Sierra Vista Metropolitan Planning Organization
Transportation Plan Update 2040

DRAFT Chapter: Travel Demand Model Validation

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Member Agencies:

City of Sierra Vista

Cochise County

Arizona Department of Transportation

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1.0 Introduction

The purpose of this report is to document the development of a focused travel demand model for the Sierra Vista Metropolitan Planning Organization (SVMPO). The SVMPO focused travel model is based on the Arizona statewide travel demand model developed by the Arizona Department of Transportation (ADOT); AZTDM2. The model operates in the TransCAD software platform.

ADOT has spent several years developing a statewide model that can focus on specific MPO planning areas of the state. The model is based on extensive data collection efforts that are beyond the reach of most MPOs. The model has been calibrated and validated to a comprehensive set of observed data. The statewide model has also undergone a national peer review which was focused on model development, calibration and validation. Additionally, ADOT continues to update features of the model. Documentation of the AZTDM2 model development and validation is available from ADOT in the following report: *"Development of the Arizona Statewide Travel Demand Model: Phase 2, September 19, 2011"*.

2.0 Model Development

The SVMPO focused model was adapted from the Cochise County travel demand model. It is focused on the communities of Sierra Vista and Fort Huachuca but simulates travel activity for all of Cochise County and Arizona. **Figure 1** shows the SVMPO planning area. To validate the AZTDM2 model for the SVMPO planning area, information on existing socioeconomic and roadway characteristics were collected for input into the model. Cordon locations were developed to summarize and compare model validation estimates with actual count data.

2.1 Socioeconomic Data

The Cochise County traffic analysis zone (TAZ) geography was updated to be consistent with Census 2010 block geography. The household and population data from Census 2010 and the American Community Survey 2006 to 2010 sample was used for population and household income data. Outside of Cochise County, the SVMPO model uses the TAZ geography and socioeconomic data from the AZTDM2.

Table 1 shows a summary of the 2010 SVMPO household and population data.

Data from the Quarterly Census of Employment and Wage, the sales leads database InfoUSA, and the Cochise County travel demand model was used for employment data. **Table 2** shows a summary of the 2010 SVMPO employment data.

