	4	5+	Total
Worker 0						
$0 to $14,999	45	68	41	21	12	187
$15,000 to $24,999	29	55	32	14	19	149
$25,000 to $39,999	30	59	32	38	17	176
$40,000 to $69,999	34	61	31	33	17	176
$70,000+	30	41	31	24	7	133
Total	168	284	167	130	72	821
Worker 1						
$0 to $14,999	45	42	62	56	29	234
$15,000 to $24,999	49	69	51	47	53	269
$25,000 to $39,999	58	56	70	57	69	310
$40,000 to $69,999	57	98	57	51	43	306
$70,000+	41	53	36	35	29	194
Total	248	318	276	246	223	1,313

Annual HH Income in 2010$ / HH Size	1	2	3	4	5+	Total
Worker 2+						
$0 to $14,999		4	16	15	12	47
$15,000 to $24,999		9	8	28	34	79
$25,000 to $39,999		15	48	53	52	168
$40,000 to $69,999		52	63	72	76	263
$70,000+		81	101	110	59	351
Total		161	236	278	233	908
Total						
$0 to $14,999	89	114	119	92	53	467
$15,000 to $24,999	77	133	91	89	106	496
$25,000 to $39,999	88	130	150	148	138	654
$40,000 to $69,999	91	211	151	156	136	745
$70,000+	71	175	168	169	95	678
Total	**416**	**763**	**679**	**654**	**528**	**3,040**

Figure 4.1 Spatial Distribution of Household Samples



The survey data were expanded using the weighing factors developed by TTI[2]. The expanded total household numbers were compared with Census 2010. Table 4.2 shows that the number of households by household sizes matches very well with that in the 2010 Census.

Table 4.2 Number of Households by Household Sizes

Household Size	Expanded Survey	Census 2010	% Difference
1	50,902	50,895	0.01%
2	63,910	63,870	0.06%
3	47,463	47,538	-0.16%
4	44,873	44,857	0.04%
5+	49,413	49,397	0.03%
Total	**256,561**	**256,557**	**0.00%**

The travel attributes from the survey data were converted into origin-destination trip table format. Each record in the origin-destination trip table represents a trip made by a person in a household. The weekend trips were identified and removed from the origin-destination trip data since the model represents an average weekday travel. The trip purposes of each origin-destination trips were identified using the activity type and the activity place information in the survey data. The following trip purposes were identified from the survey:

- Home-based work (HBW);
- Home-based nonwork retail (HBNW retail);
- HBNW education from kindergarten to grade 12 (HBNW ED1);
- HBNW education college (HBNW ED2);
- HBNW other; and
- Non-home-based (NHB).

Based on TTI's recommendation, the weighting factors were adjusted by age and gender. The age and gender information were attached to the trip records from the person data table. TTI research showed that the proxy reported trips in the survey data were significantly under-estimated compared to the trips made by the interviewed individuals. The adjustment factors found in the TTI report were applied to the proxy reported trip records. The adjusted weights were applied to the survey data to expand the trips made by household samples. The expanded trip data were summarized by household income, number of workers, household size, and trip purposes.

4.1.2 Estimation of Trip Production Rates

Person trip production rates were estimated from the expanded household and trip data. The rates were estimated for each of the trip purposes by using a cross-classification method including household income

[2] El Paso HH Survey Technical Memo.pdf prepared by Texas A&M Transportation Institute.

level, size and number of workers. The trip rates were developed for each of the household classes. The equation below shows the calculation of trip generation rates.

$$Rate_{PWSI} = \frac{Trip_{PWSI}}{Total\ HH_{WSI}}$$

Where:

$Rate_{PWSI}$ = Trip production rate of household with size *S*, income level *I* and *W* number of workers for purpose *P*.

$Trip_{PWSI}$ = Total expanded surveyed trips made by household with size *S*, income level *I* and *W* number of workers for purpose *P*.

$Total\ HH_{WSI}$ = Total expanded number households with size *S*, income level *I* and *W* number of workers.

Tables 4.3 to 4.8 show the trip production rates estimated from the household survey data.

Table 4.3 Home-Based Work Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
Worker 0						
$0 to $14,999	0.0	0.0	0.0	0.0	0.0	0.0
$15,000 to $24,999	0.0	0.0	0.0	0.0	0.0	0.0
$25,000 to $39,999	0.0	0.0	0.0	0.0	0.0	0.0
$40,000 to $69,999	0.0	0.0	0.0	0.0	0.0	0.0
$70,000 PLUS	0.0	0.0	0.0	0.0	0.0	0.0
Average	0.0	0.0	0.0	0.0	0.0	0.0
Worker 1						
$0 to $14,999	0.9	1.0	1.6	1.5	1.7	1.3
$15,000 to $24,999	1.0	1.0	1.2	1.7	1.9	1.4
$25,000 to $39,999	1.6	0.9	1.4	1.6	1.7	1.4
$40,000 to $69,999	1.0	1.0	1.1	1.4	1.7	1.2
$70,000 PLUS	1.2	0.8	1.1	1.1	1.6	1.1
Average	1.2	1.0	1.3	1.5	1.7	1.3
Worker 2+						
$0 to $14,999		2.5	3.3	2.7	3.6	3.0
$15,000 to $24,999		1.1	2.4	3.2	2.7	2.4
$25,000 to $39,999		2.3	2.5	2.8	3.9	3.0
$40,000 to $69,999		2.1	2.9	3.2	3.1	2.9
$70,000 PLUS		2.0	2.7	2.8	3.6	2.8
Average		2.0	2.7	3.0	3.4	2.8
All						
$0 to $14,999	0.3	0.6	1.1	1.0	1.2	0.7
$15,000 to $24,999	0.7	0.7	1.2	1.7	1.8	1.2

$25,000 to $39,999	1.2	1.0	1.6	1.8	2.3	1.6
$40,000 to $69,999	0.8	1.3	2.0	2.4	2.4	1.9
$70,000 PLUS	0.9	1.3	2.1	2.3	3.0	2.0
Average	0.7	1.0	1.7	2.0	2.3	1.5

Table 4.4 Home-Based Nonwork Retail Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
Worker 0						
$0 to $14,999	0.5	1.9	2.0	2.1	3.4	1.5
$15,000 to $24,999	0.8	1.6	1.8	1.7	3.2	1.7
$25,000 to $39,999	0.7	2.1	2.0	2.2	3.4	1.9
$40,000 to $69,999	1.1	1.6	2.1	1.3	1.3	1.5
$70,000 PLUS	0.9	2.1	1.7	2.0	4.4	2.0
Average	0.7	1.9	1.9	1.9	3.1	1.7
Worker 1						
$0 to $14,999	0.4	0.7	1.4	2.0	1.5	1.1
$15,000 to $24,999	0.4	1.0	1.5	1.3	2.5	1.3
$25,000 to $39,999	0.2	1.3	1.1	1.6	2.7	1.3
$40,000 to $69,999	0.4	1.1	1.7	2.2	2.9	1.5
$70,000 PLUS	0.4	1.7	2.2	2.3	4.3	2.1
Average	0.4	1.2	1.6	1.8	2.8	1.4
Worker 2+						
$0 to $14,999		0.6	0.9	2.4	2.8	1.7
$15,000 to $24,999		1.1	1.4	1.3	2.6	1.7
$25,000 to $39,999		1.1	2.3	1.9	1.1	1.6
$40,000 to $69,999		1.0	1.7	2.2	1.7	1.7
$70,000 PLUS		1.4	1.9	2.5	1.4	1.8
Average		1.2	1.8	2.2	1.6	1.7
All						
$0 to $14,999	0.5	1.3	1.6	2.1	2.5	1.4
$15,000 to $24,999	0.6	1.2	1.6	1.4	2.7	1.5
$25,000 to $39,999	0.4	1.5	1.7	1.8	2.2	1.5
$40,000 to $69,999	0.5	1.1	1.7	2.1	2.0	1.6
$70,000 PLUS	0.6	1.6	1.9	2.4	2.3	1.9
Average	0.5	1.4	1.7	2.0	2.3	1.6

Table 4.5 Home-Based Nonwork Education Trip Production Rates (Kindergarten to Grade 12)

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
Worker 0						
$0 to $14,999	0.1	0.4	1.2	5.1	8.1	1.8
$15,000 to $24,999	0.1	0.3	1.8	2.2	6.5	1.8
$25,000 to $39,999	0.0	0.2	1.6	4.7	7.1	2.1
$40,000 to $69,999	0.1	0.2	1.2	7.7	9.3	2.9
$70,000 PLUS	0.0	0.3	2.4	6.8	9.0	2.0
Average	0.1	0.3	1.5	4.9	7.8	2.0
Worker 1						
$0 to $14,999	0.0	0.2	2.0	5.1	8.2	2.8
$15,000 to $24,999	0.2	0.1	2.1	5.2	10.6	3.5
$25,000 to $39,999	0.0	0.2	2.1	5.0	9.8	3.1
$40,000 to $69,999	0.1	0.4	1.1	5.8	10.5	2.9
$70,000 PLUS	0.0	0.1	1.7	7.5	9.4	3.0
Average	0.1	0.2	1.8	5.6	9.8	3.1
Worker 2+						
$0 to $14,999	0.0	1.5	0.4	4.2	7.1	3.5
$15,000 to $24,999	0.0	0.0	0.8	2.8	9.0	3.7
$25,000 to $39,999	0.0	0.2	0.6	1.7	5.6	2.3
$40,000 to $69,999	0.0	0.1	0.6	3.8	6.9	3.2
$70,000 PLUS	0.0	0.3	1.7	4.4	6.6	3.3
Average	0.0	0.2	1.1	3.6	6.8	3.1
All						
$0 to $14,999	0.1	0.4	1.5	5.0	8.0	2.3
$15,000 to $24,999	0.2	0.2	1.7	3.9	9.3	3.1
$25,000 to $39,999	0.0	0.2	1.5	3.6	7.7	2.7
$40,000 to $69,999	0.1	0.2	0.8	4.8	8.2	3.0
$70,000 PLUS	0.0	0.2	1.7	5.3	7.4	3.1
Average	0.1	0.2	1.4	4.6	8.1	2.9

Table 4.6 Home-Based Nonwork Education (College) Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
Worker 0						
$0 to $14,999	0.0	0.0	1.1	0.3	0.4	0.2
$15,000 to $24,999	0.0	0.0	0.2	1.6	0.7	0.4
$25,000 to $39,999	0.0	0.1	0.6	1.1	1.2	0.5
$40,000 to $69,999	0.0	0.0	0.7	0.8	1.2	0.4
$70,000 PLUS	0.3	0.0	0.4	1.2	0.0	0.2
Average	0.0	0.0	0.7	0.9	0.7	0.3
Worker 1						
$0 to $14,999	0.1	0.0	0.4	0.6	0.8	0.4
$15,000 to $24,999	0.0	0.0	0.4	0.3	0.2	0.2
$25,000 to $39,999	0.0	0.0	0.7	0.6	0.8	0.4
$40,000 to $69,999	0.0	0.1	0.5	0.4	0.6	0.3
$70,000 PLUS	0.0	0.0	0.2	0.9	0.1	0.2
Average	0.0	0.0	0.5	0.5	0.5	0.3
Worker 2+						
$0 to $14,999		0.9	0.7	1.0	0.9	0.9
$15,000 to $24,999		0.5	0.8	1.0	0.9	0.8
$25,000 to $39,999		0.9	1.0	1.1	1.0	1.0
$40,000 to $69,999		0.6	0.5	1.3	1.1	0.9
$70,000 PLUS		0.4	0.4	0.9	0.8	0.6
Average		0.5	0.6	1.1	0.9	0.8
All						
$0 to $14,999	0.0	0.1	0.7	0.5	0.6	0.3
$15,000 to $24,999	0.0	0.1	0.5	0.8	0.5	0.4
$25,000 to $39,999	0.0	0.3	0.8	0.8	0.9	0.6
$40,000 to $69,999	0.1	0.3	0.5	1.0	1.0	0.6
$70,000 PLUS	0.2	0.2	0.3	0.9	0.6	0.4
Average	0.0	0.2	0.5	0.8	0.7	0.5

Table 4.7 Home-Based Nonwork Other Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
Worker 0						
$0 to $14,999	1.0	1.4	2.9	2.7	5.1	2.0
$15,000 to $24,999	1.0	1.5	1.2	2.7	1.9	1.6
$25,000 to $39,999	1.2	1.5	1.9	3.3	2.4	1.9
$40,000 to $69,999	0.7	1.3	2.0	3.2	3.2	1.9
$70,000 PLUS	0.5	1.9	2.0	3.8	4.4	2.1
Average	1.0	1.5	2.2	3.0	3.5	1.9
Worker 1						
$0 to $14,999	0.5	0.8	1.0	1.4	2.5	1.2
$15,000 to $24,999	0.3	1.1	1.7	2.5	2.5	1.6
$25,000 to $39,999	0.6	1.5	0.8	1.8	1.8	1.2
$40,000 to $69,999	0.3	1.1	1.5	2.6	3.6	1.6
$70,000 PLUS	0.3	1.4	1.3	2.8	6.5	2.3
Average	0.4	1.2	1.3	2.2	3.2	1.6
Worker 2+						
$0 to $14,999	0.0	1.6	0.7	1.5	1.5	1.3
$15,000 to $24,999	0.0	1.3	1.0	1.2	3.6	1.9
$25,000 to $39,999	0.0	0.6	2.3	1.4	2.7	1.9
$40,000 to $69,999	0.0	0.9	1.2	2.4	2.3	1.8
$70,000 PLUS	0.0	1.0	1.7	2.5	2.8	2.0
Average	0.0	1.0	1.5	2.1	2.7	1.9
All						
$0 to $14,999	0.9	1.2	1.7	2.0	3.5	1.6
$15,000 to $24,999	0.6	1.2	1.5	2.2	2.7	1.6
$25,000 to $39,999	0.7	1.3	1.5	1.9	2.3	1.5
$40,000 to $69,999	0.3	1.1	1.4	2.6	2.8	1.7
$70,000 PLUS	0.4	1.3	1.6	2.6	3.8	2.1
Average	0.6	1.2	1.5	2.3	3.0	1.7

Table 4.8 Non-Home-Based Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+	Average
$0 to $14,999	0.7	1.2	2.5	2.6	4.2	1.6
$15,000 to $24,999	0.8	1.4	1.0	1.7	2.9	1.5
$25,000 to $39,999	0.8	1.9	1.9	3.1	3.4	2.0
$40,000 to $69,999	1.2	0.9	1.7	1.9	3.4	1.6
$70,000 PLUS	0.6	1.1	1.2	2.8	5.9	1.7
Average	0.7	1.3	1.9	2.4	3.8	1.7
Worker 1						
$0 to $14,999	0.8	0.9	1.3	2.6	3.0	1.6
$15,000 to $24,999	0.4	1.0	2.2	3.8	4.1	2.2
$25,000 to $39,999	0.9	1.9	1.4	2.4	3.4	1.9
$40,000 to $69,999	1.0	1.1	2.2	2.8	4.4	2.1
$70,000 PLUS	0.5	2.4	2.2	4.3	6.8	3.0
Average	0.7	1.5	1.9	3.2	4.3	2.2
Worker 2+						
$0 to $14,999	0.0	0.4	1.0	3.6	2.4	1.9
$15,000 to $24,999	0.0	3.0	1.1	2.2	5.5	3.1
$25,000 to $39,999	0.0	1.1	1.7	1.8	4.8	2.5
$40,000 to $69,999	0.0	1.4	2.3	3.2	4.1	2.9
$70,000 PLUS	0.0	2.7	3.6	5.2	5.7	4.3
Average	0.0	2.0	2.6	3.6	4.9	3.4
All						
$0 to $14,999	0.7	1.0	1.8	2.7	3.5	1.6
$15,000 to $24,999	0.6	1.5	1.7	2.9	4.3	2.2
$25,000 to $39,999	0.9	1.7	1.6	2.3	4.0	2.1
$40,000 to $69,999	1.0	1.2	2.2	3.0	4.1	2.4
$70,000 PLUS	0.5	2.3	3.2	4.8	6.0	3.6
Average	0.7	1.6	2.2	3.3	4.5	2.5

The estimated trip rates were compared with the trip rates from other sources; namely, TTI, 2007 El Paso Horizon Model, NCHRP Report 716, and 2009 Texas SAM-V3. Figures 4.2 to 4.6 show the comparisons by trip purposes at different income levels. It should be noted that the CS estimated rates were not smoothed or adjusted. CS applied adjustments to its rates during the model calibration and validation process (see Section 12.2).

Overall, the CS raw estimated rates are not significantly different from TTI's recommended (and smoothed) rates which were also developed from 2010/2011 El Paso household survey. The differences can be explained by the fact the TTI rates were smoothed.

The comparison of the estimated rates with the rates from NCHRP Report 716 and TxDOT SAM model shows differences at some household categories. The NCHRP Report 716 rates and SAM rates were developed using data at national level and at state level, respectively. Thus, the differences are mainly due to socioeconomic differences at different geographic levels.

Figure 4.2 Home-Based Work Production Rates

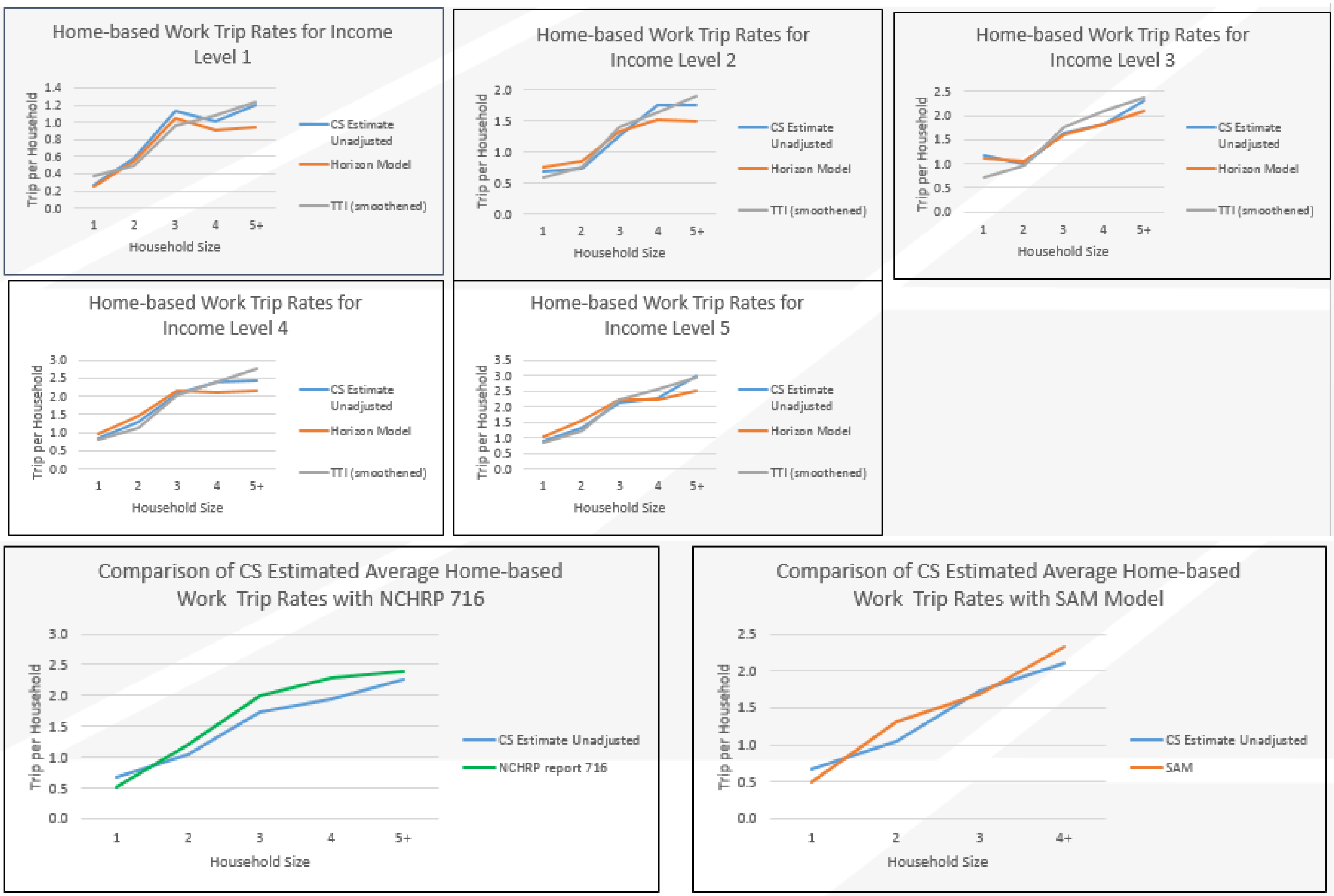


Figure 4.3 Home-Based Nonwork Retail Trip Production Rates

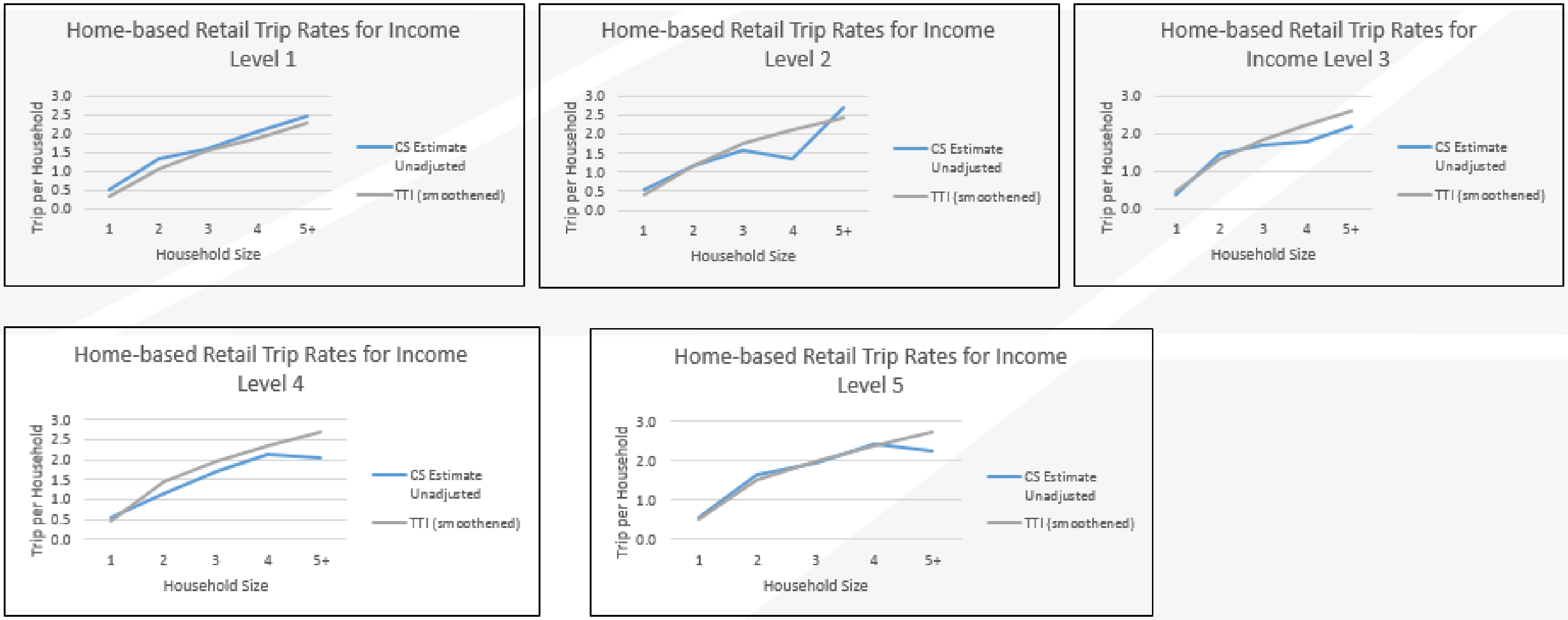


Figure 4.4 Home-Based Nonwork Education Trip Production Rates (Kindergarten to Grade 12)

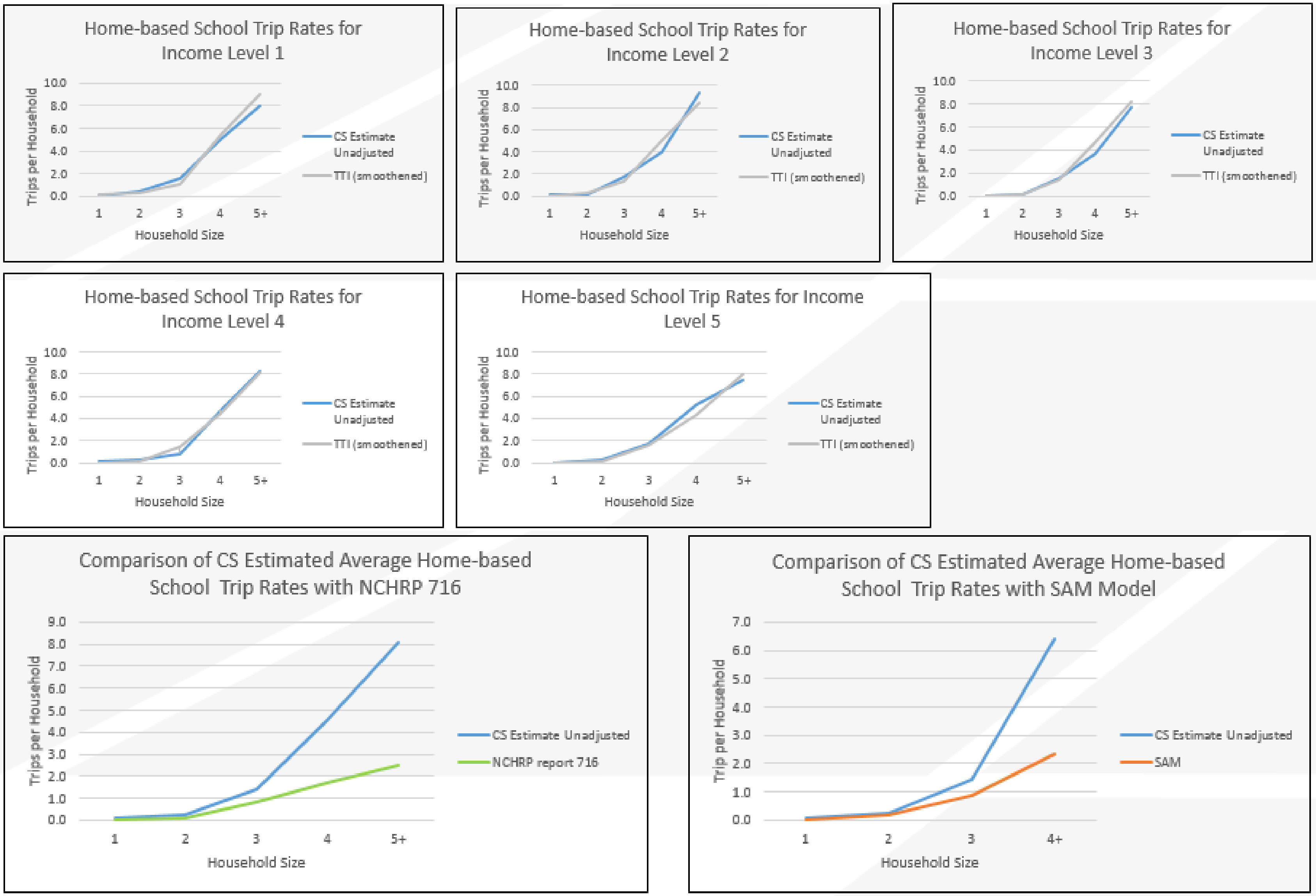


Figure 4.5 All Home-Based Nonwork (Excluding Kindergarten to Grade 12) Trip Rates

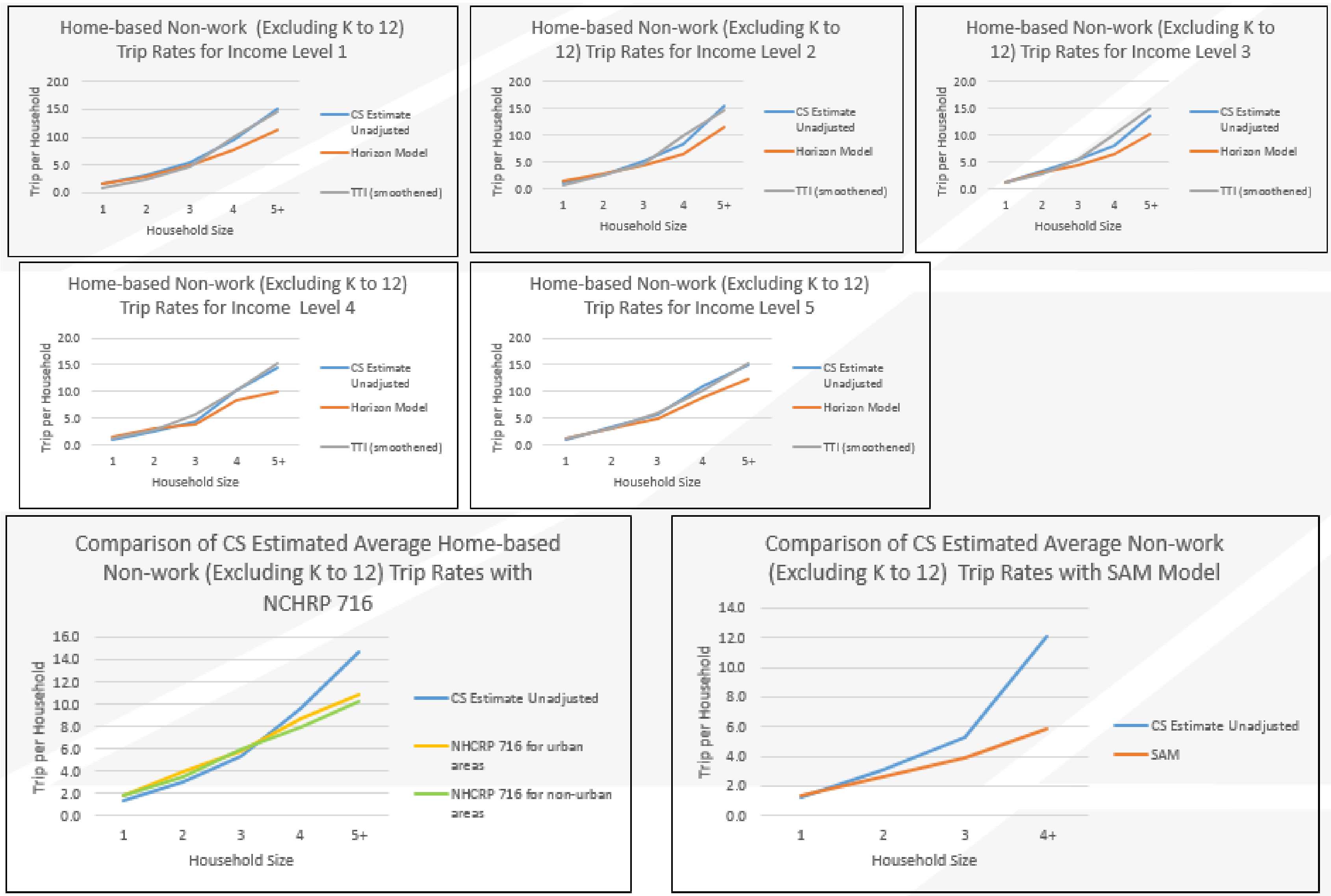
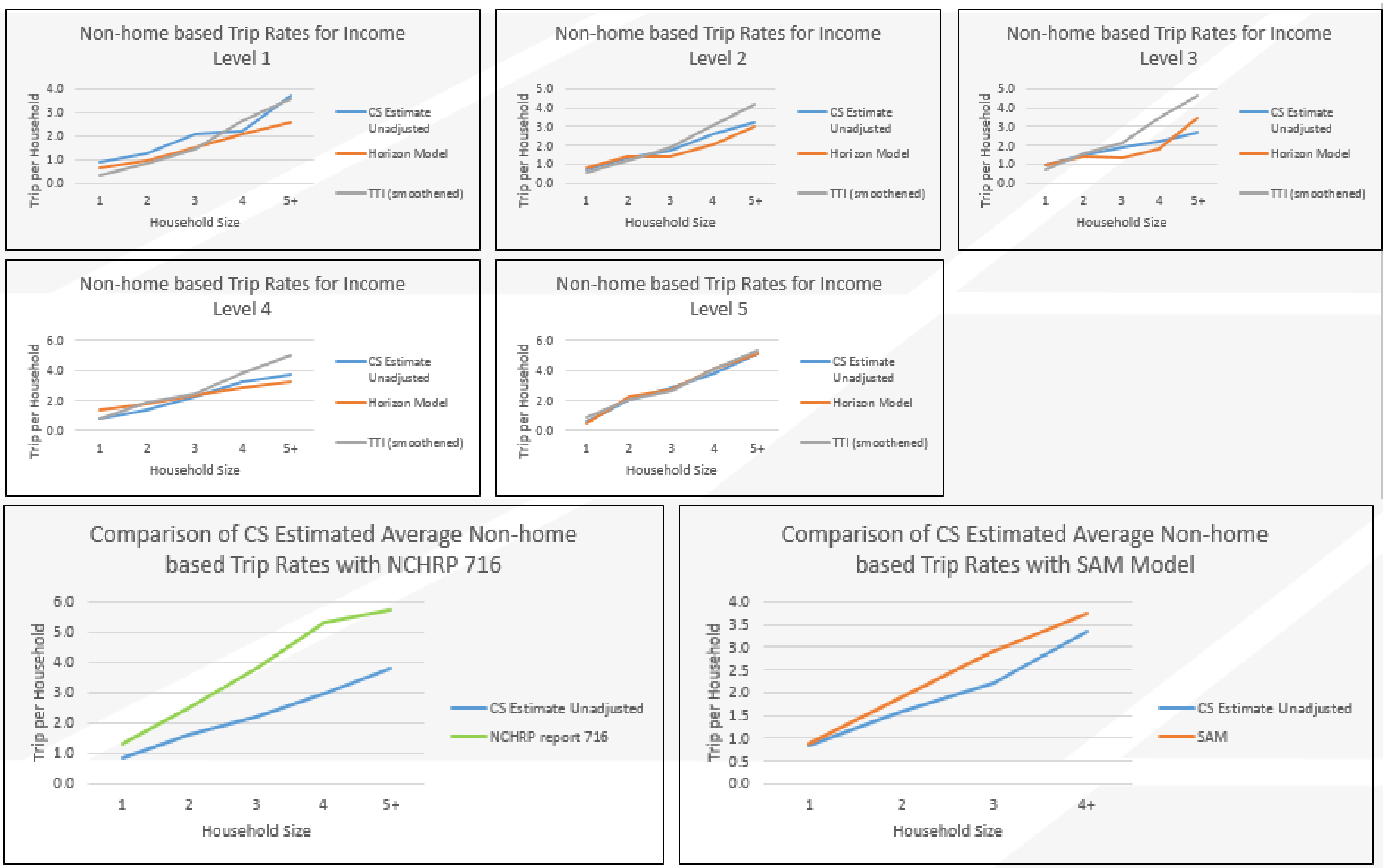


Figure 4.6 Non-Home-Based Trip Rates



4.1.3 Implementation of the Trip Production Rates

The trip generation model uses TRIPCAL5 program which was a joint effort of Texas Department of Transportation and TTI. TRIPCAL5 calculates the trip productions and attractions by trip purposes, and is capable of using user-specified household stratification and trip purposes. Input files were prepared based on TRIPCAL5's requirements. The estimated trip production rates considered a 3-dimensional household classification: size, worker and income level. The program uses the trip rates and the socioeconomic data to develop trip productions and attractions at TAZ level. The outputs from TRIPCAL5 were structured to develop trips by purpose and by five income levels for each TAZ. Table 4.9 shows the list of trip production data estimated by TRIPCAL5 program.

Table 4.9 Trip Production Output Table Structure

Fields	Description
HBW_P	Home-based work production
HBNWED1_P	Home-based nonwork education 1 (K-12) production
HBNWED2_P	Home-based nonwork education 2 (college) production
HBNWRET_P	Home-based nonwork retail production
HBNW_P	Home-based nonwork other production
NHB_P	Non-home-based
HBW_P_Ix	Home-based work production
HBNWED1_P_Ix	Home-based nonwork education 1 (K-12) production at income level x (where x=1 to 5)
HBNWED2_P_Ix	Home-based nonwork education 2 (college) production at income level x (where x=1 to 5)
HBNWRET_P_Ix	Home-based nonwork retail production at income level x (where x=1 to 5)
HBNW_P_Ix	Home-based nonwork other production at income level x (where x=1 to 5)
NHB_P_Ix	Non-home-based at income level x (where x=1 to 5)

4.1.4 Outputs from Trip Production Model

The trip production output developed by TRIPCAL5 using the estimated trip rates were compared against the existing 2007 El Paso Horizon Model results. Table 4.10 shows the comparison of trip productions from the new production model for base 2012 and from the 2007 Horizon model. The pre-existing model has three trip purposes: HBW, HBNW and NHB. The new models HBNW trip purposes were combined to produce summaries in Table 4.10. The comparison shows increases in trip productions for home-based trip purposes, which is expected due to the growth in socioeconomic data from year 2007 to year 2012. However, there is a drop in non-home-based productions from 2007 to 2012. However, the distribution of trips among trip purposes in the new model is consistent with El Paso 2010/2011 household survey data.

Table 4.10 Comparison of Distribution of Trip Productions among Trip Purposes

Purpose	Productions in 2007 Horizon Model	Productions in 2012 New Model	% in 2007 Horizon Model	% in 2012 New Model	% in El Paso 2010/2011 Household Survey
HBW	347,682	526,259	15%	15%	14%
HBNW	1,325,829	2,089,698	57%	62%	62%
NHB	663,193	783,987	28%	23%	23%
Total	**2,336,704**	**3,399,944**	**100%**	**100%**	**100%**

Table 4.11 shows the comparison of average trips per household by trip purposes in 2007 Horizon model and in the new 2012 model. The difference in the average trip rates between the two can be explained by the updated trip rates included in Chapter 12. CTPP 5-year estimate (2006-2010) shows that the average HBW trip production per household in El Paso County is 1.25, which is lower than the estimated value. This can be explained by the economic recession between years 2006 and 2010.

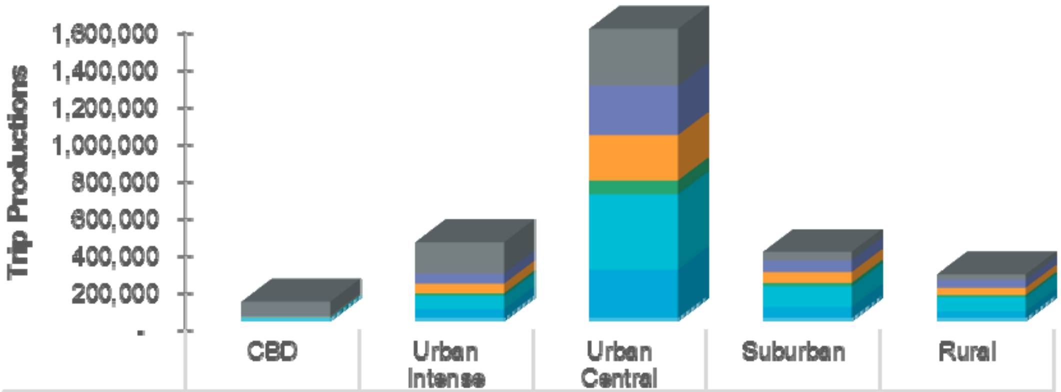
Table 4.11 Average Trips per Household by Trip Purposes

Purpose	Horizon Model	New Model
HBW	1.4	1.8
HBNW	5.2	7.2
NHB	2.6	2.7
Total	**9.1**	**11.7**

4.1.5 Summary of Productions by Purpose, Area Type and District

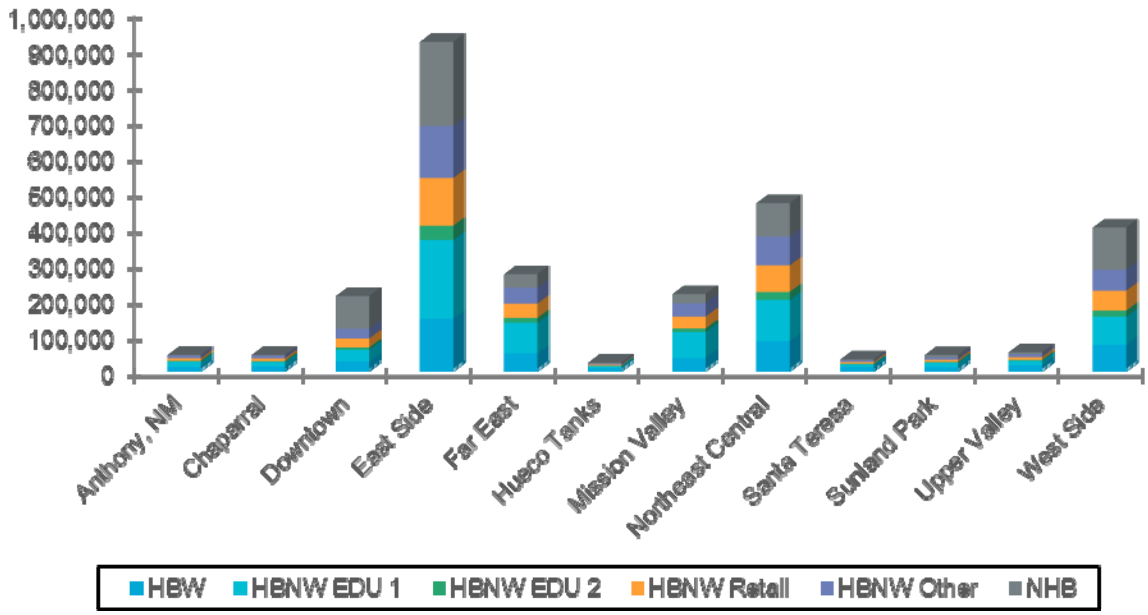
In order to examine trip productions in more detail, a summary of trips by area type and district were produced. Figures 4.7 and 4.8 present trip productions by area type and district, respectively. The summaries seem to be in line with the corresponding distribution of population and households by area type and district.

