FINAL REPORT

AUGUST 2025

ACOG Regional Travel Demand Model Update Report

(ARMv2 build 20250808)

Prepared for:

APPALACHIAN COUNCIL OF GOVERNMENTS

SCDOT South Carolina Department of Transportation

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1.0 Introduction

The Appalachian Regional Model (ARM) is the Travel Demand Model (TDM) for the seven-county Appalachian Region of South Carolina, including the counties of Anderson, Cherokee, Greenville, Laurens, Oconee, Pickens, and Spartanburg. The ARM is a traditional four-step regional travel demand model, primarily designed to support long-range transportation planning and programming decisions in the region. The model also supports corridor planning and project-level traffic forecasting. A user guide documenting the steps to prepare and run the travel model scenarios is provided in **Appendix A**.

The model is managed by the Appalachian Council of Governments (ACOG), in partnership with the South Carolina Department of Transportation (SCDOT) Office of Planning and the Metropolitan Planning Organizations (MPOs) of Anderson, Greenville-Pickens, and Spartanburg. ACOG serves as the model custodian and is responsible for developing, maintaining and updating the model with the state of the practice to meet various needs from federal, state, MPO and private sector users.

The current ARM, referred to as ARMv2, is an update to the prior version (ARMv1) developed and updated in the 2010-2014 timeframe (supporting documentation in **Appendix B**). On August 30, 2024, an ACOG Model Update Kickoff Meeting was held to discuss the overall goals of the model update effort. The meeting was attended by representatives from ACOG, SCDOT, and the partner MPOs. The following overall goals of the model update were identified:

- Implement a TransCAD-based four-step travel demand model to evaluate potential transportation projects for the seven-county region and across boundary lines.
- Develop an automated approach to integrate land use updates from ACOG and its partner agencies into the model.
- Provide a user-friendly interface for model updates, execution, and reporting.

The update includes an update to the software version, model interface, socioeconomic data inputs, roadway network assumptions, and various modeling parameters.

1.1 Model Overview

The ARM is a trip-based model consisting of the following four basic steps, each utilizing state-of-the-practice and widely accepted mathematical models to analyze travel:

- Trip Generation: How many trips people make
- Trip Distribution: Where trips start and end
- Mode Choice: How people choose to travel (car, bus, bike, walk etc.)
- Traffic Assignment: Which routes people take to make their trips

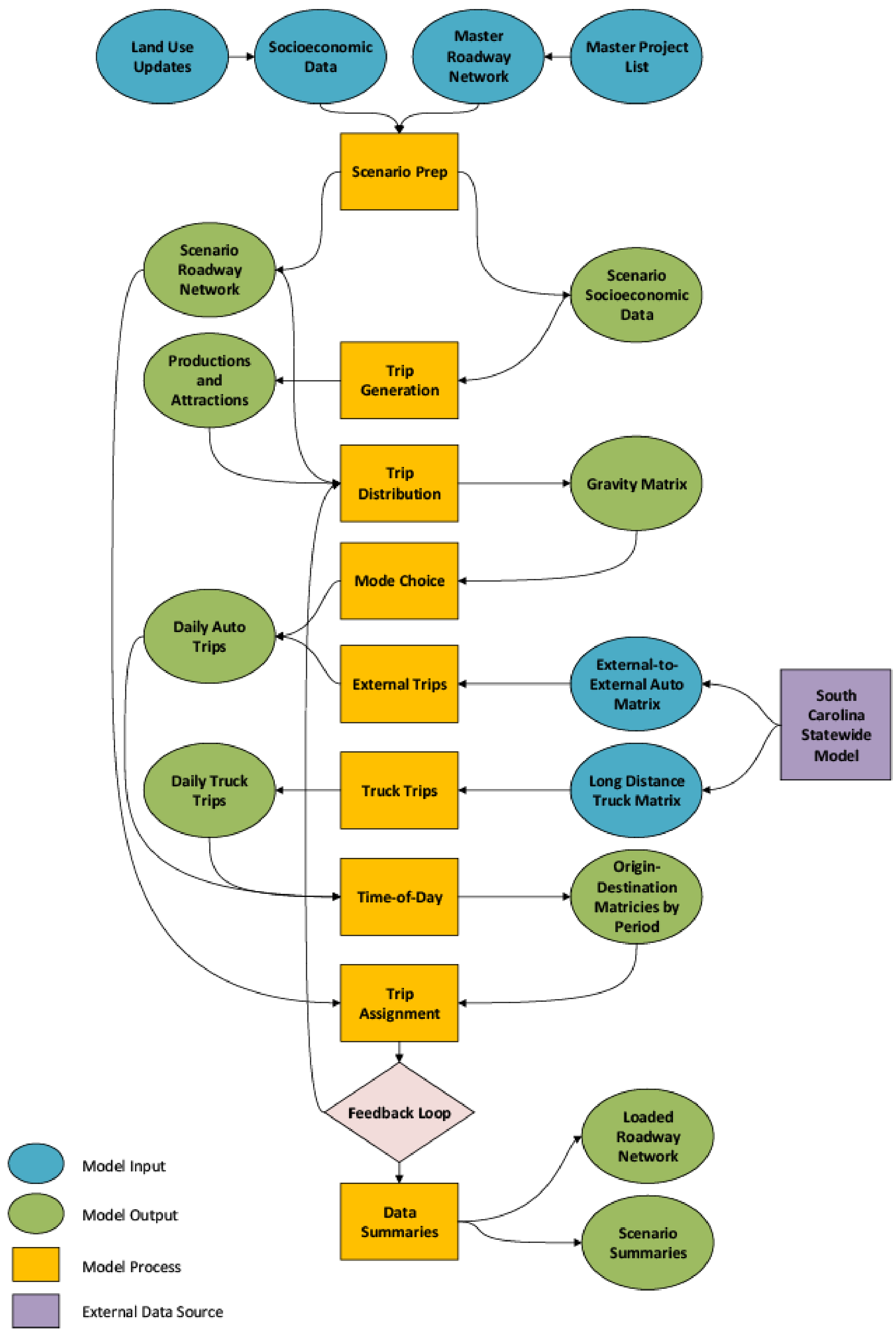
An overview of the model process is presented in **Figure 1.1**.