Figure 1 – SVMPO Planning Area

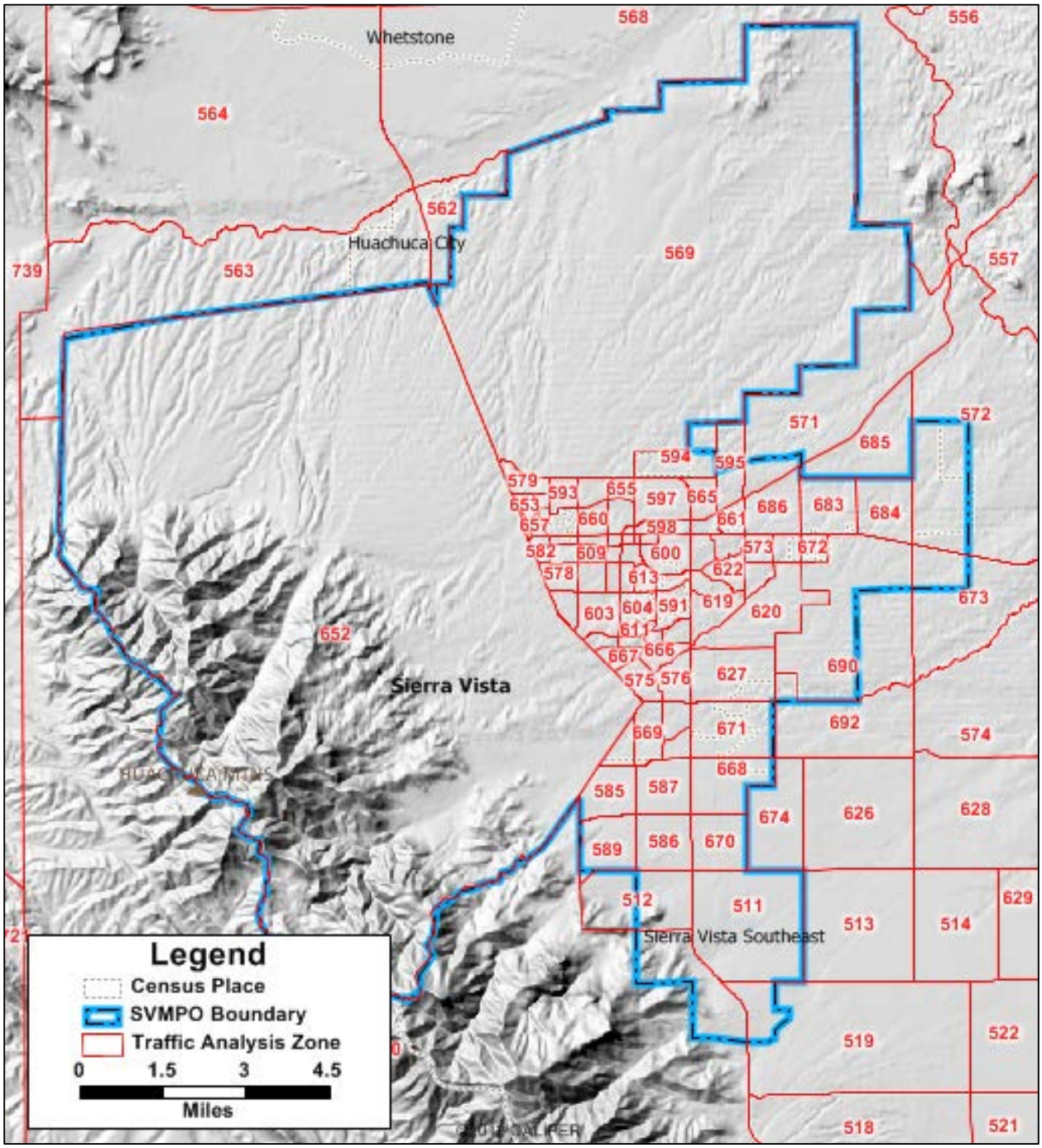


Table 1 – 2010 Households and Population Summary

Area	Households	Household Population	Group Quarters Population	Group Quarters Non-Institutional
Arizona	2,380,979	6,252,648	139,383	54,595
Cochise County	50,865	125,075	6,271	3,084
Sierra Vista[1]	21,968	53,015	3,069	2,828

Notes: (1) The Sierra Vista MPO boundary does not exactly correspond to the TAZ geography.

Table 2 – 2010 Employment Summary

Area	Ag	Construction	Health	Leisure	Manufacturing	Mining
Arizona	20,978	113,037	308,788	281,393	148,542	10,362
Cochise County	1,110	2,046	4,806	5,496	581	138
Sierra Vista	3	1,394	2,794	3,164	129	0

Area	Retail	Service	Wholesale	Total
Arizona	294,728	1,007,416	155,899	2,341,143
Cochise County	5,592	16,946	1,200	37,915
Sierra Vista	3,100	9,125	565	20,274

2.2 Highway Network

The model highway network was adapted from the Cochise County travel demand model and the AZTDM2 highway network. **Figure 2** shows the model facility types used in the Sierra Vista area. **Figure 3** shows the lanes by direction.