Figure 4.7 Trip Productions by Area Type



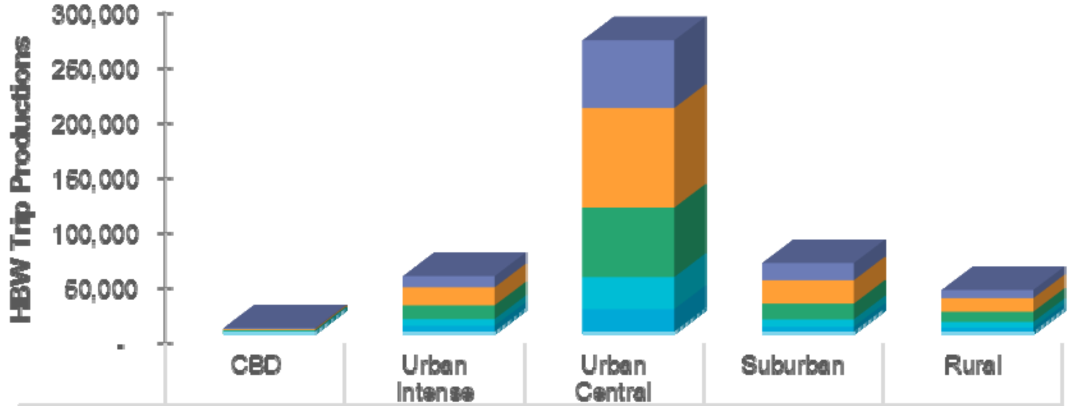
	CBD	Urban Intense	Urban Central	Suburban	Rural
NHB	74,724	167,676	305,618	44,053	28,312
HBNW Other	3,983	55,647	285,727	64,206	43,390
HBNW Retail	3,703	51,321	243,920	57,983	38,785
HBNW EDU 2	960	14,127	74,008	18,353	11,855
HBNW EDU 1	4,341	71,515	405,070	111,666	77,071
HBW	3,587	50,766	284,301	62,568	38,216

Figure 4.8 Trip Productions by District



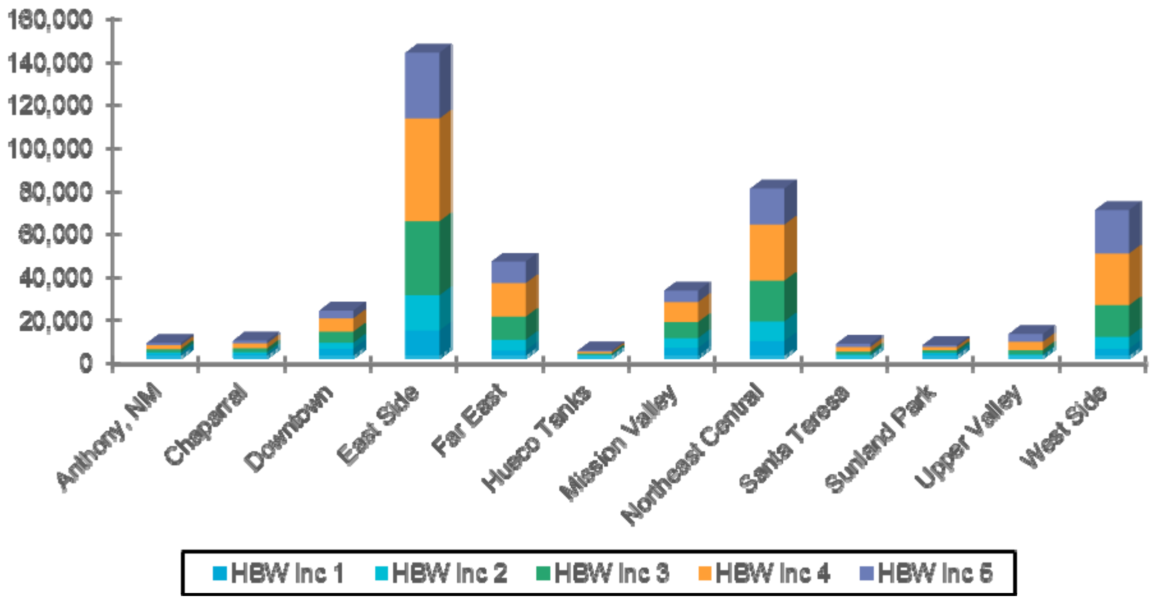
One of the key market segments that is being introduced into the new model is household income. Therefore, a summary of productions by income group are also examined. Figures 4.9 and 4.10 present productions by household income for different area types and districts.

Figure 4.9 Home-based Work Trip Productions by Income and Area Type



	CBD	Urban Intense	Urban Central	Suburban	Rural
HBW Inc 5	671	10,180	61,356	15,549	7,466
HBW Inc 4	1,103	16,327	90,166	21,167	12,197
HBW Inc 3	907	12,412	62,926	14,260	9,285
HBW Inc 2	436	6,107	29,021	6,728	5,076
HBW Inc 1	469	5,741	20,832	4,877	4,192

Figure 4.10 Home-based Work Trip Productions by Income and District



4.2 Trip Attractions

This section describes the development of trip attraction rates using the 2010 El Paso Workplace Survey. It also includes review and analysis of the survey, expansion procedures, comparison of rates against other sources, and recommended rates for the Destino 2045 travel demand model.

4.2.1 Workplace Survey Review and Analysis

TxDOT TPP designed and conducted a workplace, commercial vehicle, and special generator survey in the El Paso Metropolitan Region in 2010/2011. The main purpose of the surveys was to collect data and information needed as input to the MPO travel demand model, especially to aid in development of trip attraction models.

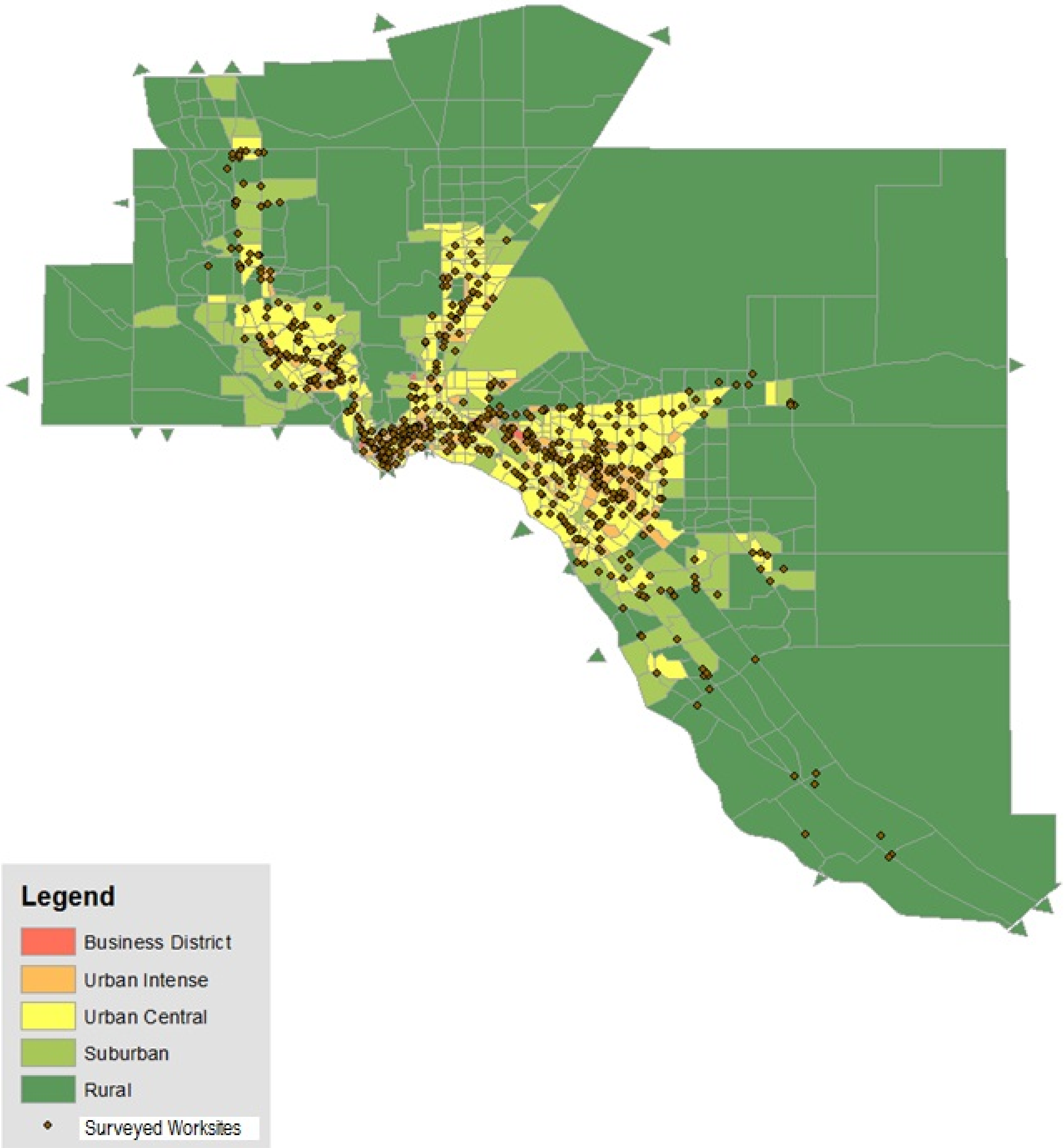
Table 4.12 presents the number of worksites that were surveyed in the El Paso study region by employment type and area type. Overall, 600 worksites were surveyed. At each, employees and visitors were asked to provide their travel behavior to and from those worksites on the day of the survey.

Table 4.12 Number of Surveyed Workplaces by Employment in the El Paso Region

Area Type	Basic	Retail	Services	Education	Total
Business District	5	10	31	1	47
Urban Intense	39	66	61	6	172
Urban Central	28	102	91	56	277
Suburban	10	17	14	15	56
Rural	8	15	13	12	48
Number of establishments	90	210	210	90	600
Total Employment	**1,226**	**1,487**	**3,432**	**2,017**	**8,162**

Figure 4.11 shows the locations of these 600 workplaces across the whole MPO region.

Figure 4.11 Spatial Distribution of Surveyed Worksites in the El Paso Region



The trip characteristics of persons entering or exiting the surveyed workplaces are further discussed below. These characteristics are based on the trip purpose to measure the amount of attractions to the work sites. The trip purposes to the workplace survey were identified as work-related, school-related, social/recreational, visiting, shopping, eating out, personal business, picking-up/droping-off passenger, delivery, or other. In order to be consistent with the proposed trip purpose definitions, we classified trips into following categories.

- **Home-based Work (HBW) –** When the purpose of the trip was work-related with origin or destination being a home.
- **Home-based Non-Work (HBNW) Retail –** When the purpose of the trip was shopping and non-work related with origin or destination being a home.
- **Home-based Non-Work (HBNW) Other –** When the purpose of the trip was non-work related with origin or destination being a home.
- **Non-Home Based (NHB) –** When the purpose of the trip was either work-related or non-work related with origin or destination being not a home.
- **Home-based Non-Work (HBNW) School –** When the purpose of the trip was school-related with either origin or destination being a home.
- **Non-Residential –** When the person making the trip to and/or from the worksite lived outside the study area and the origin/destination of the trip was inside the study area.

The two major stratification variables were considered for use in developing the attraction rates: employment type and area type. Table 4.13 and 4.14 present the frequency of trips by each purpose by employment type and area type, respectively, in the region. These tables provide alternative approaches to deriving raw person trip attraction rates based on zonal employment distributions. Development of the pre-calibration/validation attraction rates are discussed further in Section 4.2.4.

Table 4.13 Number of Trips by Purpose and Employment Type from Survey

	Trip Purpose						
Employment Type	Home-Based Work (HBW)	Home-Based Non Work (HBNW) Retail	HBNW School	HBNW Other	Non-Home Based	Non Residential	Total
Basic	692	296	–	124	178	118	1,408
Retail	1,030	5,654	2	802	1,688	784	9,960
Services	808	190	228	1,378	554	158	3,316
Education	2,284	–	18	1,010	246	74	3,632
Total	**4,814**	**6,140**	**248**	**3,314**	**2,666**	**1,134**	**18,316**

Table 4.14 Number of Trips by Purpose and Area Type from Survey

	Trip Purpose						
Area Type	Home-Based Work (HBW)	Home-Based Non Work (HBNW) Retail	HBNW School	HBNW Other	Non-Home Based	Non Residential	Total
Business District	226	220	–	320	286	98	1,150
Urban Intense	1,106	1,686	–	910	768	410	4,880
Urban Central	2,704	3,342	246	1,632	1,308	522	9,754
Suburban	472	462	–	206	178	36	1,354
Rural	306	430	2	246	126	68	1,178
Total	**4,814**	**6,140**	**248**	**3,314**	**2,666**	**1,134**	**18,316**

4.2.2 Workplace Survey Data Expansion

In order to scale the survey sample to the whole study area, the workplace survey was expanded to the whole population by using total employment by type in the El Paso study region. Table 4.15 shows the employment and establishment estimates for the El Paso study area. This employment does not include special generator employment as special generators attraction rates are computed separately from the special generator surveys. The expansion of the workplace survey was performed in a similar manner to TTI's procedure as documented in their technical summary report[3].

Table 4.15 Estimates of Establishments and Total Employment in El Paso Study Area

Employment Type	Number of Establishments[a]	Total Employment
Basic	3,799	67,304
Retail	3,301	57,587
Service	6,435	103,077
Education	301	19,481
Total	**13,905**	**247,449**

[a] Source: 2010 El Paso Workplace Survey Technical Summary – TTI Report 2013.

The trip weights by trip purpose and employment type were derived for each survey record. These weights are presented below in Table 4.16.

[3] Texas Transportation Institute, *2010 El Paso Works Place Travel Survey – Technical Summary*, June 2013.

Table 4.16 Trip Weights by Purpose and Employment Type

Employment Type	Home-Based Work (HBW)	Home-Based Non Work (HBNW) Retail	HBNW School	HBNW Other	Non-Home Based	Non Residential
Basic	270.30	851.95	-	851.95	536.29	421.97
Retail	146.53	762.74	762.74	762.74	494.31	363.32
Services	262.95	495.56	495.56	495.56	316.19	130.48
Education	30.37	-	695.75	695.75	357.45	68.47

After expansion, attraction rates were computed by purpose, employment and area type as shown in Table 4.17.

Table 4.17 Survey Person Trips per Employee

Employment Type	Home-Based Work (HBW)	Home-Based Non Work (HBNW) Retail	HBNW School	HBNW Other	Non-Home Based	Non Residential
Basic	1.390	1.873	0.000	0.785	0.709	0.370
Retail	1.310	37.444	0.013	5.311	7.245	2.473
Services	1.031	0.457	0.548	3.313	0.850	0.100
Education	1.780	0.000	0.321	18.036	2.257	0.130
Average	1.378	9.943	0.221	6.861	2.765	0.768

These rates were then applied to the zonal employment to obtain total trip attraction by employment type. These are shown in Tables 4.18 and 4.19 for employment and area types, respectively, in the region.

Table 4.18 Total Trip Attractions by Employment Type

	Total Person Trip Attractions						
Employment Type	Home-Based Work (HBW)	Home-Based Non Work (HBNW) Retail	HBNW School	HBNW Other	Non-Home Based	Non Residential	Total
Basic	93,523	126,089	–	52,821	47,730	24,896	345,058
Retail	75,464	2,156,271	763	305,859	417,197	142,423	3,097,977
Services	106,232	47,078	56,494	341,443	87,584	10,308	649,139
Education	34,680	–	6,262	351,354	43,966	2,534	438,795
Total	**309,899**	**2,329,438**	**63,519**	**1,051,477**	**596,476**	**180,161**	**4,530,970**

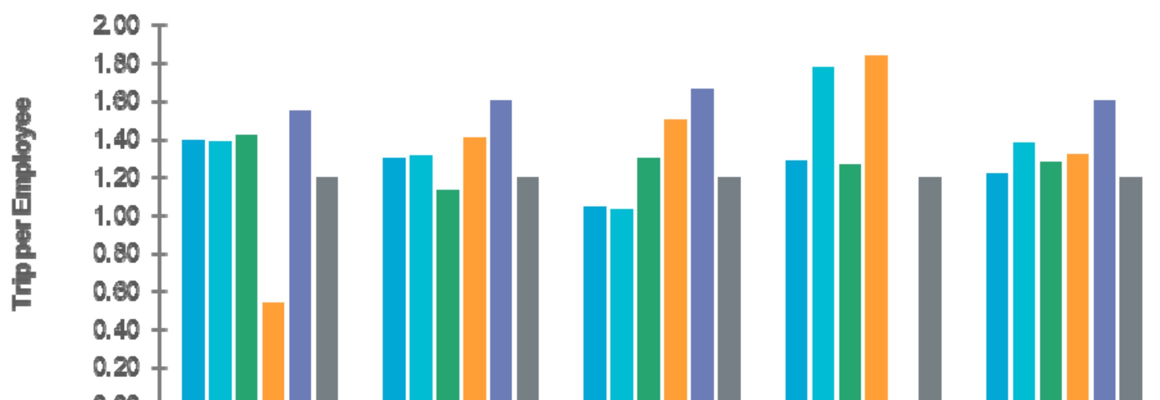
Table 4.19 Total Trip Attractions by Area Type

	Total Person Trip Attractions						
Area Type	**Home-Based Work (HBW)**	**Home-Based Non Work (HBNW) Retail**	**HBNW School**	**HBNW Other**	**Non-Home Based**	**Non Residential**	**Total**
Business District	24,811	84,707	–	89,622	66,330	16,761	282,231
Urban Intense	105,555	645,490	–	277,726	176,025	65,462	1,270,258
Urban Central	127,097	1,259,499	62,756	529,742	288,450	82,735	2,350,279
Suburban	31,179	175,659	–	69,586	38,504	4,245	319,173
Rural	21,258	164,078	763	84,799	27,169	10,956	309,023
Total	**309,900**	**2,329,433**	**63,519**	**1,051,475**	**596,478**	**180,159**	**4,530,964**

4.2.3 Comparison of Trip Attraction Rates

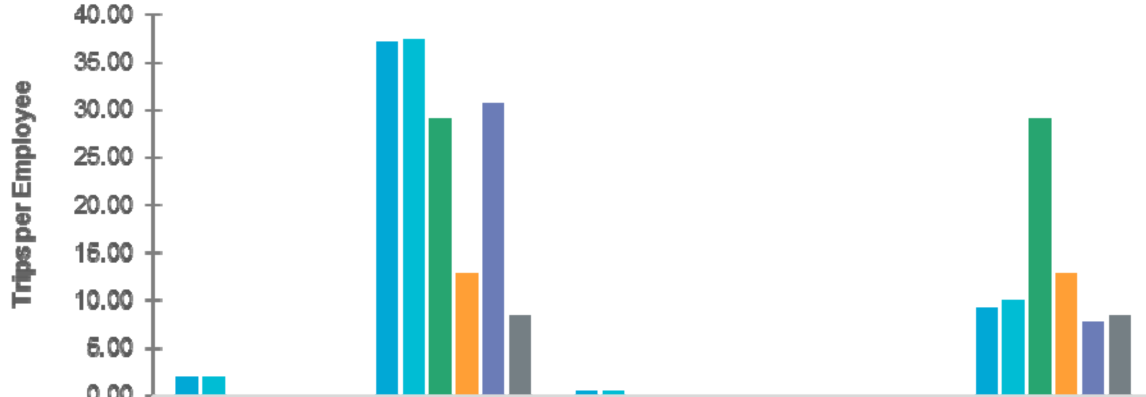
Sections 4.2.1 and 4.2.2 focused on presenting derivations and comparisons of total attractions in each classification scheme. Such comparisons are limited to a single region. Another view that can be made is to make comparisons of trip attraction rates. This view enables comparison across regions. The attraction trip rates were compared against several other sources that were deemed relevant for a reasonableness check: 1) TTI's estimates of trip attraction rates using the same 2010 Workplace Survey, 2) 2007 El Paso MPO model, 3) 2010 San Antonio MPO model, 4) 2009 TxDOT Statewide Travel Model-V3, and 5) NCHRP-716 Report. The rates were compared across different trip purposes, as shown in Figures 4.12 through 4.15.

Figure 4.12 Home-Based Work Trip Attraction Rates



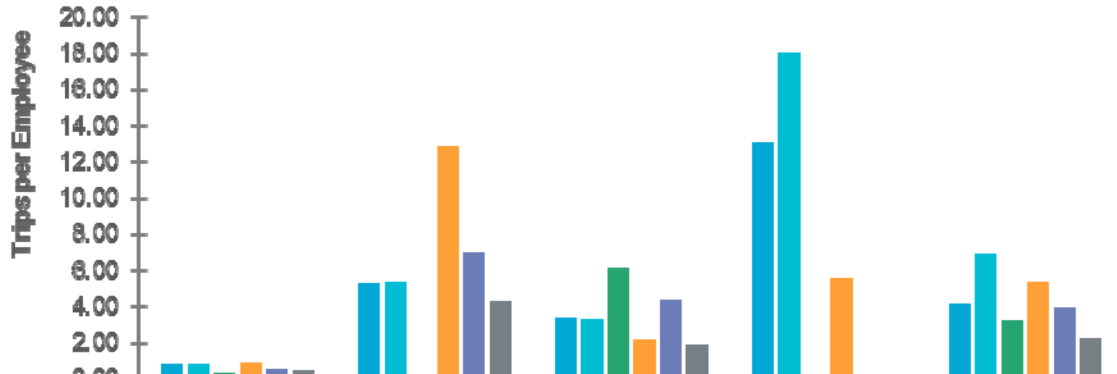
	Basic	Retail	Services	Education	Average
CS-unadjusted	1.39	1.30	1.04	1.29	1.22
TTI (smoothened)	1.39	1.31	1.03	1.78	1.38
San Antonio	1.42	1.13	1.30	1.26	1.28
TxDOT	0.54	1.41	1.50	1.84	1.32
El Paso Model	1.55	1.60	1.66	0.00	1.60
NCHRP - 716	1.20	1.20	1.20	1.20	1.20

Figure 4.13 Home-Based Non-Work (HBNW) Retail Trip Attraction Rates



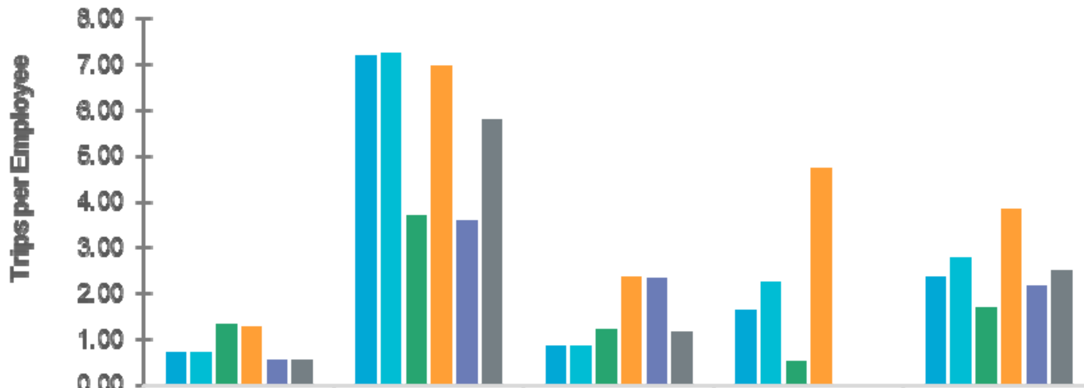
	Basic	Retail	Services	Education	Average
CS-unadjusted	1.88	37.11	0.46	0.00	9.16
TTI (smoothened)	1.87	37.44	0.46	0.00	9.94
San Antonio	0.00	29.04	0.00	0.00	29.04
TxDOT	0.00	12.81	0.00	0.00	12.81
El Paso Model	0.00	30.75	0.00	0.00	7.69
NCHRP - 716	0.00	8.40	0.00	0.00	8.40

Figure 4.14 Home-Based Non-Work (HBNW) Other Trip Attraction Rates



	Basic	Retail	Services	Education	Average
CS-unadjusted	0.79	5.28	3.36	13.06	4.13
TTI (smoothened)	0.78	5.31	3.31	18.04	6.86
San Antonio	0.30	0.00	6.11	0.00	3.21
TxDOT	0.86	12.81	2.14	5.57	5.34
El Paso Model	0.49	6.95	4.38	0.00	3.94
NCHRP - 716	0.45	4.30	1.90	0.00	2.22

Figure 4.15 Non-Home Based Trip Attraction Rates



	Basic	Retail	Services	Education	Average
CS-unadjusted	0.71	7.18	0.86	1.63	2.35
TTI (smoothened)	0.71	7.24	0.85	2.26	2.77
San Antonio	1.33	3.70	1.21	0.51	1.69
TxDOT	1.26	6.95	2.36	4.74	3.83
El Paso Model	0.55	3.58	2.32	0.00	2.15
NCHRP - 716	0.55	5.80	1.15	0.00	2.50

Overall, from the comparison charts we note that the estimated trip attractions rates (CS-unadjusted) are consistently in-line with those derived from TTI estimates. This resemblance is to be expected as the two use the same data source related to 2010 Workplace Survey. For instance, trip attraction rates related to home-based work are on an average very close to each other, with similar example also noted in non-home based trips. However, home-based nonwork retail trip rates derived from TTI are consistently higher, when compared with other sources.

4.2.4 Development of Attraction Rates by Area Type

Table 4.20 presents a summary of total attractions by purpose, employment, and area type from the expanded workplace survey database. These data and updated employment estimates stratified by area type (which do not include special generator employment), shown in Table 4.21, were used to develop trip attraction rates by employment and area type, shown in Table 4.22.

Table 4.20 Total Trip Attractions by Purpose, Employment, and Area Type

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Home-Based Work (HBW)	Business District	8,109	6,447	10,255	–	24,811
	Urban Intense	44,600	21,247	36,550	3,158	105,555
	Urban Central	21,894	35,900	43,124	26,179	127,097
	Suburban	10,812	5,568	11,307	3,493	31,180
	Rural	8,109	6,301	4,996	1,853	21,258
	Total	93,524	75,463	106,232	34,683	309,901
Home-Based Non Work (HBNW) Retail	Business District	23,003	58,731	2,973	–	84,707
	Urban Intense	39,190	603,327	2,973	–	645,490
	Urban Central	63,044	1,156,314	40,140	–	1,259,499
	Suburban	–	174,667	991	–	175,659
	Rural	852	163,226	–	–	164,078
	Total	126,089	2,156,266	47,078	–	2,329,433
HBNW School	Business District	–	–	–	–	–
	Urban Intense	–	–	–	–	–
	Urban Central	–	–	56,494	6,262	62,756
	Suburban	–	–	–	-	–
	Rural	–	763	–	–	763
	Total	–	763	56,494	6,262	63,518
HBNW Other	Business District	6,816	21,357	61,449	–	89,622
	Urban Intense	18,743	88,478	123,890	46,615	277,726
	Urban Central	5,112	126,615	123,890	274,126	529,742
	Suburban	11,927	22,119	15,362	20,177	69,586
	Rural	10,223	47,290	16,849	10,436	84,799
	Total	52,821	305,859	341,441	351,354	1,051,474
Non-Home Based	Business District	17,161	39,050	10,118	-	66,330
	Urban Intense	10,726	136,924	20,869	7,506	176,025
	Urban Central	17,698	196,735	43,634	30,383	288,450
	Suburban	1,609	25,210	6,324	5,362	38,504
	Rural	536	19,278	6,640	715	27,169
	Total	47,730	417,198	87,585	43,966	596,478
Non Residential	Business District	5,908	9,810	1,044	–	16,761
	Urban Intense	7,595	52,318	5,480	68	65,462
	Urban Central	9,705	68,304	2,740	1,986	82,735
	Suburban	1,688	1,817	261	479	4,245
	Rural	–	10,173	783	–	10,956
	Total	24,896	142,421	10,308	2,533	180,159

Table 4.21 2014 Total Employment by Sector and Area Type

Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Business District	5,642	2,937	7,111	122	15,812
Urban Intense	29,027	34,018	66,606	9,478	139,129
Urban Central	17,482	23,602	20,890	12,678	74,652
Suburban	7,558	4,071	5,876	3,220	20,725
Rural	3,794	2,498	3,299	2,360	11,951
Total	**63,503**	**67,126**	**103,782**	**27,858**	**262,269**

Table 4.22 Trip Attraction Rates by Employment and Area Type

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Home-Based Work (HBW)	Business District	1.44	2.20	1.44	-	**5.07**
	Urban Intense	1.54	0.62	0.55	0.33	**3.04**
	Urban Central	1.25	1.52	2.06	2.06	**6.90**
	Suburban	1.43	1.37	1.92	1.08	**5.81**
	Rural	2.14	2.52	1.51	0.79	**6.96**
Home-Based Non Work (HBNW) Retail	Business District	4.08	20.00	0.42	-	**24.49**
	Urban Intense	1.35	17.74	0.04	-	**19.13**
	Urban Central	3.61	48.99	1.92	-	**54.52**
	Suburban	-	42.91	0.17	-	**43.07**
	Rural	0.22	65.34	-	-	**65.57**
HBNW School	Business District	-	-	-	-	**0.00**
	Urban Intense	-	-	-	-	**0.00**
	Urban Central	-	-	2.70	0.49	**3.20**
	Suburban	-	-	-	-	**0.00**
	Rural	-	0.31	-	-	**0.31**
HBNW Other	Business District	1.21	7.27	8.64	-	**17.12**
	Urban Intense	0.65	2.60	1.86	4.92	**10.02**
	Urban Central	0.29	5.36	5.93	21.62	**33.21**
	Suburban	1.58	5.43	2.61	6.27	**15.89**
	Rural	2.69	18.93	5.11	4.42	**31.16**
Non-Home Based	Business District	3.04	13.30	1.42	-	**17.76**
	Urban Intense	0.37	4.03	0.31	0.79	**5.50**
	Urban Central	1.01	8.34	2.09	2.40	**13.83**
	Suburban	0.21	6.19	1.08	1.67	**9.15**
	Rural	0.14	7.72	2.01	0.30	**10.17**

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Non Residential	Business District	1.05	3.34	0.15	-	**4.53**
	Urban Intense	0.26	1.54	0.08	0.01	**1.89**
	Urban Central	0.56	2.89	0.13	0.16	**3.74**
	Suburban	0.22	0.45	0.04	0.15	**0.86**
	Rural	-	4.07	0.24	-	**4.31**

4.2.5 Adjustments to Attraction Rates

Following the development of trip attractions and trip attractions rates as described above, we focused on verifying and adjusting these to reflect observed conditions in the El Paso Region. Development of trip productions and trip attractions are two key components of the trip generation model. Since information used to develop trip productions is generally tied to more robust data than that used for developing trip attractions, trip attractions are normally balanced to trip productions. While balancing is done in application as well, it is beneficial to perform this as part of estimation to arrive at adjusted trip attraction rates.

Based on the trip productions estimated in the region as shown in Table 4.23, we balanced the trip attractions to match these estimates. This was done using a law of conservation, where trips were neither created nor lost in the system. That is, total productions and attractions per zone were kept equal within the travel model system.

Tables 4.24 and 4.25 present the adjusted trip attractions and rates, where trip attractions (and rates) for all the trip purposes are balanced, with the exception of non-residential trips (again, typical approach).

Table 4.23 Total Trip Productions in El Paso Study Region (Based on Adjusted Production Rates)

Trip Purpose	Total Trips
Home-Based Work	526,259
Home-Based Non Work Retail	505,866
Home-Based Non Work	560,678
Non-Home Based	783,987
Home-Based Education	1,023,154
Total	3,399,944

Table 4.24 Adjusted Total Trip Attractions in El Paso Study Region

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Home-Based Work (HBW)	Business District	10,971	8,723	13,875	-	**33,569**
	Urban Intense	60,344	28,747	49,452	4,273	**142,816**
	Urban Central	29,623	48,573	58,347	35,420	**171,962**
	Suburban	14,629	7,534	15,298	4,726	**42,187**
	Rural	10,971	8,525	6,760	2,507	**28,762**
	Total	126,538	102,101	143,732	46,926	**419,296**
Home-Based Non Work (HBNW) Retail	Business District	3,225	8,234	417	-	**11,876**
	Urban Intense	5,494	84,586	417	-	**90,498**
	Urban Central	8,839	162,115	5,628	-	**176,582**
	Suburban	-	24,488	139	-	**24,627**
	Rural	119	22,884	-	-	**23,004**
	Total	17,678	302,308	6,600	-	**326,587**
HBNW School	Business District	-	-	-	-	**-**
	Urban Intense	-	-	-	-	**-**
	Urban Central	-	-	602,565	66,790	**669,355**
	Suburban	-	-	-	-	**-**
	Rural	-	8,138	-	-	**8,138**
	Total	-	8,138	602,565	66,790	**677,483**
HBNW Other	Business District	2,806	8,793	25,299	-	**36,897**
	Urban Intense	7,716	36,426	51,006	19,191	**114,340**
	Urban Central	2,105	52,127	51,006	112,858	**218,095**
	Suburban	4,910	9,106	6,325	8,307	**28,649**
	Rural	4,209	19,469	6,937	4,297	**34,912**
	Total	21,746	125,922	140,571	144,652	**432,892**
Non-Home Based	Business District	17,847	40,612	10,523	-	**68,983**
	Urban Intense	11,155	142,401	21,704	7,806	**183,066**
	Urban Central	18,406	204,604	45,379	31,598	**299,988**
	Suburban	1,673	26,218	6,577	5,576	**40,044**
	Rural	557	20,049	6,906	744	**28,256**
	Total	49,639	433,886	91,088	45,725	**620,337**
Non Residential	Business District	5,908	9,810	1,044	-	**16,761**
	Urban Intense	7,595	52,318	5,480	68	**65,462**
	Urban Central	9,705	68,304	2,740	1,986	**82,735**
	Suburban	1,688	1,817	261	479	**4,245**
	Rural	-	10,173	783	-	**10,956**
	Total	24,896	142,421	10,308	2,533	**180,159**

Table 4.25 Adjusted Trip Attraction Rates in El Paso Study Region

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment	Total
Home-Based Work (HBW)	Business District	1.49	1.64	0.68	-	**3.81**
	Urban Intense	2.38	1.19	1.32	1.27	**6.16**
	Urban Central	1.36	2.23	2.12	2.82	**8.53**
	Suburban	2.25	2.51	2.16	1.39	**8.31**
	Rural	2.91	6.93	1.19	1.08	**12.11**
Home-Based Non Work (HBNW) Retail	Business District	-	1.93	-	-	**-**
	Urban Intense	-	3.55	-	-	**-**
	Urban Central	-	5.71	-	-	**-**
	Suburban	-	7.87	-	-	**-**
	Rural	-	8.03	-	-	**-**
HBNW School	Business District	-	-	-	-	**-**
	Urban Intense	-	-	-	-	**-**
	Urban Central	-	-	-	-	**-**
	Suburban	-	-	-	-	**-**
	Rural	-	-	-	-	**-**
HBNW Other	Business District	0.38	1.66	1.23	-	**1.93**
	Urban Intense	0.30	1.49	1.37	5.70	**3.55**
	Urban Central	0.09	2.38	1.86	8.94	**5.71**
	Suburban	0.75	3.04	0.89	2.44	**7.87**
	Rural	1.11	3.72	1.22	1.85	**8.03**
Non-Home Based	Business District	2.42	7.66	0.51	2.33	**3.28**
	Urban Intense	0.45	5.83	0.58	2.33	**8.86**
	Urban Central	0.45	5.83	0.58	2.33	**13.28**
	Suburban	0.45	5.83	0.58	2.33	**7.12**
	Rural	0.45	5.83	0.58	2.33	**7.90**
Non Residential	Business District	0.77	1.78	0.05	-	**2.60**
	Urban Intense	0.29	2.06	0.14	0.02	**2.51**
	Urban Central	0.43	3	0.1	0.15	**3.68**
	Suburban	0.25	0.58	0.04	0.14	**1.00**
	Rural	-	7.94	0.13	-	**8.07**

4.2.6 Recommended Attraction Rates

After reviewing the above adjusted attraction rates, the following recommendations were made based on reasonableness checks:

- There were no observations in the workplace survey to compute a HBW rate for education employment in the business district. We recommended using the “urban intense” rate of 1.22 in the model since it is the closest area type for which data were available.

- We eliminated retail trip attraction rates for basic and service employment to create consistency between employment type and trip purposes in the trip generation framework. While there were some observations related to retail trips being attracted to basic and service employment in the calibration data, it was seen as being more useful for planning purposes to tie attractions for retail trip purposes to retail employment.

- The lack of survey observations for school trips led us to calculate rates only for “urban central” locations, but the model needs rates across area types. Therefore, for school trips, we used the TTI derived rates which were based on their professional judgment of school trips in the region.

- For NHB and non-residential trips, missing trip rates were substituted directly from the adjacent area type for that particular employment type.

The resulting recommended rates are shown in Table 4.26. These are presented preceding further changes developed through the calibration and validation process described in Chapter 12 of this report.

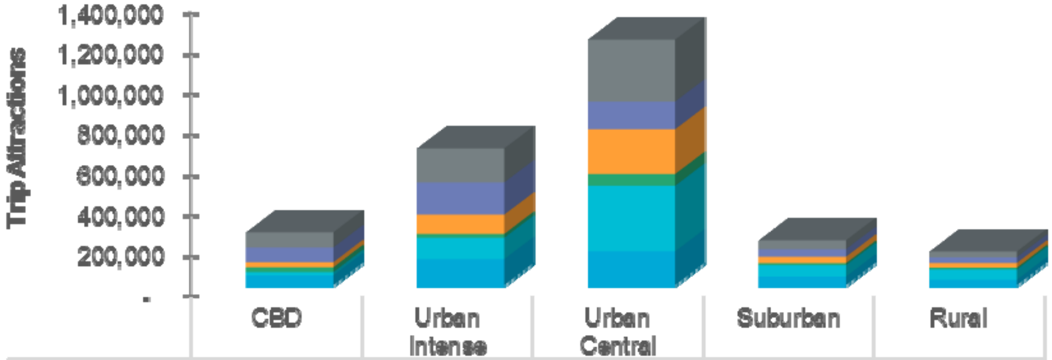
Table 4.26 Recommended Trip Attraction Rates

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment
Home-Based Work (HBW)	Business District	1.43	1.58	0.65	1.20
	Urban Intense	2.29	1.14	1.27	1.22
	Urban Central	1.31	2.14	2.04	2.71
	Suburban	2.16	2.41	2.08	1.34
	Rural	2.80	6.66	1.14	1.04
Home-Based Non Work (HBNW) Retail	Business District		1.49		
	Urban Intense		3.33		
	Urban Central		7.12		
	Suburban		7.85		
	Rural		17.86		
HBNW School	Business District				8.00
	Urban Intense				6.00
	Urban Central				4.72
	Suburban				3.80
	Rural				3.70
HBNW Other	Business District	0.37		1.18	
	Urban Intense	0.29		1.32	
	Urban Central	0.09		1.79	
	Suburban	0.72		0.86	
	Rural	1.07		1.17	
Non-Home Based	Business District	2.33	7.37	0.49	2.24
	Urban Intense	0.43	5.61	0.56	2.24
	Urban Central	0.82	8.99	1.59	2.41
	Suburban	0.25	8.40	0.89	1.57
	Rural	0.15	15.65	1.16	0.31
Non Residential	Business District	0.77	1.78	0.05	0.02
	Urban Intense	0.29	2.06	0.14	0.02
	Urban Central	0.43	3.00	0.1	0.15
	Suburban	0.25	0.58	0.04	0.14
	Rural	0.25	7.94	0.13	0.14

4.2.7 Summary of Attractions by Purpose, Area Type and District

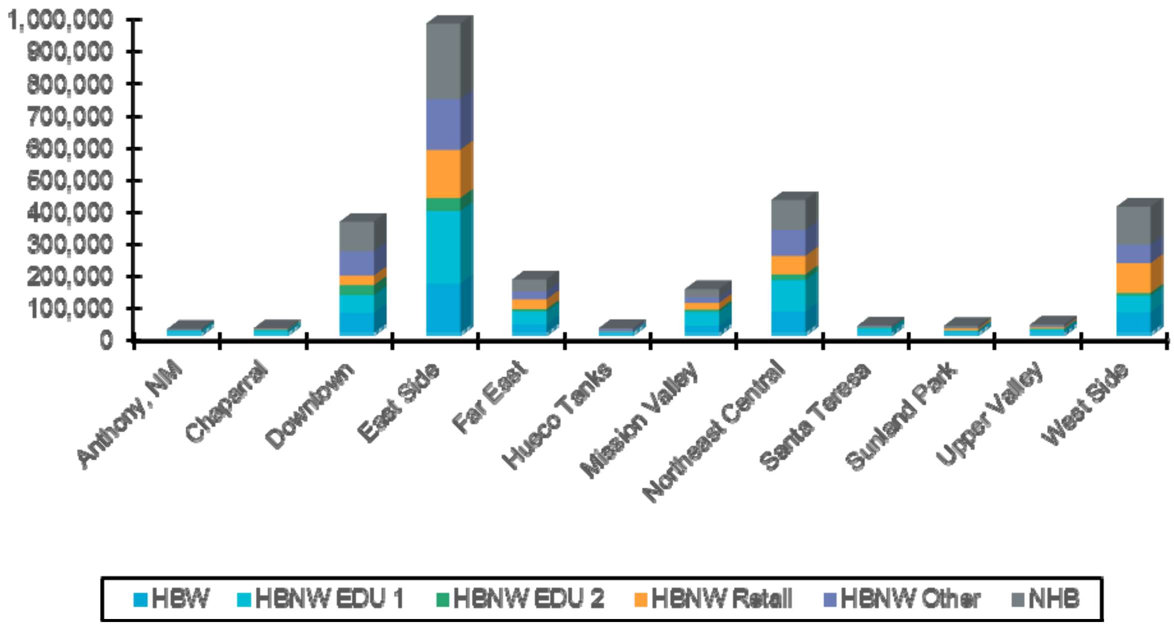
In order to examine trip attractions in more detail, a summary of trips by area type and district were produced. Figures 4.16 and 4.17 present trip attractions by area type and district, respectively. The summaries are in line with the corresponding distribution of employment by area type and district.