The ARM is designed to estimate trip making patterns and traffic conditions in the region on an average weekday (Monday-Friday) in the current "base" year of 2022 and forecast year of 2050. The traffic assignment step in the ARM is segmented to generate outputs for the following three time periods of the average weekday:

- AM Peak Period: 6 AM to 9 AM
- PM Peak Period: 4 PM to 7 PM
- Off Peak Periods: 9 AM to 4 PM and 7 PM to 6 AM

The current version of the ARM is in Caliper's TransCAD software – version 9.0 and build 32910. The current version also includes an automated land use importer tool (detailed in Chapter 5), designed to be used with Esri's ArcGIS Pro software platform.

Figure 1.1 ACOG Model Design Flow Chart



2.0 Base Year Model Input Update

This chapter describes the key input data sources to the model, including zonal geography, socioeconomic data, and highway network.

2.1 Zonal Geography

In the ARM, the ACOG region is subdivided into smaller geographical units known as transportation analysis zones (TAZs). Each TAZ contains demographic and socioeconomic data, including information on population, households, employment, and school enrollment. TAZs are also classified as urban or rural area types based on their location, which helps differentiate model parameters between urban and rural areas. The ARM zone system, shown in **Figure 2.1**, consists of 1,768 TAZs, and their boundaries align with those defined in the South Carolina Statewide Model (SCSWM).

In addition to the TAZs that are internal to the model boundary, the ARM includes external stations which represent locations where trips enter or exit the model boundary. These stations are typically placed along major roadways that cross the model boundary. The previous version of the ARM had 53 external stations, and the current update identified 11 new ones, bringing the total to 64 external stations, as listed in **Table 2.1**.

Each TAZ in the ARM is represented by a TAZ centroid, which is a single point that represents the origin and destination for trips within the zone. These centroids are connected to the highway network through centroid connectors, which represent access to the highway network from all locations within the TAZ.