Figure 2 – Facility Types

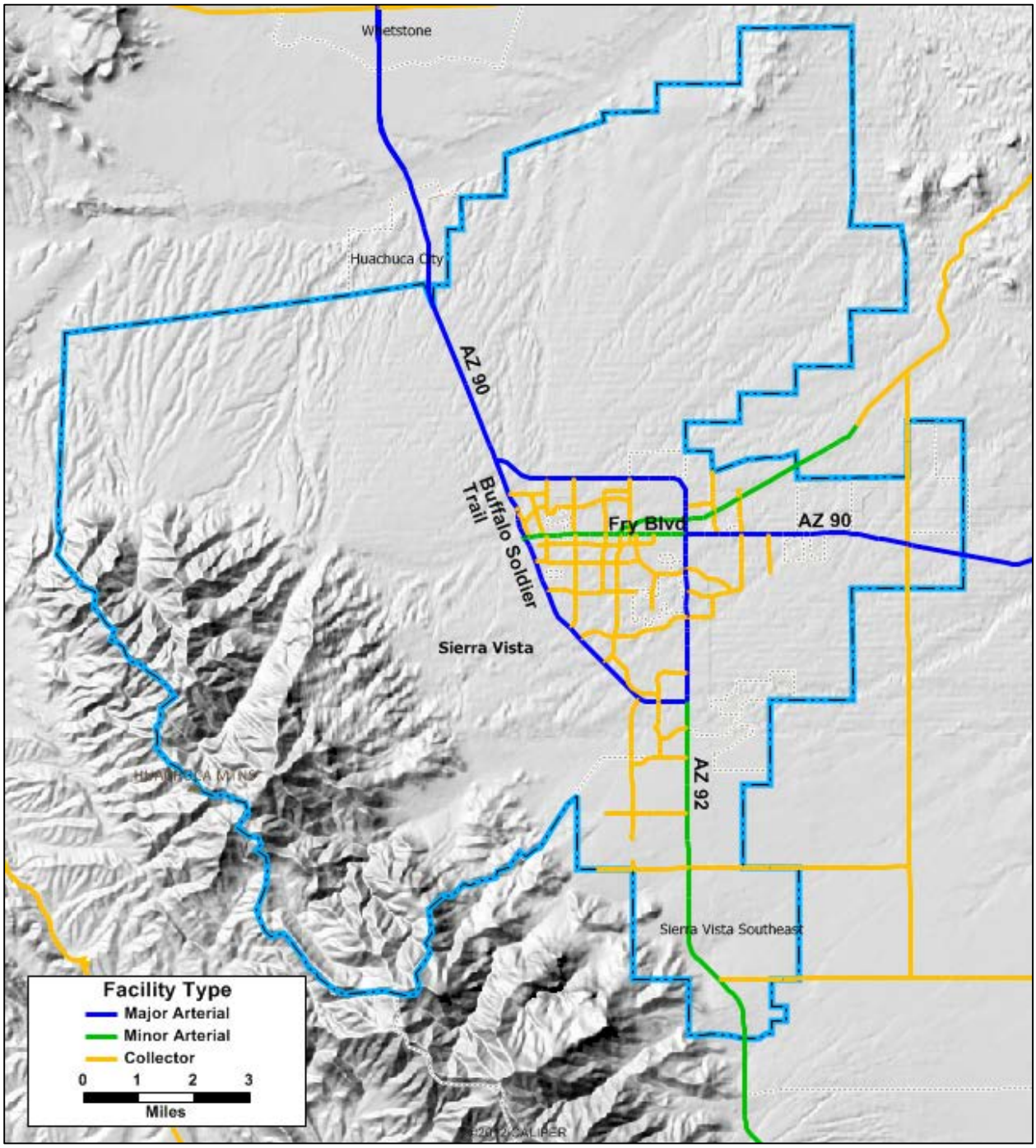
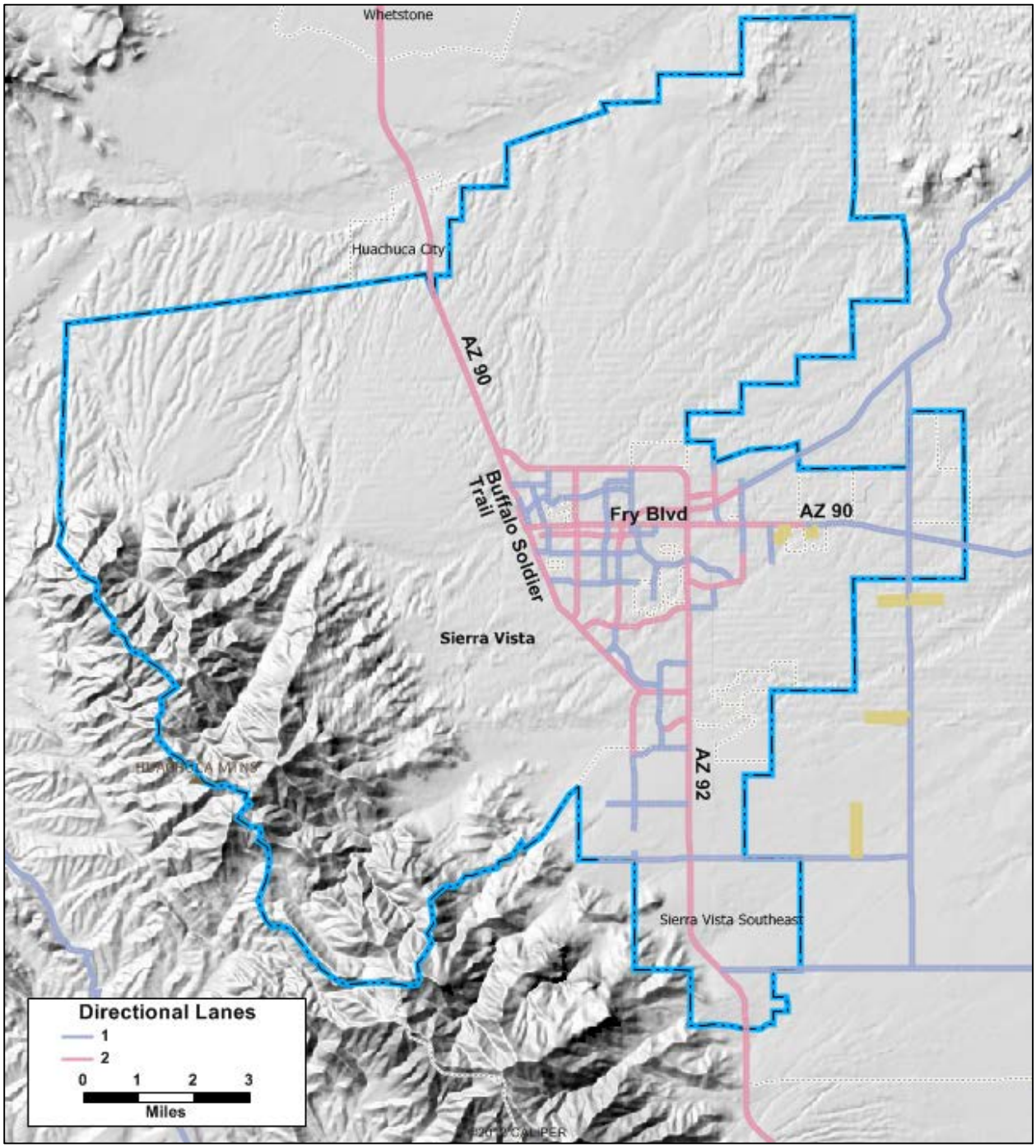