Figure 4.16 Trip Attractions by Area Type



	CBD	Urban Intense	Urban Central	Suburban	Rural
NHB	74,724	167,676	305,618	44,053	28,312
HBNW Other	72,446	158,784	136,368	37,140	28,225
HBNW Retail	25,128	95,295	220,946	31,498	22,845
HBNW EDU 2	23,723	18,782	57,679	10,016	9,094
HBNW EDU 1	16,943	105,450	323,781	56,212	51,049
HBW	49,305	129,890	168,158	43,895	28,190

Figure 4.17 Trip Attractions by District



4.3 Special Generators

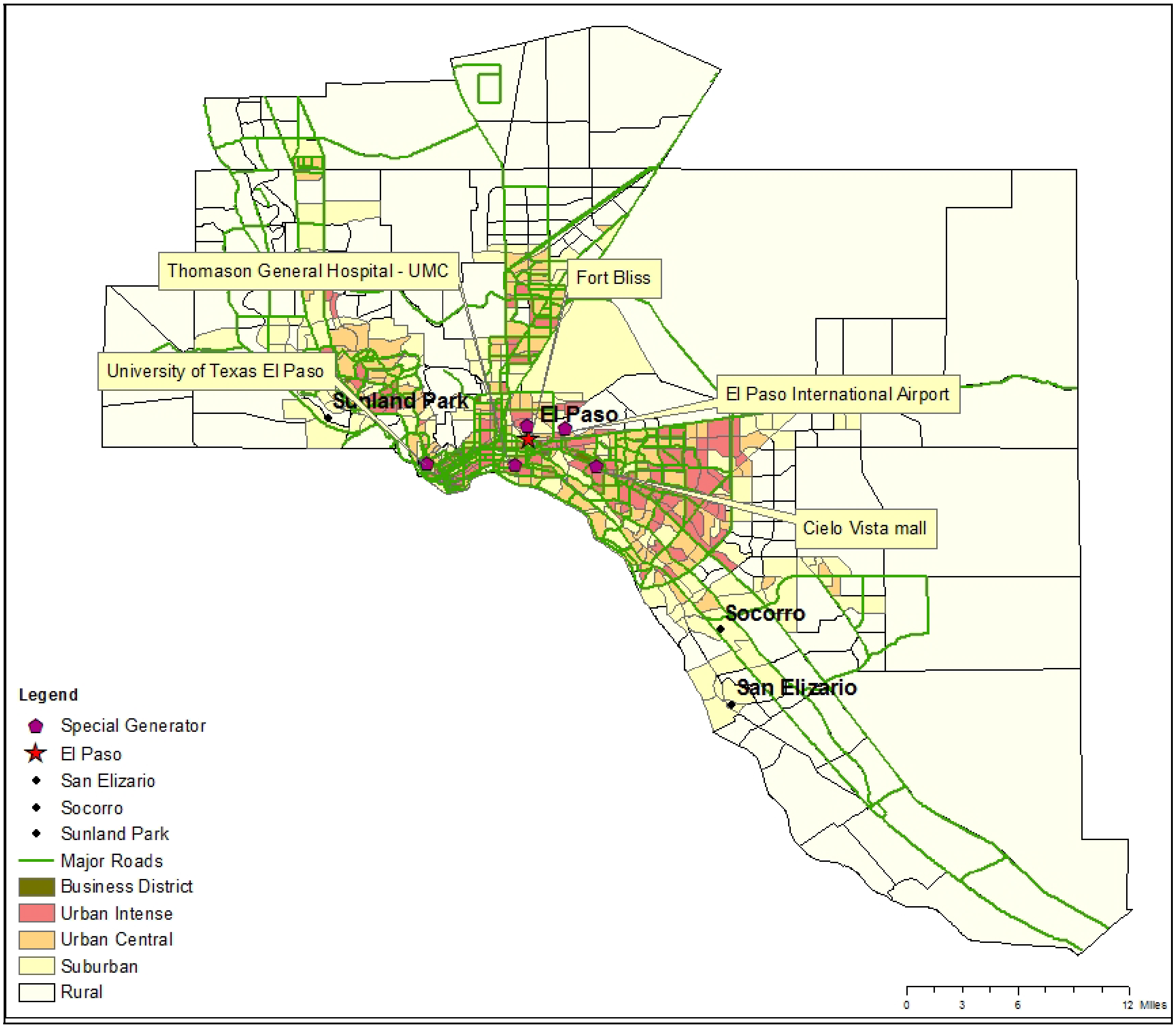
Special generators are defined as establishments that generate a disproportionate amount of trips compared to the underlying employment. As a result, regular household travel or workplace surveys do not capture travel to and from these sites. Some typical special generators that are included in travel demand models are large shopping centers, hospitals, colleges/universities, recreational facilities, military bases, airports, and other developments that have unique trip generation characteristics.

The travel associated with special generators are captured through special generator surveys using a similar methodology as the workplace surveys. TxDOT conducted such surveys in 2010 at five different special generators in the region. Specifically, data were collected at El Paso International Airport, Thomason General Hospital-UMC, Cielo Vista Mall, University of Texas at El Paso (UTEP), and Fort Bliss. The survey involved a recruit survey, followed by an intercept survey of employees and visitors, person and/or vehicle counts, and commercial vehicle counts. Figure 4.18 shows the location of these special generators in the MPO region.

TTI's analyses of these special generator surveys were reviewed and adopted as a starting point for this model. The data were used to develop trip rates for a number of other special generators as shown below:

- Education
  - Colleges in every district
- Basic
  - Fort Bliss is a mixed use development
- Retail
  - Sunland Park
  - Cielo Vista
  - Bassett Place
- Service
  - Hospitals, Clinics, Health centers
  - Airport

Figure 4.18 Location of Special Generators



Source: 2010 El Paso Workplace Survey Technical Summary, TTI, 2013.

The final special generator trip generation rates were derived through a process of making several rounds of adjustments until they produced total attractions that closely matched the estimated trips derived from TTI's analysis of individual special generator surveys. Table 4.27 shows the final special generator trip rates by special generator and trip purpose fed into the model calibration and validation work. HBNW ED1 and ED2 trips are addressed via the standard trip production and trip attraction models. All of the special generator commercial vehicle trips are assumed to be made by medium trucks since there was no detailed breakdown available to use.

Table 4.27 Special Generator Trip Rates

Final Rates	HBW	HBNW ED1	HBNW ED2	HBNW Retail	HBNW Other	NHB	Light Truck	Medium Truck	Heavy Truck	Non-Res	Total
Airport	1.10	-	-	-	24.10	1.58	-	1.30	-	4.86	**32.94**
Fort Bliss	0.65	-	-	-	7.35	0.67	-	0.33	-	0.37	**9.36**
UT El Paso	1.32	-	-	-	9.11	0.66	-	0.64	-	0.37	**12.10**
Other Colleges	3.14	-	-	-	4.03	1.44	-	0.64	-	0.36	**9.60**
Thomason	0.92	-	-	-	6.07	0.29	-	0.18	-	0.07	**7.54**
Other Hospitals	1.28	-	-	-	1.64	0.92	-	0.39	-	0.20	**4.43**
Shopping Mall	0.54	-	-	7.70	-	1.30	-	0.13	-	0.83	**10.50**

Table 4.28 presents special generator trips by employment type and district. Special generator trips associated with education employment are distributed across all the districts because these institutions are located throughout the region. Special generator trips associated with retail employment are derived from the locations where there are major shopping centers. Special generators associated with service employment are spread over a few districts including Northeast Central, location of the El Paso international airport.

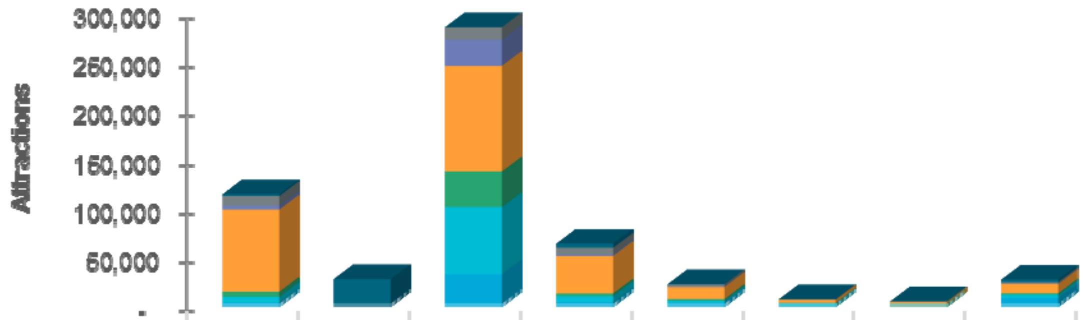
Table 4.28 Special Generator Trips by District and Employment Type

District	Education	Basic	Retail	Service
Anthony, NM	294	-	-	-
Chaparral	436	-	-	-
Downtown	5,900	-	-	4,346
East Side	8,732	-	2,420	7,038
Far East	2,014	-	-	-
Hueco Tanks	94	5,400	-	-
Mission Valley	2,143	-	-	-
Northeast Central	4,371	39,314	4,003	17,023
Santa Teresa	670	-	-	56
Sunland Park	253	-	-	-
Upper Valley	419	-	-	-
West Side	2,404	-	919	-
Total	**27,730**	**44,714**	**7,342**	**28,462**

Figure 4.19 shows the distribution of special generator trips by trip purpose and special generator. The home-based nonwork retail trips represent all the malls in the region, while home-based work trips are

generated from all special generators owing to the presence of employment at these establishments. Most of the airport trips are home-based nonwork other-indicating trips that correspond to departing and arriving air passengers. The trucks are further split into light, medium and heavy based on the regional splits of trucks trips. The non-resident trip purpose reflects travel from Juarez. Student travel across the border is captured in the special generator figures for this trip purpose relating to trips to/from UTEP and other colleges.

Figure 4.19 Special Generator Trip Summary by Purpose



	HBW	HBNW Retail	HBNW Other	NHB	LTrk	MTrk	HTrk	Non-Res
Shopping Mall	1,785	25,696	-	4,335	313	78	44	2,775
Other Hospitals	9,845	-	12,616	7,076	2,155	534	303	1,539
Thomason	4,068	-	28,870	1,293	588	146	83	325
Other Colleges	83,977	-	107,972	38,389	12,265	3,039	1,728	9,597
UTEP	5,281	-	36,365	2,634	1,831	454	258	1,475
Fort Bliss	6,138	-	68,873	6,306	2,201	545	310	3,481
Airport	1,389	-	30,516	1,998	1,186	294	167	6,150

4.4 External Model

The external travel model was developed using a combination of external station counts and the Texas Statewide Analysis Model (SAM-V3). The last external travel survey in the region was conducted in 2002. Therefore, information from recent counts and the SAM-V3 were deemed the most appropriate sources for updating external trips coming into, going out of, and passing through the MPO region. These data address observed differences between travel across international and domestic external stations. Figure 4.20 depicts the locations of these external stations along the periphery of the modeling region.

Table 4.29 shows external station data for each base year external station: percentage of count that is E-E automobile traffic; percentage of count that is E-E truck traffic, average daily traffic count (ADT), and percent of count that is truck traffic. Since data sources vary, there can be some anomalies encountered.

Figure 4.20 External Stations around the MPO Region

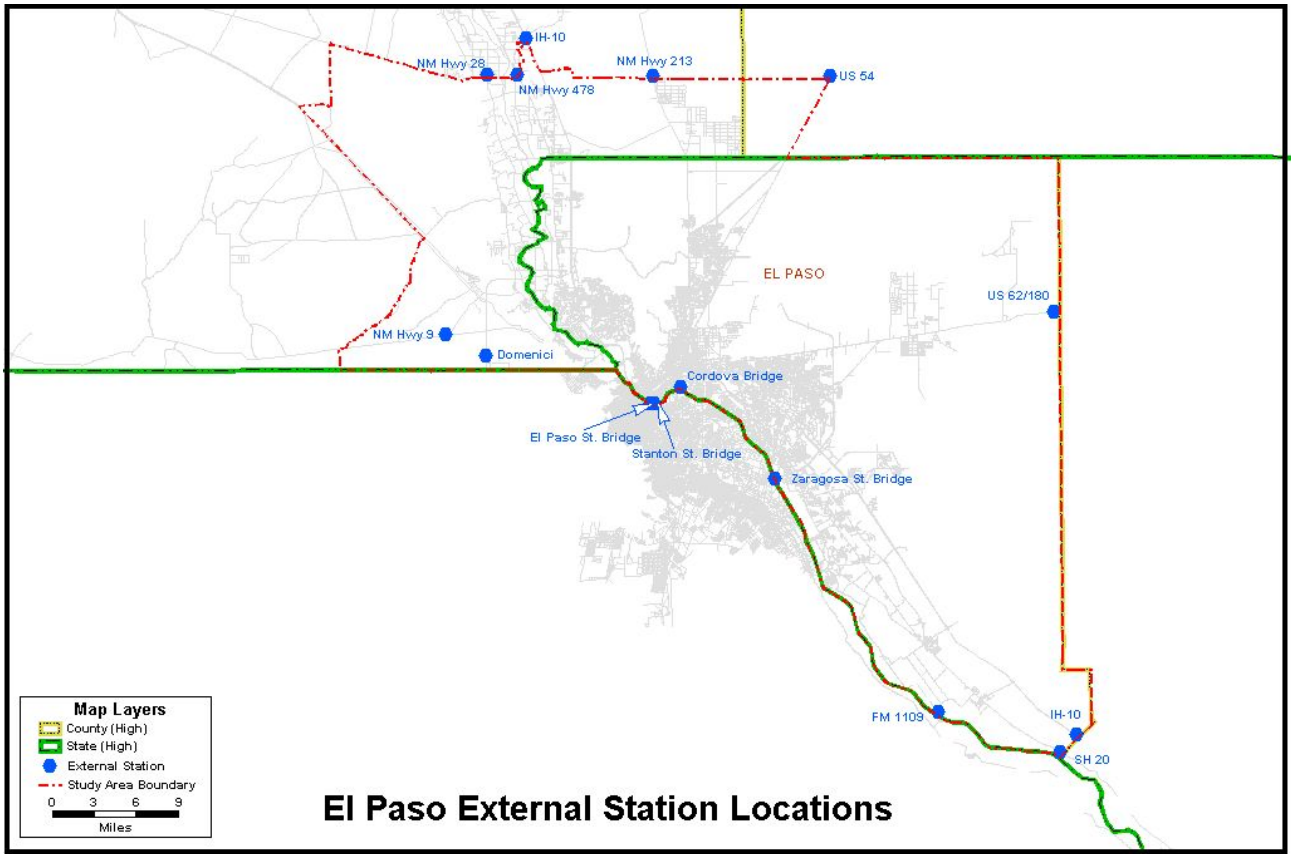


Table 4.29 External Station Data

EP_ID	Location	Percent Auto E-E	Percent Truck E-E	ADT	Truck Percent
849	Route 62/180	5.1%	11.1%	2,300	30%
850	I-10 South	23.7%	29.6%	15,760	13%
851	Route 20	3.5%	0.0%	530	22%
852	Caseta	3.5%	0.0%	1,210	0%
854	Ysleta/Zaragoza	3.3%	6.3%	19,123	7%
856	BOTA - Trucks	0.0%	0.9%	2,018	100%
857	BOTA - Autos	1.6%	0.0%	22,517	0%
858	Stanton	0.0%	0.0%	3,821	0%
859	Paso Del Norte	1.7%	0.0%	6,656	0%
862	Santa Theresa	20.3%	7.7%	4,638	52%
863	A003	0.0%	0.0%	420	2%
864	A020	0.0%	55.6%	200	20%
865	Route 28	1.0%	0.0%	2,370	12%
866	Route 478	0.4%	12.6%	4,120	14%
867	I-10 North	15.4%	22.8%	20,340	36%
868	Route 213	2.0%	0.0%	3,320	11%
869	Route 54	3.7%	1.8%	4,900	33%
	Survey Data				
	Count				
	Estimated				

A series of steps were undertaken to use the available data to develop external trip tables for auto passenger vehicles and trucks. These are as follows:

- Obtained classified traffic counts at each external station location from a variety of sources accessible to the MPO, TxDOT and NMDOT.
- Split the external station traffic volumes into through trips and trips with a trip-end at an internal TAZ (E-I trips). The splits were based on ratio of through trips from the last external survey for the MPO area at each external station location.
- Developed E-E trip tables or through trip tables for both autos and trucks by combining the distribution patterns from the SAM-V3 model with the E-E trip portion of the counts at each external station.
- Estimated external trip attractions (E-I) by subtracting the E-E trip-ends from the total counts at each external station location.
- Estimated external trip productions (I-E) by using trip rates from the external survey data.
- Balanced I-E trip productions to the observed E-I trip attractions.
- Distributed external trips using ATOM2 for both auto and truck external trips with one trip-end at an internal TAZ.

5.0 Trip Distribution

This chapter describes the trip distribution model put into place for the 2012 El Paso MPO model. The methodology uses ATOM2, the model that is widely used for trip distribution in Texas MPO models. In addition to providing an overview of ATOM2, this chapter also discusses the inputs used for ATOM2 and some of the interim results from the model including trip summaries at the district level. (Chapter 12 of this report is devoted to the 2012 El Paso MPO Model calibration and validation).

5.1 ATOM2

The original Texas Spatially Disaggregate Trip Distribution Model, also known as the Atomistic model, was formulated, implemented, and tested by TTI in the mid-1970s under a study sponsored by TxDOT. The basic concept of the Atomistic model is similar to that of a gravity model. However, unlike a gravity model, the Atomistic model considers travel opportunities to be spatially distributed within a zone rather than concentrated at the zone's centroid. That is, the trips between two zones do not always happen at a constant travel time but rather at a range of estimated times.

For example, if the centroid-to-centroid travel time is 15 minutes between two zones of radii two and four minutes, the trips between the two zones would occur over a range of travel times from approximately 9 (=15-(2+4)) to 21 (=15+(2+4)) minutes. These travel times are estimated in an iterative process, initially estimating the relative attraction factors, and then the relative trip length frequency factors.

The ATOM2 users' manual developed by TTI describes an iteration as the application of the Atomistic model to estimate the region's trip table for the trip purpose being modeled. After each iteration, the desired and resulting attractions are compared and used to estimate the attraction factors for the next iteration. Similarly, the resulting Atomistic trip length frequency from the preceding iteration is compared with the desired trip length frequency and used to estimate the relative trip length frequency factors (i.e., friction factors) for the next iteration.

ATOM2 needs following input files:

1. Trip length frequency distribution for each purpose. This is developed from survey.
2. A bias file for each purpose similar to K-factor file. This is set to 1.
3. Friction factor distribution for each purpose. This is developed using gamma distribution as follows:

$$f(d_{ij}) = \partial \times d_{ij}^{-b} \times e^{-c \times d_{ij}}$$

Where:

$f(d_{ij})$ = Friction factor for zone pair i,j

d_{ij} = Impedance (i.e., travel time) between zones i and j

∂, b, c = Calibration parameters

For this project, CS adapted the TTI TransCAD procedures for using ATOM2 to handle 6 trip purposes with 5 income categories. The ATOM2 trip distribution was then run within TransCAD interface for all purposes.

The average trip length, coincidence ratio and trip length distribution from model were compared against the survey during the calibration process.

5.2 District to District Trip Distribution

In order to ensure that trips are being distributed between the right groups of zones, the distribution patterns of trips were first examined spatially and aggregated to districts. This exercise helped to determine if the trip distribution models were over or under representing trips in certain geographic areas. Figure 5.1 shows the district map that was used for this summary.

Figure 5.1 District Map

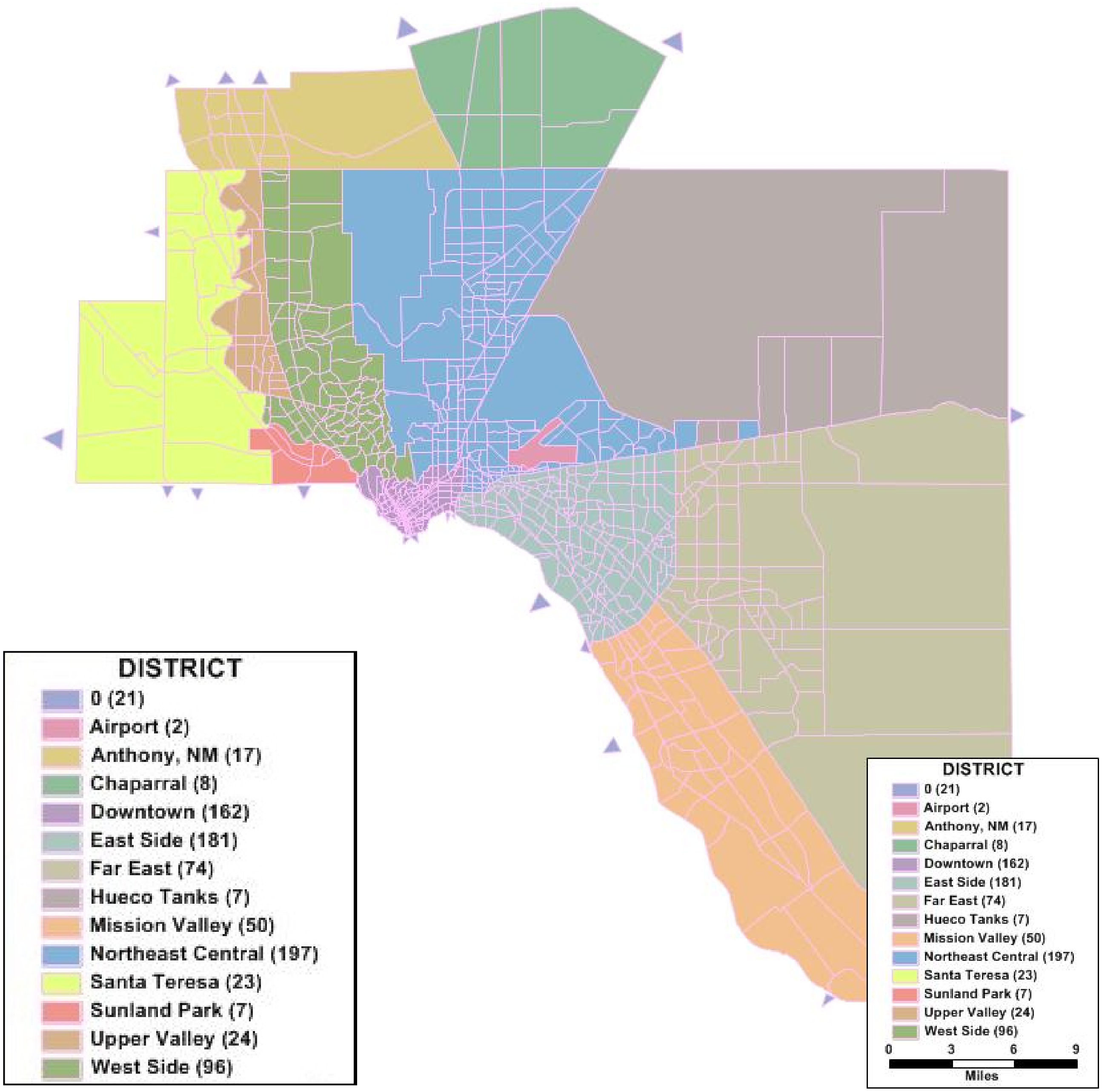
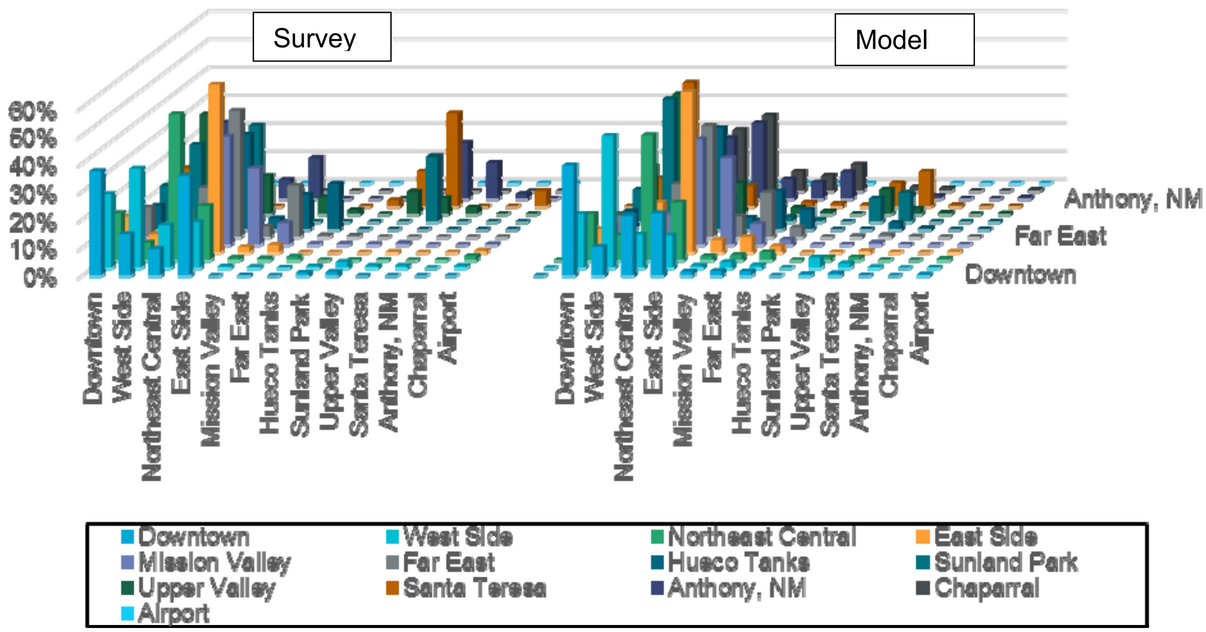


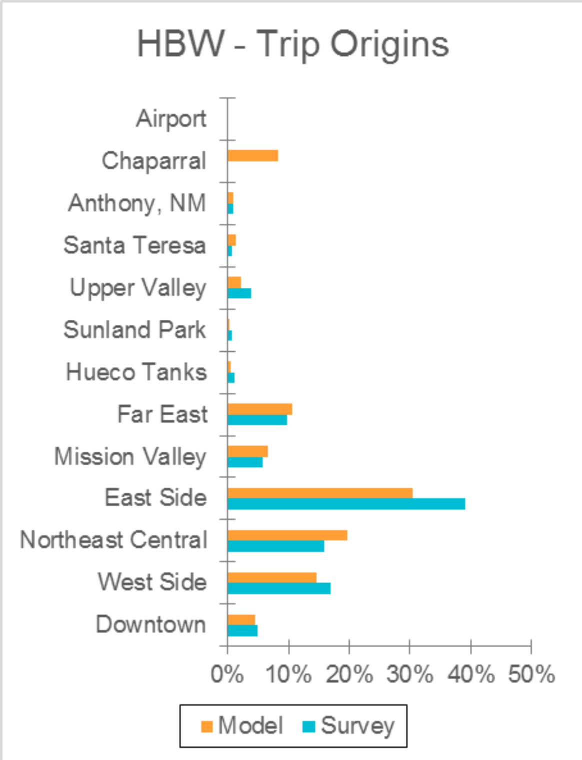
Figure 5.2 depicts the comparison of modeled shares of trips by district against the expanded survey. The bars on this chart indicate that the pre-calibration model compared reasonably well with the survey percentages.

Figure 5.2 Trips by District – Model versus Survey



Figures 5.3, 5.4, and 5.5 present the number of origins and destination by district for the trip purposes of home-based work, home-based nonwork, and non-home based, respectively. The top three work destinations include East Side, Northeast Central and Downtown regions of the MPO area. The districts West Side, Far East, and Mission Valley contribute to a lot of non-work trip origins. There are a very few origins and destinations in the four districts of the New Mexico side of the MPO region due to their relatively low population and employment.

Figure 5.3 Home-Based Work – Trip Origins and Destinations



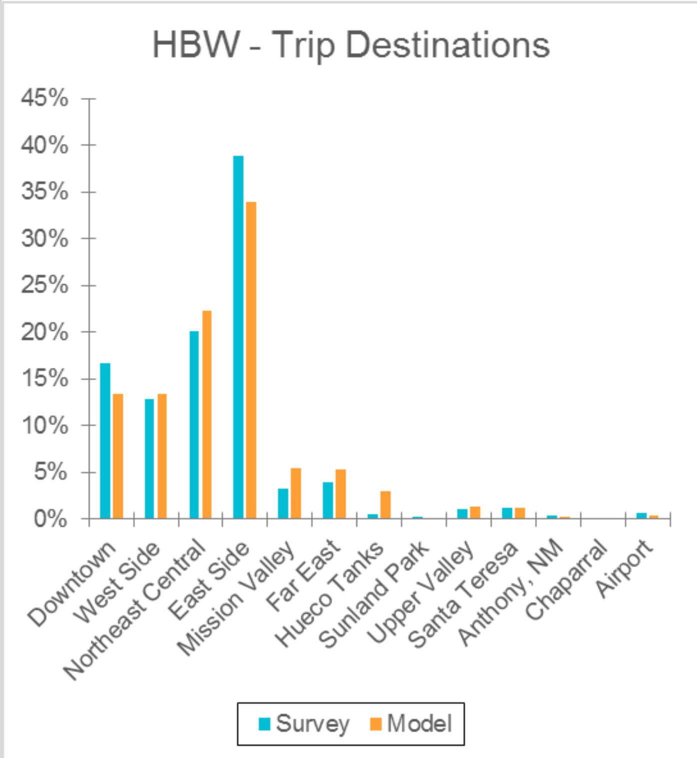
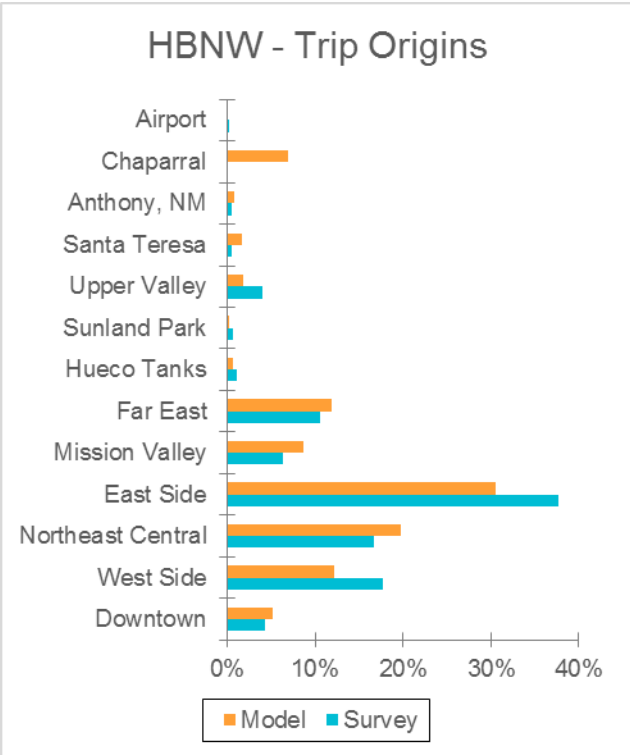


Figure 5.4 Home-Based Non Work – Trip Origins and Destinations



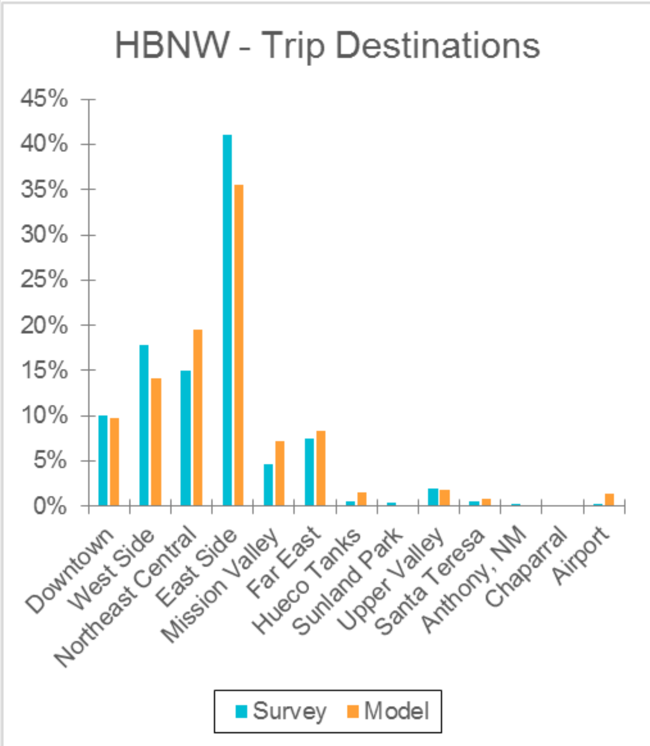
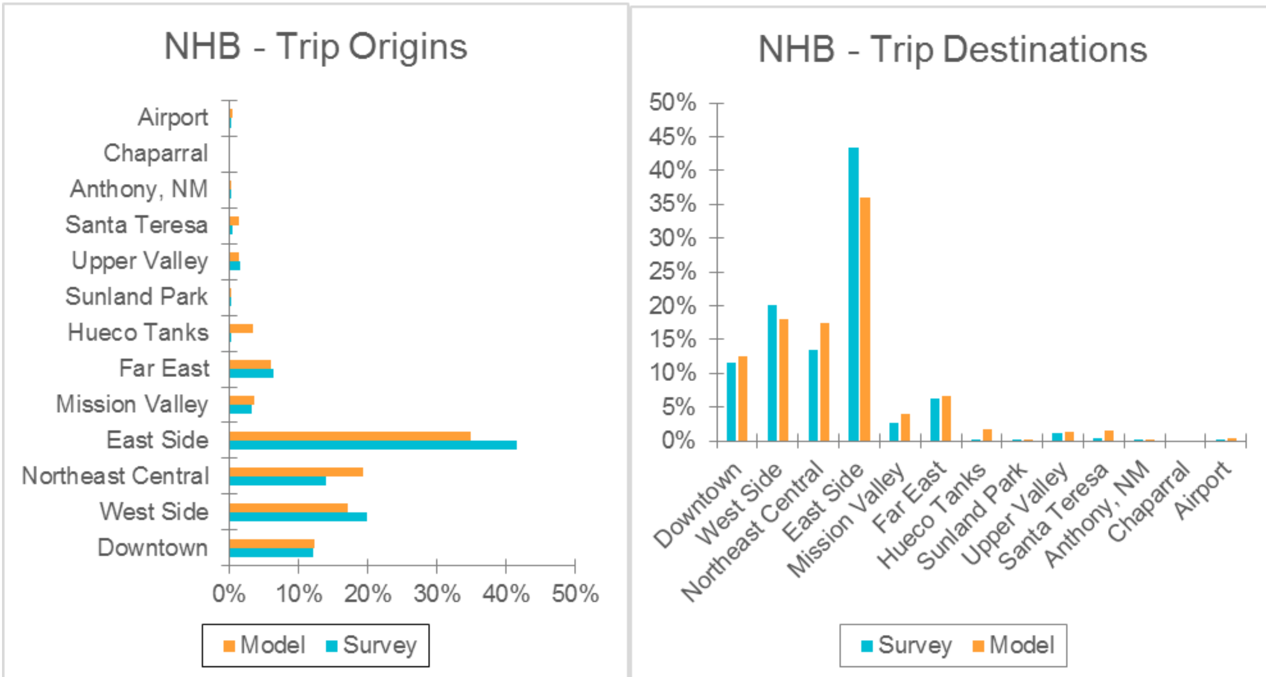


Figure 5.5 Non-Home-Based – Trip Origins and Destinations

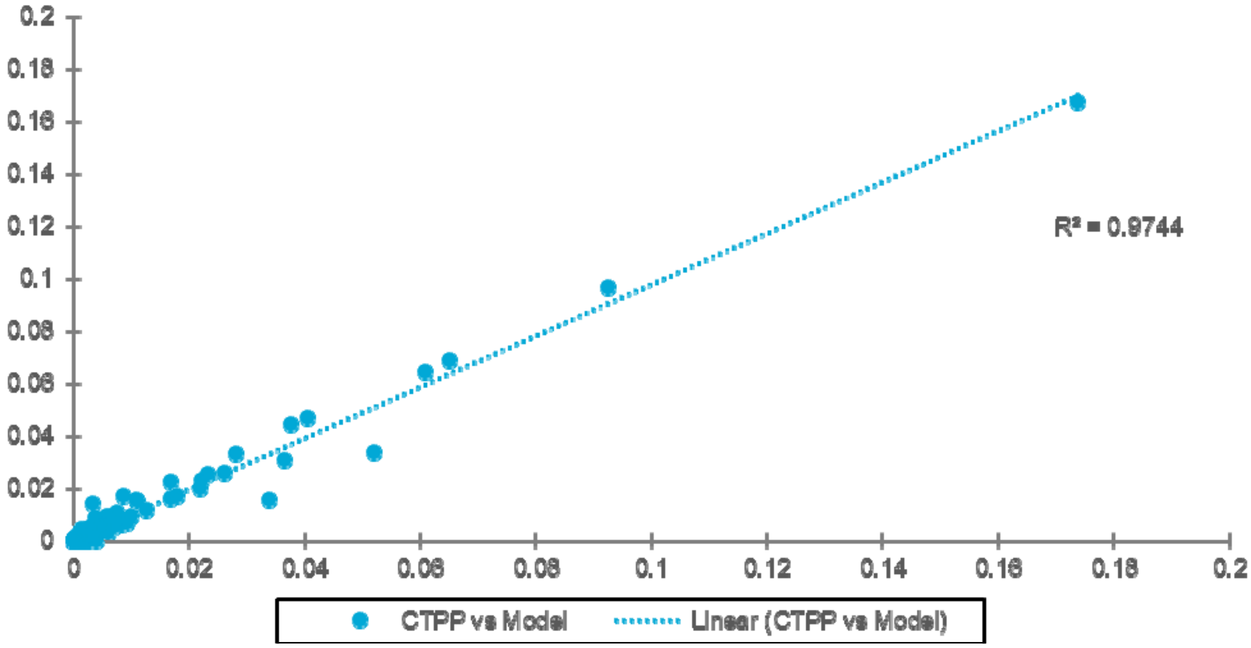


In addition to calibrating the distribution model to survey data, the HBW trip distributions were compared against the Census Transportation Planning Products journey to work data (CTPP 2010). Trip origin and destination shares were derived by district type from the CTPP 2010 and compared against the modeled trips. This comparison is shown in Table 5.1 below. The same information is also presented in Figure 5.6 in the form of a scatterplot.