Figure 2.1 ACOG Model Zone Structure

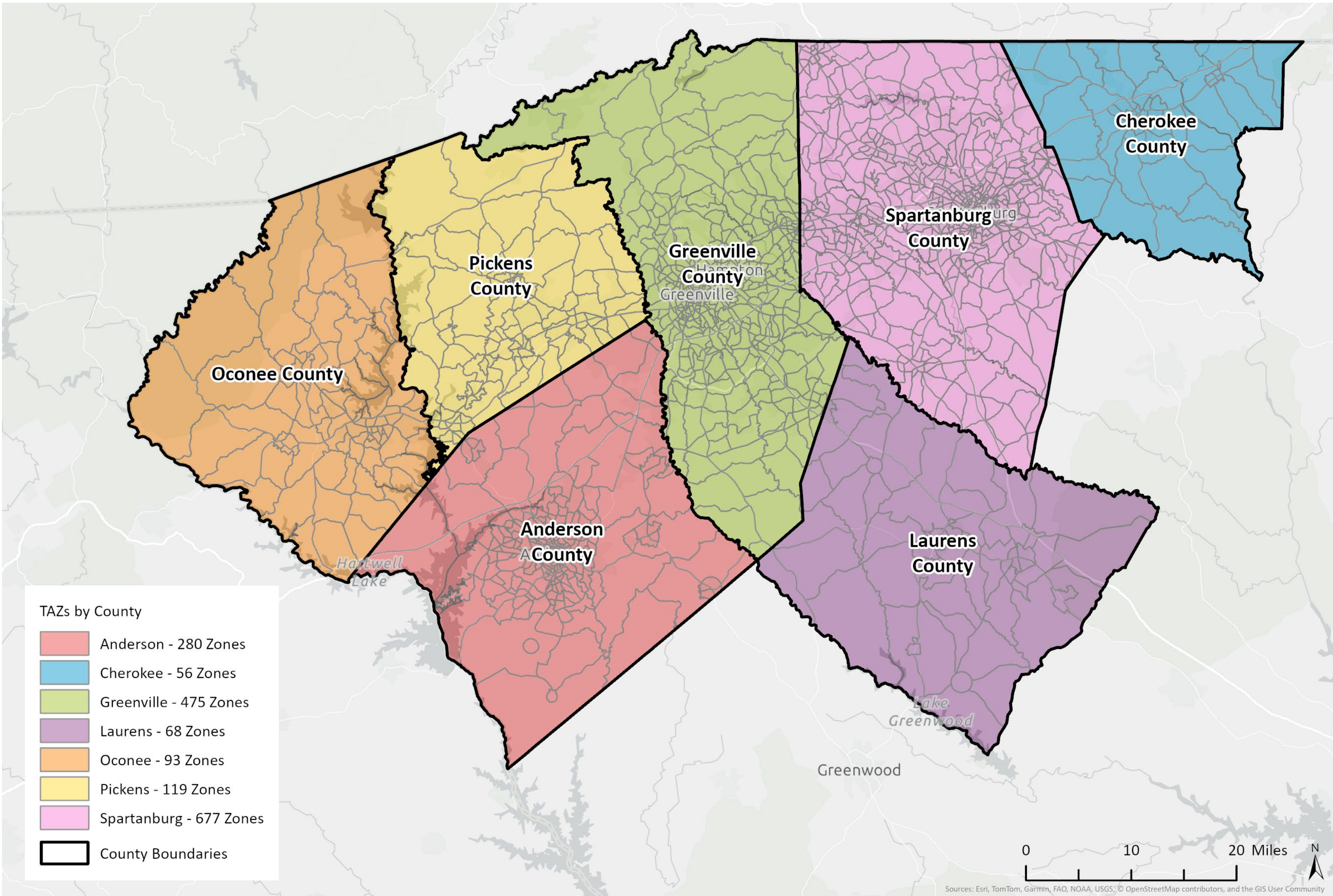


Table 2.1 ARM External Zones

#	Zone #	Description
1	900001	I-85 at Hartwell Lake and GA State Line
2	900002	US 123 at Hartwell Lake and GA State Line
3	900003	US 76 at Chattooga River and GA State Line
4	900004	SC 107 at NC State Line
5	900005	US 178 at NC State Line
6	900006	US 276 at NC State Line
7	900007	US 25 at NC State Line
8	900008	US 176/Ashville Hwy at NC State Line
9	900009	I-26 at NC State Line
10	900010	Hunting Country Rd at NC State Line
11	900011	SC 14/Landrum road at NC State Line
12	900012	Jackson Grove Rd/N Pacolet Rd at NC State Line
13	900013	SC 9 at Melvin Hill Rd at NC State Line
14	900014	W Melvin Hill Rd at SC 9 at NC State Line
15	900015	Melvin Hill Rd/Peachtree Rd at NC State Line
16	900016	Cooley Springs School Rd at McSwain Rd and NC State Line
17	900017	Parris Bridge Rd at NC State Line
18	900018	Jack McKinney Rd at NC State Line
19	900019	US 221/Rutherfordton Hwy at NC State Line
20	900020	Cliffside Hwy at NC State Line
21	900021	SC 18/Shelby Hwy at NC State Line
22	900022	US 29 at I-85 and NC State Line
23	900023	I-85 at US 29 and NC State Line
24	900024	SC 5/Kings Creek Dr at SC 55/Clover Hwy
25	900025	SC 105/Skull Shoals Rd at SC 211/Hickory Grove Rd
26	900026	SC 18/Union Hwy at SC 211/Gowdeysville Rd
27	900027	Jerusalem Rd at SC 150
28	900028	SC 9/Pine St at SC 150/Glenn Springs Rd
29	900029	US 176 at SC 150/Glenn Springs Rd
30	900030	SC 284/Trail Rd at SC 201/Level Land Rd
31	900031	SC 181/Smith McGee Rd at SC 187
32	900032	SC 184/Elberton Hwy at Savannah River and GA State Line

#	Zone #	Description
33	900033	SC 81
34	900034	E Broad St at Flat Rock Rd
35	900035	Flat Rock Rd at E Broad St
36	900036	US 29 at Savannah River and GA State Line
37	900037	SC 28/Abbeville Hwy
38	900038	SC 20/Due West Rd
39	900039	SC 201/Level Land Rd at SC 284/Trail Rd
40	900040	SC 185/Due West Hwy at Trail Rd
41	900041	US 178/Church St
42	900042	SC 49/Cross Keys Hwy
43	900043	S 511/Toal Road at SC 56/Shealton Rd
44	900044	SC 215
45	900045	SC 56 at SC 560
46	900046	SC 39
47	900047	US 76 at SC 560
48	900048	I-26 at SC 66/Whitmire Hwy
49	900049	SC 66/Whitmire Hwy at I-26
50	900050	SC 72/Clinton Hwy
51	900051	US 221/SC 72 at Saluda River
52	900052	US 25 at Power House Rd
53	900053	US 25 Business/SC 252 at US 25
54	1000001	SC 28/Highlands Hwy at GA State Line
55	1000002	SC 130/Whitewater Rd at NC state line
56	1000003	SC 150/Gaffney Rd/Boiling Springs Hwy at NC State Line
57	1000004	SC 198/Blacksburg Rd/N Mountain St at NC State Line
58	1000005	SC 55/Clover Hwy at SC 5/Kings Creek Dr
59	1000006	McGill Hwy at Rock Cut Rd
60	1000007	Rock Cut Rd at McGill Hwy
61	1000008	Old Chester Rd at McGill Hwy
62	1000009	SC 211/Hickory Grove Rd at SC 105/Wilkinsville Hwy
63	1000010	SC 184/Antreville Hwy at Lake Secession
64	1000011	Old Laurens Rd at Saluda River

2.2 Base Year Socioeconomic Data Update

The socioeconomic data inputs for the ARM's base year 2022 were provided by SCDOT through the extraction of ACOG TAZs from the statewide model (SCSWMv6)[1]. Initially, key demographic and employment variables from the SCSWM dataset were compared at the county level with American Community Survey (ACS) estimates[2] to verify their reasonableness.

The next step was to translate the SCSWM employment data into ARM categories by creating a crosswalk between the SCSWM and ARM employment classifications. Because the broader SCSWM employment categories are not directly aligned with the more granular ARM employment categories, the process involved disaggregating the employment into the North American Industry Classification System (NAICS) categories based on the Business Dynamics Statistics (BDS) NAICS data[3] to establish the necessary mapping between SCSWM and ARM. The SCSWM-NAICS-ARM employment mapping is presented in **Table 2.2**, and the county-level comparisons of the updated 2022 ARM socioeconomic data and ACS estimates are provided in **Table 2.3**. The resulting TAZ-level population and employment densities are visualized in **Figure 2.2** and **Figure 2.3**, respectively.