Figure 3 – Lanes by direction



3.0 Validation and Reasonableness Checking

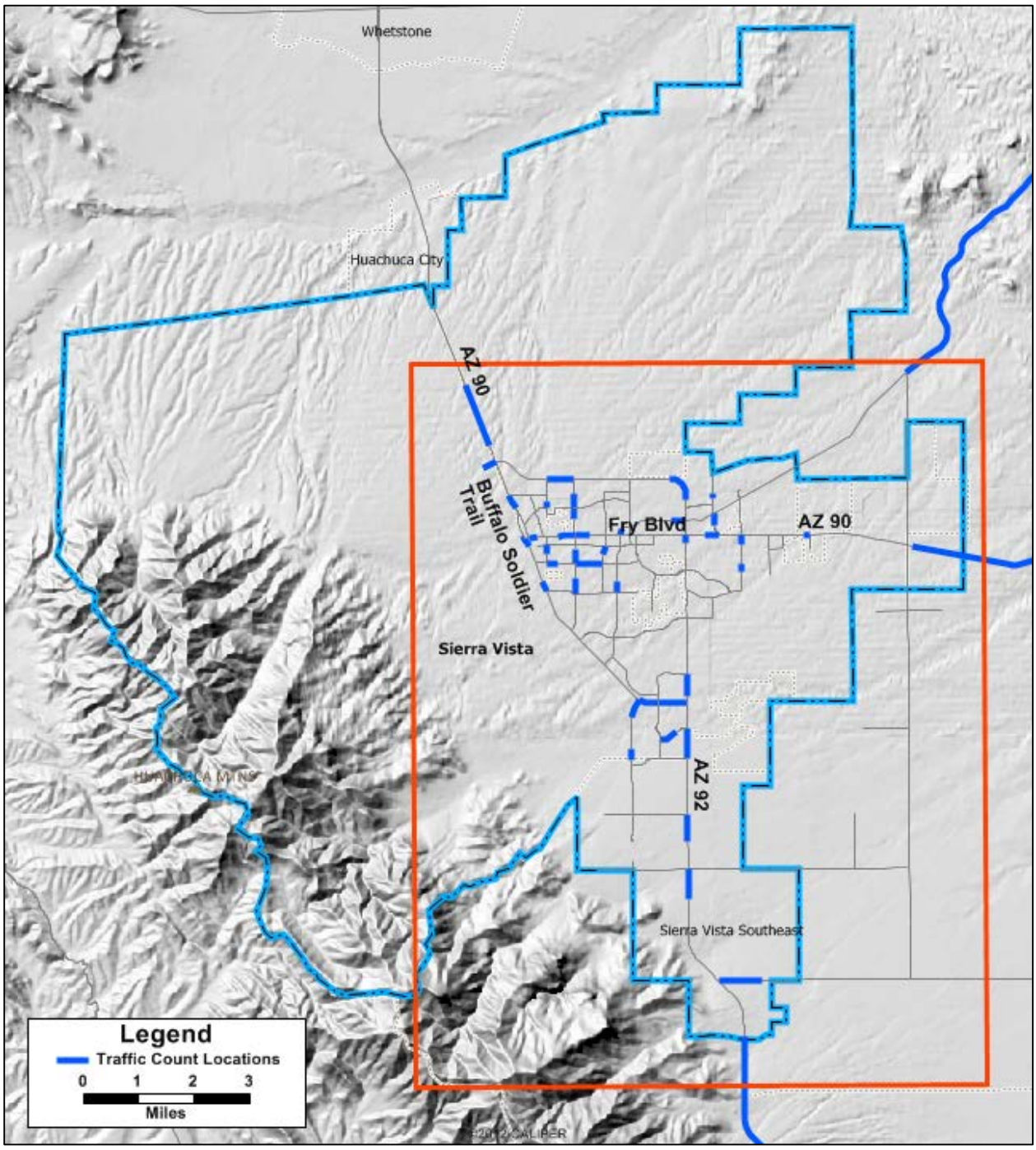
The purpose of validation and reasonableness checking is to confirm the ability of the SVMPO model to predict future behavior by comparing its predictions to independent observations. The FHWA *Travel Model Validation and Reasonableness Checking Manual, Second Edition* (2010) and the Ohio Department of Transportation's *Ohio Certified Traffic Manual (2007)* are the two main references used in this process.