Table 5.1 Home-Based Work Trip Origins and Destinations – Model versus CTPP

District	CTPP O's	Model O's	CTPP D's	Model D's
Downtown	5%	5%	16%	14%
West Side	16%	16%	16%	14%
Northeast Central	20%	18%	22%	22%
East Side	36%	33%	32%	33%
Mission Valley	7%	7%	4%	5%
Far East	10%	13%	3%	5%
Hueco Tanks	1%	1%	1%	3%
Sunland Park	1%	2%	1%	1%
Upper Valley	2%	2%	1%	1%
Santa Teresa	1%	1%	1%	1%
Anthony, NM	1%	1%	0%	1%
Chaparral	1%	1%	1%	0%
Airport	0%	0%	1%	0%

Figure 5.6 Home-Based Work Trips by District – Model versus CTPP



6.0 Vehicle Availability Model

This chapter describes the vehicle availability model, the dataset used for estimating this model, and a description of the estimated coefficients.

6.1 Estimation Dataset

The model update plan called for using the 2010/2011 Household Travel Survey as the estimation data set for the vehicle availability model. A summary of vehicle availability by household size statistics for this data set are given in Table 6.1. Table 6.2 shows the number of records, expanded records, and share of expanded records by income category and vehicle availability. Differences in totals between the tables are due to absence of responses on some records. Note that the majority of households in the lowest income group (< $20K) have fewer than two vehicles available while the majority of households in all other income groups have at least two vehicles available.

Distinct household records, including number of workers per household, were extracted from the household travel survey so that each surveyed household is represented once in the data set. The number of workers in the household is a significant explanatory variable for vehicle availability because work trips are typically made regularly and tie up a car for the day. Accessibility and other attribute data were then attached to the records (the development of these attribute data is described in Section 6.2, below). Finally, the observations were expanded according to the expansion factor from the household survey.

Table 6.1 Summary of Vehicle Availability by HH Size

	Unexpanded (Survey)						Expanded					
	Vehicle Available							Vehicle Available				
HH Size	**0**	**1**	**2**	**3**	**4+**	**Total**	**HH Size**	**0**	**1**	**2**	**3**	**4+**	Total
1	41	273	81	15	2	412	1	7,565	33,643	7,663	1,278	187	50,336
2	17	208	419	85	20	749	2	1,369	16,448	35,411	7,561	2,002	62,791
3	10	107	303	190	41	651	3	645	6,619	21,156	14,042	3,077	45,538
4+	12	145	535	284	171	1,147	4+	1,254	11,094	41,071	23,632	14,507	91,558
Total	80	733	1,338	574	234	2,959	Total	10,833	67,804	105,301	46,513	19,773	250,223
HH Size	**0**	**1**	**2**	**3**	**4+**	**Total**	**HH Size**	**0**	**1**	**2**	**3**	**4+**	**Total**
1	10%	66%	20%	4%	0%	100%	1	15%	67%	15%	3%	0%	100%
2	2%	28%	56%	11%	3%	100%	2	2%	26%	56%	12%	3%	100%
3	2%	16%	47%	29%	6%	100%	3	1%	15%	46%	31%	7%	100%
4+	1%	13%	47%	25%	15%	100%	4+	1%	12%	45%	26%	16%	100%
Total	3%	25%	45%	19%	8%	100%	Total	4%	27%	42%	19%	8%	100%

Source: 2010/2011 Household Travel Survey

Table 6.2 Survey Summary of Household Vehicles by Income

	Household Vehicles					
Income	**0**	**1**	**2**	**3**	**4**	**Total**
Household Survey Records						
$0 to $19,999	45	199	161	45	13	**463**
$20,000 to $34,999	22	185	214	49	17	**487**
$35,000 to $49,999	10	165	298	112	48	**633**
$50,000 to $74,999	1	129	347	164	60	**701**
$75,000+	5	55	268	189	91	**608**
Total	83	733	1,288	559	229	**2,892**
Expanded Survey Records						
$0 to $19,999	5,434	20,633	12,282	2,864	916	**42,130**
$20,000 to $34,999	1,757	14,430	17,388	4,177	1,271	**39,023**
$35,000 to $49,999	800	12,121	20,950	7,657	3,308	**44,836**
$50,000 to $74,999	101	8,671	24,593	13,812	5,329	**52,507**
$75,000+	138	3,554	21,623	16,493	8,182	**49,990**
Total	8,231	59,409	96,836	45,004	19,006	**228,486**
Vehicle Availability Share by Income of Expanded Records						
$0 to $19,999	13%	49%	29%	7%	2%	**100%**
$20,000 to $34,999	5%	37%	45%	11%	3%	**100%**
$35,000 to $49,999	2%	27%	47%	17%	7%	**100%**
$50,000 to $74,999	0%	17%	47%	26%	10%	**100%**
$75,000+	0%	7%	43%	33%	16%	**100%**
Total	4%	26%	42%	20%	8%	**100%**

Source: 2010/2011 Household Travel Survey

6.2 Model Structure

The vehicle availability model was developed as a discrete choice model with five alternatives:

- 0-vehicles available;
- 1-vehicle available;
- 2-vehicles available;
- 3-vehicles available; and
- 4-vehicles or more available.

Because the dependent variable (vehicles) demonstrates a natural ordering, the ordered logit (ORL) model form was chosen to model the choice. The ORL is specifically suited for choice contexts where the alternatives follow a natural ordering. The ORL assumes a single latent function (modeled as a linear function of explanatory variables), which measures the propensity for a household to own more or less vehicles. The higher the latent variable for a specific household, the more likely that household is to own a higher number of vehicles.

Variables

Household characteristic variables available for estimation are limited to those variables that are generated by TripCal5, including income, household size, and number of workers. Therefore, each of these variables was tested during model estimation and included in the final model.

Two locational attributes of a household's zone were also included in the final model. The first is the land use density at the home zone, which takes the following function form:

$$Density = Ln\left(1 + \frac{Population + 2.0 \times Employment}{Acres}\right)$$

The second variable was a measure of relative transit accessibility. Transit accessibility is important to vehicle ownership, since having accessible transit allows for lower auto ownership with similar mobility levels. Transit accessibility is measured relative to highway accessibility since transit networks and highway networks typically share many characteristics spatially:

$$Acc_i = A_{i,DA} - A_{i,TW}$$

Here, Acc_i is the relative transit accessibility, $A_{i,DA}$ is the absolute highway accessibility, and $A_{i,TW}$ is the absolute transit accessibility. The absolute accessibilities are computed as follows:

$$A_{im} = \ln\left[\sum_j S_j \times \exp\left(U_{ijm}\right)\right]$$

Here, the sum is across all zones in the region. S_j is the size of the zone (measured as total employment in the zone) and U_{ijm} is an idealized mode utility from zone *i* to zone *j* by mode *m*. Table 6.3 shows the parameters assumed for the utility function for this variable. Note that these parameter values were not estimated for the region, they were set based on values typically found in similar regions across the U.S. Separate accessibilities are computed for low and high income households (the cost coefficient used in the utility function varies as indicated in Table 6.2).

Table 6.3 Utility Parameters for Accessibility Variables

Mode	Variable	Value
All	In-Vehicle Travel Time	-0.025
All	Cost – Low Income (Cat = 1,2)	-0.200
All	Cost – High Income (Cat = 3,4,5)	-0.100
TW	Transfers	-0.100
TW	Local Bus Used (0/1)	-1.000
TW	OVT Ratio	2.5

6.3 Model Estimation Results

The estimation results are presented in Table 6.4. Some of the key findings of the vehicle availability model estimation are as follows:

- All else being equal, higher income households have higher propensity to own vehicles;
- Household size and number of workers both have positive impacts on vehicle availability propensity;
- Land use density in the home zone has a negative relationship to the propensity to own vehicles, which makes sense since denser areas have more employment centers more closely spaced, making non-auto modes more viable.
- Relative transit accessibility has a positive effect on the propensity to own vehicles. This makes sense, since relative transit accessibility is defined as the difference between highway and transit accessibility. The better the highway accessibility, the higher the value of the variable. We would expect when highway accessibility is high, households will own more vehicles.

Table 6.4 Vehicle Availability Model Estimation Results

Variable		Coefficient	t-stat
Income Category	$20,000 to $34,999	0.32	2.5
	$35,000 to $49,999	0.97	7.8
	$50,000 to $74,999	1.38	11.2
	$75,000+	1.80	13.8
Household Size	2 persons	1.58	12.1
	3 persons	2.35	17.0
	4 persons	2.50	17.8
	5 persons	2.81	19.0
Workers	1 worker	0.29	3.3
	2 workers	1.28	11.9
Zonal	Relative Transit Access	0.11	1.6
	Land Use Density	-0.17	-2.9
Thetas	0|1	-1.31	-6.3
	1|2	1.95	9.6
	2|3	4.61	21.2
	3|4	6.35	27.9
Number of Observations		2892	
Log Likelihood of Model		-3205.0	
Log Likelihood of Constants Only		-3842.1	
Rho Squared		0.166	

The thetas shown in the table were not discussed earlier. These serve as alternative specific constants in the ORL model. They ensure that the model replicates the alternative shares represented in the survey data. The ORL uses only a single latent variable and the thetas assign the breakpoints at which a household's propensity to own more or less vehicles actually manifests in changing auto ownership level. The first theta (0|1) represents the breakpoint between 0 and 1 vehicles, the second (1|2) represents the breakpoint between 1 and 2 vehicles, and so on. To illustrate how the model works, consider shifting from a propensity of 1.5 to 2.0, which will result in a shift of owning 1 vehicle to 2 vehicles. However, shifting from a propensity of 1.0 to 1.5 results in no change in auto ownership (one vehicle is owned at both propensity levels).

6.4 Calibration

The model was calibrated by adjusted the thetas (or constants) upwards or downwards. A downward shift in the theta values will result in overall vehicle availability increasing, while an upward shift in the theta values will result in overall vehicle availability decreasing. The key element in the calibration was to ensure that zero-vehicle household shares were matched well, since these are the most critical households in terms of transit usage. Table 6.5 shows the estimated and calibrated theta values.

Table 6.5 Estimated and Calibrated Theta Values for Vehicle Availability Model

Thetas	Estimated	Calibrated
0|1	-1.31	-1.50
1|2	1.95	2.26
2|3	4.61	4.92
3|4	6.35	6.66

For model calibration, we looked at three vehicle ownership categories instead of the five used by the vehicle availability model, since the five categories are not actually used subsequently by the mode choice model. The three categories are:

1. Zero vehicles;
2. Vehicles less than workers, greater than zero; and
3. Vehicles greater than or equal to workers and greater than zero.

Table 6.6 shows the expanded survey versus modeled vehicle availability shares.

Table 6.6 Survey versus Model Vehicle Availability Shares

Vehicle Category	Expanded Survey	Modeled
Zero Vehicles	3.5%	3.5%
Vehicles < Workers	52.9%	52.7%
Vehicles >= Workers	43.6%	43.8%

7.0 Mode Choice Model

This chapter describes the mode choice models, preparation of the estimation dataset using different surveys, and a description of the estimated coefficients by trip purpose.

7.1 Estimation Dataset

The estimation dataset was created by merging the auto and non-motorized observations from the 2010/2011 Household Travel Survey records for El Paso with the transit observations from the 2012 onboard transit survey. There were very few transit observations from the household travel survey. The household travel survey data also does not distinguish transit access mode (drive versus walk). Therefore, these were not included in the dataset. The on-board surveys provide information regarding transit trips that supplements the low number of transit trip samples captured in the household survey. For mode choice model estimation, the transit on-board survey observations were weighted according to the transit shares from the household travel survey. That is, the total weight assigned to the transit on-board survey observations equaled the total weight of household travel survey transit records.

The combined (household and on-board) survey data were further supplemented by information about the travel time and cost between the origin and destination, referred to as level of service (LOS) data. That is, the highway and transit skims were attached to the merged survey dataset. The LOS data for highway modes includes in-vehicle times, out-of-vehicle times, and distances. The LOS data for transit modes includes wait, transfer, walk access, auto access, and egress times; number of transfers; in-vehicle times by transit mode; and transit fares. Wait times are split into two variables to test short and long wait times, such as less than or equal to seven minutes and greater than seven minutes (the data often dictates what the cut offs should be).

The information about the origin and destination areas, known as *zonal data*, such as area type, levels of population and employment, and parking costs, were obtained from the pre-existing regional model and used in estimation.

The survey, zonal, and level of service data were merged to provide estimation data sets for each trip purpose. These data sets consisted of survey trip records, extended to include household and person variables from the surveys; zonal data for the zones of trip origin, destination, production, and attraction (as appropriate); and level of service data for all modes available between the trip end zones.

7.1.1 Observation Weighting

When estimating most discrete choice models using choice-based data or enriched sample data (as we are by using the combined household survey data and the transit onboard surveys), it is necessary to use weighted exogenous sampling maximum likelihood (WESML) estimation techniques. The weighted estimation techniques correct for the biases in alternative specific constants (ASC) that are introduced by the nonrandom combined data source[4]. For WESML, the weight for each observation is the fraction of the

[4] An exception to the weighting requirement is the case where multinomial logit models are being employed. For these models, standard ESML estimation techniques may be employed without biasing the alternative-specific constants.

population choosing the alternative selected by the decision maker divided by the corresponding fraction in the entire sample[5].

As the mode choice models are estimated using the nested logit model structure, it is necessary to employ the WESML estimation, and to develop observation-specific weights. The fraction of the sample choosing each modal alternative is derived from the enriched dataset we prepared from combining the household survey trip data and the transit onboard survey data. Table 7.1 shows the sample sizes and observation weights.

Table 7.1 Mode Choice Estimation Survey Weights

Survey	Mode	Number of Observations	Sample Share	Expanded Total	Population Share	Observation Weights	Weight Total
HTS	DA	11,357	0.371	1,005,644	0.401	1.081	12,277
HTS	SR2	7,486	0.245	682,396	0.272	1.113	8,330
HTS	SR3+	5,915	0.193	655,655	0.262	1.353	8,004
HTS	Bike	80	0.003	8,371	0.003	1.277	102
HTS	Walk	1,177	0.038	124,973	0.050	1.296	1,526
On-Board	Transit-Drive	256	0.008	1,816	0.001	0.087	22
On-Board	Transit-Walk	4,319	0.141	26,942	0.011	0.076	329
Total	**All**	**30,590**	**1.000**	**2,505,798**	**1.000**	**1.000**	**30,590**

Market Segmentation

Three separate models were estimated for the following trip purposes:

1. Home-based work;
2. Home-based non-work; and
3. Non home-based.

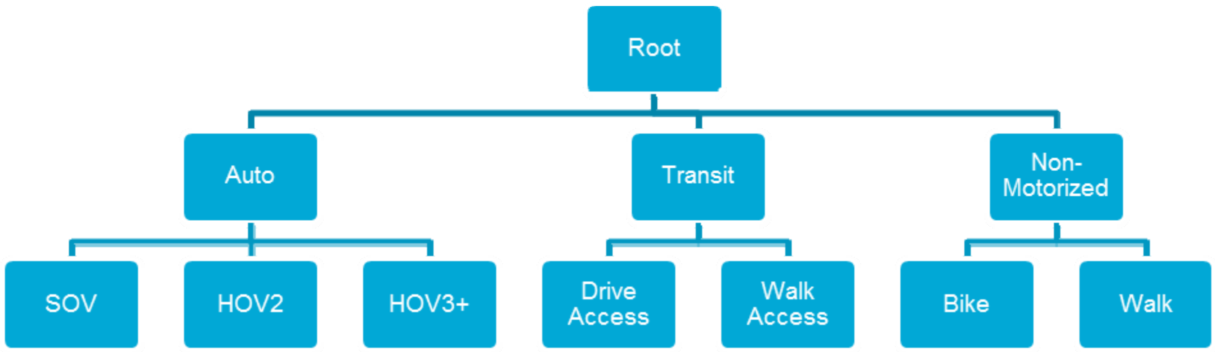
In addition, separate modal constants were estimated to distinguish between the four home-based non-work sub-purposes (school, college, retail, and other) and the two non home-based sub-purposes (work and other). Income segmentation was also used to distinguish cost effects on mode choices. That is, separate cost coefficients were estimated for each of the five income categories.

7.2 Model Structure

The model was estimated as a nested logit model. The nested logit model allows for correlation between choice alternatives in the model, which is particularly important for transit modes. Figure 7.1 shows the asserted nesting structure of the choice alternatives.

[5] See Moshe Ben-Akiva and Steven Lerman, *Discrete Choice Analysis* (MIT Press, 1985), Chapter 8 for a complete discussion of the sampling issues.

Figure 7.1 Mode Choice Model Nesting Structure



7.2.1 Mode Availability

Mode availability is restricted in the estimation and application of the model to avoid illogical mode choice forecasts.

The walk and bike modes are restricted to long distance trips, since they are not necessarily true alternatives as trip distance increases. The survey data shows that about 94 percent of all walk trips are less than 3 miles in length and 94 percent of all bike trips are less than 5 miles in length. To allow for some buffer, the maximum walk trip length was restricted to 4 miles (which includes about 96 percent of walk trips), and the maximum bike trip length was restricted to 16 miles (which includes about 98 percent of bike trips).

Transit alternatives are only available if a valid transit path exists in the transit skim generated by the skimming procedures.

7.2.2 Variables

Four major variables (variable categories) were incorporated in the development of the model: attraction zone density, income-specific constants, household vehicle ownership, and level of service, as follows:

- **Attraction zone density**: Higher density attraction zones were expected to promote non-SOV modes because of the higher congestion, walkability, and transit service. A density factor was calculated as:

  *(Population + 2.0 * Employment) / Acres*

- **Income Specific Constants**: HBW and HBNW were segmented by income. We expected that lower income travelers may have less availability of vehicles and thus be more likely to use public transit or to carpool. Conversely, higher income travelers would have higher vehicle availability and be more likely to drive alone.

- **Household vehicle ownership**: The number of vehicles in the household were expected to be directly correlated to the propensity to use auto modes over transit or non-motorized modes. Households with zero vehicles would be significantly more likely to take transit or non-motorized models. The vehicle sufficiency segmentation variable has three levels: zero vehicles, vehicles less than household size, and vehicles greater or equal to household size.

- **Level-of-service**: Several level-of-service variables were included in the model specification, including the following variables:
  - In-vehicle time (IVT), which includes drive access time for drive-transit mode;
  - Out-of-vehicle-time (OVT);
  - Cost; and
  - Trip distance (for non-motorized modes only).

It was found simpler to estimate separate trip distance coefficients for the walk and bike modes than trying to assert average walk and bike speeds. Therefore, walk and bike travel times were not included in the utility formulations, only the trip distances were included for non-motorized modes.

7.2.3 Constraints and VOT Assumptions

Initial estimation of the models yielded unreasonable sets of level-of-service coefficients for travel times and costs. As a result, the ratio of OVT to IVT was constrained to 2.5. FTA guidelines suggest that this ratio be in the range of 2.0 and 3.0. Furthermore, the value of the effective IVT coefficient in the home-based work model was constrained to be -0.02[6], which is in the FTA's recommended range. For home-based non-work, the magnitude of the IVT coefficient was assumed to be two-thirds of the value for home-based work (e.g., -0.013), and for non home-based, the magnitude of the IVT coefficient was assumed to be one-half of the value for home-based work (e.g., -0.01).

In order to constrain cost coefficients, value of time (VOT) assumptions were made. Since the El Paso model employs income segmentation (with five income segments), it was desirable to recognize value of time variability across income levels. This could be done by making different value of time assumptions for each income group.

The approach taken to develop VOTs for El Paso was to relate VOTs to wage rates, which is a fairly common approach to quantifying VOTs.[7] Typically, VOTs are found to range between 30 and 60 percent of wage rates for personal travel, depending on a variety of factors, most importantly, trip purpose. For the El Paso model, home-based work (HBW) trips were chosen to be based on 60 percent of the wage rate (i.e., near the top of the typical scale for commute trips) and other trips on 40 percent of the wage rate (i.e., about two-thirds of the value established for commute trips) .

To determine a wage rate for the El Paso region, the Bureau of Labor Statistics (BLS) was utilized. For the El Paso MSA, BLS reports that in May 2015 median wages in the region were $12.70 per hour and mean wages were $17.78 per hour.[8] From this information and the relationship cited above, median and mean VOTs of $7.62 and $10.67 per hour can be computed, respectively, for HBW trips (with non-HBW trips being $5.08 and $7.11, respectively).

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[6] The effective coefficient here refers to the scaled version of the utility function. The utility function is scaled by the nest coefficient of the model. Since the nest coefficient is less than 1, the actual constrained value used in model estimation has magnitude greater than -0.02.

[7] See, e.g., Litman, T. (2013) Transportation Cost and Benefit Analysis II – Travel Time Costs, Victoria Transport Policy Institute (VTPI), http://www.vtpi.org/tca/tca0502.pdf.

[8] http://www.bls.gov/oes/current/oes_21340.htm#00-0000.

The model used the following five income categories with corresponding low and high thresholds shown in Table 7.2. Also shown in Table 7.1 are the assigned mean income for each income category, the share of all households that each income category represents in the expanded survey data, and a wage index, which was intended to generate approximate wage rates for each income category. The wage index was assigned based on judgment and reflects the relative wage differences across income categories. Note that the ratio of wage index to assumed household income is highest for low income households and lower for high income households (e.g., the ratio is 1/1000 for low income and 1/2000 for high income). This was done purposefully to reflect that personal wage rates likely have lower variability than household income.

Table 7.2 Income Segments

Income Level	Lower Bound	Upper Bound	Mean Household Income	Frequency	Wage Index Divisor	Wage Index
Low Income	$0,000	$15,000	$7,500	18.4%	1000	$7.50
Modest Income	$15,000	$25,000	$20,000	17.1%	1600	$12.50
Middle Income	$25,000	$40,000	$32,500	19.6%	1800	$18.06
Upper Income	$40,000	$70,000	$55,000	23.0%	2000	$27.50
High Income	$70,000	n/a	$110,000	21.9%	2000	$55.00

While a wage index was assigned above based on judgment, it was not directly used to compute VOT for each income category. That is, it is not as simple as multiplying our assumed 60 percent wage rate to wage index arrive at VOTs. Instead, we used the relative wage indices along with the income category frequency in order to match the calculated overall VOT for the El Paso MSA. For these purposes, we used the mean wage rate (of $17.78) and corresponding HBW VOT of $10.67. Table 7.3 shows the results.

Table 7.3 Income Segment Assumed VOTs

Income Level	Lower Bound	Upper Bound	VOT Index	HBW VOT	Non-HBW VOT
Low Income	$0,000	$15,000	1.00	$3.15	$2.10
Modest Income	$15,000	$25,000	1.67	$5.25	$3.50
Middle Income	$25,000	$40,000	2.41	$7.58	$5.06
Upper Income	$40,000	$70,000	3.67	$11.55	$7.70
High Income	$70,000	n/a	7.33	$23.10	$15.40

The VOT index shown in Table 7.3 directly corresponds to the wage index in Table 7.2, just simply dividing all of the indices by $7.50. The VOT index tells us the multiple of the low income VOT that each other income category VOT is, based upon the wage index assumptions we made. For instance, once we set the wage index, the middle income VOT was constrained to be 2.41 times larger than low income VOT and high income VOT was constrained to be 7.33 times larger than low income VOT. Average VOT was computed using the income category frequencies in Table 7.2.

7.3 Model Estimation Results

Several rounds of model estimation were carried out, testing a variety of model specifications. The best models were chosen based on the sign and magnitude of the variables, t-statistics of each variable, and the overall model fit. Implied values of time by income category and overall model fit statistics for the three models are shown in Table 7.4.

Table 7.4 VOTs and Model Fit Statistics for Mode Choice Models

	HBW	HBNW	NHB
Values of Time ($/hr)			
Income < $15K	$3.15	$2.10	$5.06
Income $15-25K	$5.25	$3.50	$5.06
Income $25-40K	$7.58	$5.05	$5.06
Income $40-70K	$11.55	$7.70	$5.06
Income > $70K	$23.10	$15.40	$5.06
Model Fit			
Number of Observations	4,936	19,768	6,916
Log Likelihood Constants Only	-3904.0	-29030.5	-9298.8
Log Likelihood at Convergence	-3276.6	-23237.2	-8553.1
Rho-Squared	0.161	0.200	0.080

7.3.1 Home-Based Work

Characteristics of the HBW estimated mode choice model include:

- **Income constants –** Higher income households are much less likely to use transit, all else being equal. Very low income households tend to travel to work in carpools of 3 or more people more often, but not necessarily carpools of 2 people. Walk-transit usage is also slightly lower for this household segment. This is likely a result that the model already controls for vehicle ownership, and zero-vehicle households are also very frequently very low income households.

- **Zero-vehicle households –** As expected, zero-vehicle households are much more likely to use transit (either drive or walk access) to travel to work than any other mode (relative to other households). Moreover, zero-vehicle households are more likely to carpool to work than other households.

- **Land use density –** As expected, more densely employed areas have higher propensity to use transit and walk modes to travel to work. This is largely due to the lower opportunity costs of making other non-work trips to shops and restaurants before, during, or after work activities.

- **Non-motorized distance –** Bike and walk mode specific trip distance variables were estimated to have significant and negative coefficients, as expected.

Model estimation results are provided in Table 7.5.

Table 7.5 Home-Based Work Mode Choice Model Estimation Results

Variable	Modes	Coeff	t-stat
ASC	SOV	2.814	3.2
	HOV2	0.058	0.1
	HOV3+	-1.914	-2.1
	DRVTRN	-4.151	-3.8
	WKTRN	-0.148	-0.2
	BIKE	-2.654	-2.4
	WALK	0.000	0.0
In Vehicle Time	Auto + Transit	-0.027	constr.
Out of Vehicle Time	Auto + Transit	-0.067	constr.
Cost - Income < $15K	Auto + Transit	-0.508	constr.
Cost - Income $15-25K	Auto + Transit	-0.305	constr.
Cost - Income $25-40K	Auto + Transit	-0.211	constr.
Cost - Income $40-70K	Auto + Transit	-0.139	constr.
Cost - Income > $70K	Auto + Transit	-0.069	constr.
Trip distance	Bike	-0.826	-3.0
	Walk	-1.739	-6.7
Zero Vehicle Household	HOV2	3.775	7.0
	HOV3+	2.217	2.0
	Drive Transit	9.343	14.8
	Walk to Transit	10.820	20.1
Income < $15K	HOV2	-0.124	-0.9
	HOV3+	0.777	2.9
	Drive Transit	0.191	0.5
	Walk to transit	-0.375	-1.9
Income > $70K	Drive Transit	-3.968	-4.4
	Walk to Transit	-4.509	-12.9
Land Use Density at Destination	Drive Transit	0.936	5.1
	Walk to Transit	0.875	10.7
	Walk	0.209	0.7
Nest Coefficient		0.750	constr.

7.3.2 Home-Based Non-Work

Characteristics of the HBNW estimated mode choice model include:

- **Income constants –** Higher income households are much less likely to use transit, all else being equal. Very low income households tend to use non-motorized modes more than other households. This is evidenced by the negative coefficients for each of the non-motorized modes.
- **Zero-vehicle households –** As expected, zero-vehicle households are much more likely to use transit (either drive or walk access) for non-work travel (relative to other households). Unlike for work purposes, zero-vehicle households are not much more likely to use shared ride modes, relative to drive alone. This is not particular surprising, since for work trips, drive alone tends to dominate mode choice overall, while for non-work purposes, shared ride modes are already more prevalent among all households.
- **Land use density –** As expected, more densely employed areas have higher propensity to use transit and walk modes to travel. This is largely due to the lower opportunity costs of chaining trips when activity centers are more closely spaced.
- **Non-motorized distance –** Bike and walk mode specific trip distance variables were estimated to have significant and negative coefficients, as expected.

Model estimation results are provided in Table 7.6.

Table 7.6 Home-Based Non-Work Mode Choice Model Estimation Results

Variable	Modes	Coeff	t-stat
ASC	SOV	0.374	3.0
	HOV2	0.061	0.5
	HOV3+	-0.297	-2.3
	DRVTRN	-6.247	-18.1
	WKTRN	-3.590	-18.4
	BIKE	-3.181	-15.8
	WALK	0.000	0.0
Home-Based College Trips	SOV	-0.618	-5.4
	HOV2	0.239	2.1
	HOV3+	0.874	7.7
	DRVTRN	-1.339	-3.8
	WKTRN	-1.173	-7.1
Home-Based School Trips	SOV	0.678	1.5
	HOV2	-0.115	-2.5
	HOV3+	-1.090	-2.3
	DRVTRN	1.718	3.4
	WKTRN	1.532	3.3

Variable	Modes	Coeff	t-stat
Home-Based Shopping Trips	SOV	2.364	11.0
	HOV2	2.391	11.1
	HOV3+	2.147	9.9
	DRVTRN	2.023	6.8
	WKTRN	1.901	8.2
In Vehicle Time	Auto + Transit	-0.018	constr.
Out of Vehicle Time	Auto + Transit	-0.044	constr.
Cost - Income < $15K	Auto + Transit	-0.508	constr.
Cost - Income $15-25K	Auto + Transit	-0.305	constr.
Cost - Income $25-40K	Auto + Transit	-0.211	constr.
Cost - Income $40-70K	Auto + Transit	-0.139	constr.
Cost - Income > $70K	Auto + Transit	-0.069	constr.
Trip distance	Bike	-1.058	-8.5
	Walk	-1.531	-22.8
Zero Vehicle Household	HOV2	-0.335	-1.6
	HOV3+	0.137	0.7
	Drive Transit	4.659	20.4
	Walk to Transit	5.641	36.3
	Bike	1.250	2.6
Income < $15K	SOV	-0.796	-8.0
	HOV2	-0.690	-7.0
	HOV3+	-0.805	-8.2
	Drive Transit	-1.196	-6.0
	Walk to transit	-1.000	-8.0
Income > $70K	Drive Transit	-2.976	-9.8
	Walk to Transit	-3.976	-22.2
Land Use Density at Destination	Drive Transit	0.799	9.7
	Walk to Transit	0.714	16.8
Nest Coefficient		0.750	constr.

7.3.3 Non Home-Based

Characteristics of the NHB estimated mode choice model include:

- **Land use density –** As expected, more densely employed areas have lower propensity to use auto modes and bike mode, suggesting that transit and walk modes are more popular for non home-based trips. As described above for the other trip purposes, this is largely due to the lower opportunity costs of chaining trips when activity centers are more closely spaced.
- **Non-motorized distance –**Bike and walk mode specific trip distance variables were estimated to have significant and negative coefficients, as expected.

Model estimation results are provided in Table 7.7.

Table 7.7 Non Home-Based Mode Choice Model Estimation Results

Variable	Modes	Coeff	t-stat
ASC	SOV	7.705	26.4
	HOV2	6.619	23.1
	HOV3+	5.279	18.4
	DRVTRN	-2.998	-11.6
	WKTRN	-1.130	-5.8
	BIKE	1.318	0.7
	WALK	0.000	0.0
Non Home-Based Work Trip	SOV	2.189	12.4
	HOV2	-2.034	-10.1
	HOV3+	-4.120	-16.5
In Vehicle Time	Auto + Transit	-0.013	constr.
Out of Vehicle Time	Auto + Transit	-0.033	constr.
Cost - All Trips	Auto + Transit	-0.158	constr.
Trip distance	Bike	-0.469	-2.0
	Walk	-2.294	-13.7
Land Use Density at Destination	SOV	-2.009	-27.6
	HOV2	-1.958	-27.6
	HOV3+	-1.933	-26.8
	Bike	-3.681	-4.0
Nest Coefficient		0.750	constr.

7.4 Calibration

The mode choice model calibration process involved the following steps:

- Checking all estimated parameters for reasonableness and consistency with experience elsewhere;
- Performing disaggregate validation to ensure that the model accurately estimates travel demand by mode not only for the region as a whole, but also for various demographic market segments;
- Performing aggregate validation to ensure that the model accurately reproduces demand by mode and trip purpose for the base year;

Using the processed survey database, a calibration target matrix was prepared for use in mode choice calibration. This matrix included shares representing the estimated demand by mode and trip purpose for appropriate market segments. Each of the three mode choice models were subjected to the steps described above during calibration. The biggest change or set of modifications done were to the alternate specific constants (ASCs). The goal was to keep the constants as low as possible and also to ensure their magnitude relative to one another made sense. This was an iterative process that involved adjusting the ASCs and running the mode choice model.

Table 7.8 presents the calibrated shares by trip purpose and mode. The modeled trip totals are different than the survey trip totals because of the trip rate factoring explained in Chapter 12 of this report. Also, these are pre-final mode choice results. Mode choice models were finalized as discussed in Chapter 12 of this report.

Table 7.8 Survey versus Model Mode Shares

	HBW	ED1	ED2	RET	OTH	NHBW	NHBO	Total
Survey								
SOV	89%	16%	68%	38%	35%	82%	29%	**42%**
HOV2	7%	32%	23%	34%	31%	12%	38%	**28%**
HOV3+	2%	46%	6%	26%	29%	4%	30%	**26%**
Transit-Dr	0%	0%	0%	0%	0%	0%	0%	**0%**
Transit-Wk	1%	0%	2%	1%	1%	1%	1%	**1%**
Bike	0%	1%	0%	0%	0%	0%	0%	**0%**
Walk	1%	7%	1%	1%	4%	1%	2%	**3%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Modeled								
SOV	90%	14%	67%	38%	34%	84%	29%	**41%**
HOV2	7%	29%	22%	34%	30%	11%	40%	**27%**
HOV3+	2%	41%	6%	25%	27%	3%	30%	**25%**
Transit-Dr	0%	0%	0%	0%	0%	0%	0%	**0%**
Transit-Wk	1%	0%	4%	1%	1%	0%	0%	**1%**
Bike	0%	1%	0%	0%	0%	0%	0%	**0%**
Walk	1%	15%	1%	1%	7%	1%	1%	**5%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Differences in Shares								
SOV	1%	-1%	-1%	0%	-1%	2%	0%	**-1%**
HOV2	0%	-3%	-1%	0%	-1%	-1%	2%	**-1%**
HOV3+	0%	-5%	0%	-1%	-2%	-1%	0%	**-1%**
Transit-Dr	0%	0%	0%	0%	0%	0%	0%	**0%**
Transit-Wk	0%	0%	2%	0%	0%	-1%	-1%	**0%**
Bike	0%	0%	0%	0%	0%	0%	0%	**0%**
Walk	0%	8%	0%	0%	3%	0%	-1%	**2%**

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8.0 Commercial Vehicle Model

The chapter describes the approach to and enhancements made to the commercial vehicle model in the El Paso regional travel demand model. The pre-existing El Paso model forecasts the demand and performance of all commercial vehicles combined. The new model addresses three types of trucks. This enhances the ability to validate to classification counts and allows for consideration of different physical (e.g., pavement) impacts, air quality impacts, and travel behavior.

The following stratification of trucks was adopted for this model update:

- Light – 2-axle, 4-tire commercial vehicles (FHWA Class 3);
- Medium – 3+axle, 6+tire, single unit commercial vehicles (FHWA Class 5, 6, and 7); and
- Heavy – 3+axle, 6+tire, combination unit commercial vehicles (FHWA Class 8, 9, 10, 11, 12 and 13).

These definitions derive from FHWA truck classes. Since vehicle classification counts are also based on FHWA classes that distinguish trucks by axles and body type, a direct correlation can be achieved between those that are modeled versus observed. The only pitfall is that the modeled truck volumes need to be converted to gross vehicle weight (GVW) ratings before applying the model to perform air quality analyses, however guidance on this process is available from FHWA and EPA.

8.1 Commercial Vehicle Surveys

In 2010 and 2011, TxDOT TPP funded a work place[9] and commercial vehicle survey[10] in the EPMPO region, which included household, work place, and commercial vehicle surveys. The purpose of the surveys were to collect data and information needed as input to the MPO travel demand model to forecast traffic levels on area roadways, evaluate the region's transportation plan, and aid in the region's air quality conformity analyses.

The commercial vehicle survey collected information about the trips made by commercial vehicles in the EPMPO region. The workplace surveys also included a survey of commercial vehicles that stopped at the establishments that were surveyed. Each survey included an attribute, vehicle class, which allowed for the computation of rates for different commercial vehicles using the crosswalk shown in Table 8.1.

[9] Simek, C. and Hard, E., Texas A&M Transportation Institute, "2010 El Paso Work Place Travel Survey Technical Summary", Texas Department of Transportation Travel Survey Program, June 2013.

[10] Farnsworth, S. and Bauer, J., Texas A&M Transportation Institute, "2010-2011 El Paso Urban Transportation Study (EUTS) Commercial Vehicle Survey TECHNICAL SUMMARY", Texas Department of Transportation Travel Survey Program, November 2012

Table 8.1 Commercial Vehicle Classifications

TTI Survey Vehicle Classification Codes	Proposed EL Paso TDM Classifications
1 - Passenger Car	N/A
2 - Pick-up	Light Trucks (LT)
3 - Van (cargo or mini)	Light Trucks (LT)
4 - Sport Utility Vehicle (SUV)	Light Trucks (LT)
5 - Single Unit 2-axle (6 wheels)	Medium Trucks (MT)
6 - Single Unit 3-axle (10 wheels)	Medium Trucks (MT)
7 - Single Unit 4-axle (14 wheels)	Medium Trucks (MT)
8 - Semi (tractor-trailer combination)	Heavy Trucks (HT)
9 - Other	N/A

8.2 Commercial Vehicle Trip Generation

CS initially explored using the CV survey as the basis for developing the commercial vehicle trip generation rates, but encountered data limitations that prevented completion of this approach. Instead, the CV part of the Workplace Survey was explored. In this survey, the explanatory variable of employees at a stop was available in the same record as the number of commercial vehicles, by vehicle class, that stopped at different workplaces. A summary of this survey is shown in Table 8.2.

Table 8.2 Number of CV Trucks by Workplace Type

Place Type	Light Trucks	Medium Trucks	Heavy Trucks
1 - Office Building (Non- Government)	327	103	40
2 - Retail/Shopping	513	79	71
3 - Industrial/Manufacturing	76	61	22
4 - Medical/Hospital	77	55	21
5 - Educational (12th grade or less)	114	56	24
6 - Educational (college, trade, etc.)	33	7	2
7 - Government Office /Building	100	19	14
8 - Residential	296	123	31
9 - Airport	9	0	1
10 - Intermodal Facility	1	0	0
11 - Warehouse	163	102	54
12 - Distribution Center	96	18	24
13 - Construction Site	127	32	22
14 - Other (specify)	129	58	20

The data allowed the development of CV trips rates per employee by vehicle class by workplace type. These rates are shown in Table 8.3. The rates for non-retail employment types that were surveyed (i.e., Basic, Service, Education and Other), were fairly similar to each other. Therefore, they were combined into a single non-retail employment category. Additionally, while there was no reported information on households as attractions in the workplace survey, it is reasonable to assume that CVs are produced and attracted by households. The Quick Response Freight Manual (QRFM)[11] reports truck rates per retail employee and per household. The household rates that are proposed in Table 8.3 were calculated based on retail rates, as computed from the Workplace Survey, scaled by the relationship between household and retail rates by vehicle class as reported in the QRFM.

Table 8.3 CV Trip Rates by Vehicle Class

	Retail	Non-Retail	Households
LT Attractions per employee (or per household)	0.530	0.232	0.636
MT Attractions per employee (or per household)	0.779	0.201	0.646
HT Attractions per employee (or per household)	0.152	0.060	0.020

Since a commercial vehicle attracted to a TAZ also must later leave that TAZ, commercial vehicle attractions are considered equal to commercial vehicle productions in developing the commercial vehicle trip generation model (consistent with typical practice and similar to handling NHB trips).

8.3 Commercial Vehicle Trip Distribution

As described in Chapter 5, Trip Distribution, trips between productions and attractions in the El Paso model are distributed by a gravity model. In addition to productions and attractions, the gravity model requires the use of a friction factor of travel between the production and attraction zones. This friction factor is a function of the travel time between zones as computed in the model.

The QRFM recommends that for CVs the friction factors be a negative exponential function of travel time and that the coefficient of that exponential be the inverse of average trip time for each CV class. Due to limitations of the CV survey, average trip lengths from the QRFM were used in the initial CV distribution model development. These average travel times are shown in Table 8.4. Section 12.6 of this report discusses the final parameters and validation of the model.

Table 8.4 CV Average Trip Lengths in Minutes

CV Type	QRFM
Light Truck	12.5
Medium Truck	10.0
Heavy Truck	33.3

[11] Cambridge Systematics, “Quick Response Freight Manual: Second Edition”, Federal Highway Administration, 2007, access at http://www.ops.fhwa.dot.gov/Freight/publications/qrfm2/sect04.htm#tab_0401

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9.0 Time of Day Factors

Time of day factors are essential to modeling and analyzing the travel demand that has the most impact on the El Paso region's transportation system. Modeling by time of day is very useful from a congestion management standpoint. It allows the study of bottlenecks and allows the ready comparison of congested and uncongested conditions. In this model, four time periods were incorporated, namely, morning peak (AM), midday (MD), evening peak (PM), and night (NT), into the assignment procedures. This resulted in four different assignment models. In addition, the model retains the ability to produce a 24-hour daily assignment.