Table 2.2 SCSWM-NAICS-ARM Employment Classification Mapping

SCSWMv6 Category	NAICS Code and Category		ARM Category
Industry	11	Agriculture, Forestry, Fishing and Hunting	Agriculture, Forestry, Fishing
	21	Mining, Quarrying, and Oil and Gas Extraction	Mining
	23	Construction	Construction
	31-33	Manufacturing	Manufacturing
	42	Wholesale Trade	Wholesale
	22	Utilities	Transportation & Public Utilities
	48-49	Transportation and Warehousing	Transportation & Public Utilities
Office	51	Information	Transportation & Public Utilities
	52	Finance and Insurance	Finance, Insurance, Real Estate
	53	Real Estate and Rental and Leasing	Finance, Insurance, Real Estate
	54	Professional, Scientific, and Technical Services	Services
	55	Management of Companies and Enterprises	Services
	56	Administrative and Support and Waste Management and Remediation Services	Services
Services	61	Educational Services	Services
	62	Health Care and Social Assistance	Services
	71	Arts, Entertainment, and Recreation	Services
	72	Accommodation and Food Services	Services
	81	Other Services (except Public Administration)	Services
	92	Public Administration	Public Administration
Retail	44-45	Retail Trade	Retail

[1] *Cutouts from SWMv6.x for ACOG Model\SEDATA_04_25_24.xlsx*, October 2024, SCDOT
[2] U.S. Census Bureau, 2018-2022 American Community Survey 5-Year Estimates, accessed September 2024
[3] U.S. Census Bureau, *Economic Surveys, ECNSVY Business Dynamics Statistics, Table BDSNAICS*, accessed October 2024

Table 2.3 County-level Socioeconomic Data: Updated ARM vs ACS - Base Year 2022

County	Population			Households			Total Employment			School Enrollment		
	ARM	ACS	% Δ	ARM	ACS	% Δ	ARM	ACS	% Δ	ARM	ACS	% Δ
Anderson	204,420	201,722	1%	79,348	80,301	-1%	92,578	92,914	0%	32,664	31,324	4%
Cherokee	59,905	55,162	9%	22,081	21,288	4%	26,028	24,212	8%	8,299	8,563	-3%
Greenville	530,212	516,242	3%	205,189	210,349	-2%	286,600	262,211	9%	86,217	81,280	6%
Laurens	72,832	65,048	12%	27,790	25,757	8%	29,625	29,264	1%	8,930	9,686	-8%
Oconee	81,049	77,898	4%	33,058	33,240	-1%	35,432	32,079	10%	10,229	10,984	-7%
Pickens	133,755	123,564	8%	50,477	50,341	0%	49,639	60,097	-17%	16,651	17,106	-3%
Spartanburg	311,924	322,087	-3%	117,909	125,394	-6%	168,550	154,712	9%	52,557	51,485	2%
Total	**1,394,097**	**1,361,723**	**2%**	**535,852**	**546,670**	**-2%**	**688,452**	**655,489**	**5%**	**215,547**	**210,428**	**2%**

In addition to the household, population, school enrollment, and employment variables described above, household income distributions for each TAZ were also adopted from the SCSWMv6 dataset provided by SCDOT.