3.1 Validation Database

The first step in the model validation process is to establish the database and validation guideline(s) for each of the categories. The traffic count database used for model validation was assembled from the Arizona Department of Transportation's Transportation Data Management System (TDMS). This online resource includes traffic counts collected by ADOT, Sierra Vista, and Cochise County. While the validation year for the SVMPO model is 2010, some counts from 2011 and 2012 were also used. Since growth in the community has been very slow, traffic volumes have changed little between 2010 and 2012.

A cordon line is used to evaluate whether the correct number of trips are entering and exiting the study area. An imaginary circle is drawn across facilities at the boundary of the study area. The imaginary circle is drawn to include, to the extent possible, locations were traffic counts exist on the roadways that serve as entry/exit points to the region. These counts are then totaled to estimate the total daily volume entering and exiting the SVMPO region. **Figure 4** shows the SVMPO area cordon line and traffic count locations.

Figure 4 – SVMPO traffic locations and cordon lines



3.2 Validation steps

Model validation consists of several steps including estimation of person and truck trips (trip generation), distribution of trips (trip distribution), assignment of trips to the network (trip assignment) and aggregate and roadway level comparisons of model assigned daily vehicle trips to traffic counts.

The validation process starts with estimation of the number for trips within the region and ending with roadway level analysis. At each step, daily traffic counts are used to evaluate whether the model is performing within acceptable standards. The validation standards used for this analysis are similar to those used to validate the AZTDM2 model. The AZTDM2 model validation followed guidelines from several sources, such as the Federal Highway Administration, the National Cooperative Highway Research Project and best practices.

Initial model validation runs showed that overall model volume estimates were 29 percent lower than the traffic counts within the SVMPO planning area. This started an investigation into several areas of the model to address the under-estimation. Areas investigated during the validation process included:

- Additional travel markets data collection
- County-to-county worker flows
- Non-home-based trip rates
- Short-distance trucks
- Long distance auto and truck flows

Additional travel markets data collection

Review of the SVMPO socioeconomic data showed that Cochise College and University of Arizona-South enrollment were missing. Online sources showed the enrollment of Cochise College was 1,911 in 2010. The University of Arizona-South reported its enrollment at 904. Total university enrollment in TAZ 595 was estimated at 2,815.

County-to-county worker flows

Fort Huachuca is a regional employer that attracts workers from as far as Tucson, which is 75 miles distant. Early validation runs of the SVMPO model showed volume estimates up to 20 percent lower than traffic counts on SR 90 north of Sierra Vista. Comparing model-estimated worker flows between Cochise County and Pima County with worker flow data from the Census Transportation Planning Products (CTPP) showed that the model was not reflecting the observed interaction. A K-factor between Pima and Cochise Counties was introduced to increase the attractiveness of Cochise County jobs to workers in Pima County. K-factors are usually justified to account for additional aspects of travel behavior not explained by the trip distribution model. No adjustments were made to the distribution of intra-county work flows.

Non-home-based trip rates

While adding university trips and adjusting home-based work flows between Pima and Cochise Counties improved the validation, model estimates were still 15 percent lower than traffic counts.

The initial trip rates used in the SVMPO model were the same as those used in the AZTDM2 model. The trip rates are based on Arizona household travel survey information. Non-home based trips are often under reported in household travel surveys. The non-home based trip purpose is often linked with other trips. For example there are three trips and two different trip purposes in the following travel sequence:

Home --→ Grocery Store → Hardware Store→ Home

The above trip sequence translates into the following trips and trip purposes:

Home to Grocery Store:	Home to shopping trip
Grocery Store to Hardware Store:	Non-home-based trip
Hardware Store to Home:	Home to Shopping trip

The second trip listed above is often missed in travel surveys because the traveler will see this as part of the first trip and thus the non-home based trip is under reported. Therefore non-home-based trip rates in regional travel models are often adjusted during the model validation process.

Non-home-based trip rates information was collected and analyzed from other regions. Of the data collected, the French Broad River MPO region (FBR) stood out as being similar in nature to the Sierra Vista region. The FBR area encompasses the Asheville, North Carolina, region. The non-home based trip generation model structure used in the FBR model is the same as that used in the SVMPO model and therefore it was possible to efficiently update the non-home based trip rates and measure the impact on SVMPO model validation. **Tables 3** and **Table 4** list the SVMPO and FBR non-home-based trip rates. These are the same non-home-based trip rates used in the Central Yavapai MPO model.