9.1 Peak versus Off-Peak Periods

The time of day factors were derived from the 2010/2011 household travel survey data. The first step was to examine the peak and off-peak periods by trip purpose. These are presented in Table 9.1 below. As expected, a significant amount of HBW trips (~63 percent) occur during peak periods (AM and PM) though the off-peak period share is not insignificant at 37 percent. A majority of all school trips happen during the peak periods that is constrained to the school schedules. A majority of the non-work trips happen during off-peak periods as expected.

Table 9.1 Peak and Off-Peak Period Splits by Trip Purpose

Purpose Code	Purpose Name	Peak (AM + PM)	Off-Peak (MD + NT)
1	HBW	0.627	0.373
2	HBNWED1 (School)	0.929	0.071
3	HBNWED2 (College)	0.500	0.500
4	HBNW RETAIL	0.359	0.641
5	HBNW OTHER	0.427	0.573
6	NHB	0.531	0.469

9.2 Four Time Periods

As the goal was to implement four time periods into the model, the 2010/2011 household travel survey was used to derive TOD factors for the following four periods:

- Morning peak = AM – 7:00 AM to 10:00 AM;
- Midday = MD – 10:00 AM to 3:30 PM;
- Evening peak = PM – 3:30 PM to 7:30 PM; and
- Night = NT – 7:30 PM to 7:00 PM.

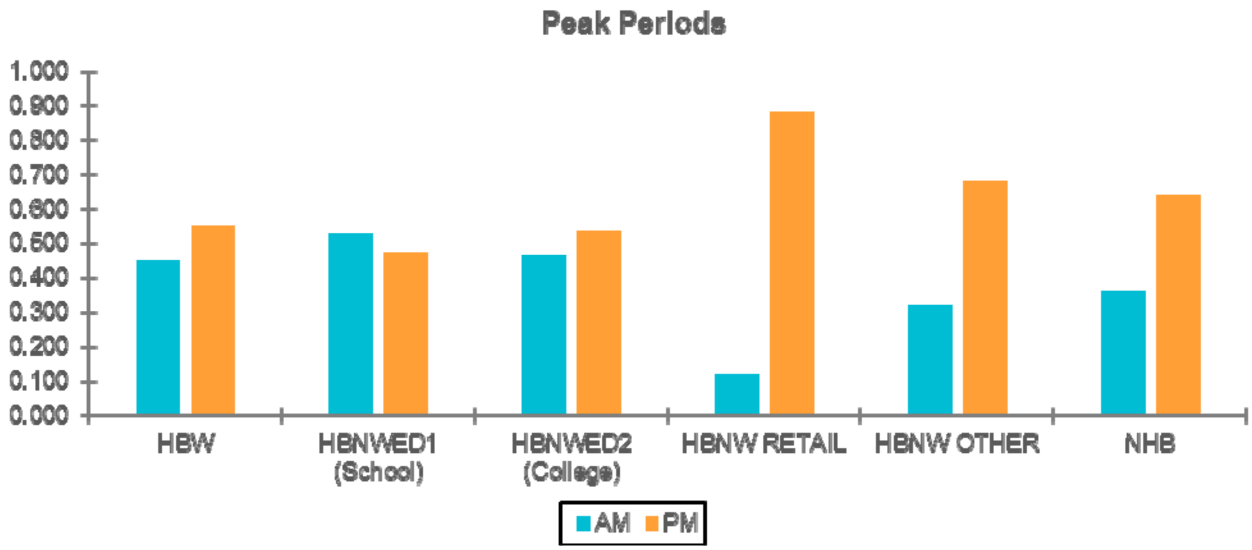
Given the wide variations of temporal distribution of traffic across different areas in the region, time of day factors were also analyzed for potential geographic market segmentations. This task involved reviewing existing time of day factors, analyzing household travel survey data for time of day factors by mode, purpose and/or market segment, developing capacity factors by time of day to be input into the volume-delay functions, and developing scripts for implementation.

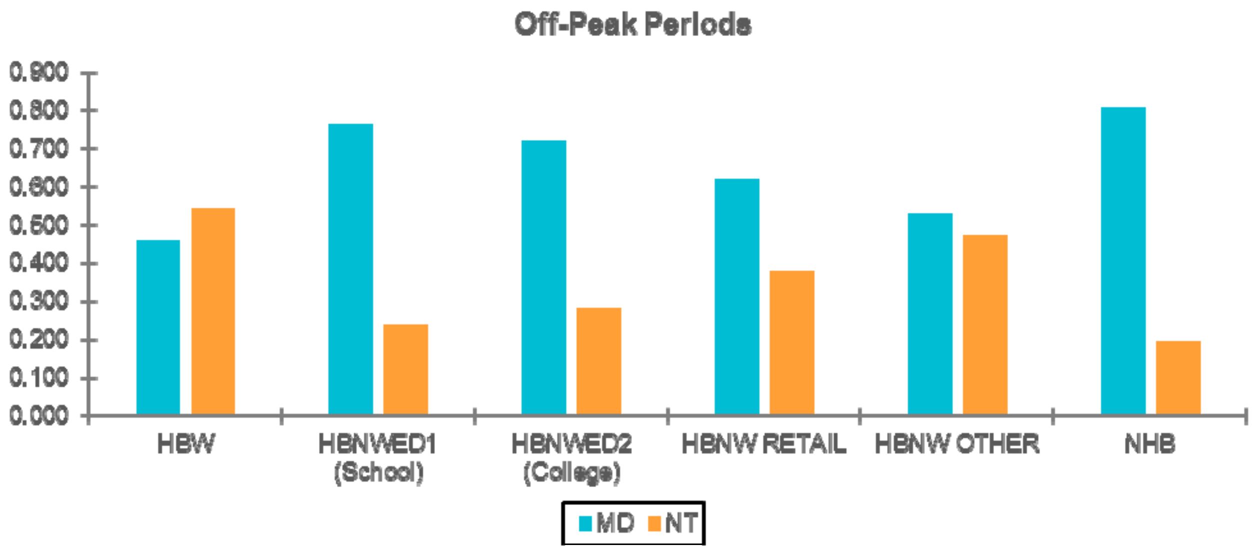
The four time periods were assigned to the household travel survey data based on the start and end time of each record. Based on this, TOD factors were derived from the expanded survey as shown in Table 9.2 and Figure 9.1.

Table 9.2 Time of Day Factors by Trip Purpose

	Peak		Off-Peak	
Purpose Name	**AM**	**PM**	**MD**	**NT**
HBW	0.449	0.551	0.458	0.542
HBNWED1 (School)	0.529	0.471	0.762	0.238
HBNWED2 (College)	0.466	0.534	0.718	0.282
HBNW RETAIL	0.118	0.882	0.621	0.379
HBNW OTHER	0.319	0.681	0.527	0.473
NHB	0.359	0.641	0.805	0.195

Figure 9.1 Four Time Periods by Trip Purpose





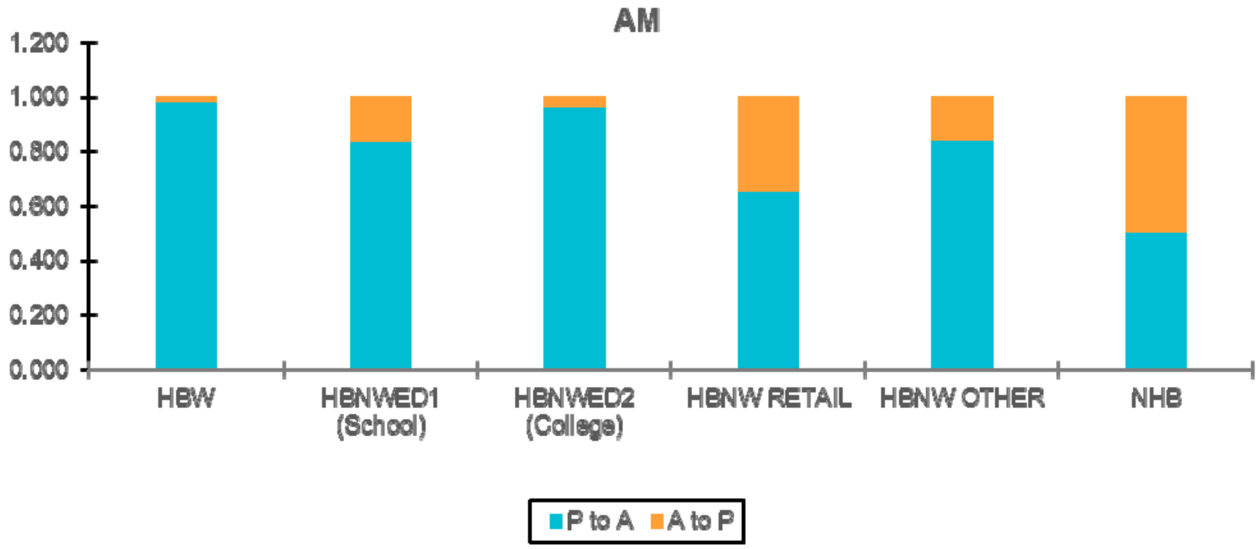
In order to apply the right TOD factor to each trip, factors by direction of travel were also derived from the survey. It is important to assign trips to the right time period based on the direction of the trip. That is, if it is a production (home) to attraction (work) or attraction (work) to production (home). Table 9.3 presents the TOD factors by direction of travel.

Table 9.3 Time of Day Factors by Trip Purpose and Direction of Travel

	AM		PM		MD		NT	
Purpose Name	P to A	A to P	P to A	A to P	P to A	A to P	P to A	A to P
HBW	0.978	0.022	0.109	0.891	0.651	0.349	0.450	0.550
HBNW ED1 (School)	0.834	0.166	0.192	0.808	0.505	0.495	0.362	0.638
HBNW ED2 (College)	0.958	0.042	0.284	0.716	0.528	0.472	0.180	0.820
HBNW RETAIL	0.650	0.350	0.428	0.572	0.495	0.505	0.306	0.694
HBNW OTHER	0.839	0.161	0.418	0.582	0.542	0.458	0.325	0.675
NHB	0.499	0.501	0.502	0.498	0.490	0.510	0.609	0.391

Figure 9.2 shows these factors graphically by each of the four time periods and by direction of the trip. As expected, a majority of P to A trips happen in the AM period for most of the trip purposes with the exception of non-home based. On the other extreme, most of the NT period trips are A to P indicating people getting back to their homes after performing work or non-work related activities.

Figure 9.2 Time of Day Factors by Trip Purpose and Direction of Travel



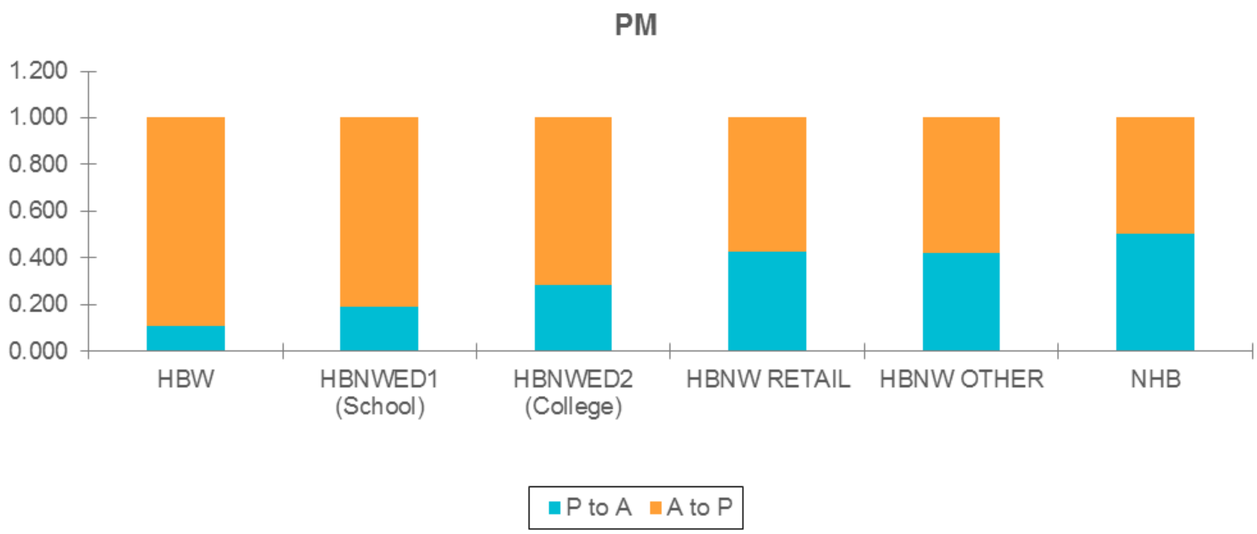
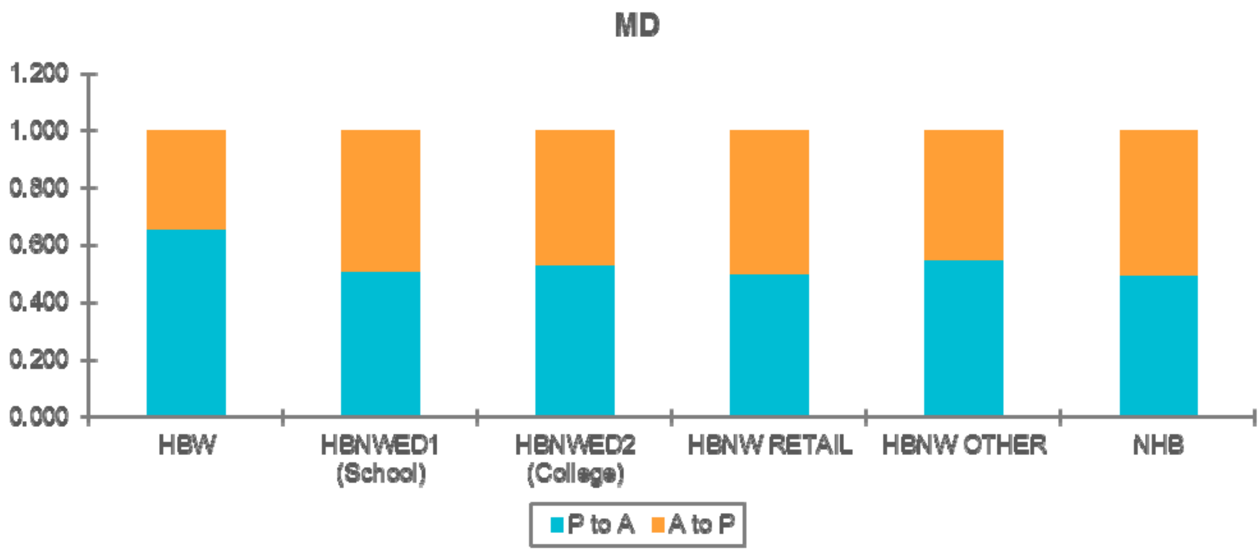
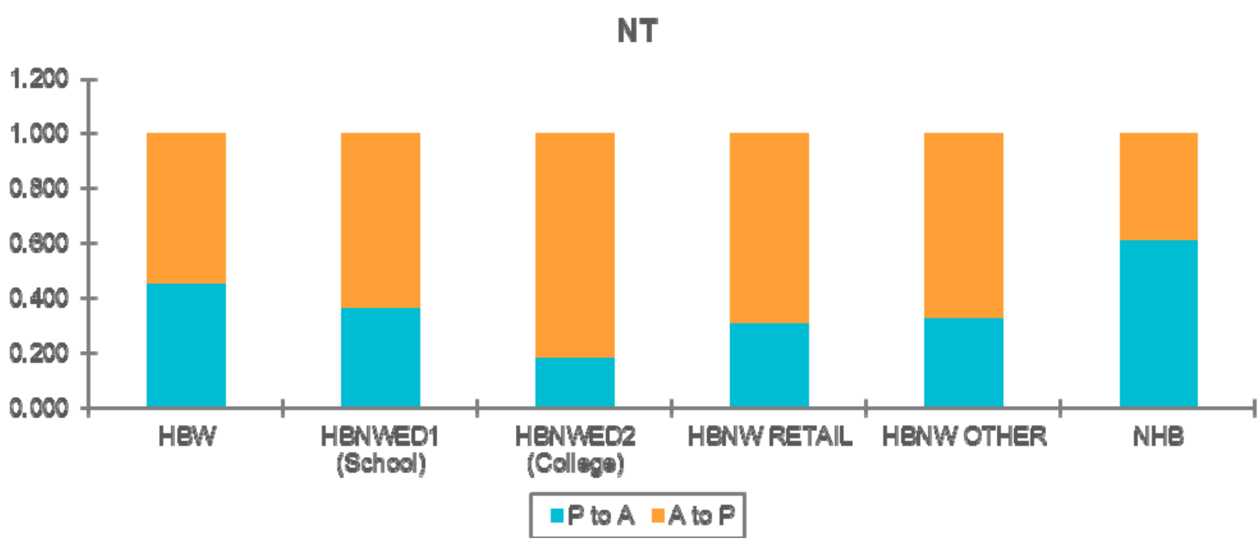


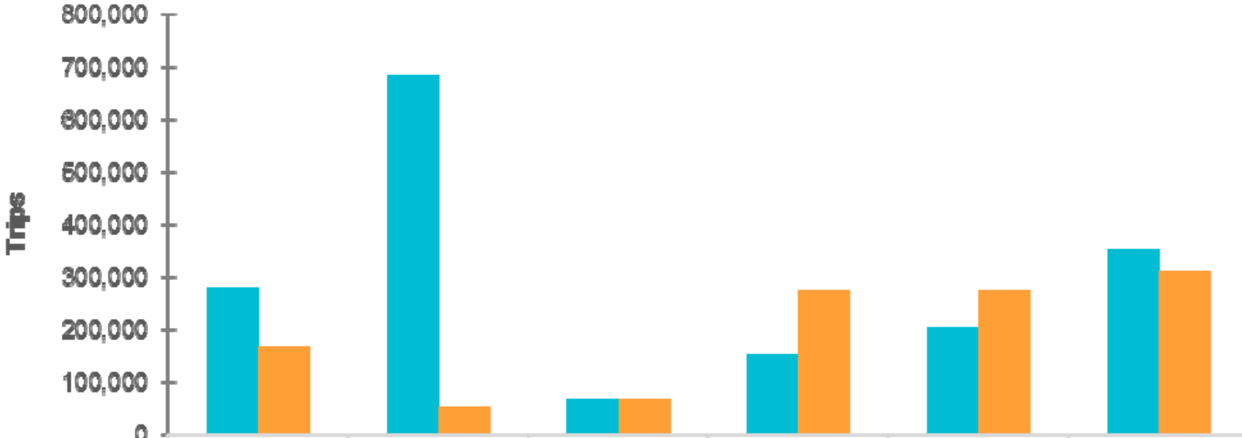
Figure 9.2 Time of Day Factors by Trip Purpose and Direction of Travel (continued)





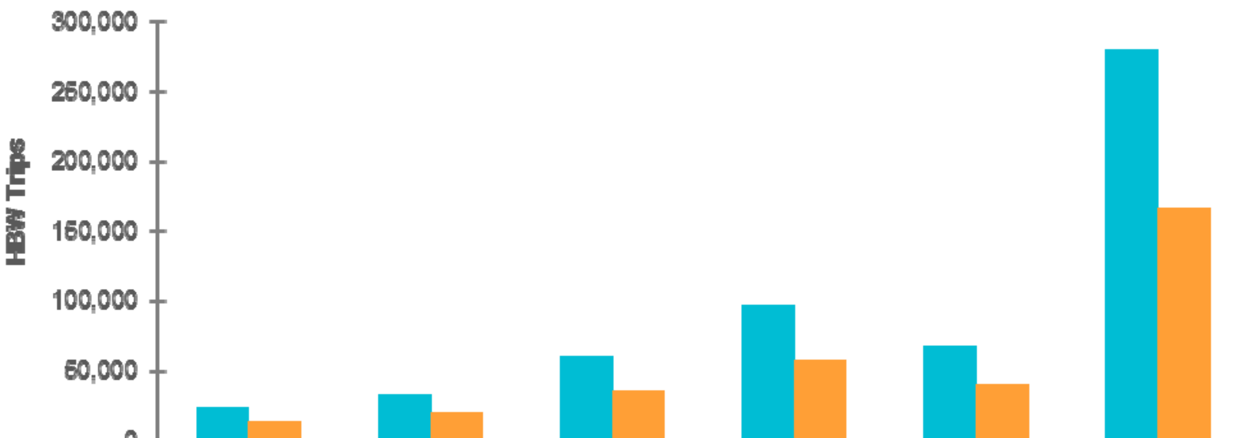
The TOD factors were applied to passenger trips after the mode choice step so that they could be assigned to the right time period during the assignment step of the model. Figure 9.3 presents a summary of trips by purpose and time period while Figure 9.4 presents similar information for HBW trips by income.

Figure 9.3 Trips by Purpose and Time of Day



	HBW	HB ED1	HB ED2	HB RET	HB NW	NHB
Peak	279,943	686,439	66,613	153,920	204,108	354,143
Off-Peak	166,536	52,385	66,613	274,828	273,897	312,794

Figure 9.4 HBW Trips by Income and Time of Day



	Income 1	Income 2	Income 3	Income 4	Income 5	Total
Peak	23,092	32,877	60,216	96,374	67,384	279,943
Off-Peak	13,737	19,558	35,822	57,333	40,086	166,536

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10.0 Traffic Counts

This chapter describes various sources of traffic counts that were collected and compiled for this model update. It also describes how counts from different years were processed and adjusted to the base year of 2012 for model development and validation purposes.

10.1 New Mexico Traffic Counts

CS team member ETC Institute collected vehicle classification counts by the FHWA 13-vehicle classification system at 71 locations in the New Mexico side of the MPO region. There have not been any large scale attempts to collect traffic count data in the recent past, and so this was a key exercise as prat of this project to obtain new traffic counts. ETC staff deployed personnel and equipment to collect traffic counts at these 71 predetermined locations. Several technologies were used to collect data including videos, radar-based, pneumatic tubes and manual counts. These were 24-hour weekday counts for Tuesdays, Wednesdays and Thursdays in March-April 2016. Figure 10.1 shows the location of these counts in light green dots.

Pre-Deployment

Many steps were undertaken by the ETC team pre-deployment to help ensure success of the count program. ETC's field supervisors were personally responsible for the placement and removal of equipment as well as the data collection. Each site was reviewed prior to deployment using Google Earth to assist in selecting the best location to collect good quality counts. From this, a daily work plan was put together including coordinates for pre-approved equipment deployment. Locations were chosen where variable speeds could be eliminated, keeping in mind the distance to intersections as well as road curvature, incline/decline, and road condition. Figure 10.2 shows a Google Earth image of the various locations as red (numbered) dots.

Deployment and Technology

Once on-site, the final deployment decision was made based on further evaluation of current traffic behavior and road condition. The equipment was then placed to collect for 48 hours and the deployment coordinates recorded. After equipment removal and data retrieval, the field supervisor reported the detailed description for placement at each site, coordinates, time, date, equipment used, and status. All data were collected using road tube count and classification systems.

The picture in Figure 10.3 provides an example aerial view of count location FID 38, situated on NM 478 north of Elm St. The red marker indicates where the tube counter system was set up. This location was chosen to provide traffic ample time to accelerate to the posted speed limit prior to reaching the road tube counter and for traffic to reach the road tube counter prior to decelerating as it approaches an intersection. The chosen location for the tube counter system in this example was placed an appropriate distance away from Acosta Road to the north and the daycare located on Discovery Lane just south of Acosta Road. Similarly it was placed an appropriate distance away from Elm Street and the businesses to the north of Elm Street. All but three sites studied were able to be completed, with classification, without significant issues. For these three sites that were not able to be broken down by vehicle class, the total volume and a breakdown by time of day was able to be provided. Numerous attempts were made over several days to get accurate classification from these three sites, but due to construction on off ramps, poor horizontal alignment for a site requested on a curved road, and extreme variable speeds, it was not possible to report reliable classification within an acceptable degree of confidence.

Figure 10.1 New Mexico Traffic Count Locations

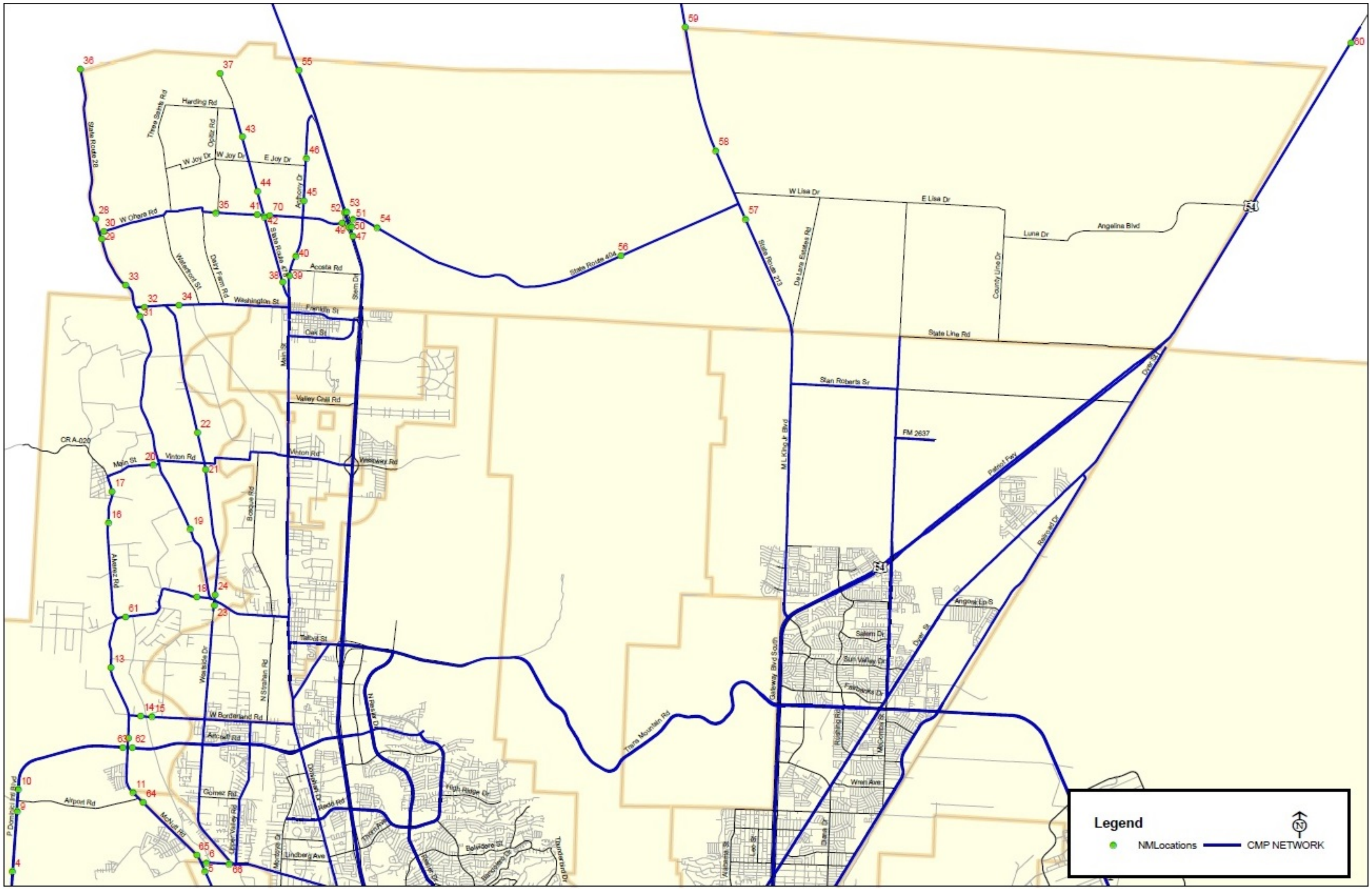


Figure 10.2 Google Earth Image of New Mexico Traffic Count Locations

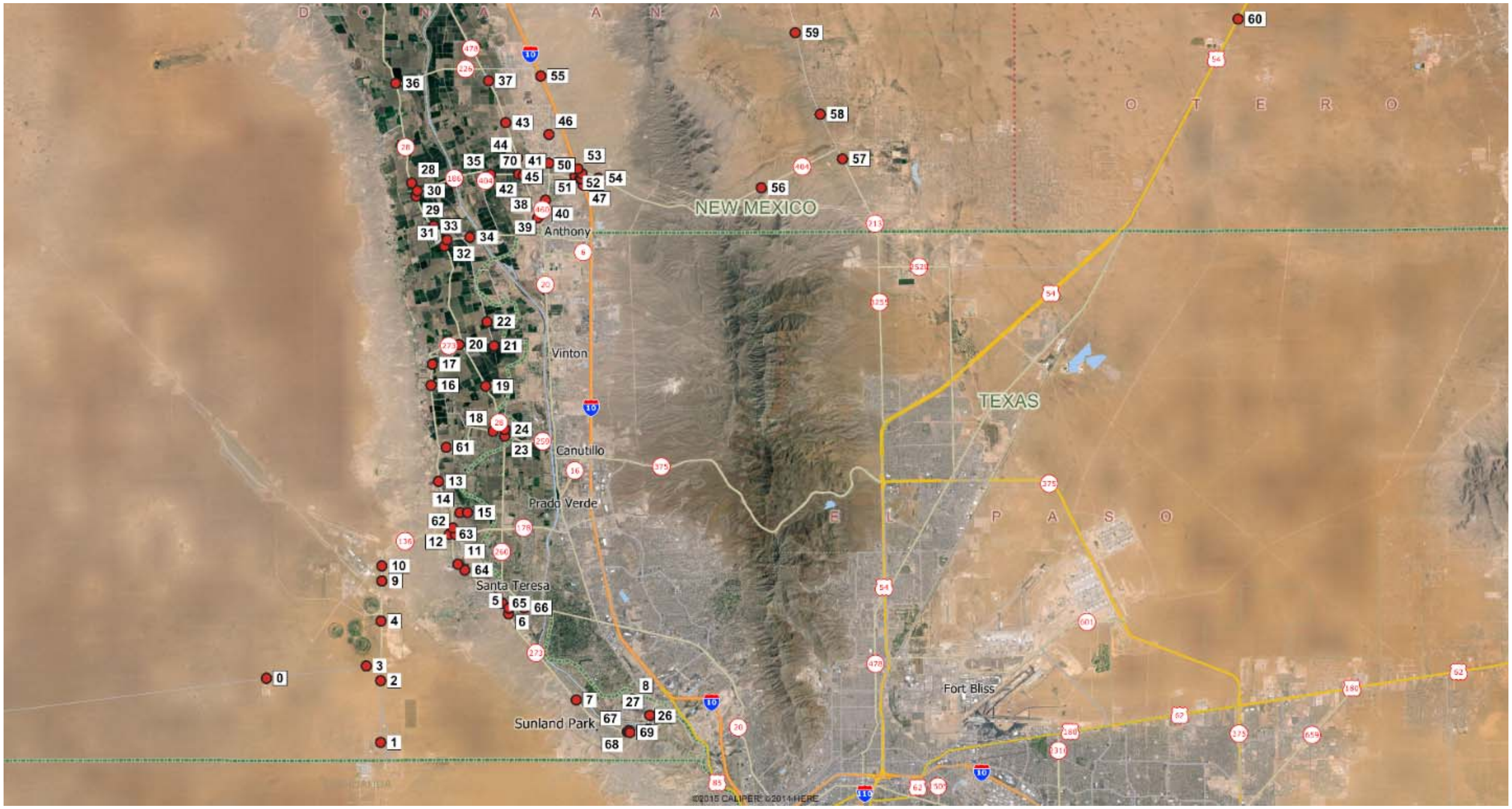
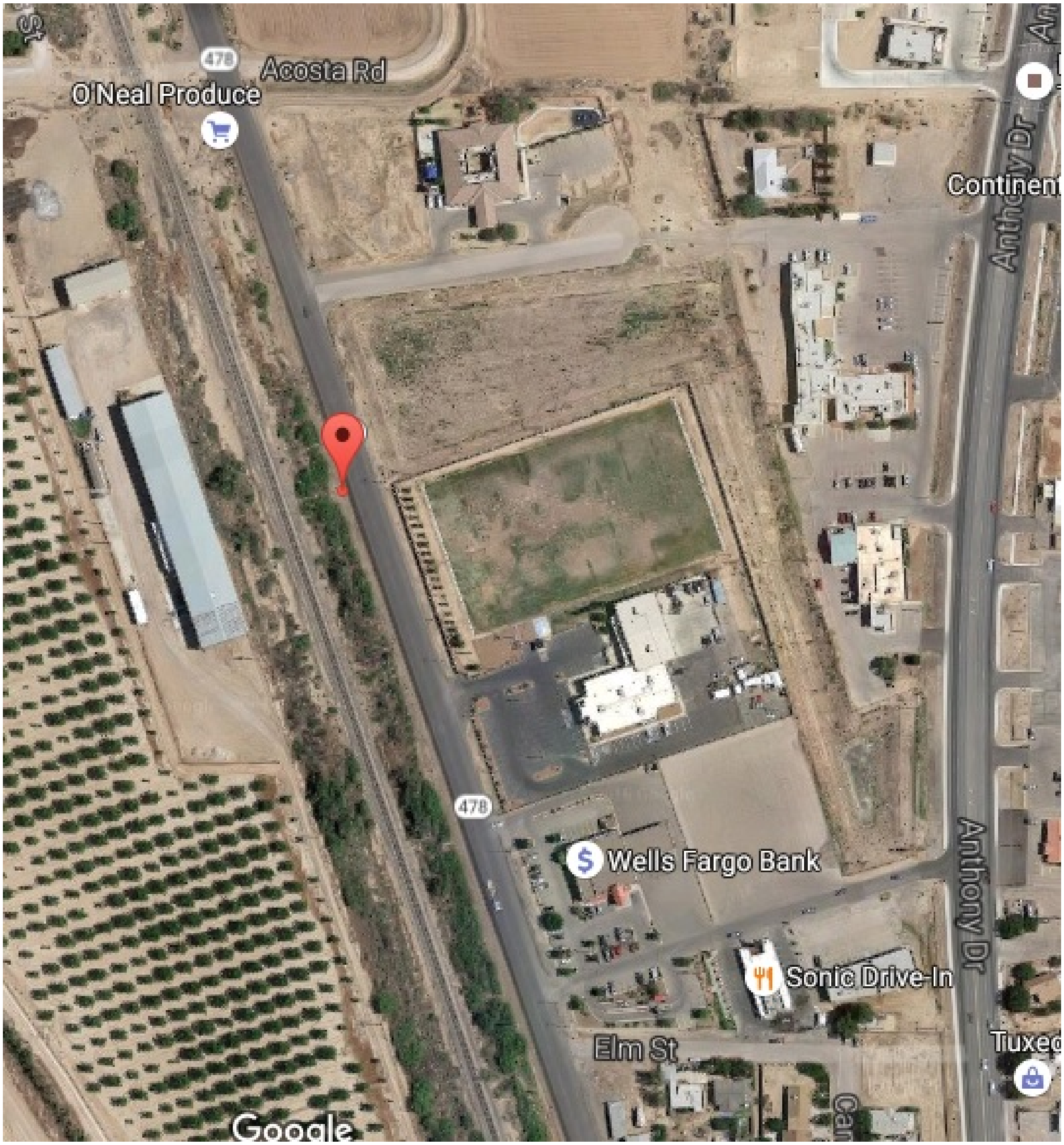
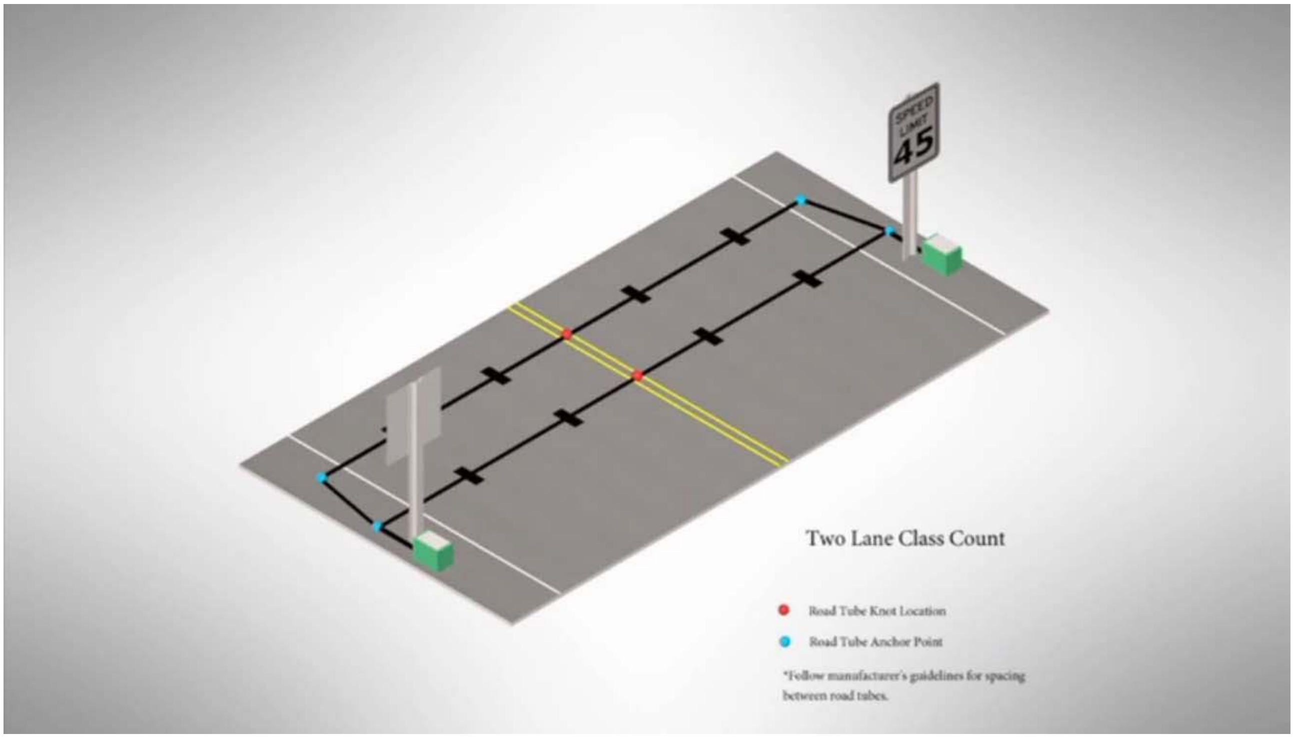


Figure 10.3 Example Aerial View of Count Location



The two pictures in Figure 10.4 show the road tube system diagrams to help illustrate how equipment was deployed at the sites studied.

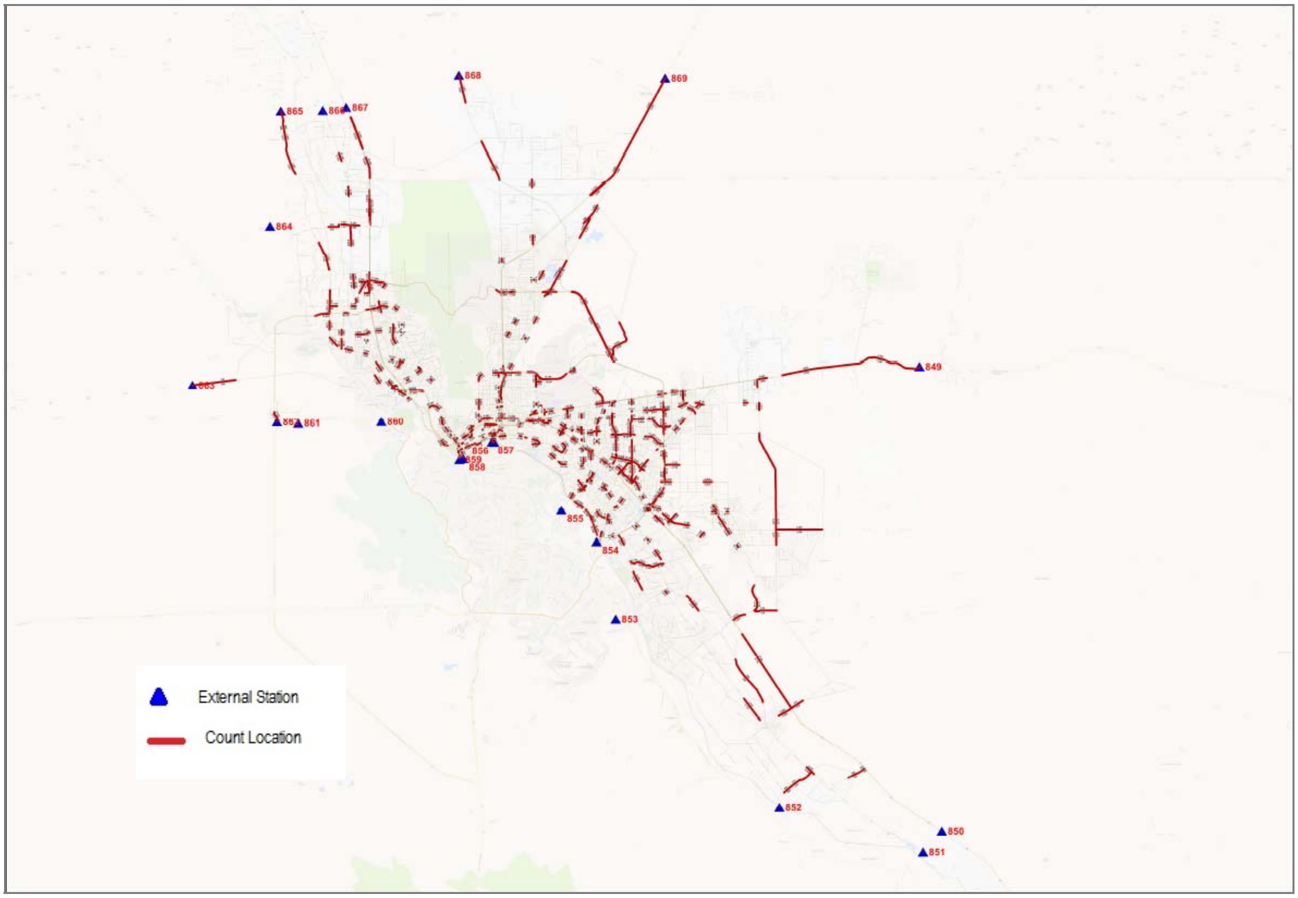
Figure 10.4 Road Tube Systems



10.2 TxDOT Counts

In addition to the New Mexico counts, the TxDOT El Paso District also engaged their consultant and collected several hundred vehicle class counts during the same time frame, but in the Texas side of the EPMPO region. These are shown in Figure 10.5.