Figure 2.2 Base Year 2022 Population Density

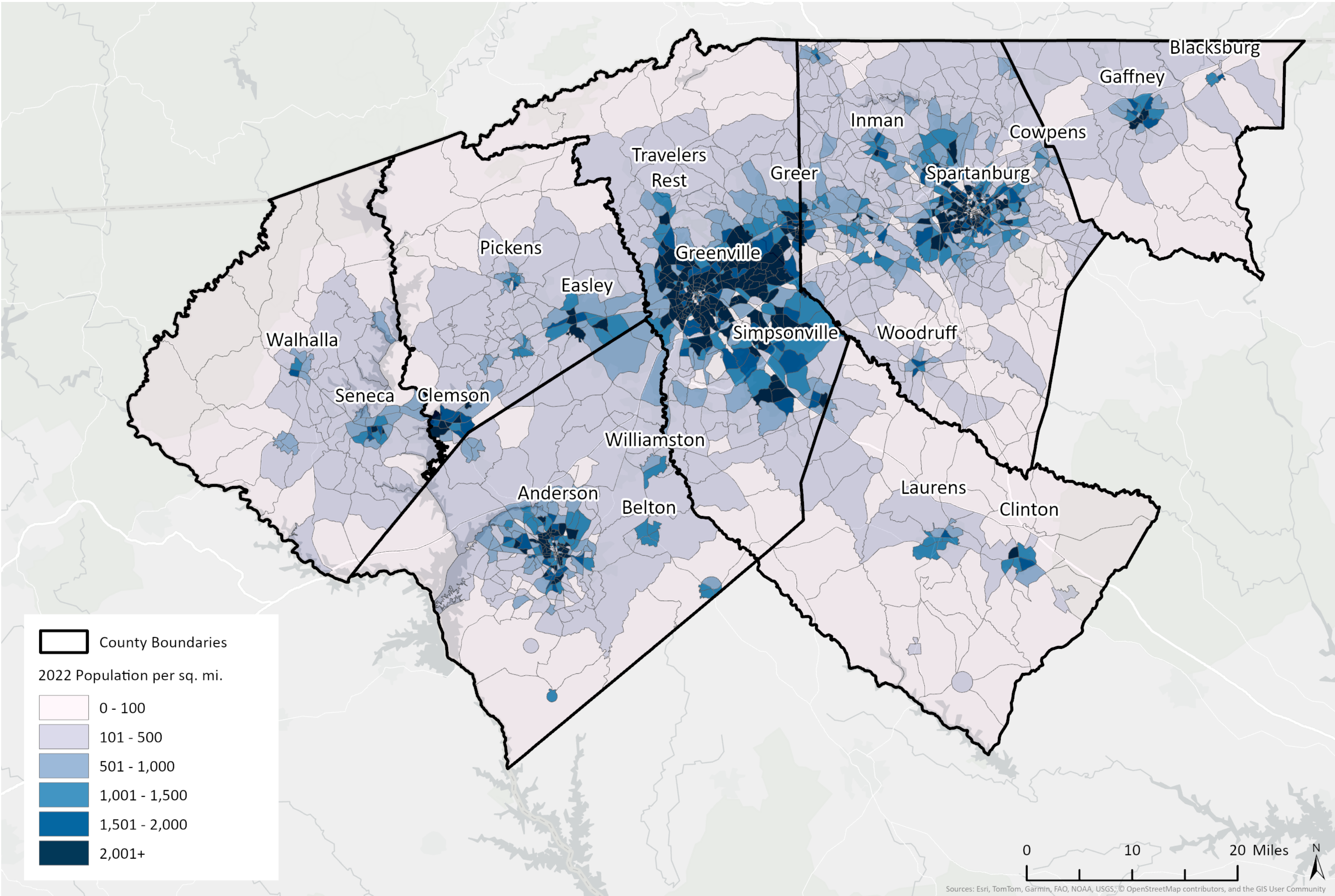
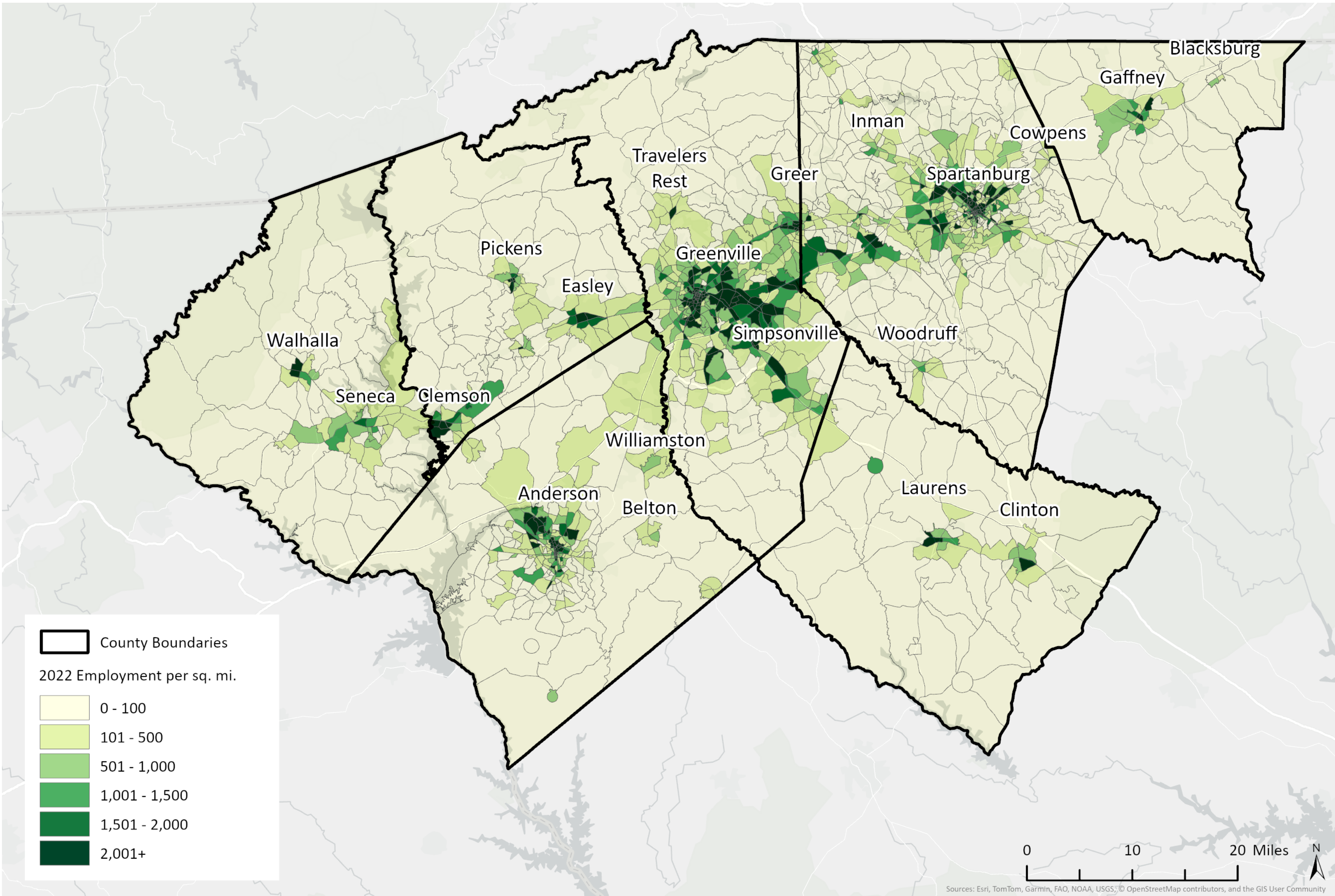


Figure 2.3 Base Year 2022 Employment Density



2.3 Highway Network Update

The ARM highway network is a geospatial data layer that represents the region's roadway infrastructure. In TransCAD, intersections, junctions, and TAZ centroids are represented with point data, known as nodes, while roadway segments and centroid connectors are represented with line data, known as links. Each roadway link contains necessary attributes required for traffic assignment step of the model, including roadway functional classifications, capacities, speeds, number of lanes, traffic counts, and more.