Table 3 – SVMPO Model AZTDM2 NHB Trip Rates

0-1 Autos Per Household				
Household Income	1 Person	2 Person	3 Person	4+ Person
0 – 25K	0.38	1.24	1.24	1.24
25 - 45K	0.38	1.55	2.57	2.57
45 – 65K	0.38	1.55	2.57	2.57
65 – 100K	2.16	1.55	4.27	4.27
100+K	2.16	1.55	6.28	7.23
2+ Autos Per Household				
Household Income	1 Person	2 Person	3 Person	4+ Person
0 – 25K	0.91	2.81	2.81	2.81
25 - 45K	0.91	3.26	3.27	3.27
45 – 65K	0.91	3.26	3.27	3.27
65 – 100K	2.16	3.26	4.27	4.27
100+K	2.16	3.26	6.28	7.23

Table 4 – French Broad River NHB Trip Rates

0-1 Autos Per Household				
Household Income	1 Person	2 Person	3 Person	4+ Person
0 – 25K	0.68	1.864	1.27	1.68
25 - 45K	0.68	2.63	1.27	1.68
45 – 65K	0.68	1.43	3.70	4.30
65 – 100K	2.46	2.63	3.71	4.30
100+K	2.46	1.43	3.71	5.11
2+ Autos Per Household				
Household Income	1 Person	2 Person	3 Person	4+ Person
0 – 25K	0.98	2.53	2.81	2.81
25 - 45K	0.98	4.13	2.81	3.63
45 – 65K	1.04	4.73	3.91	4.47
65 – 100K	2.46	4.73	5.50	6.06
100+K	2.46	4.73	5.50	6.06

The SVMPO model non-home-based trip rates were replaced with the FBR rate. The SVMPO model was rerun with the updated rates and the model results reevaluated. While the inclusion of the FBR non-home-based trip rates improved the validation of the SVMPO model within Sierra Vista, model volumes at cordon lines continued to be low compared to the counts.

Short distance truck model

The AZTDM2 includes both short distance and long-distance truck models. Long distance truck trips are estimated from commodity flow data provided by the Federal Highway Administration. The long distance model simulates truck trips across North America to account for trips passing through Arizona and trips beginning and ending in Arizona. The long distance truck model also simulates truck trips between urban areas.

The short distance truck model is implemented to capture local truck trips and service deliveries not included in the FHWA commodity flow data. The model implemented within the AZTDM is based on travel behavior observed in the Phoenix metropolitan area. The short distance truck model estimates single-unit trucks and multi-unit trucks. It uses the model's population and employment database in a three-step trip generation, distribution, and assignment process. The model segments trip generation and distribution into twelve land use categories to match truck trips between compatible land uses.

The SVMPO model uses both the long-distance and short-distance truck model. The SVMPO long distance truck model uses the long distance trip table from the AZTDM2. The SVMPO short-distance truck model implements the trip generation and trip distribution procedures used in the AZTDM2. The key difference between the AZTDM2 short distance truck model and the SVMPO truck model is the geographic modeled area. The SVMPO model simulates short distance truck trips for Cochise County to avoid overlap with the long distance trip model and short distance trips related to other urban areas.

Both short and long distance truck trips, combined with passenger vehicles on each modeled roadway segment results in the estimate of total traffic. Truck traffic estimates were not compared to truck counts. Rather, total traffic volume estimates were compared to total traffic counts.

Long distance auto and truck trips

Located in southeastern Arizona, Sierra Vista is relatively isolated from the population centers in the central Arizona. Tucson, the closest metropolitan area, is 75 miles distant. Travel analysis research using mobile telephone signal data from AirSage shows significant interaction between Sierra Vista and the surrounding communities (Crowther, 2014). This research is presented in the Appendix.

While the AZTDM2 allows work trips to travel up to 120 miles, other trip types are limited to 50 miles. The mobile telephone signal data suggests that AZTDM2 may be under estimating non-work trips longer than 50 miles from Sierra Vista. This may account for the apparent under-estimate of vehicle trips at the cordon line. To account for non-work trips greater than 50 miles, long distance personal vehicle trips to and from Sierra Vista were increased until model estimates more closely matched the four cordon line counts.

Other adjustments

Other validation adjustments include changes to the location of the Fort Huachuca traffic analysis zone centroid. Its position was adjusted so that model estimates more closely matched traffic counts

at the two main entry gates to the U.S. Army base.

3.3 Validation results

After each of the described adjustments, model volumes were compared to traffic counts using three different techniques:

- Cordon line
- Assignment Scatterplots
- Percent root mean square error by volume group

The results presented below represent the performance of the SVMPO model at conclusion of the validation process.

Cordon line

Table 5 lists the facilities that comprise the SVMPO area cordon line and the existing traffic count for each of the facilities.