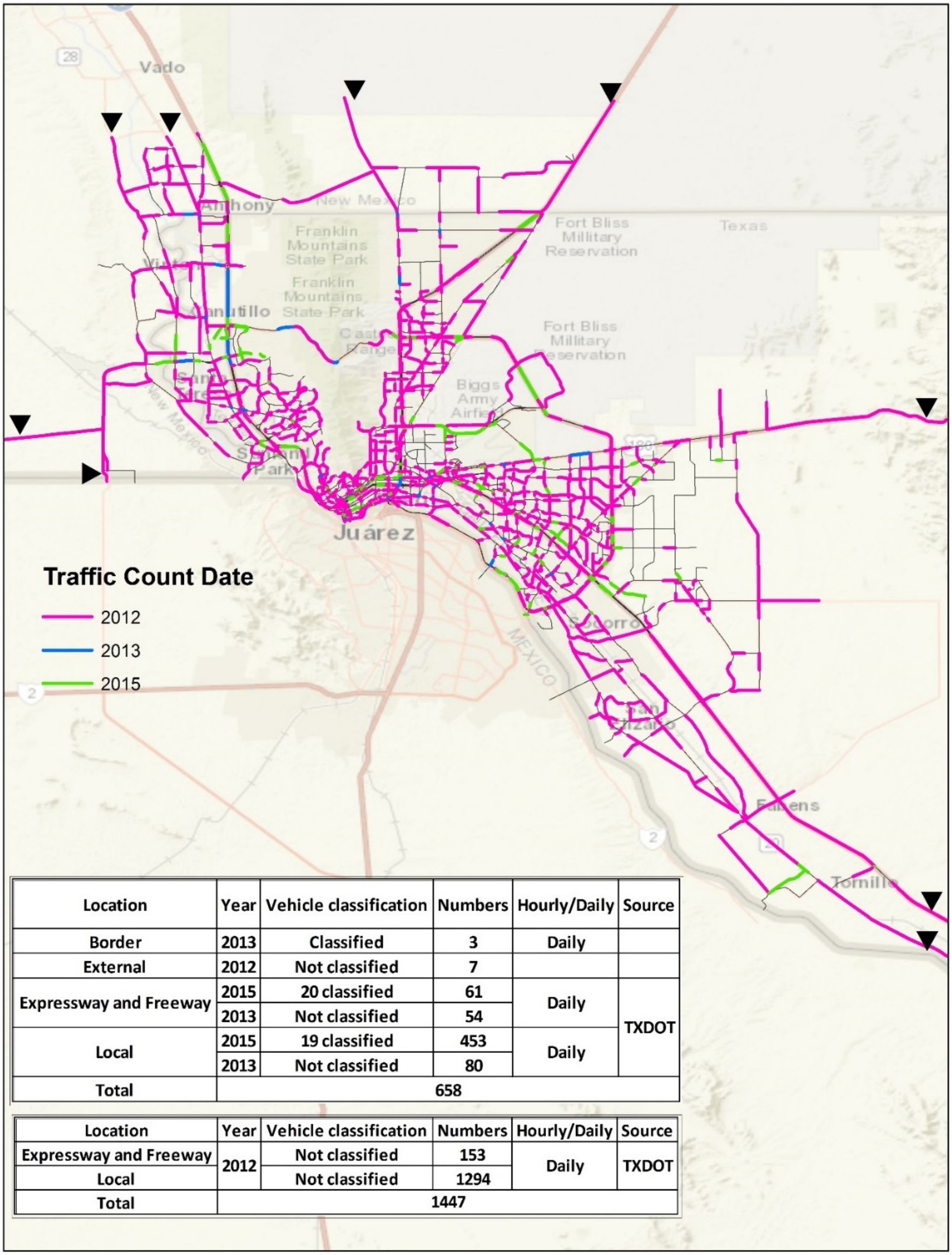
Figure 10.5 TxDOT Count Locations



10.3 All Counts

Figure 10.6 shows a compilation of all the traffic counts, including New Mexico, TxDOT counts, and several others from previous years. A large number of traffic counts from 2012 were also reviewed and processed to use in this study. The table inside the Figure 10.6 shows counts from different years, and their locations are color-coded on the map.

Figure 10.6 Traffic Counts by Year and Location



Location	Year	Vehicle classification	Numbers	Hourly/Daily	Source
Border	2013	Classified	3	Daily	
External	2012	Not classified	7		
Expressway and Freeway	2015	20 classified	61	Daily	TXDOT
	2013	Not classified	54		
Local	2015	19 classified	453	Daily	
	2013	Not classified	80		
Total	658				

Location	Year	Vehicle classification	Numbers	Hourly/Daily	Source
Expressway and Freeway	2012	Not classified	153	Daily	TXDOT
Local		Not classified	1294		
Total	1447				

10.4 Adjusting Counts

For model development and reasonableness checking purposes, a global adjusting factor was used to address counts collected in different years. In order to convert 2016, 2015 and 2013 traffic counts to the base year 2012, a factor of 0.011 or 1.11 percent was used. For example, a 2013 count was reduced by (1.11% * (2013-2012), and a 2015 count was reduced by (1.11% * (2015-2012). The factor of 1.11 percent is the average percent change in employment between 2012 and 2017. It was assumed that employment drives vehicular trips and traffic counts; therefore, traffic counts were adjusted to account for percent changes in employment.

A future project can consider a more refined method for scaling counts at each location using either segment-specific or district-level traffic growth considerations. Counts are used to test the fit of the assignment model and the tolerances used for this comparison allow for there to be deviations in “ground truth”. Proper use of the model for local study should involve post-processing of model output using the procedures found in NCHRP Report 765 and locally checked and prepared traffic counts.

There were several truck count percentages available and these were used as available. These were converted to truck counts for use in the validation efforts along with several other vehicle class counts.

The entire count database included counts from close to 1,800 highway network links that were coded into the TransCAD network layer.

11.0 Assignment Model

In the traffic assignment step, vehicle trip tables by time of day are assigned to the network using an equilibrium procedure for the four time periods. After traffic assignment is completed, resulting travel times are fed back to trip distribution and the model is run iteratively until speeds input to trip distribution are reasonably consistent with speeds resulting from traffic assignment.

After speed feedback has been completed, transit person trips are assigned to the transit route system. Transit trips are assigned separately for peak and off-peak periods and by drive and walk access. These individual assignment results are combined to form daily transit assignment results. Accordingly, this chapter is organized into 3 major subsections: Highway Assignment, Speed Feedback Convergence; and Transit Assignment.

11.1 Highway Assignment

The highway traffic assignment step loads the travel demand represented by the vehicle trip tables onto the roadway network. A user equilibrium assignment method is applied in the model that accounts for traffic congestion and the associated rerouting of trips to avoid congestion. The equilibrium assignment process minimizes the total travel time on the roadway network, representing a condition in which each highway user has perfect knowledge of traffic conditions in the region.

11.1.1 Closure Criteria

With equilibrium traffic assignment, oscillations between equilibrium iterations can sometimes result in unstable assignment results. If closure criteria are not sufficient, two very similar model runs (e.g., with only one small adjustment to the roadway network) can produce unexpected differences in traffic volumes. This generally occurs when the equilibrium traffic assignment algorithm converges at a different number of iterations – sometimes only one iteration difference – for each run. Even when equilibrium traffic assignment converges after the same number of iterations, alternating oscillations in traffic volumes can sometimes be observed in traffic assignment results based on slightly different model networks.

While oscillations introduced by the equilibrium traffic assignment procedure are of some concern, they can be managed through introduction of a very tight closure criterion. By default, traffic assignment is performed with a closure gap of 0.00001 (10^{-5}) and a maximum number of iterations of 500. If oscillations are observed when performing alternatives analysis, it may be necessary to adjust the closure criteria.

11.1.2 Impedance Calculations

The impedance used for determining the shortest path in the traffic assignment model typically includes travel time, and may also include auto operating cost and tolls. When including variables in addition to travel time, a generalized cost function converts all variables to a consistent cost using a value of time, as demonstrated in the equation below.

$$Generalized\ Cost = Time * Value\ Of\ Time + Operating\ Cost + Toll\ Cost$$

The base year model does not have any tolls in the network; so toll costs are zero. The operating costs take into account the auto operating cost of 15 cents per mile. Operating cost was computed in order to represent both travel time and distance in the traffic assignment algorithm. The validated travel model includes a weight of 50% on distance and 50% on travel time. This is accomplished by computing a vehicle operating rate that results in the specified weight on travel distance.

11.1.3 Volume-Delay Functions

A volume-delay function represents the effect of increasing traffic volume on link travel time in the assignment process. While several volume delay functions are available for consideration, the most commonly used function is the modified Bureau of Public Roads (BPR) function. The modified BPR function is based on the original BPR equation shown below.

$$T_C = T_F\left(1 + \alpha\left(\frac{V}{C}\right)^{\beta}\right)$$

Where:

T_C	= Congested travel time
T_F	= Freeflow travel time
V	= Traffic volume
C	= Highway design capacity (i.e., upper limit level of service E capacity)
α	= Coefficient alpha (0.15)
β	= Exponent beta (4.0)

The modified BPR equation uses the same form, but replaces design capacity with ultimate (i.e., upper limit LOS E) capacity. The modified function also replaces the coefficient alpha and the exponent beta with calibrated values that vary by facility type and area type.

As shown in Table 11.1, a look-up table based on facility type (FTYPE) and area type (ATYPE) is used to identify appropriate free flow speed, highway design capacity, and the calibrated alpha and beta values. The network was developed based on a master network database prepared by EPMPO. Alpha and beta values, which follow TxDOT guidelines, were developed by monitoring link speed and VMT balance by facility type during the model validation process. Alpha and beta for centroid connectors were specified so that congestion is not represented on centroid connectors.

Table 11.1 Speed-Capacity and Volume Delay Parameters

FTYPE	FTYPE Description	ATYPE	SPEED	CAP	Alpha	Beta
0	Centroid Connector	1	16	10000	0.15	4.0
0	Centroid Connector	2	20	10000	0.15	4.0
0	Centroid Connector	3	24	10000	0.15	4.0
0	Centroid Connector	4	28	10000	0.15	4.0
0	Centroid Connector	5	42	10000	0.15	4.0
1	Freeway	1	55	2000	0.98	5.5
1	Freeway	2	65	2000	0.98	5.5
1	Freeway	3	70	2000	0.98	5.5

FTYPE	FTYPE Description	ATYPE	SPEED	CAP	Alpha	Beta
1	Freeway	4	70	2000	0.98	5.5
1	Freeway	5	70	2000	0.98	5.5
2	Expressway	1	42	1750	0.98	5.5
2	Expressway	2	45	1750	0.98	5.5
2	Expressway	3	50	1700	0.98	5.5
2	Expressway	4	52	1700	0.98	5.5
2	Expressway	5	55	1700	0.98	5.5
3	Principal Arterial	1	22	860	0.638	1.92
3	Principal Arterial	2	37	840	0.638	1.92
3	Principal Arterial	3	41	840	0.638	1.92
3	Principal Arterial	4	43	840	0.638	1.92
3	Principal Arterial	5	44	800	0.638	1.92
4	Minor Arterial	2	32	800	0.45	1.92
4	Minor Arterial	3	33	800	0.45	1.92
4	Minor Arterial	4	37	780	0.45	1.92
4	Minor Arterial	5	37	770	0.45	1.92
5	Collectors and Frontage	1	18	750	0.55	1.73
5	Collectors and Frontage	2	32	750	0.55	1.73
5	Collectors and Frontage	3	33	750	0.55	1.73
5	Collectors and Frontage	4	34	720	0.55	1.73
5	Collectors and Frontage	5	35	720	0.55	1.73
7	Local Streets	1	15	550	0.55	1.73
7	Local Streets	2	21	550	0.55	1.73
7	Local Streets	3	22	550	0.55	1.73
7	Local Streets	4	23	500	0.55	1.73
7	Local Streets	5	24	500	0.55	1.73
20	Ramps	1	27	1550	0.638	1.92
20	Ramps	2	31	1550	0.638	1.92
20	Ramps	3	35	1550	0.638	1.92
20	Ramps	4	40	1550	0.638	1.92
20	Ramps	5	51	1550	0.638	1.92

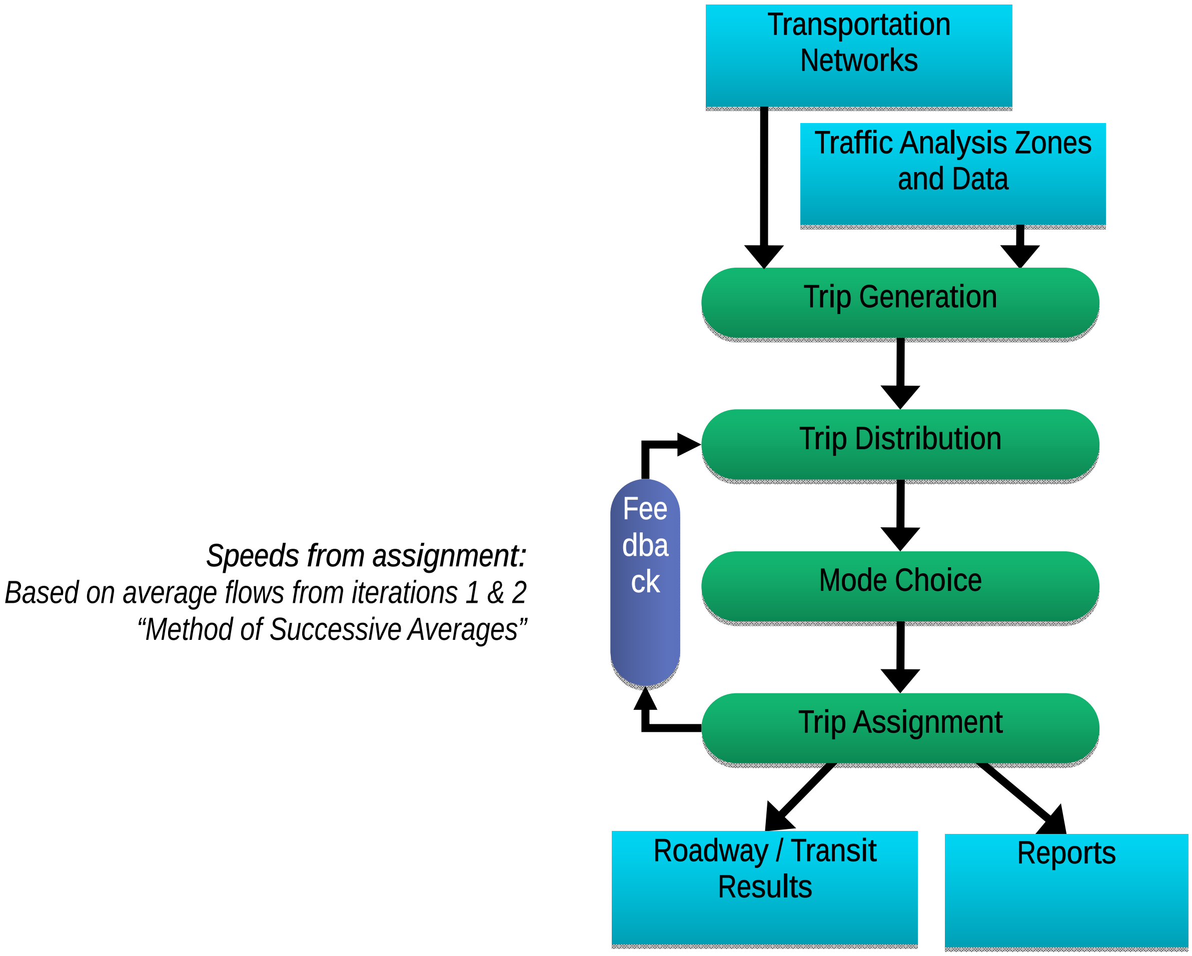
11.2 Speed Feedback

The trip distribution and mode choice model steps rely on congested zone to zone travel time information to distribute trips and identify mode shares. The traffic assignment step produces estimated congested travel speeds based on traffic flows and application of the volume-delay function. The speeds input to trip distribution and mode choice are generally not consistent with the speeds output from traffic assignment. To rectify this inconsistency, results from the AM traffic assignment are used to re-compute peak zone to zone travel times, and the results from the MD traffic assignment are used to re-compute off-peak zone to zone travel times. The model is re-run, and a comparison is then made between the initial and updated zone to zone travel times, as depicted in Figure 11.1. If the travel times are not reasonably similar, the updated travel times are then fed back to trip distribution and mode choice. This process can be repeated iteratively until a convergence criterion or iteration limit is met.

Inclusion of a speed feedback process in the travel model can have interesting and desirable effects on the way the travel model represents the effects of network improvements in congested situations. Without speed feedback, overall regional travel demand remains constant regardless of the roadway network assumptions because trip distribution and mode choice patterns are not affected by changing congestion levels.

When speed feedback is added to the model, heavy congestion results in slower speeds, thereby leading to shorter trip patterns in areas with heavy congestion. As roadway improvements are added to the model, the associated capacity increase results in faster travel speeds as localized congestion decreases. The higher speeds result in longer trip lengths, which has the effect of incrementally increasing overall travel demand. In the mode choice model, slower roadway speeds typically result in slower transit speeds as well, minimizing the effect of speed feedback on transit results. Speed feedback has a more notable effect on transit results when modeling transit options that do not experience speed degradation as traffic congestion increases. Inclusion of speed feedback is most important from a mode choice perspective when using the model to test options such as BRT, rail, or even improvements such as transit signal prioritization or queue jumps.

Figure 11.1 Feedback Process



11.2.1 Method of Successive Averages

The simplest approach to speed feedback merely feeds link speeds from traffic assignment back to the trip distribution and mode choice model steps. This approach will often lead to convergence problems as trip distribution oscillates between long and short trip lengths. Instead, the model uses the method of successive averages (MSA) to implement speed feedback. With this approach, volumes resulting from traffic assignment are averaged over multiple iterations. These average volumes are then input to the volume delay equation to compute speeds for use in trip distribution and mode choice.

The Method of Successive Averages uses a simple average of all flows resulting from previous assignment runs. MSA Flows can be computed as shown in the equations below.

$$MSAFlow_n = \left(MSAFlow_{n-1} - \frac{MSAFlow_{n-1}}{n}\right) + \frac{Flow_n}{n}$$

$$MSAFlow_n = MSAFlow_{n-1} + \frac{1}{n}\left(Flow_n - MSAFlow_{n-1}\right) \quad [Simplified]$$

Where:

$MSAFlow$ = Flow calculated using the MSA

n = current iteration

$Flow$ = Flow resulting from traffic assignment

The method of successive averages effectively assigns a weight to the traffic volumes from each traffic assignment iteration that is equal to the reciprocal of the iteration number. In other words, the volume results from each previous iteration are weighted equally when computing travel times for trip distribution. After the new MSA-weighted flows are calculated, speeds on each link in the roadway network are re-estimated, and the remainder of the model is run to complete the iteration.

11.2.2 Initial Speeds and Borrowed Feedback Results

Use of the MSA feedback procedure produces results that are sensitive to the initial speeds/travel times input to the first iteration of the trip distribution model. For this reason, caution must be used when comparing results of different model runs that include speed feedback. In cases where different model runs will be compared directly, initial congested speeds should be initialized using speed limit and conversion factors if the speed feedback model is active.

In some cases, it is desirable to run the model to test multiple alternatives without running speed feedback for each scenario. For these cases, it is possible to run the model once with speed feedback enabled to establish a baseline forecast scenario (e.g., future growth on an existing plus committed network) and then save the final model results with speed feedback for use in alternatives testing runs. With this approach, speed feedback is disabled when using the copied feedback results. In addition, the baseline scenario should be run a second time with speed feedback disabled and using copied speeds to ensure consistency between all scenarios.

11.2.3 Convergence Criteria

It is important that a meaningful convergence criterion is specified when running a model with speed feedback. The convergence criterion should be monitored during model runs to prevent unnecessary iterations of the speed feedback process, as the convergence measure will provide diminishing benefits after a certain point. The point at which the best possible convergence has been met will often vary with the level of congestion in a network. Therefore, it is particularly important to monitor speed feedback convergence when first running a dataset that is significantly different than previously considered scenarios.

Traffic assignment convergence settings also affect speed feedback convergence. If traffic assignment does not adequately converge, the speed feedback convergence measure may improve slowly or inconsistently. Alternately, if traffic assignment is set to converge more thoroughly, the speed feedback convergence measure may improve more consistently and more quickly. However, closure settings that are too stringent can result in unreasonably long model run times.

Shortest Path Root Mean Square Error (% RMSE) is a common way to measure speed feedback convergence. This measure compares zone to zone travel time matrices between subsequent iterations, so %RMSE provides an indication of how similar the two travel time matrices are to one another. This approach directly satisfies the requirement that inputs to trip distribution and outputs from traffic assignment are reasonably similar. This method also has the advantage of measuring convergence criteria without the need to run traffic assignment for the final iteration. This facilitates a simpler structure for the speed feedback model. The model uses % RMSE to monitor speed feedback convergence using the equation below.

$$\%RMSE = \frac{100 \cdot \sqrt{\sum_z \left(t_{z(i)} - t_{z(i-1)}\right)^2}}{\frac{\sum_z t_{z(i)}}{n}}$$

Where:

$\%RMSE$ = Percent Root Mean Square Error

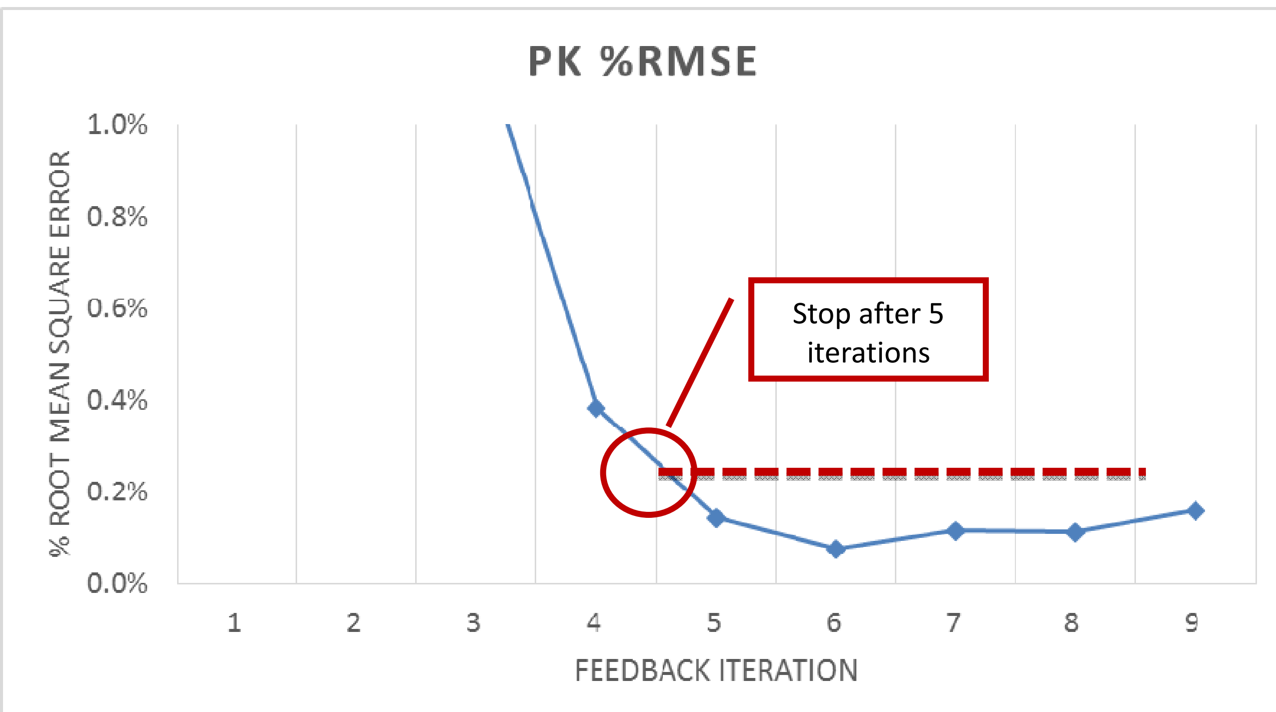
$t_{z(i)}$ = Travel time for zone pair z for feedback iteration i

$t_{z(i-1)}$ = Travel time for zone pair z for feedback iteration $i-1$

n = Number of zone to zone pairs

Figure 11.2 shows the decrease in peak period %RMSE after every feedback loop or iteration. After the 5th iteration, the %RMSE does not change much indicating that the model stabilizes after 5 iterations. Therefore, the base year model is set to run through five feedback loops.

Figure 11.2 Peak Period % RMSE by Iteration



11.2.4 Application of Speed Feedback for Alternatives Analysis

Speed feedback ensures travel time consistency within the entire modeling structure. Generally, the effects of speed feedback are most noticeable when modeling network changes that provide a significant travel time improvement, such as a new freeway in a developing area. These types of alternatives warrant running the feedback process because they can affect regional travel patterns. Less significant improvements may not result in a significant change in trip distribution patterns.

Speed feedback should be executed to closure for the base network in each of the horizon and interim milestone years. This base network could be defined as a no-build, existing plus committed, cost-feasible, or build network for each of these future years. In any given year, speed feedback should generally be run when a scenario includes major changes to socioeconomic data assumptions or significant changes to the roadway network.

When comparing minor improvements, it is often best to run the model with speed feedback disabled. This will increase consistency between scenarios being compared.

11.3 Transit Assignment

Transit person trips resulting from the mode choice model are assigned to the transit route system. Each trip is assigned from zone centroid to zone centroid using walk or drive access links, transit routes, and walk egress links. The transit assignment step does not include capacity constraint, so increasing transit volumes do not result in diversion of transit trips to other transit services.

Transit assignment results include the total number of boardings at each transit stop, as well as transit volumes on all stop to stop transit route segments. However, transit results are generally best evaluated at the systemwide or route group level. Individual route, stop, and segment values have not been validated to observed conditions. Prior to using the model to support detailed transit corridor studies, a focused transit model calibration and validation effort is recommended.

12.0 Model Calibration and Validation

This chapter presents the new 2012 El Paso Travel Demand Model which resulted from the calibration and validation procedures and discusses the TexPACK model system in which the new EPMPO model was built. Calibration and validation often go hand in hand. Validation failure leads to adjustments in calibration to arrive at validation success. Validation may also include sensitivity testing and reasonableness checking. This chapter is focused on base year model calibration and basic validation checks of each component and the model as a whole through the assignment results. Potential future validation checks are outlined in Section 12.9.

12.1 Overview of the TexPACK System

The TexPACK Scenario Manager, developed by TxDOT[12], is used to manage modeling scenarios through a graphical user interface. The TexPACK Scenario Manager allows for the cataloging and management of scenarios representing the various model applications. At a minimum, the Scenario Manager contains the standard base year validation and the forecast application of the regional travel demand model. The user can add, modify and/or delete as many alternative scenarios and model test runs as desired with the Scenario Manager.

The Scenario Manager is also used to view and modify all scenario input and output files, as well as parameters for each scenario. Additionally, the Scenario Manager directs TransCAD to the standard location of the TexPACK subfolders that contain the files for each application.

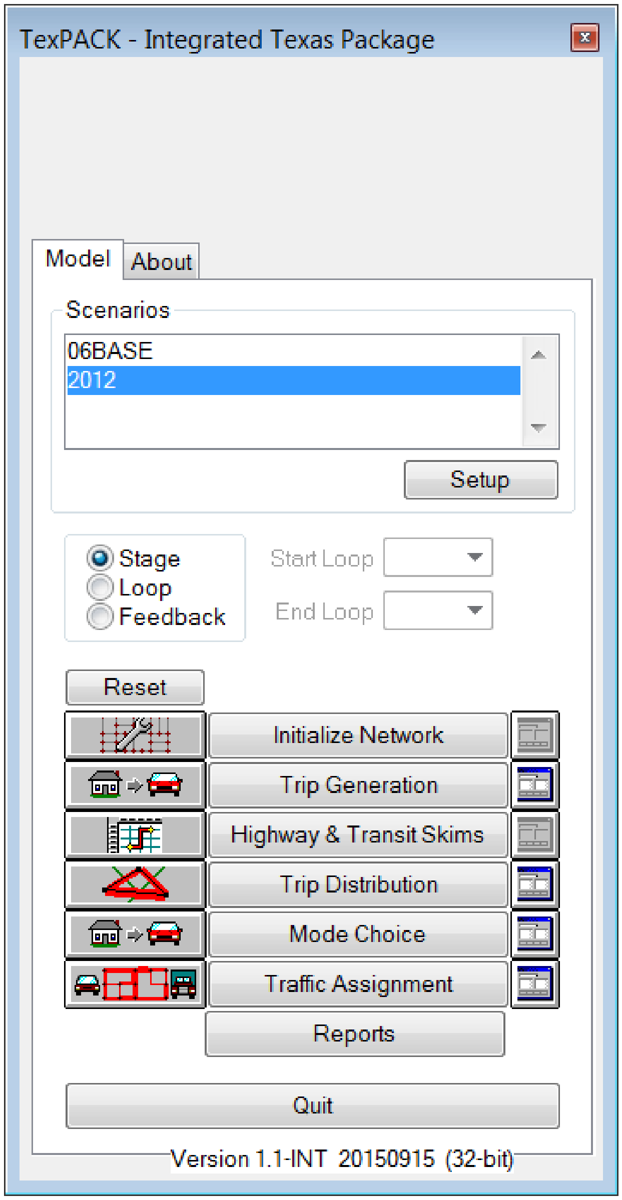
For this model update, GISDK code from the Lubbock MPO Model was used initially and then modified for the specific needs of El Paso MPO model. In particular, the interface was updated to include modeling feedback capabilities. This functionality allows the user to run the model for:

- A single modeling step like Trip Generation;
- A single Loop, (all model steps without feedback); and
- All Loops which applies the feedback procedures until convergence criteria are satisfied.

Figure 12.1 below shows the updated GUI for the new MPO Model. This updated TexPACK integrated El Paso model system was used to work with the model and support the validation of each model component separately as well as combined.

[12] TexPACK Application Guide, Texas A&M Transportation Institute, 2015

Figure 12.1 El Paso MPO Model Interface



12.2 Trip Generation Model

The 2010/2011 El Paso expanded household travel survey served as the basis for calibration the trip production model while the workplace survey was used for calibrating trip attraction model. The initial calibration was performed by adjusting the trip rates by market segment to match the expanded trip totals as much as possible. The final calibration of these models was dependent upon a full model run and the comparison of modeled volumes with traffic counts at the end of assignment. In order to develop and retain additional market segments, the productions and attractions were stratified by different income groups from TripCal5 and input into the TransCAD GISDK part of the model system.

During calibration (informed by validation attempts), the production trip rates were increased by 10% then 5% to match the modeled VMT to the count VMT. Tables 12.1 through 12.6 present the final calibrated and validated trip production rates.

Table 12.1 Home-Based Work Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+
Worker 0					
$0 to $14,999	0.000	0.000	0.000	0.000	0.000
$15,000 to $24,999	0.000	0.000	0.000	0.000	0.000
$25,000 to $39,999	0.000	0.000	0.000	0.000	0.000
$40,000 to $69,999	0.000	0.000	0.000	0.000	0.000
$70,000+	0.000	0.000	0.000	0.000	0.000
Worker 1					
$0 to $14,999	1.067	0.961	1.927	1.853	2.282
$15,000 to $24,999	1.231	0.997	1.802	1.802	2.162
$25,000 to $39,999	1.261	1.033	1.735	1.766	2.042
$40,000 to $69,999	1.297	1.235	1.502	1.730	2.013
$70,000+	1.417	1.237	1.342	1.562	1.900
Worker 2+					
$0 to $14,999	0.000	2.042	2.763	3.226	3.604
$15,000 to $24,999	0.000	2.162	2.844	3.243	3.844
$25,000 to $39,999	0.000	2.282	3.016	3.390	3.964
$40,000 to $69,999	0.000	2.402	3.123	3.865	4.084
$70,000+	0.000	2.440	3.194	3.964	4.378

Table 12.2 Home-Based Non-work Retail Trip Production Rates

Annual HH Income in 2010$/HH Size	1	2	3	4	5+
$0 to $14,999	0.643	1.802	2.162	1.922	4.109
$15,000 to $24,999	0.721	1.922	2.282	2.010	4.324
$25,000 to $39,999	0.799	2.162	2.436	2.162	4.565
$40,000 to $69,999	0.961	2.402	2.555	2.282	4.805
$70,000+	1.093	2.555	2.643	2.436	5.288
Worker 1					
$0 to $14,999	0.444	0.792	1.719	1.321	1.810
$15,000 to $24,999	0.462	1.190	1.859	1.528	3.017
$25,000 to $39,999	0.480	1.565	1.922	2.282	3.300
$40,000 to $69,999	0.500	1.802	2.041	2.620	3.445
$70,000+	0.537	1.986	2.584	2.769	5.220
Worker 2+					
$0 to $14,999	0.000	0.726	1.061	2.871	3.365
$15,000 to $24,999	0.000	1.081	1.672	2.823	3.132
$25,000 to $39,999	0.000	1.271	1.802	2.745	2.282
$40,000 to $69,999	0.000	1.441	2.006	2.699	2.061
$70,000+	0.000	1.739	2.240	2.523	1.644

Table 12.3 Home-Based Non-work Education Trip Production Rates *(Kindergarten to Grade 12)*

Annual HH Income in 2010$/HH Size	1	2	3	4	5+
Worker 0					
$0 to $14,999	0.143	0.252	1.439	6.137	9.009
$15,000 to $24,999	0.114	0.276	1.682	2.699	9.610
$25,000 to $39,999	0.084	0.288	1.965	5.628	10.210
$40,000 to $69,999	0.072	0.318	2.643	9.296	11.138
$70,000+	0.035	0.360	2.884	8.145	11.291
Worker 1					
$0 to $14,999	0.012	0.120	1.994	6.094	9.823
$15,000 to $24,999	0.060	0.145	2.162	6.291	12.132
$25,000 to $39,999	0.102	0.205	2.402	6.607	12.372
$40,000 to $69,999	0.149	0.264	2.523	6.943	12.644
$70,000+	0.180	0.312	2.643	7.688	12.973
Worker 2+					
$0 to $14,999	0.000	0.480	1.682	3.604	7.568
$15,000 to $24,999	0.000	0.360	1.562	3.964	7.688
$25,000 to $39,999	0.000	0.300	1.201	4.324	7.808
$40,000 to $69,999	0.000	0.240	1.081	4.602	8.275
$70,000+	0.000	0.192	0.961	5.278	8.348

Table 12.4 Home-Based Nonwork Education (college) Trip Production Rates

Annual HH Income in 2010$/HH Size	1	2	3	4	5+
Worker 0					
$0 to $14,999	0.000	0.000	0.360	0.961	0.461
$15,000 to $24,999	0.000	0.000	0.480	1.081	0.814
$25,000 to $39,999	0.000	0.012	0.668	1.270	1.321
$40,000 to $69,999	0.000	0.036	0.802	1.321	1.389
$70,000+	0.306	0.072	1.081	1.487	1.441
Worker 1					
$0 to $14,999	0.130	0.020	0.360	0.408	0.240
$15,000 to $24,999	0.480	0.054	0.480	0.480	0.360
$25,000 to $39,999	0.721	0.066	0.661	0.677	0.480
$40,000 to $69,999	0.961	0.115	0.781	0.841	0.744
$70,000+	0.132	0.120	0.841	1.102	0.841
Worker 2+					
$0 to $14,999	0.000	1.140	1.081	1.441	1.091
$15,000 to $24,999	0.000	1.117	0.990	1.207	1.064
$25,000 to $39,999	0.000	1.091	0.841	1.141	1.021
$40,000 to $69,999	0.000	0.715	0.604	1.081	0.961
$70,000+	0.000	0.452	0.466	1.057	0.933

Table 12.5 Home-Based Nonwork Other Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+
Worker 0					
$0 to $14,999	1.240	1.729	2.222	3.240	5.165
$15,000 to $24,999	1.246	1.743	2.282	3.483	5.405
$25,000 to $39,999	1.457	1.778	2.341	3.964	5.526
$40,000 to $69,999	1.502	2.042	2.448	4.324	5.646
$70,000+	1.526	2.323	2.643	4.608	5.766
Worker 1					
$0 to $14,999	0.596	0.918	1.225	1.715	3.028
$15,000 to $24,999	0.625	1.319	1.562	1.922	3.043
$25,000 to $39,999	0.676	1.441	1.682	2.129	4.084
$40,000 to $69,999	0.697	1.562	1.803	3.181	4.285
$70,000+	0.721	1.741	2.042	3.419	7.802
Worker 2+					
$0 to $14,999	0.000	0.601	0.848	1.787	1.849
$15,000 to $24,999	0.000	0.661	1.238	2.162	2.162
$25,000 to $39,999	0.000	0.745	1.441	2.402	3.262
$40,000 to $69,999	0.000	1.071	1.475	2.900	3.363
$70,000+	0.000	1.243	2.008	3.002	3.413

Table 12.6 Non-home-Based Trip Production Rates

Annual HH Income in 2010$/ HH Size	1	2	3	4	5+
$0 to $14,999	0.788	1.498	1.441	2.763	3.243
$15,000 to $24,999	1.013	1.723	1.802	3.003	3.446
$25,000 to $39,999	1.201	2.261	2.239	3.123	4.078
$40,000 to $69,999	1.405	2.282	2.402	3.243	5.045
$70,000+	1.441	2.402	2.643	3.338	7.136
Worker 1					
$0 to $14,999	0.480	1.034	1.616	3.105	3.661
$15,000 to $24,999	0.841	1.229	1.922	3.123	3.844
$25,000 to $39,999	1.128	1.32	2.402	3.243	4.108
$40,000 to $69,999	1.192	1.335	2.593	3.416	5.23
$70,000+	1.201	2.903	2.658	5.146	8.144
Worker 2+					
$0 to $14,999	0.000	0.841	1.189	2.402	4.565
$15,000 to $24,999	0.000	1.321	1.330	2.650	5.405
$25,000 to $39,999	0.000	1.338	2.071	3.243	5.789
$40,000 to $69,999	0.000	1.719	2.712	3.895	6.486
$70,000+	0.000	3.196	4.382	6.235	6.800

Table 12.7 shows the final calibrated and validated attraction rates by purpose and area type.