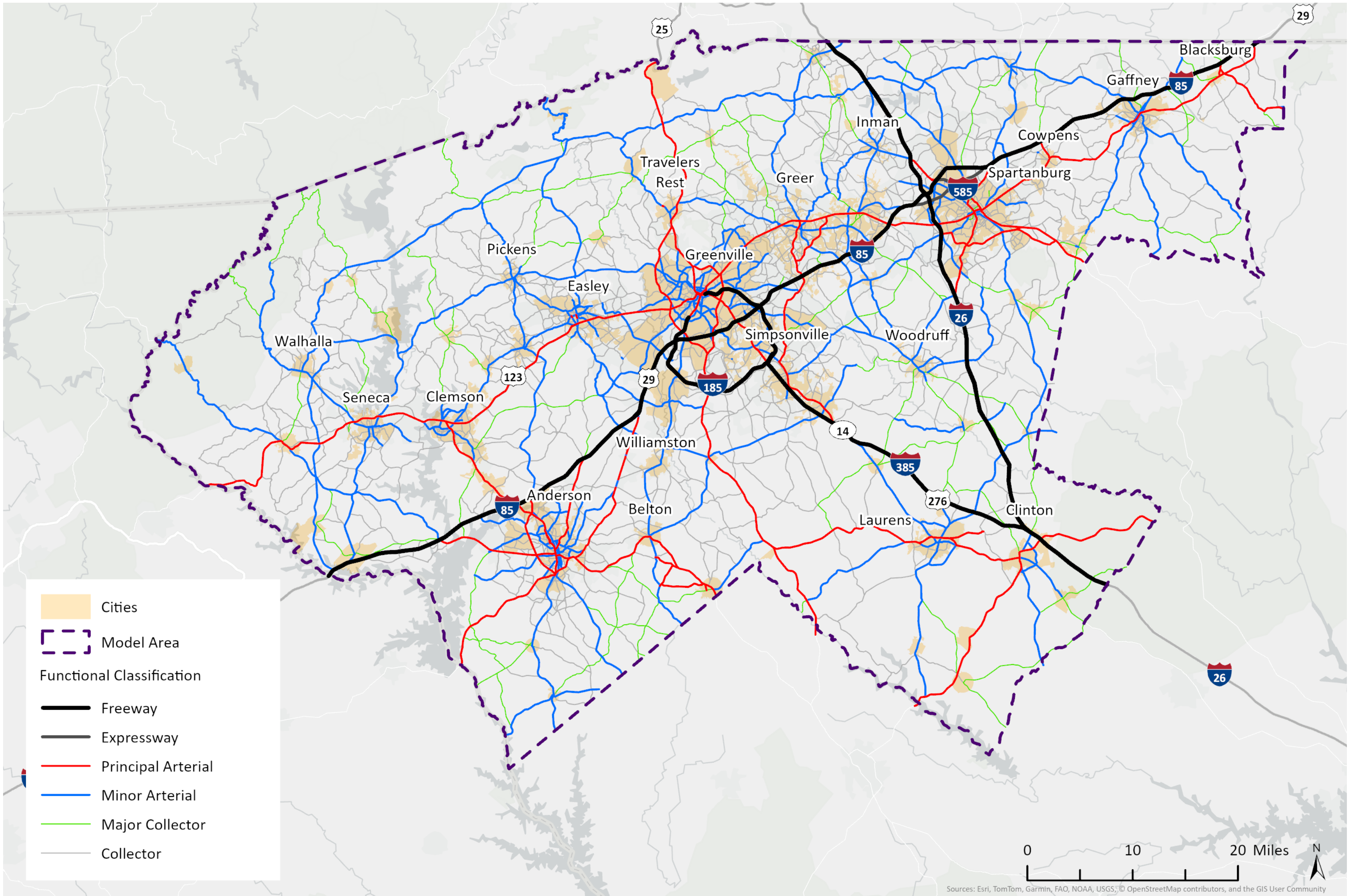
The ARM maintains a single "master network" that houses all modeled scenarios for base and forecast years in one single geographic file. During the model execution, a scenario-specific network is automatically generated from the master network based on user-defined variables. **Appendix A** details the full list of highway network attributes, scenario-specific variables, and the workflow for editing the master network.

For the previous ARM, the base year was 2010. For this update, the base year was advanced to 2022 through a series of updates and enhancements summarized below. The primary reference for the highway network was provided by SCDOT through an extraction of the ACOG network from the statewide model (SCSWMv6)[4]. Additional data sources for network verification included aerial and street-level imagery. **Figure 2.4** shows the updated base year network by functional classification. Key updates include:

- Network geometry – updated alignments and link attributes focusing primarily on changes that occurred between 2010 and 2022.
- Functional classifications – updated the roadway functional class to be consistent with SCSWMv6.
- Speeds and number of lanes – refreshed the free-flow speeds and number of travel lanes to be consistent with SCSWMv6.
- Turn penalties – updated to reflect prohibited turning movements.
- Directional link coding – split freeway links coded as two-way links into separate, paired one-way links, and relocated centroid connectors off freeway links to reflect access limitations.
- Quality control – performed visual checks using recent aerial and street-level imagery.
- Traffic counts – integrated annual average daily traffic (AADT) count data from the SCSWM network counts at over 2000 locations.

[4] *Cutouts from SWMv6.x for ACOG Model\Master Network*, October 2024, SCDOT

Figure 2.4 Base Year 2022 Highway Network and Functional Classification



3.0 Model Calibration and Validation Update

Model estimation is the use of observed data and statistical analysis to develop model parameters, while model calibration is the adjustment of those parameters to produce reasonable and acceptable model results. Model validation is the process of evaluating the calibrated model's performance by comparing its outputs to independent, observed data.

This chapter details the data sources used in the ARM estimation, adjustments made to calibrate the model, and the resulting base year 2022 model outputs, and comparisons against industry standard benchmarks. With SCODT's input, the model calibration and validation benchmarks were selected based on published guidelines from FHWA[5] and University of Tennessee[6].

3.1 Trip Generation Update

Trip generation estimates the number of trip-ends produced or attracted by each TAZ based on land-use characteristics. This step has three components:

- Trip productions – person trips generated by households
- Trip attractions – person trips drawn to employment and other activity centers
- P/A balancing – an adjustment to ensure the total number of productions (P) matches with the number of attractions (A) in the region

Prior to applying the trip production rates, the model splits each zone's households into different size categories using household-size distribution curves adopted from the SCSWM[7]. These curves were developed using ACS data and are presented in **Table 3.1**.