Table 5 – SVMPO Cordon Line

Roadway	Location	Existing Count	Model Estimate
S.R. 90	N. of Hartfield St	20,600	20,100
Charleston Road	E. of Moson Rd	2,000	1,100
S.R. 90	E. of Moson Rd	4,100	5,600
S.R. 92	E. Coronado Memorial Rd.	4,300	5,300
TOTAL		**31,000**	**32,100**

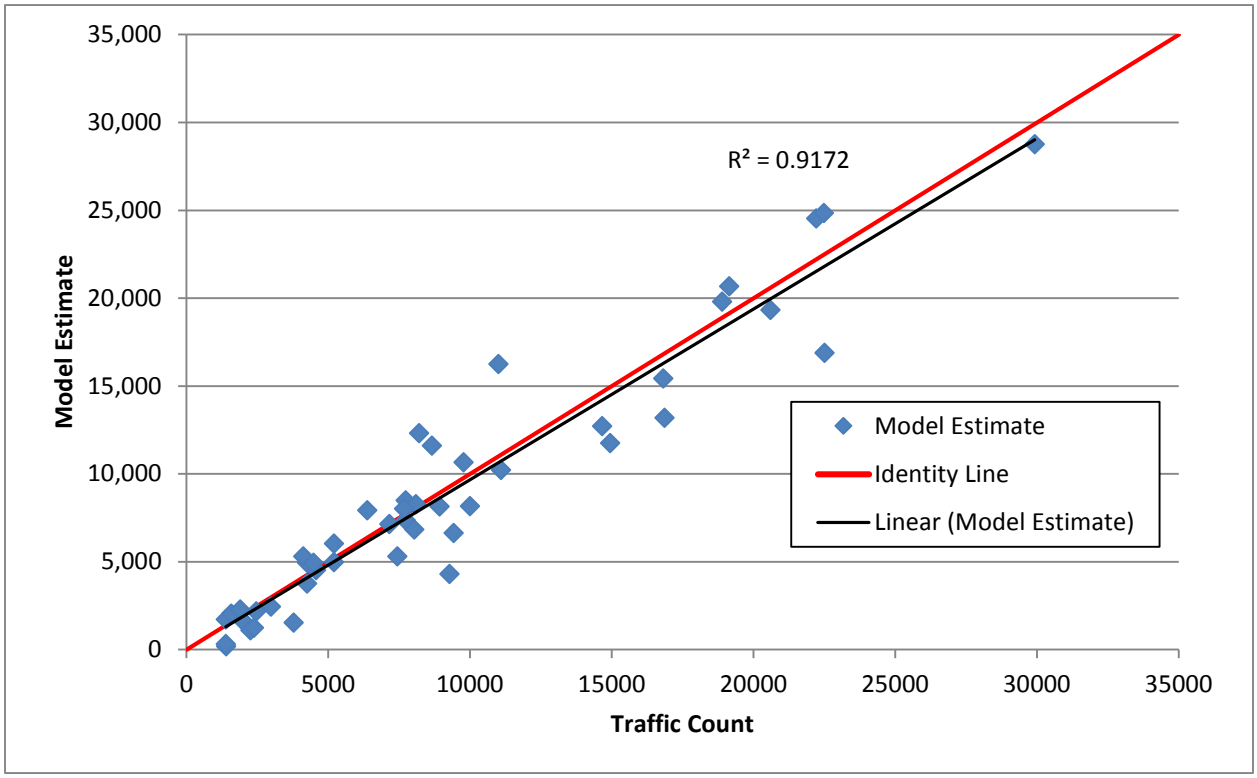
Based on the information in Table 5 it is estimated that there are approximately 31,000 daily trips between the SVMPO area and the rest of the region. After the validation adjustments, the SVMPO model is over-estimating travel across the cordon line by nearly four percent. Maximum percent error for screenline or cordon line volumes ranges from 65 percent to 20 percent depending on volume (FHWA, 2010, p. 9-21). The difference between SVMPO model cordon line estimates and the traffic counts is within an acceptable range.

Assignment scatterplot

Pearson's product-moment correlation coefficient (R) is a standard statistical measure that reflects the extent of a linear relationship between two data sets. The coefficient of determination R^2 is generally interpreted as the proportion of the variance of a dependent variable attributable to variance of an independent variable. Scatterplots of modeled traffic volumes versus observed traffic volumes used together with R^2 summaries can be useful tools in model validation. While there are no hard and fast guidelines for R^2, values closer to 1 are better.

Figure 5 shows a scatterplot comparing model estimated average weekday traffic volumes for all vehicles compared to average weekday traffic counts. This scatterplot shows that model estimates generally correspond well to traffic counts.