Table 12.7 Final Trip Attraction Rates by Purpose and Area Type

Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment
1	1	1.4872	1.6432	0.6760	0.0000
1	2	2.3816	1.1856	1.3208	1.2688
1	3	1.3624	2.2256	2.1216	2.8184
1	4	2.2464	2.5064	2.1632	1.3936
1	5	2.9120	6.9264	1.1856	1.0816
2	1	0.0000	0.0000	0.0000	0.0000
2	2	0.0000	0.0000	0.0000	0.0000
2	3	0.0000	0.0000	0.0000	0.0000
2	4	0.0000	0.0000	0.0000	0.0000
2	5	0.0000	0.0000	0.0000	0.0000
3	1	0.0000	0.0000	0.0000	0.0000
3	2	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000
3	4	0.0000	0.0000	0.0000	0.0000
3	5	0.0000	0.0000	0.0000	0.0000
4	1	0.0000	1.9300	0.0000	0.0000
4	2	0.0000	3.5500	0.0000	0.0000
4	3	0.0000	5.7100	0.0000	0.0000
4	4	0.0000	7.8700	0.0000	0.0000
4	5	0.0000	8.0300	0.0000	0.0000
5	1	0.3848	1.6640	1.2272	0.0000
5	2	0.3016	1.4872	1.3728	5.6992
5	3	0.0936	2.3816	1.8616	8.9440
5	4	0.7488	3.0368	0.8944	2.4440
5	5	1.1128	3.7200	1.2168	1.8512
6	1	2.4232	7.6648	0.5096	2.3296
6	2	0.4472	5.8344	0.5824	2.3296
6	3	0.4472	5.8344	0.5824	2.3296
6	4	0.4472	5.8344	0.5824	2.3296
6	5	0.4472	5.8344	0.5824	2.3296

Table 12.8 shows a summary of the final trip generation model output by trip purpose and income. These trip ends are after balancing productions and attractions.

Table 12.8 Final Trip Generation Summary by Purpose and Income

Income Category	HBW	HBNW ED1	HBNW ED2	HBNW RET	HBNW OTH	NHB
INC 1	49,496	129,207	14,440	77,764	96,138	104,571
INC 2	64,230	135,997	19,824	79,781	80,585	108,168
INC 3	112,903	200,568	38,394	111,441	116,867	154,158
INC 4	177,335	256,511	57,026	149,331	164,900	238,928
INC 5	122,295	144,047	27,140	87,549	102,188	178,162
Total	526,259	866,330	156,824	505,866	560,678	783,987
Model	15%	25%	5%	15%	17%	23%
Survey	15%	27%	4%	15%	17%	22%

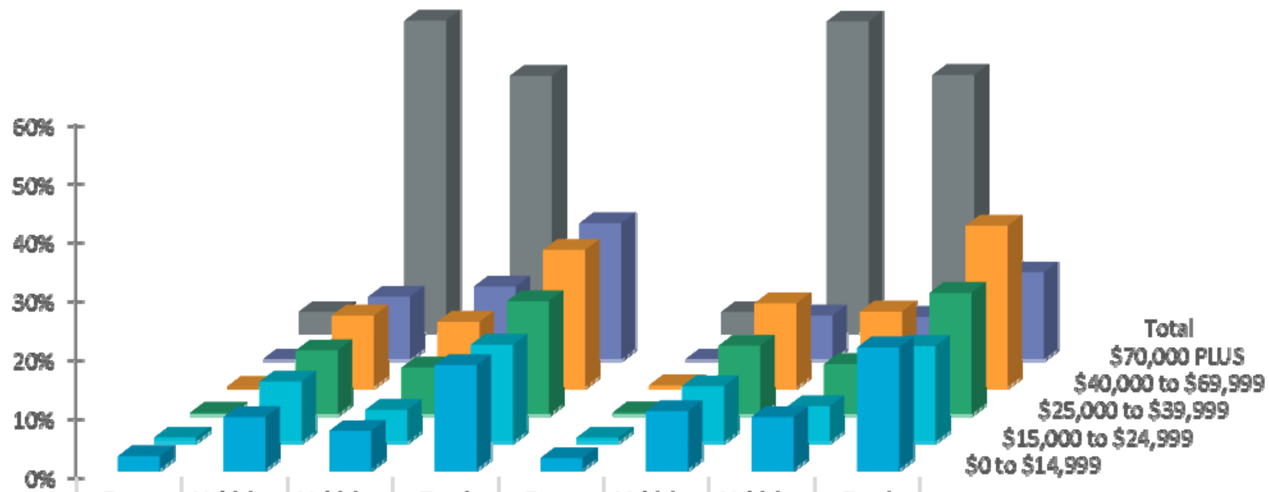
12.3 Vehicle Availability Model

The vehicle availability model is applied after the trip generation model and predicts the number of vehicle available to a household in making trips. This model is dependent upon income level, household size, the proximity to employment opportunities, and the accessibility to transit. This model provides another layer of market segmentation in the model stream that helps explain transit rider behavior.

Figure 12.2 depicts the performance of the calibrated vehicle availability model in predicting vehicle sufficiency for undertaking a trip. This is classified into three categories – zero-vehicle households, fewer vehicles than household size, and more vehicles than household size.

Figures 12.3, 12.4, and 12.5 shows the distribution of households with zero vehicles, less vehicles than household size, and more vehicles than household size. Figure 12.6 depicts the distribution of vehicle availability compared against the land use density for the region. Collectively, these performance figures provided assurance around the reasonableness of the vehicle availability model.

Figure 12.2 Vehicle Availability (or Sufficiency) by Income – Model versus Survey



	Zero-Vehicles	Vehicles <Workers	Vehicles >=Workers	Total	Zero-Vehicles	Vehicles <Workers	Vehicles >=Workers	Total
$0 to $14,999	2%	9%	7%	18%	2%	10%	9%	21%
$15,000 to $24,999	1%	10%	5%	17%	1%	9%	6%	16%
$25,000 to $39,999	0.3%	11%	8%	19%	0.4%	12%	9%	21%
$40,000 to $69,999	0.04%	12%	11%	23%	0.3%	14%	13%	27%
$70,000 PLUS	0.1%	11%	12%	23%	0.1%	8%	7%	15%
Total	3%	53%	44%		3%	53%	44%	

Figure 12.3 Distribution of Zero Vehicle Households

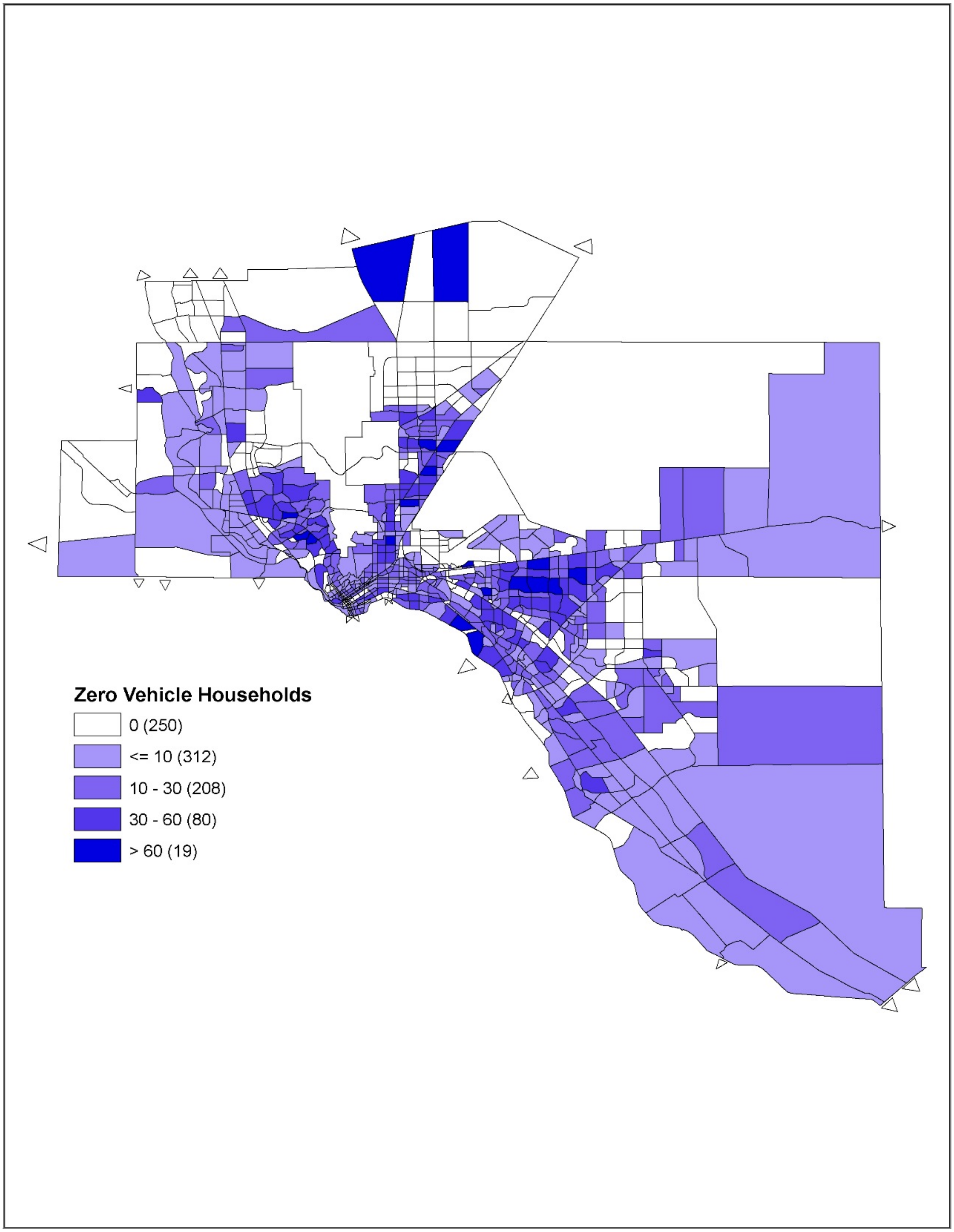


Figure 12.4 Households with Vehicles less than Household Size

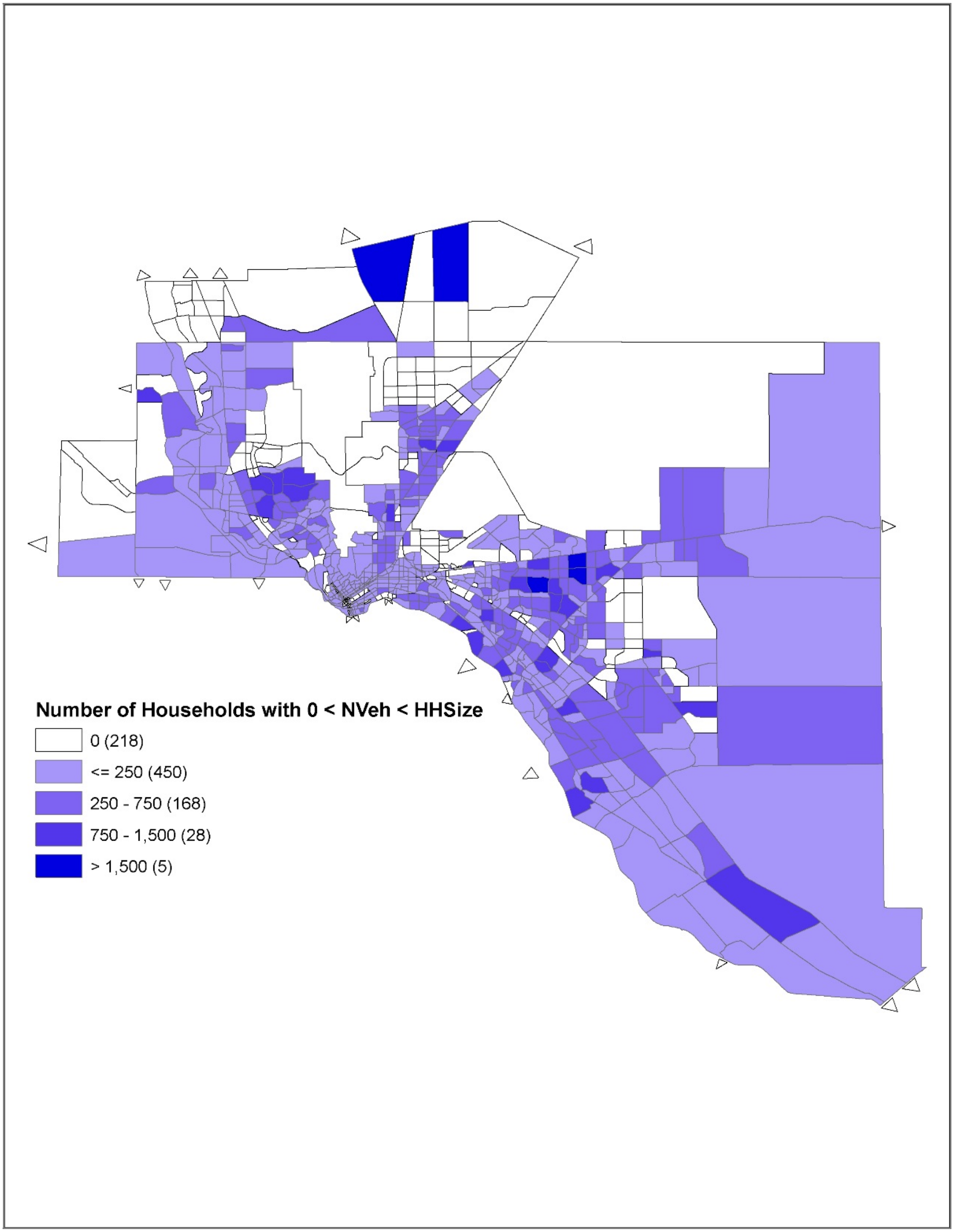


Figure 12.5 Households with Vehicles more than Household Size

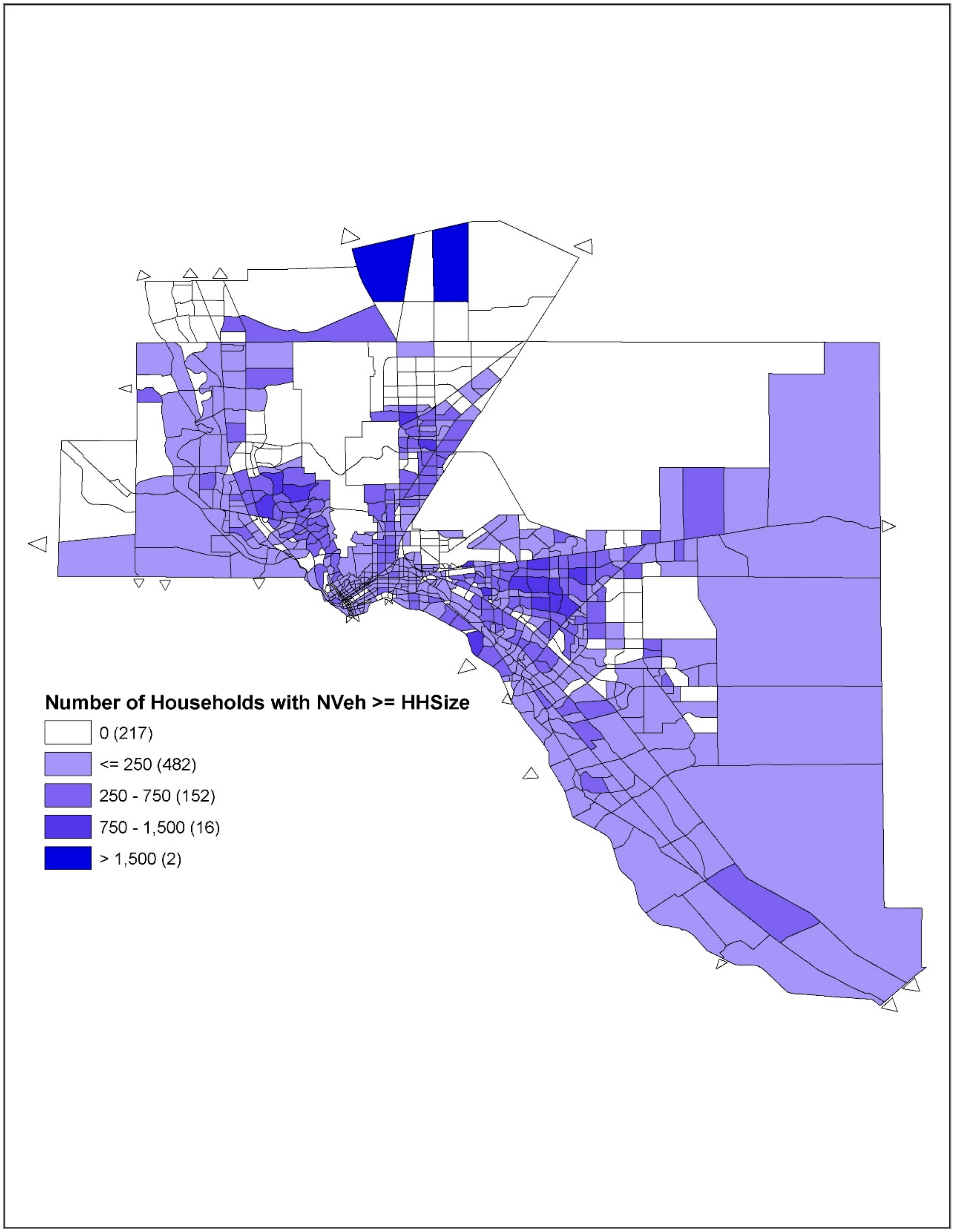
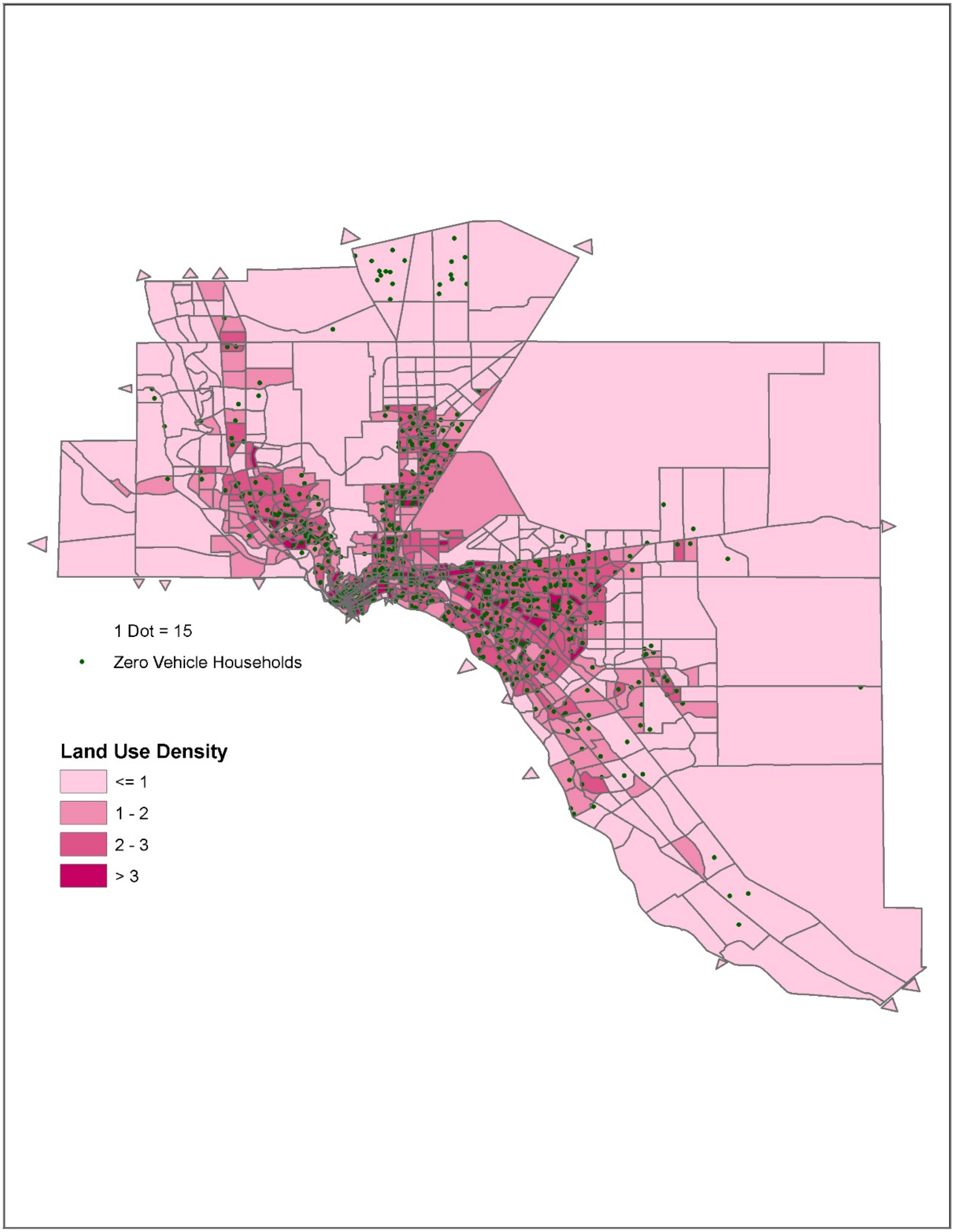


Figure 12.6 Land Use Density versus Vehicle Availability



12.4 Trip Distribution Model

The ATOM2-based trip distribution model was calibrated by adjusting the friction factors that serve as impedances to trips between origins and destinations. The peak and off-peak trips were calibrated separately until they matched the survey with acceptable percent differences. In all, the three types of summaries that were looked into were average trip lengths (ATL), trip length frequency distributions (TLFD), and coincidence ratios (CR). The ATLs by trip purpose were computed and compared to that of the weighted 2010/2011 household travel survey. The TLFDs were also plotted for both modeled and surveyed observations, and the CRs of these plots indicate how well the distribution models are performing.

Tables 12.9 and 12.10 show the ATLs and CRs by trip purpose for peak and off-peak periods, while Figures 12.7 and 12.8 show the TLFDs for peak and off-peak periods.

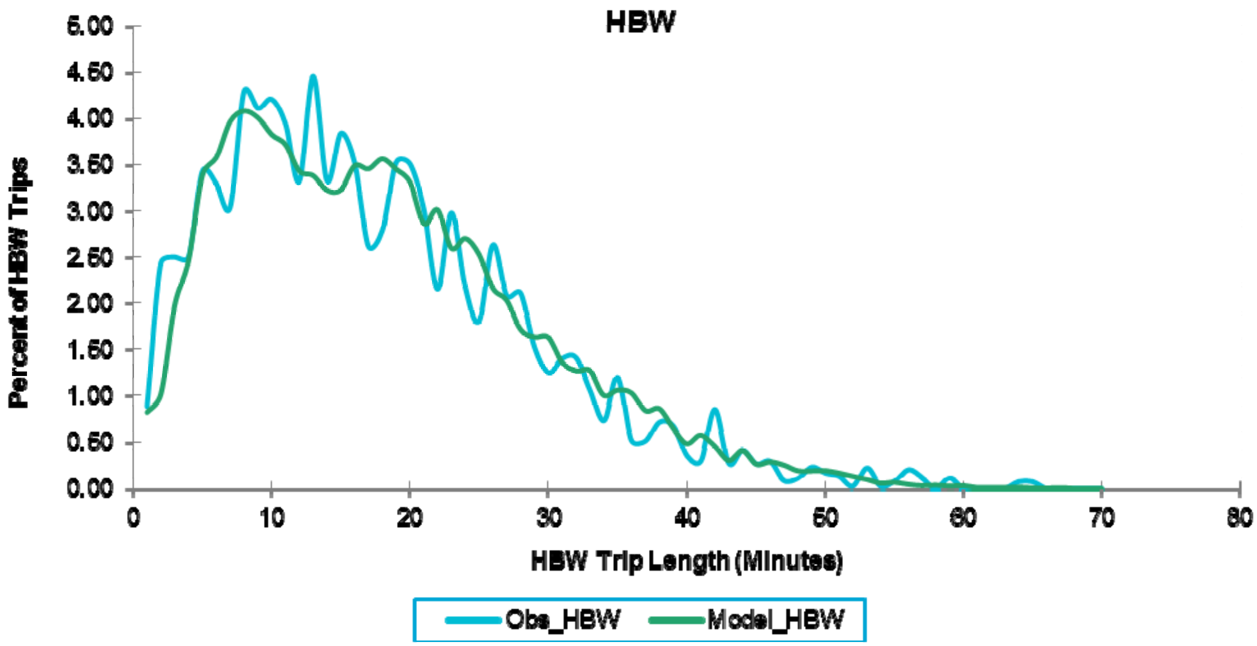
Table 12.9 Average Trip Lengths in Minutes by Purpose – Peak Periods

Peak Periods	HBW	HBNW RETAIL	NHB	HBNW OTHER	HBNW ED1	HBNW ED2
Survey	17.62	10.35	12.17	11.91	8.46	19.38
Model	18.16	10.69	10.21	12.47	7.74	19.07
Difference	0.54	0.34	(1.95)	0.57	(0.72)	(0.31)
Coincidence Ratio	0.85	0.76	0.79	0.76	0.73	0.71

Table 12.10 Average Trip Lengths in Minutes by Purpose – Off-Peak Periods

Off-Peak Periods	HBW	HBNW RETAIL	NHB	HBNW OTHER	HBNW ED1	HBNW ED2
Survey	13.76	10.95	10.20	13.13	7.30	18.37
Model	12.61	10.63	9.30	13.33	6.93	17.14
Difference	(1.15)	(0.33)	(0.90)	0.19	(0.37)	(1.23)
Coincidence Ratio	0.75	0.80	0.82	0.75	0.63	0.69

Figure 12.7 Trip Length Frequency Distributions by Purpose – Peak Periods



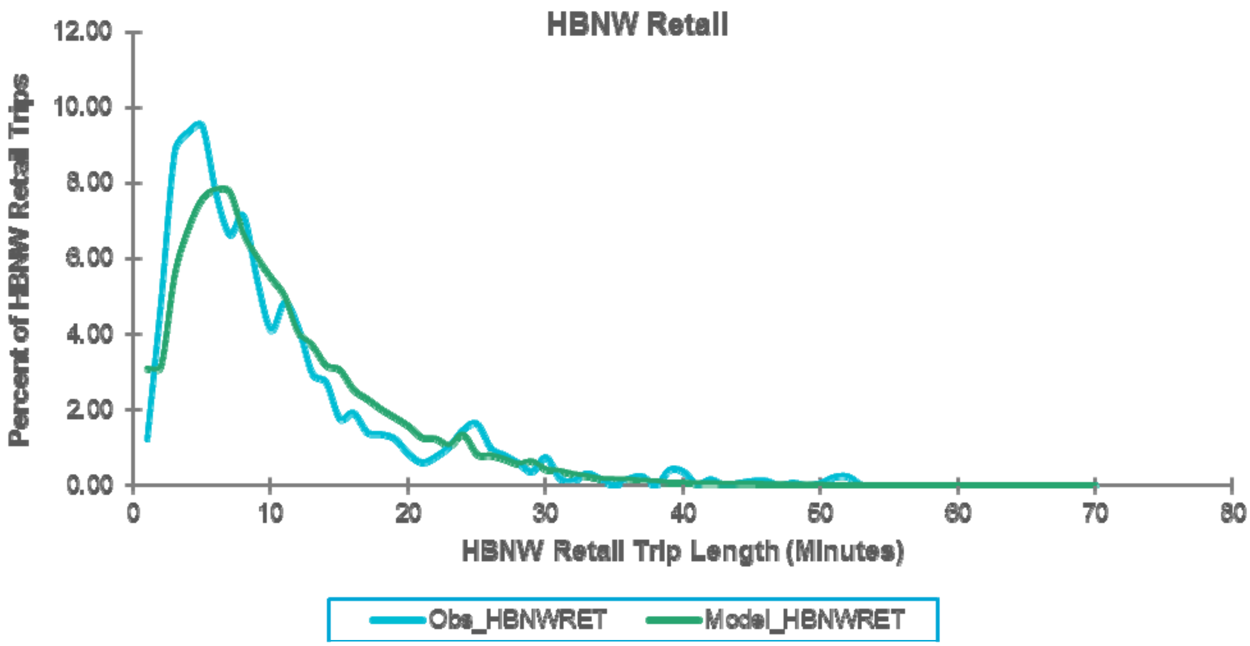
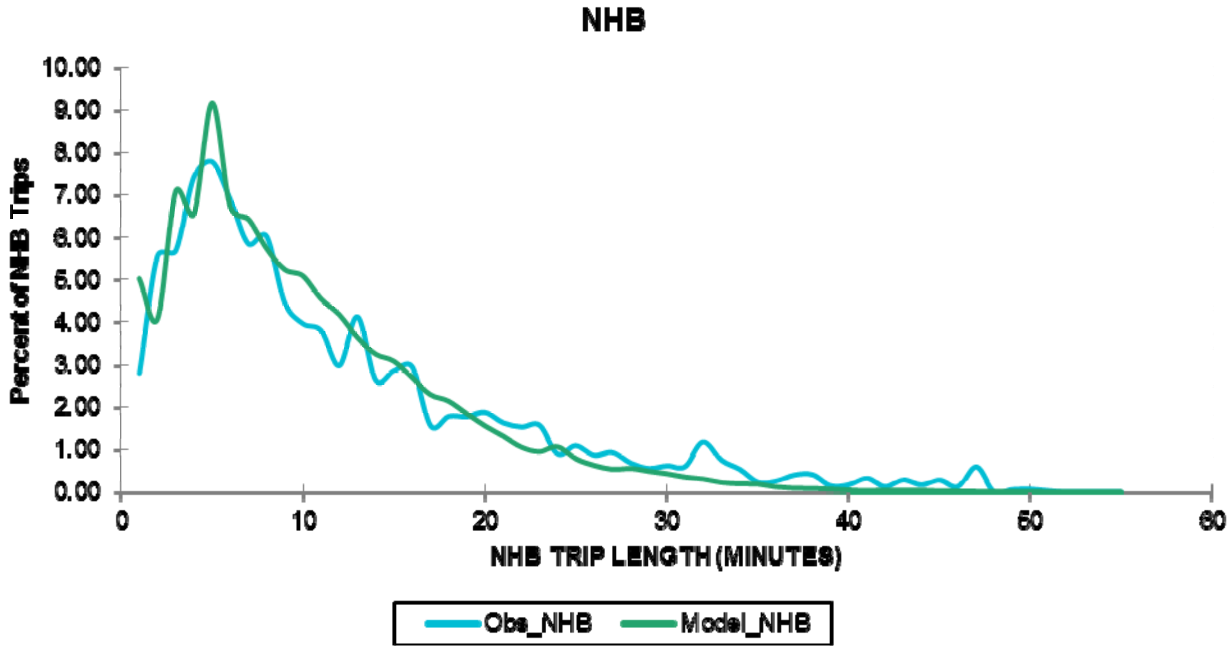


Figure 12.7 Trip Length Frequency Distributions by Purpose – Peak Periods (continued)



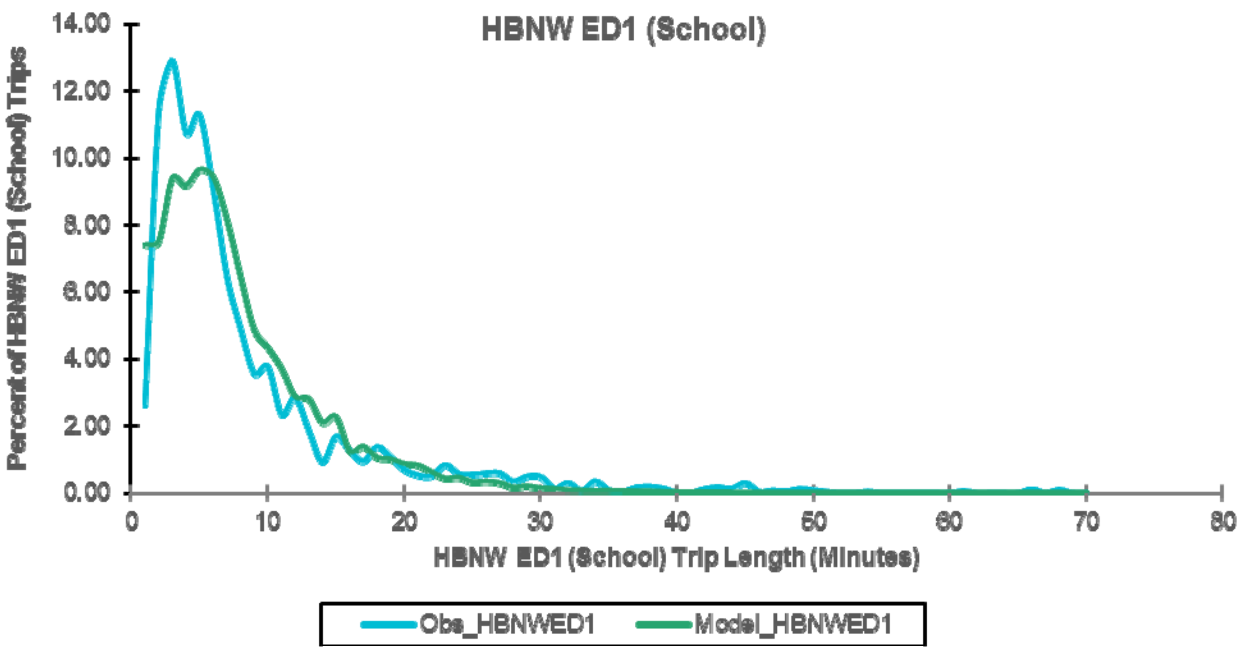
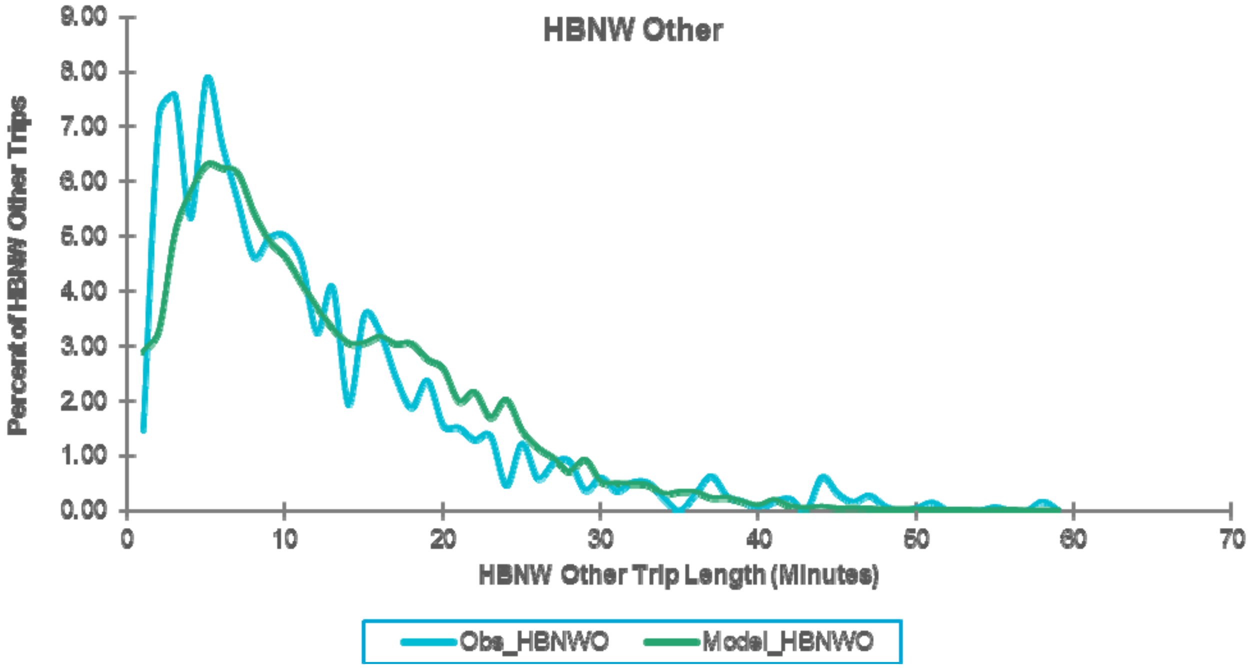


Figure 12.7 Trip Length Frequency Distributions by Purpose – Peak Periods (continued)



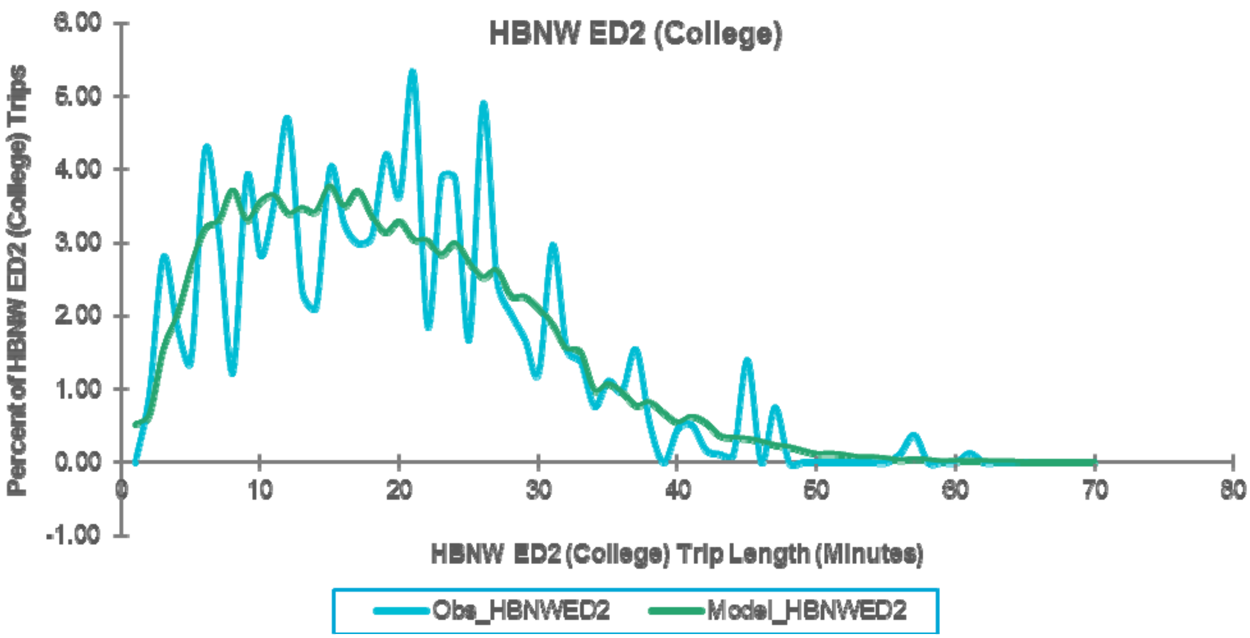
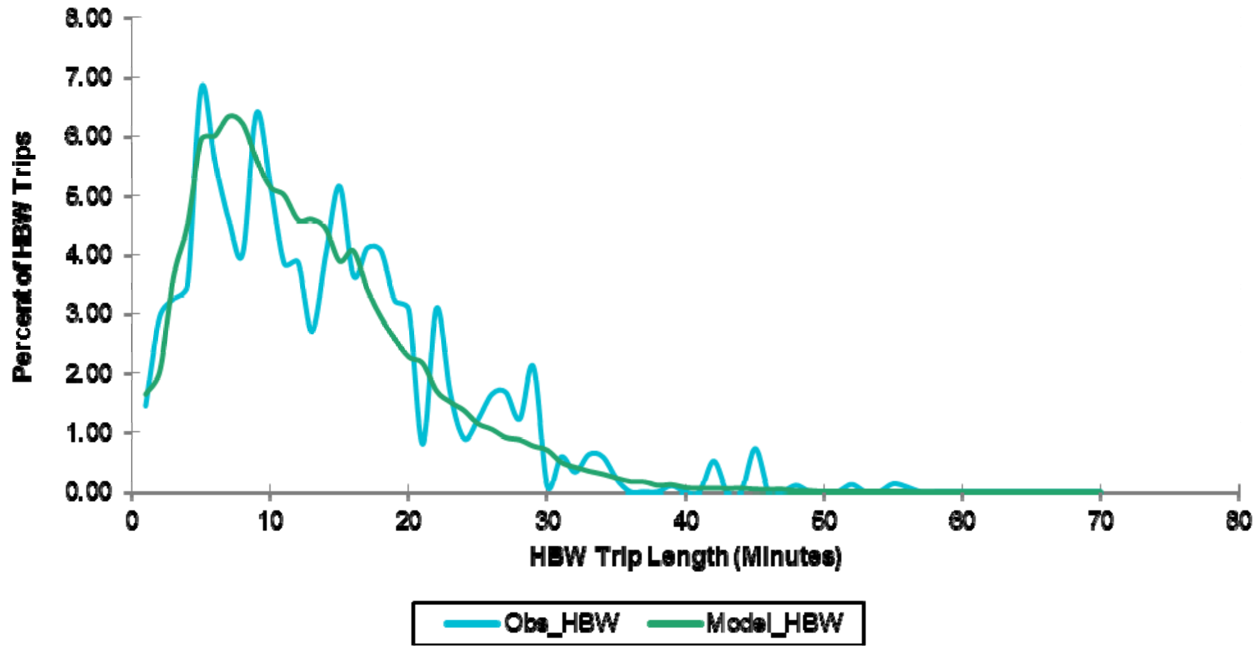