[5] *Travel Model Validation and Reasonableness Checking Manual.* 2nd Edition. FHWA, 2010

[6] *Minimum Travel Demand Model Calibration and Validation Guidelines for the State of Tennessee.* Updated 2016

[7] South Carolina Statewide Travel Demand Model, SCSWMv5 build 20230905, September 2023

Table 3.1 Household Size Distribution Curve Adopted from SCSWM

TAZ Average Household Size	Share of Households			
	Size 1	Size 2	Size 3	Size 4
1.0	100%	0%	0%	0%
1.1	92%	7%	1%	0%
1.2	84%	14%	2%	0%
1.3	75%	22%	3%	0%
1.4	70%	27%	2%	1%
1.5	66%	25%	7%	2%
1.6	57%	34%	8%	2%
1.7	56%	32%	7%	5%
1.8	48%	39%	8%	5%
1.9	44%	40%	9%	7%
2.0	41%	40%	11%	8%
2.1	39%	39%	12%	10%
2.2	36%	38%	14%	12%
2.3	32%	40%	14%	14%
2.4	30%	38%	16%	16%
2.5	29%	36%	17%	18%
2.6	26%	37%	17%	20%
2.7	23%	36%	17%	23%
2.8	22%	36%	18%	25%
2.9	22%	34%	18%	26%
3.0	21%	30%	19%	29%
3.1	20%	29%	20%	30%
3.2	18%	32%	18%	33%
3.3	15%	30%	19%	36%
3.4	17%	27%	20%	36%
3.5	16%	30%	17%	37%
3.6	21%	25%	20%	34%
3.7	15%	32%	11%	42%
3.8	20%	25%	20%	35%
3.9	20%	20%	19%	40%
4.0+	14%	25%	18%	43%

3.1.1 Trip Production Inputs

Trip production rates in the ARM are cross-classified by household size and income for three primary purposes: Home-Based Work (HBW), Home-Based Other (HBO), and Non-Home-Based (NHB), and differentiated by urban and rural types (based on the area type of the TAZ) to capture different trip making characteristics observed in survey data.

For the previous version of the ARM, production rates were estimated based on 2009 National Household Travel Survey (NHTS) data which included the South Carolina addon. For the current update, 2017 and 2022 NHTS data were reviewed as the latest available sources. Due to the significant impact of the COVID-19 pandemic on trip production in the 2022 dataset, the 2017 data—reflecting more typical post-recovery conditions—was deemed more suitable. While the 2017 NHTS data did not independently have the same regional or state-level detail as the 2009 dataset, adjustment factors were derived based on the relative change in trip rates from 2009 to 2017 at the *national* level. These factors were applied to the 2009 ACOG trip rates and manual adjustments were made to smooth out the trip rates across the different household and income size bins. The updated ARM trip production rates are presented in **Table 3.2**.

These trip rates were compared with those from comparable models including SCSWM and the SUATS MPO model for reasonableness checks.

Table 3.2 Trip Production Rates

Area Type	Household Size	Household Income	HBW	HBO	NHB
Urban	1	<= $14,999	0.47	2.00	1.10
		$15,000 to $49,999	0.82	2.45	1.90
		>= $50,000	1.16	2.38	3.27
	2	<= $14,999	1.22	2.97	2.13
		$15,000 to $49,999	1.28	3.53	2.38
		>= $50,000	1.68	4.09	3.40
	3	<= $14,999	1.36	4.42	2.56
		$15,000 to $49,999	1.62	5.23	3.22
		>= $50,000	1.88	6.05	4.07
	4+	<= $14,999	2.17	5.93	4.40
		$15,000 to $49,999	2.46	6.87	4.74
		>= $50,000	2.78	7.82	5.60
Rural	1	<= $14,999	0.38	0.99	0.88
		$15,000 to $49,999	0.41	1.84	1.12
		>= $50,000	0.45	2.22	1.36
	2	<= $14,999	0.58	2.68	1.75
		$15,000 to $49,999	0.73	3.23	1.83
		>= $50,000	0.91	3.90	2.15
	3	<= $14,999	1.53	4.35	2.35
		$15,000 to $49,999	1.60	4.79	2.37
		>= $50,000	1.69	5.21	2.40
	4+	<= $14,999	1.69	5.87	3.50
		$15,000 to $49,999	1.78	6.56	3.54
		>= $50,000	1.87	7.34	3.57

3.1.2 Trip Attraction Inputs

Trip attraction rates are estimated using a linear regression analysis of household, employment, and school enrollment for the three primary purposes and differentiated by urban and rural area types. Household variables are used to capture activities at the home end, while the non-household variables are used to activities at the non-home end. Trip attraction rates are estimated separately for trucks and external trips and are described in Section 3.4 and Section 3.5 of this report.

Trip attraction rates for the ARM update leveraged the trip attraction model in the SCSWM, which was developed using a comprehensive analysis of the 2017 NHTS data and 2019 ACS data. The linear regression analysis was updated by filtering the SCSWM trip attraction outputs for ACOG zones, and the resulting trip attraction rates for the ARM are presented in **Table 3.3**.

Table 3.3 Trip Attraction Rates

Area Type	TAZ Socioeconomic Variable	HBW	HBO	NHB
Urban	Household Population	-	-	-
	Dwelling Units	-	3.10	0.91
	Agriculture, Forestry, Fishing	-	-	-
	Mining	-	-	-
	Construction	-	4.58	0.19
	Manufacturing	-	-	-
	Transportation & Public Utilities	-	-	-
	Wholesale	-	-	-
	Retail	-	1.17	3.18
	Finance, Insurance, Real Estate	-	-	-
	Services	-	-	0.24
	Public Administration	-	-	-
	School Enrollment	-	1.15	0.80
	Total Employment	1.10	-	-
Rural	Household Population	-	-	-
	Dwelling Units	-	3.10	0.92
	Agriculture, Forestry, Fishing	-	-	-
	Mining	-	-	-
	Construction	-	4.58	-
	Manufacturing	-	-	-
	Transportation & Public Utilities	-	-	-
	Wholesale	-	-	-
	Retail	-	1.17	3.16
	Finance, Insurance, Real Estate	-	-	-
	Services	-	-	0.26
	Public Administration	-	-	-
	School Enrollment	-	1.15	0.80
	Total Employment	0.85	-	-

3.1.3 Special Generators

Special generators are land uses with unique characteristics that do not produce or attract trips at the same typical rates as the other land uses. In the ACOG region, these include specific zones around the Clemson University campus and within Greenville County with group quarter facilities and regional employment centers including the BMW manufacturing plant. The ARM uses special generator factors, defined at the TAZ level in the socioeconomic input file and presented in **Table 3.4**, as multipliers to the production and attraction rates.