Figure 5 – Average weekday traffic scatterplot

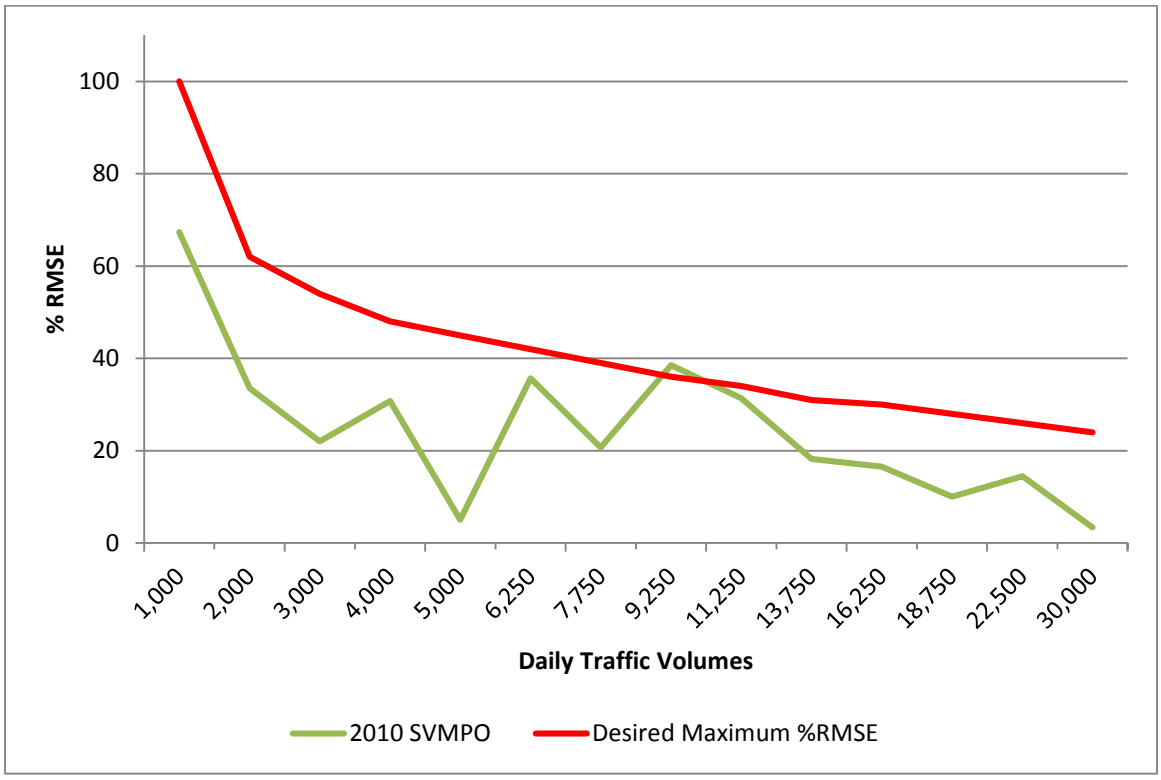


4.3 Percent Root Mean Squared Error

Percent Root Mean Squared Error (RMSE) is a measure of the accuracy of the traffic assignment that shows the average error between the observed and modeled traffic volumes on links with traffic counts. Percent RMSE is summarized by link volume group. The *Ohio Certified Traffic Manual* (Appendix C) identifies allowable percent RMSE by directional link volume group. The Ohio percent RMSE targets by volume group are shown graphically in the following figures.

Figure 6 shows the percent RMSE for all vehicles. It shows that modeled traffic volumes are within acceptable ranges of the observed traffic counts for most volume groups. The overall model percent RMSE is 24.

Figure 6 – Average weekday traffic percent RMSE by volume group



4.0 Model Validation Results

A total of 10 validation runs were completed to validate the SVMPO model. After each validation run the model assigned volumes were compared to the daily traffic counts for each of the validation categories identified in Section 3 of this report. This was an iterative process. At each successive model run, inputs and parameters were adjusted until further changes to the model no longer improved overall model validation.

On an average weekday basis the SVMPO model results in the following[1]:

- Trips Per Person 3.8
- Trips Per household 9.3
- Assigned Trips 219,600
- Vehicle Miles of Travel 639,800
- Vehicle Hours of Travel 14,200

Following the guidelines outlined by FHWA (2010), the SVMPO model accurately estimates existing daily traffic in the SVMPO planning area. Validation statistics show the following results:

- Cordon validation: model assigned trips to counts within 4%
- Scatterplot: Overall correlation coefficient is 0.92
- Percent RMSE: 24 overall

[1] VMT/VHT do not include centroid connectors

Reference List

Arizona Department of Transportation. (2011). Development of the Arizona Statewide Travel Demand Model: Phase 2 (AZTDM2)

Crowther, Brent. (2014). Arizona Modeling Users' Group Presentation "Sierra Vista Commuting Patterns."

Federal Highway Administration. (2010). Travel Model Validation and Reasonableness Checking Manual, Second Edition. Accessed on March 3, 2015 at http://www.camsys.com/pubs/FHWA-HEP-10-042.pdf.

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Appendix

Sierra Vista Commuting Patterns