Figure 12.8 Trip Length Frequency Distributions by Purpose – Off-Peak Periods



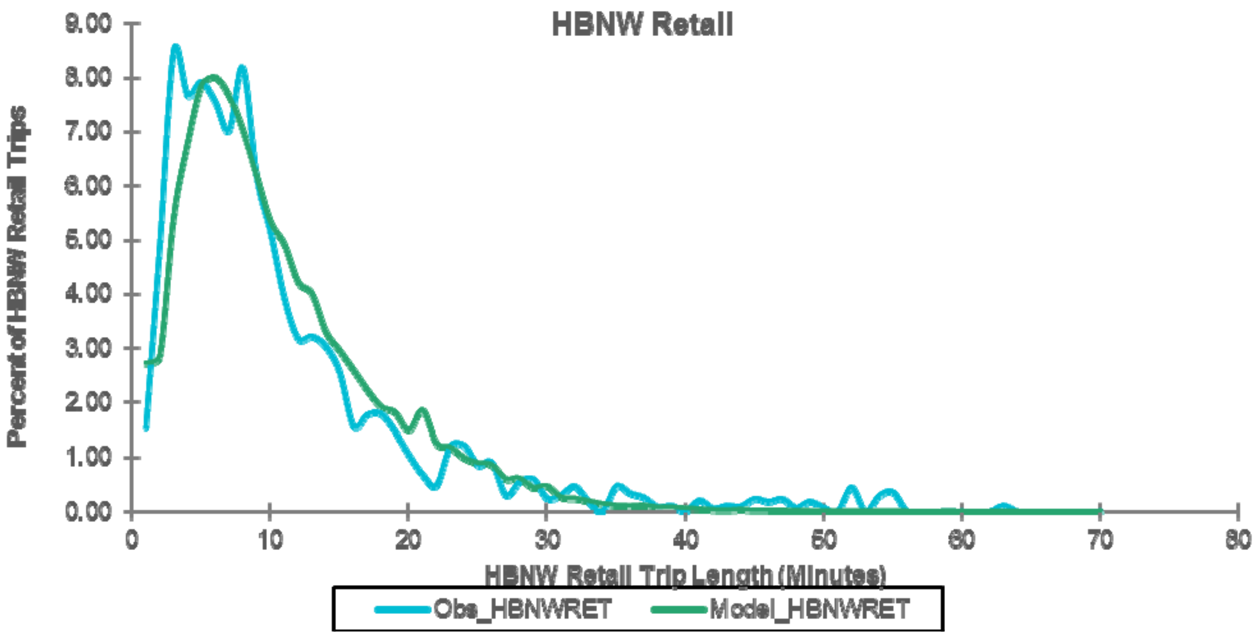
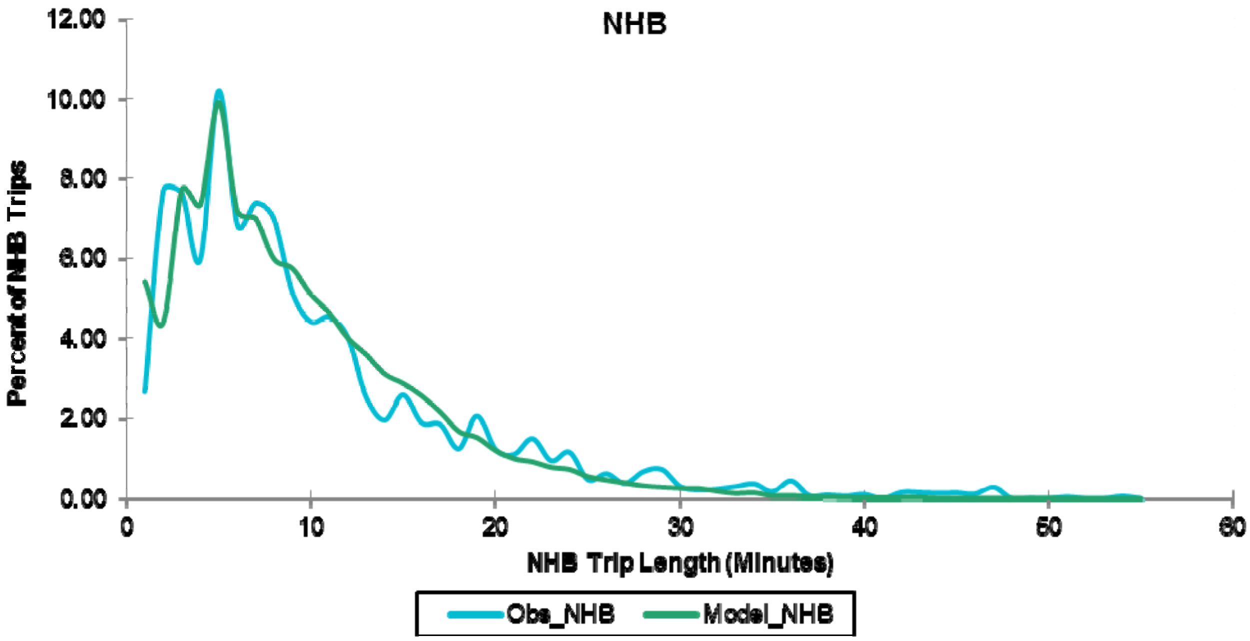


Figure 12.8 Trip Length Frequency Distributions by Purpose – Off-Peak Periods (continued)



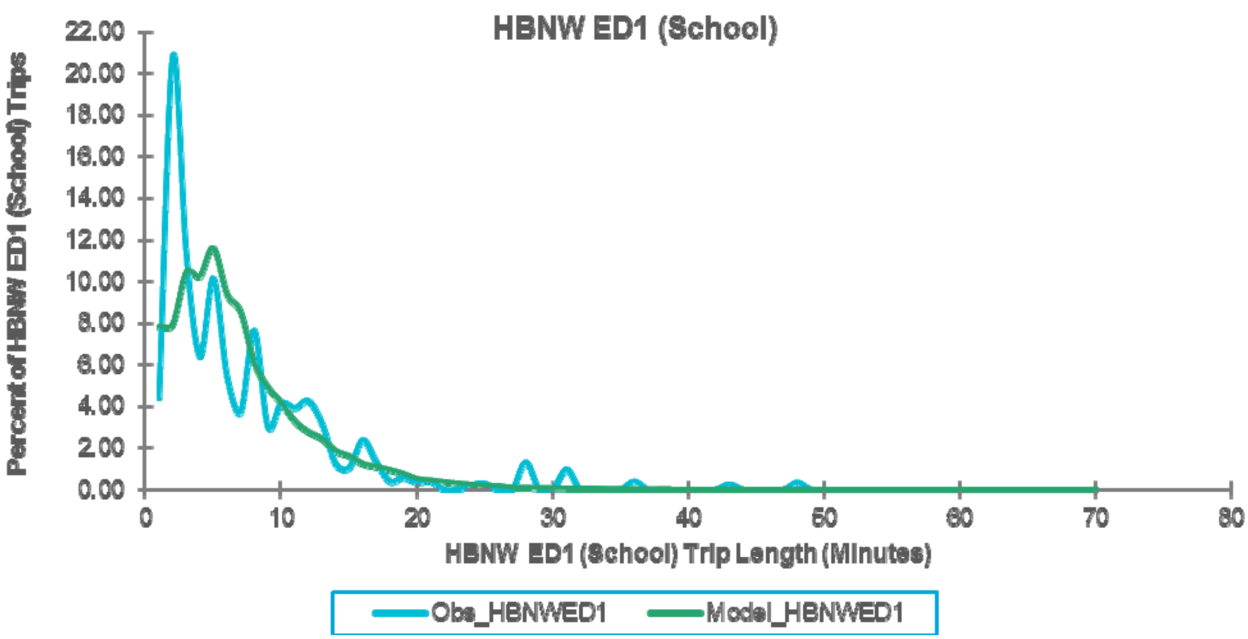
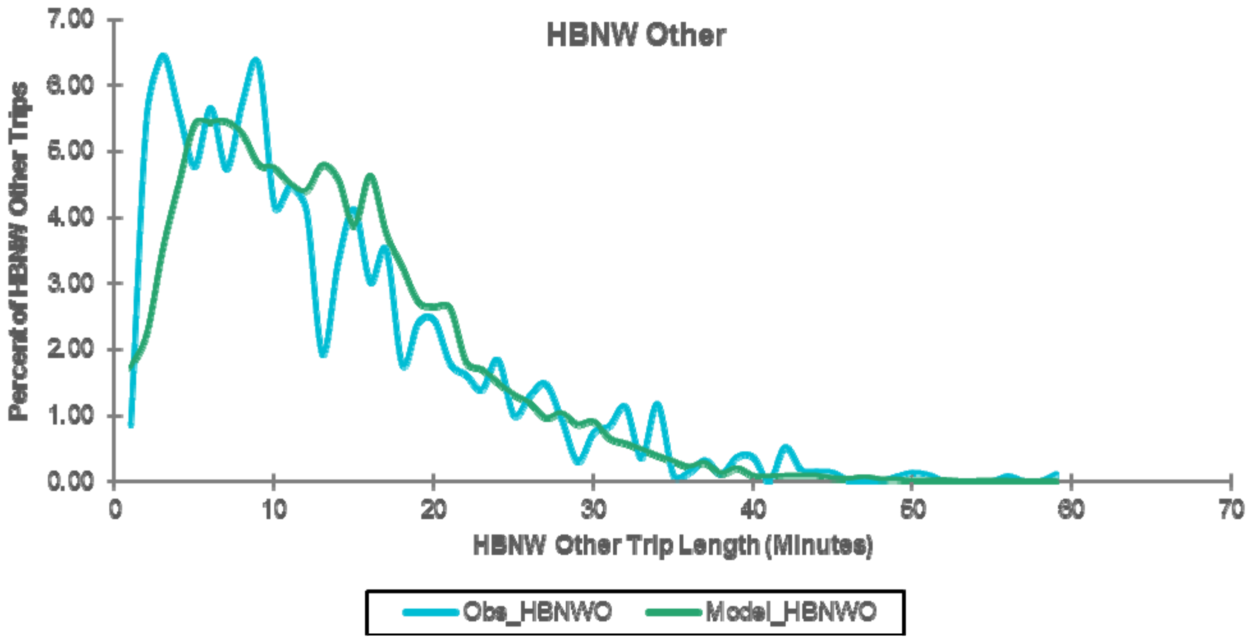
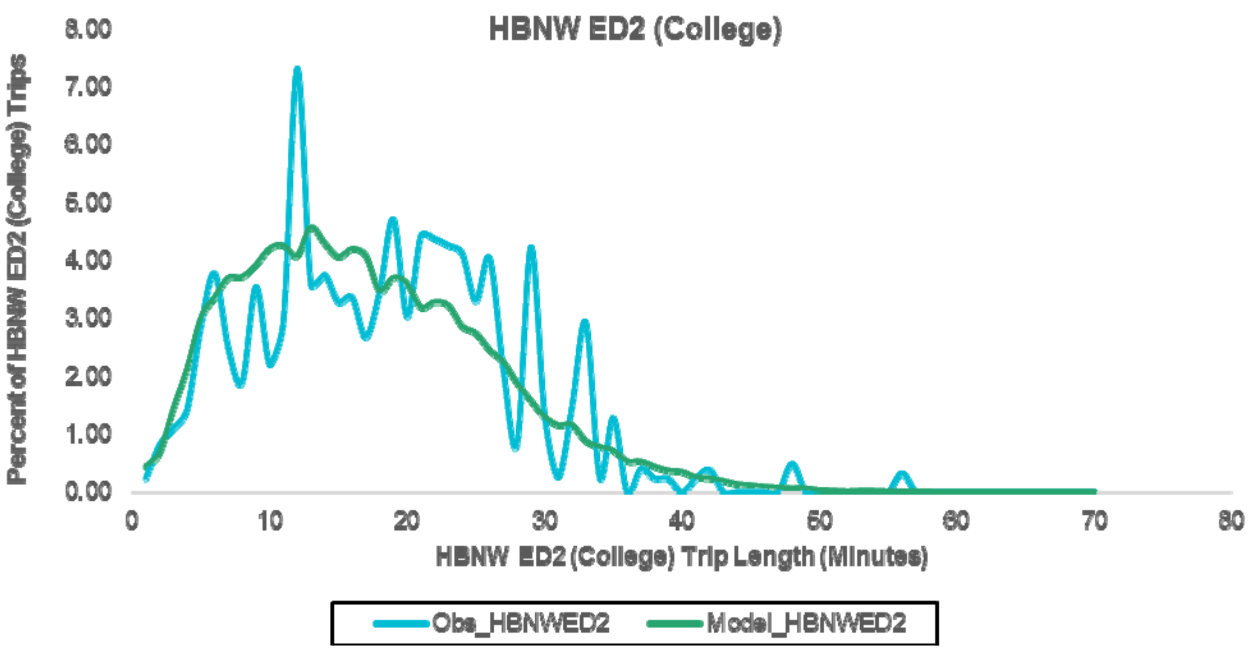


Figure 12.8 Trip Length Frequency Distributions by Purpose – Off-Peak Periods (continued)





12.5 Mode Choice

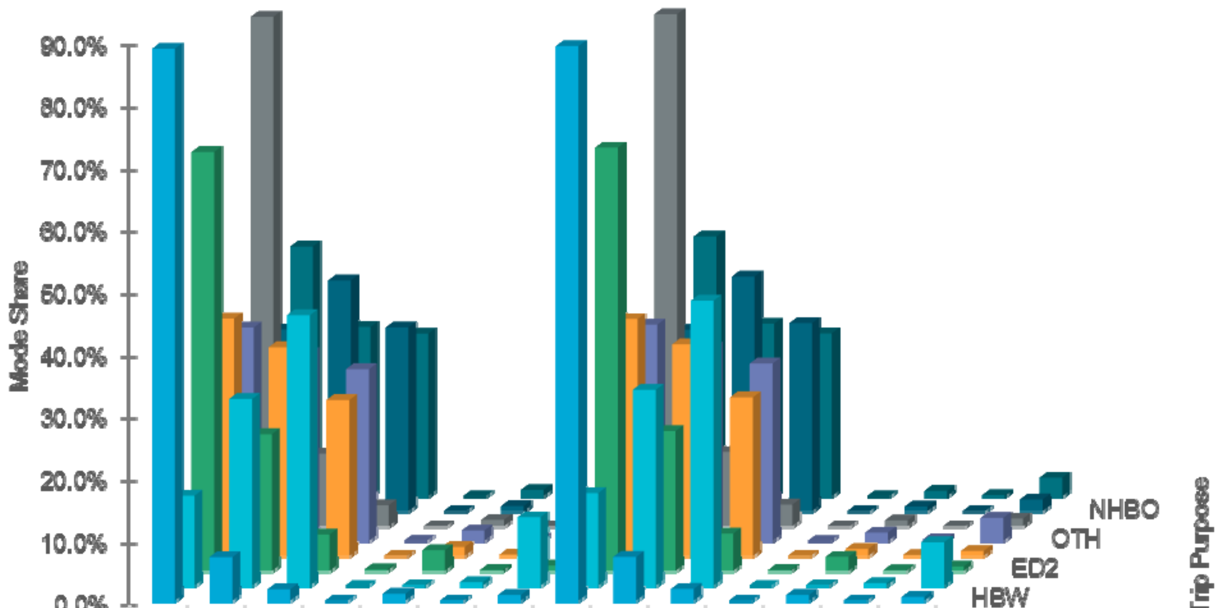
The mode choice model calibration and validation process involved the following steps:

- Checking all estimated parameters for reasonableness and consistency with experience elsewhere;
- Performing disaggregate validation to ensure that the model accurately estimates travel demand by mode, not only for the region as a whole, but also for various demographic market segments; and
- Performing aggregate validation to ensure that the model accurately reproduces demand by mode and trip purpose for the base year.

All of the calibration and validation was undertaken along with model estimation that followed FTA guidelines and exhausted the available data (i.e., household and transit on-board surveys).

Figure 12.9 presents the mode choice summary by trip purpose and mode.

Figure 12.9 Mode Choice Summary by Trip Purpose and Mode – Model versus Survey



	sov	hov 2	hov 3	trd	trw	bike	walk	sov	hov 2	hov 3	trd	trw	bike	walk
HBW	88.7	7.0%	1.9%	0.1%	1.2%	0.1%	1.0%	89.1	7.1%	2.0%	0.1%	1.0%	0.1%	0.7%
ED1	14.5	30.1	43.5	0.0%	0.2%	0.6%	11.1	14.9	31.5	45.8	0.0%	0.2%	0.5%	7.0%
ED2	67.3	22.0	5.9%	0.3%	3.4%	0.2%	0.9%	68.0	22.5	6.0%	0.2%	2.3%	0.2%	0.8%
RET	38.2	33.6	25.1	0.1%	1.5%	0.3%	1.3%	38.1	34.0	25.5	0.1%	1.2%	0.2%	0.9%
OTH	34.3	30.2	27.6	0.1%	1.7%	0.4%	5.6%	34.8	31.1	28.6	0.1%	1.4%	0.3%	3.8%
NHBW	81.8	11.7	3.4%	0.1%	1.1%	0.0%	2.0%	82.2	12.0	3.5%	0.0%	1.0%	0.0%	1.3%
NHBO	29.2	37.1	29.6	0.1%	0.9%	0.1%	3.1%	29.2	37.7	30.3	0.0%	0.8%	0.1%	1.9%
total	40.1	27.2	26.2	0.1%	1.1%	0.3%	5.0%	41.8	27.7	26.2	0.1%	0.9%	0.2%	3.1%

Survey Mode Shares | Model Mode Shares

Using the processed survey database, a calibration target matrix was prepared for use in mode choice calibration. This matrix included shares representing the estimated demand by mode and trip purpose for appropriate market segments. Each of the mode choice models was subjected to the steps described above during calibration. The biggest change or set of modifications done were to the alternate specific constants (ASCs). The goal was to keep the constants as low as possible and also to ensure their magnitude relative to one another made sense. This was an iterative process that involved adjusting the ASCs, and running the mode choice model. This process was done until we reached model results that are within state of practice and FTA standards.

12.6 Commercial Vehicle Model

The commercial vehicle model was calibrated based on truck counts from a limited set of locations spread across the region. The trip rates were adjusted globally until the truck volumes matched the observed counts. The calibration was not done by truck type but rather all trucks were combined for calibration purposes though three truck types were assigned to the network. Table 12.11 presents the final trip rates that were used in the commercial vehicle model.

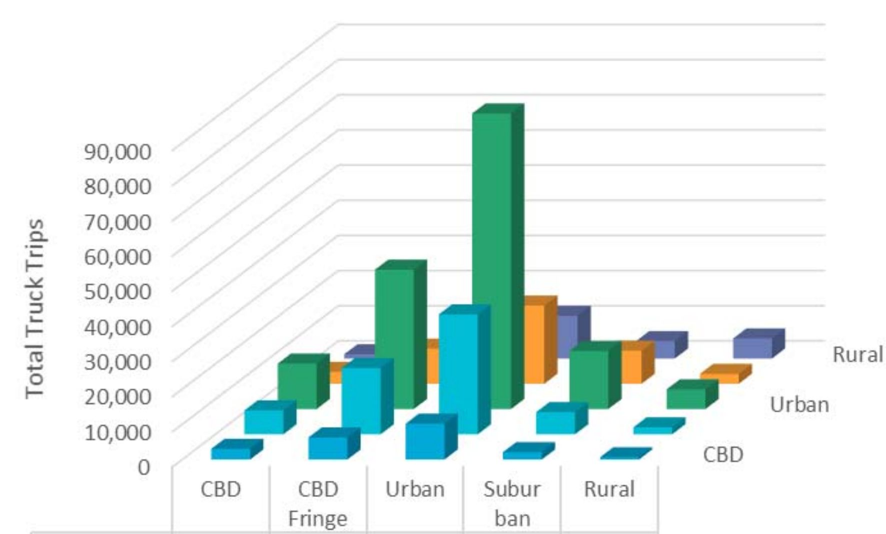
Table 12.11 Final Commercial Vehicle Trip Rates

Truck Type	Area Type	Total Households	Basic Employment	Retail Employment	Service Employment
Light	1,2,3,4,5	0.3770	0.1375	0.3142	0.1375
Medium	1,2,3,4,5	0.3829	0.1192	0.4618	0.1192
Heavy	1,2,3,4,5	0.0119	0.0356	0.0901	0.0356

In application, these trip rates are implemented within the overall trip generation procedure of the model system. Resulting trips are distributed among zones using a gravity model. The resulting trip tables are retained as three separate set of vehicle classes for assignment purposes. These trips are converted to passenger car equivalents before getting assigned. These are 1.0 for light, 1.5 for medium and 2.0 for heavy trucks.

Figure 12.10 shows total truck trip distributions by area type, which was reviewed as one aspect of validation and reasonableness checking for this model component.

Figure 12.10 Final Commercial Vehicle Trip Table Summary by Area Type



	CBD	CBD Fringe	Urban	Suburban	Rural
CBD	3,030	6,268	10,203	2,089	649
CBD Fringe	6,816	18,846	34,115	6,305	1,986
Urban	12,930	39,629	84,071	16,469	5,605
Suburban	3,389	9,999	22,238	9,402	2,809
Rural	1,220	4,068	12,166	4,951	5,722

12.7 External Travel Model

The external travel model was calibrated in conjunction with the overall calibration and validation. External trip rates are external-internal attraction rates. Most of the changes to the external trip rates were based on screenline calibration, especially those that were closer to the external stations and those that had the maximum impact as a result of external trips. These calibration adjustments to the external travel model helped the validation statistics along screenline #2 and the over assignment of trucks along I-10 corridor passing through the CBD region. Table 12.12 presents the final calibrated external trip rates by area type.

Table 12.12 Final External Trip Rates by Area Type

Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment
Business District	0.8008	1.8512	0.0520	0.0000
Urban Intense	0.3016	2.1424	0.1456	0.0208
Urban Central	0.4472	3.1200	0.1040	0.1560
Suburban	0.2600	0.6032	0.0416	0.1456
Rural	0.0000	8.2576	0.1352	0.0000

12.8 Assignment Results

12.8.1 Highway Assignment

The highway assignment calibration involved comparing model volumes to counts by screenline, functional class and area type. All the available data for calibration and validation were compiled and stored in the TransCAD network as described in Chapter 10.

Figure 12.11 shows the location of the 16 screenlines. Screenline 16 is a new screenline that was added to the New Mexico-side of the MPO model.

Figure 12.11 Screenline Map

Table 12.13 presents a comparison of modeled volumes (after calibration) and observed counts along the 16 screenlines. Most of the differences are within acceptable limits of +/- 15-20%. There are a couple of screenlines that are over this limit, namely, 8 and 11. The RMSEs for most screenlines are low which indicates that the model is performing well at these screenlines (i.e., support validation).

Table 12.13 Screenline Summary – Model versus Counts

Screenline	Sum of Count	Sum of Volume	DIFF	PCT DIFF	RMSE
1	68,562	70,763	2,201	3%	26%
2	192,667	216,448	23,781	12%	29%
3	215,789	254,270	38,481	18%	32%
4	97,530	92,329	(5,201)	-5%	31%
5	109,090	113,157	4,067	4%	13%
6	239,400	273,425	34,025	14%	17%
7	156,811	150,986	(5,825)	-4%	21%
8	80,260	60,802	(19,458)	-24%	56%
9	276,446	260,808	(15,638)	-6%	41%
10	123,400	105,643	(17,757)	-14%	32%
11	39,650	50,105	10,455	26%	45%
12	194,534	176,735	(17,799)	-9%	34%
13	107,250	101,631	(5,619)	-5%	39%
14	116,174	102,629	(13,545)	-12%	20%
15	38,640	38,185	(455)	-1%	54%
16	9,950	9,560	(390)	-4%	44%
Total	2,066,153	2,077,476	11,323	1%	33%

The next assignment validation check is presented in Table 12.14 which gives a summary of model versus counts by functional classes. The model is predicting volumes very close to the observed counts especially for the major functional classes such as freeways and expressways, while a considerable margin of error is acceptable for the lower functional classes such as collectors, locals, and ramps.

Table 12.14 Functional Class Summary – Model versus Counts

	FUNC CLASS	Sum of COUNT VMT	Sum of Modeled VMT	DIFF	PCT DIFF	RMSE
Freeways	1	2,011,556	2,150,846	139,291	7%	22%
Expressways	2	1,030,797	943,094	(87,703)	-9%	47%
Principal Arterials	3	2,679,459	2,829,360	149,901	6%	85%
Minor Arterials	4	1,226,400	1,114,979	(111,421)	-9%	75%
Collectors & Locals	5 & 7	704,725	554,175	(150,551)	-21%	94%
Ramps	20	29,524	25,973	(3,551)	-12%	143%
Total		**7,682,461**	**7,618,427**	**(64,034)**	**-1%**	**29%**

Table 12.15 and Table 12.16 show the differences by volumes and VMT between the model and counts by area type. All the differences are acceptable and support the validation of the model.

Table 12.15 Area Type Summary – Model versus Counts

	Area Type	Sum of Count	Sum of Volume	Diff	PCT Diff	RMSE
Business District	1	367,595	444,388	76,793	21%	79%
Urban Intense	2	11,526,517	12,277,389	750,872	7%	38%
Urban Central	3	8,148,663	8,063,420	(85,243)	-1%	45%
Suburban	4	2,733,288	2,832,398	99,110	4%	61%
Rural	5	1,310,299	1,383,643	73,344	6%	76%
Total		**24,086,362**	**25,001,238**	**914,876**	**4%**	**46%**

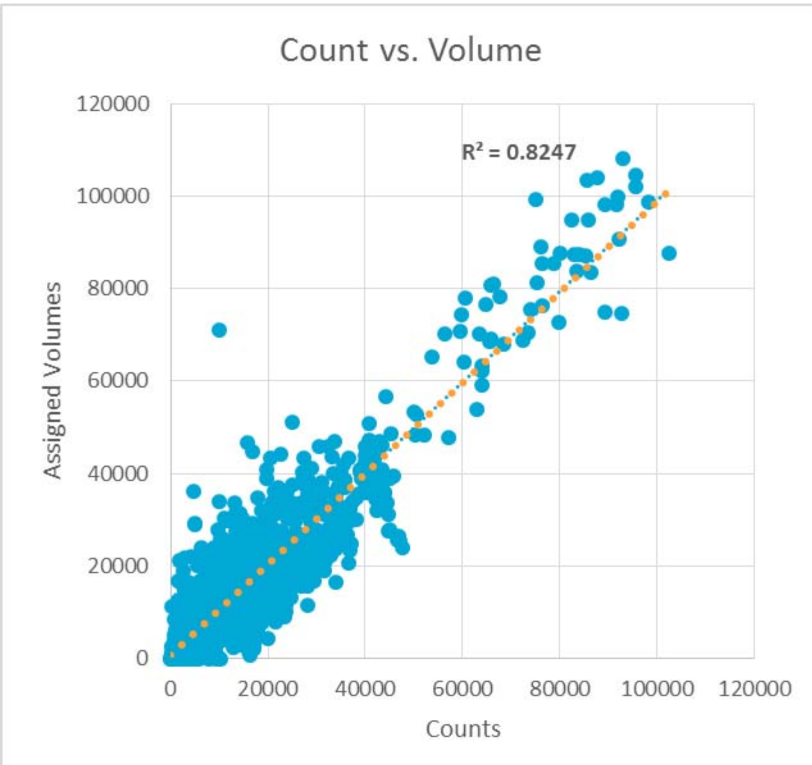
Table 12.16 Area Type Summary – Modeled VMT versus Count VMT

	Area Type	Sum of COUNT_VMT	Sum of VOLUME_VMT	Diff	PCT Diff
Business District	1	21,093	21,896	803	4%
Urban Intense	2	2,522,643	2,570,802	48,159	2%
Urban Central	3	2,492,369	2,335,530	(156,839)	-6%
Suburban	4	1,364,131	1,380,721	16,590	1%
Rural	5	1,282,225	1,309,477	27,252	2%
Total		**7,682,461**	**7,618,427**	**(64,034)**	**-1%**

Overall, the percent differences between the model and observed counts are in line with state of practice guidelines, where the differences are very low for major functional classes while they are higher (and acceptable) for functional classes that carry low volumes. The root mean square error is another measure to evaluate the closeness of modeled volumes to the observed (count) volumes. The RMSE statistics are also within acceptable limits for all the screenlines, functional classes and area types. The percent differences in VMT by functional class and area type are reasonable when compared to validation guidelines from FHWA and other state DOTs[13].

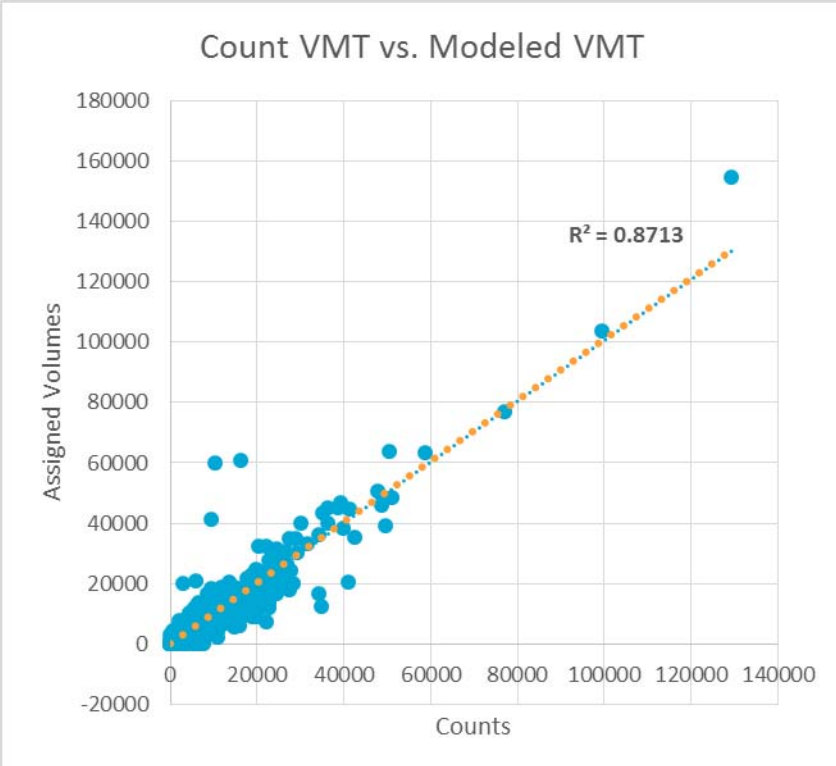
Figures 12.12 and 12.13 show scatterplots of modeled volumes and VMT versus observed counts and count VMT. The R^2 values of these two plots are very high indicating that the model predicts volumes very close to observed values.

Figure 12.12 Scatterplot of Volumes versus Counts



[13] https://connect.ncdot.gov/projects/planning/tpb%20training%20presentations/fhwa%20model%20validation%20handbook.pdf

Figure 12.13 Scatterplot of Model VMT versus Count VMT



12.8.2 Transit Assignment

The transit assignment provides insights into the accuracy of the transit demand estimated by the model at a subarea or corridor level, and can identify errors in the transit network or trip distribution model that would prevent validation of the mode choice model.

- The transit assignment results were compared to both the observed ridership on transit lines (and groups of lines) and to the outputs of the assignment of the "observed" trip tables from the on-board survey.
- The assignment of "observed" transit trip tables (derived from the transit on-board survey) to the coded transit networks were also performed while building the transit path parameters at this beginning of this project.

Transit assignment calibration involved both establishing transit path parameters to generate level of service inputs to mode choice and generation of reasonable transit trip demand out of mode choice. Transit path parameters were initially established when preparing transit skims for model estimation by assigning "observed" transit trip tables (derived from the transit on-board survey) to the coded transit networks. Various transit path parameters were iteratively adjusted until the observed assignments were comparable to the actual boardings from the survey. The parameters in Table 12.17 were found to generate reasonable transit demand out of mode choice. The only change to the parameters was the removal of transfer penalty to/from Downtown Circulators to encourage transfers.

Table 12.17 Final Transit Path Parameters

	Peak		Off-Peak	
	Walk Transit	Drive Transit	Walk Transit	Drive Transit
Local IVT Weight	1.0	1.0	1.0	1.0
Express Buses IVT Weight	1.0	1.0	1.3	1.0
Walk/Transfer Weight	2.5	2.5	2.5	2.5
Drive Access weight	-	1.0	-	1.0
Out-of-Vehicle Time Weight	2.5	2.5	2.5	2.5
Boarding Penalty (min)	-	-	-	-
Path Threshold[1]	0.15	0.15	0.15	0.15
Transfer Penalty (min) Circulators	0	0	0	0
Transfer Penalty (min) Local	2	2	2	2
Transfer Penalty (min) Express	5	5	5	5
Maximum Walk Access/Egress (min)	30	30	30	30

1 – Factor to control route combinations. Higher factor increases route combinations.

To address validation, Table 12.18 was prepared to summarize transit boardings from the model and the observed ridership counts by service type as well as by geography. Overall, the model performs well at the regional and group level. Since the drive market is very small, the table shows boardings for walk access and drive access combined.

Table 12.18 Transit Assignment Summary by Service Type and Geography

Transit Route Groups	Observed	Model	Difference	Percent
Local Bus and Circulator	39,922	41,064	1,142	3%
Express Bus	1,968	478	-1,490	-76%
Total	**41,890**	**41,542**	**-348**	**-1%**
Transit Route Groups	**Observed**	**Model**	**Difference**	**Percent**
Westside	10,916	11,821	905	8%
Central / Northeast	13,184	12,924	-260	-2%
Eastside / Mission Valley	17,790	16,797	-993	-5%
Total	**41,890**	**41,542**	**-348**	**-1%**

The transit routes were grouped into three based on their location in the region. These groups are depicted in Figure 12.14.

Figure 12.14 Transit Routes by Geography

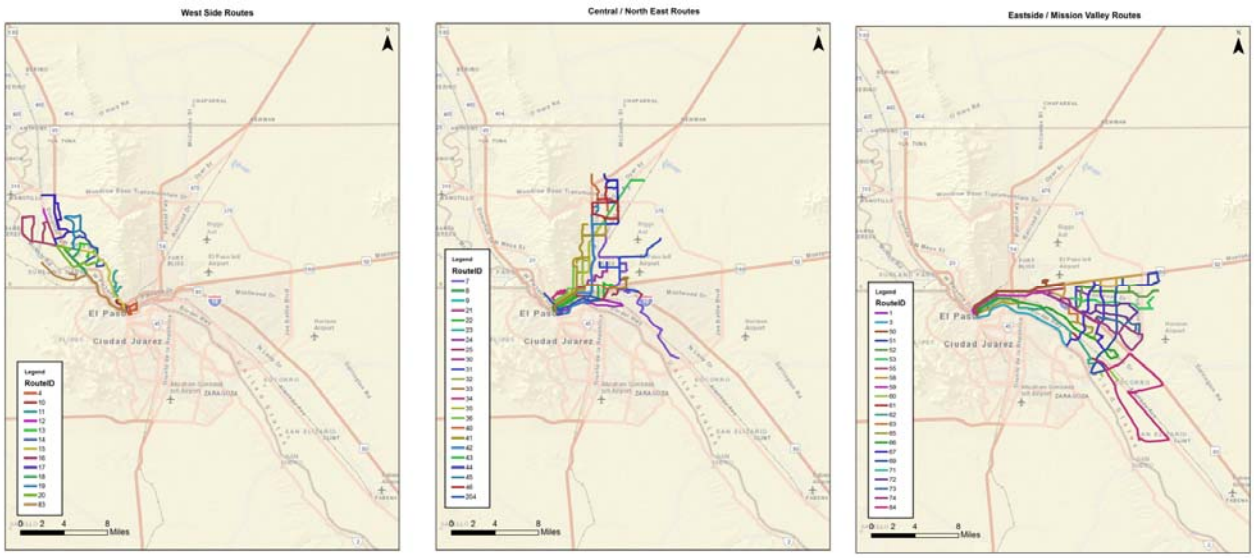


Table 12.19 presents the transit assignment results at the route level for each geography group. The differences at the route level are larger in magnitude but that is expected as that's usually beyond the resolution of a regional travel demand model. As mentioned earlier, a more focused transit corridor validation is recommended as part of any transit focused study.

Table 12.19 Transit Assignment Summary by Route and Geography

	Observed			Modeled			Difference		
Eastside / Mission Valley	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
1	16	19	35	306	0	306	290	-19	271
3	754	793	1,547	112	115	227	-642	-678	-1320
50	1,025	1,362	2,387	482	525	1007	-543	-837	-1380
51	351	306	657	521	563	1084	170	257	427
52	255	179	434	532	558	1090	277	379	656
53	373	342	715	696	806	1,502	323	464	787
55	307	474	781	248	265	513	-59	-209	-268
58	167	195	362	156	180	336	-11	-15	-26
59	1,389	1,756	3,145	899	1,133	2,032	-490	-623	-1113
60	321	245	566	197	212	409	-124	-33	-157
61	427	598	1,025	721	807	1,528	294	209	503
62	295	387	682	281	289	570	-14	-98	-112
63	345	279	624	350	396	746	5	117	122
65	502	792	1,294	414	421	835	-88	-371	-459
66	469	591	1,060	546	596	1142	77	5	82
67	205	185	390	271	301	572	66	116	182
69	503	279	782	332	403	735	-171	124	-47
71	122	170	292	200	251	451	78	81	159
72	171	168	339	213	263	476	42	95	137
73	102	94	196	406	491	897	304	397	701
74	231	246	477	160	179	339	-71	-67	-138
Subtotal	**8,330**	**9,460**	**17,790**	**8,043**	**8,754**	**16,797**	**-287**	**-706**	**-993**
Westside	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**
4	632	1,113	1,745	204	196	400	-428	-917	-1345
10	262	348	610	646	696	1342	384	348	732
11	67	115	182	150	157	307	83	42	125
12	159	187	346	165	182	347	6	-5	1
13	85	139	225	94	103	197	9	-36	-28
14	701	798	1,499	1,144	1,303	2,447	443	505	948
15	774	1,049	1,823	1,427	1,384	2,811	653	335	988
16	117	180	297	135	148	283	18	-32	-14
17	196	95	291	149	167	316	-47	72	25
18	1,194	1,406	2,600	530	811	1,341	-664	-595	-1259
19	166	238	403	227	244	471	61	6	68
20	65	180	245	73	82	155	8	-98	-90
70	216	147	363	454	583	1037	238	436	674
83	132	155	287	169	198	367	37	43	80

	Observed			Modeled			Difference		
Subtotal	**4,766**	**6,150**	**10,916**	**5,567**	**6,254**	**11,821**	**801**	**104**	**905**
Central / Northeast	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**	**Peak**	**Off-Peak**	**Total**
7	635	685	1,320	845	935	1,780	210	250	460
8	17	49	66	42	31	73	25	-18	7
9	84	73	157	3	2	5	-81	-71	-152
21	167	199	366	207	225	432	40	26	66
22	167	113	280	200	223	423	33	110	143
23	153	86	239	26	23	49	-127	-63	-190
24	155	117	272	49	43	92	-106	-74	-180
25	281	229	510	223	279	502	-58	50	-8
30	134	70	204	71	83	154	-63	13	-50
31	30	29	59	186	243	429	156	214	370
32	260	212	472	92	99	191	-168	-113	-281
33	322	353	675	253	282	535	-69	-71	-140
34	283	323	606	151	152	303	-132	-171	-303
35	1,415	1,083	2,498	1,327	1,425	2,752	-88	342	254
36	254	222	476	209	216	425	-45	-6	-51
40	116	129	245	264	300	564	148	171	319
41	133	260	393	170	184	354	37	-76	-39
42	893	1,284	2,177	799	878	1,677	-94	-406	-500
43	106	178	284	11	12	23	-95	-166	-261
44	200	160	360	819	848	1,667	619	688	1307
45	83	161	244	33	38	71	-50	-123	-173
204	635	685	1,320	845	935	1,780	210	250	460
Subtotal	**6,424**	**6,760**	**13,184**	**6,183**	**6,741**	**12,924**	**-241**	**-19**	**-260**
Total	**19,520**	**22,370**	**41,890**	**19,793**	**21,749**	**41,542**	**273**	**-621**	**-348**

12.9 Future Validation Tasks

Future regional forecasting work can be considered to further demonstrate validation of the model. These include:

- **Future year sensitivity tests** – Sensitivity testing will be performed to ensure that the model parameters are sensitive to a range of input variables and the sensitivities are reasonable. For example, if transit fares or headways were to change, the resulting change in transit ridership must be reasonable. This will be done at the aggregate level by comparing the model's aggregate elasticity of demand with respect to the input variables against compilations of observed and estimated elasticity from other sources. Another potential test could be to test future P/R lots and its impact to transit ridership. These tests will be performed through application of the model.

- **Evaluating transit path builder for non-existent modes** – This is key to evaluate the model performance regarding non-existent high capacity transit sub-modes (LRT, etc.). The results from these tests may warrant a re-visit to base year models (especially, mode choice - modal constants) and make further adjustments.

- **Coding of future year highway and transit networks** – The MPO will develop future year scenarios. These networks will be used to apply the model for various forecast years. The MPO will also use the model to develop their 2045 metropolitan transportation plan (MTP).