Table 3.4 Special Generator Factors

TAZ	County	Land Use	Factor
214032	Cherokee	Walmart/Lowes	2
452029	Greenville	Clemson University-ICAR/Hubbell	1.5
452032	Greenville	Regional Retail Employment	1.5
452054	Greenville	Medical Center	1.5
452062	Greenville	Costco/Regional Employment	2
452156	Greenville	Neighborhood Activity	2
452157	Greenville	Regional Industry Employment	2
452167	Greenville	Greenville Public Safety	2
452183	Greenville	Regional Service/Manufacturing Employment	1.5
452266	Greenville	Greenville County Square	2
452404	Greenville	Regional Manufacturing/Retail Employment	3
452410	Greenville	Regional Service Employment	2
772008	Pickens	Clemson University	2.5
772009	Pickens	Clemson University	2.5
772015	Pickens	Clemson University	2.5
772016	Pickens	Clemson University	2.5
772044	Pickens	Pickens Schools	1.5
772045	Pickens	Pickens Schools	1.5
772082	Pickens	Clemson University	2.5
772085	Pickens	Clemson University	2.5
833176	Spartanburg	BMW Manufacturing	1.5

3.1.4 Trip Balancing

The production and attraction totals from the trip generation were reviewed for reasonableness. Industry practice recommends that the regional difference between unbalanced productions and attractions remain within 10 percent for each trip purpose. **Table 3.5** lists the unbalanced productions and attractions, P-to-A ratios, and corresponding calibration benchmarks.

Table 3.5 Unbalanced Productions and Attractions

Trip Purpose	Productions	Attractions	P/A Ratio	Benchmark
HBW	748,187	765,761	0.98	0.90 - 1.10
HBO	2,270,517	2,252,690	1.01	0.90 - 1.10
NHB	1,562,380	1,599,757	0.98	0.90 - 1.10

The ARM balances trips separately by purpose. Consistent with common convention and the nature of the input data, home-based trips (HBW and HBO) are constrained to match productions. This is because household variables, which drive productions, are collected in finer detail and generally more reliable than the aggregated employment data used for attractions. Non-home-based (NHB) trips, on the other hand, are constrained to match attractions, as employment and other activity measures provide a more stable basis. **Table 3.6** presents the balanced trip totals for the three purposes.

Table 3.6 Balanced Productions and Attractions

Trip Purpose	Balanced Trips	Percentage of Trips
HBW	748,187	16.2%
HBO	2,270,517	49.2%
NHB	1,599,757	34.6%
Total	**4,618,461**	**100.0%**

Table 3.7 presents benchmarks for average person trip rates. The average trip rates fall within benchmark ranges, except for HBW-person-trips-per-employee, which is slightly below the low end of the range. This result aligns with the observed downward trend in HBW production rates in NHTS data between 2009 and 2017, at both the state and national levels.

Table 3.7 Average Person Trip Rates

Statistic	Model Output	Benchmark
Person Trips / TAZ	2,612	<15,000
Person Trips / Person	3.3	3.3 - 4.0
Person Trips / Household	8.6	8-10
HBW Person Trips / Employee	1.09	1.20 - 1.55

3.2 Trip Distribution Update

Trip distribution is the spatial allocation of trips between TAZs in the model. The ARM uses a gravity model for trip distribution, which estimates person trips between a set of zones by a relationship that is directly proportional to the number of productions and attractions in the zones, and inversely proportional to the travel time between the zones.

The gravity model is formulated as follows for each trip purpose:

$$T_{ij} = P_i * \frac{(A_j F_{ij} K_{ij})}{\sum_{j=1}^{n}(A_j F_{ij} K_{ij})}$$

where:

T_{ij} = Number of trips from zone j to zone i

P_i = Number of trip projections in zone i

A_j = Number of trip attractions in zone j

F_{ij} = Friction Factor, a function of the travel time impedance between zone i and zone j

K_{ij} = K-Factor, an optional factor used to account for effects of variables other than travel time

Friction factors, used to express the effect of travel time on the trip distribution, are estimated in the ARM using a gamma function formulated as follows. The parameters of the gamma function are adjusted to achieve a reasonable fit for the average trip length distributions.

$$F_{ij} = a * t_{ij}^{b} * e^{c(t_{ij})}$$

where:
F_{ij} = Friction Factor between zone i and zone j
t_{ij} = Travel time between zone i and zone j
$a, b, and\ c$ are model coefficients

For the ARM update, gamma function parameters form the previous ARM were used as starting points and adjusted to account for changes in trip lengths within the ACOG region between the 2009 and 2017 NHTS datasets. Based on the observed average trip lengths (in minutes), the NHTS data indicated an increase in HBW trip lengths, while HBO and NHB trip lengths remained relatively the same. **Table 3.8** presents the updated gamma function parameters.

Table 3.8 Trip Distribution Gamma Function Parameters

Parameter	HBW	HBO	NHB	EIIE
a	1.000	1.000	1.000	1.000
b	-0.400	-1.625	-1.775	-1.600
c	-0.055	-0.045	-0.040	-0.250

The ARM also incorporates K-factors to account for trip distribution patterns influenced by unknown factors beyond travel time. While the use of K-factors is generally discouraged, K-factors were implemented specifically to calibrate HBW trip distribution, where it was found that the model underestimated *intra*-county movements compared to ACS data for county-to-county commuting flows. The K-factors shown in **Table 3.9** were used to encourage more HBW trips to remain within the county. A future model update to the model with county-level calibration is recommended to eliminate the need for K-factors.

Table 3.9 K-Factors for Intra-County HBW Trips

County	Intra-County K-Factor
Anderson	1.75
Cherokee	2.00
Greenville	2.00
Laurens	2.50
Oconee	2.50
Pickens	1.75
Spartanburg	1.50

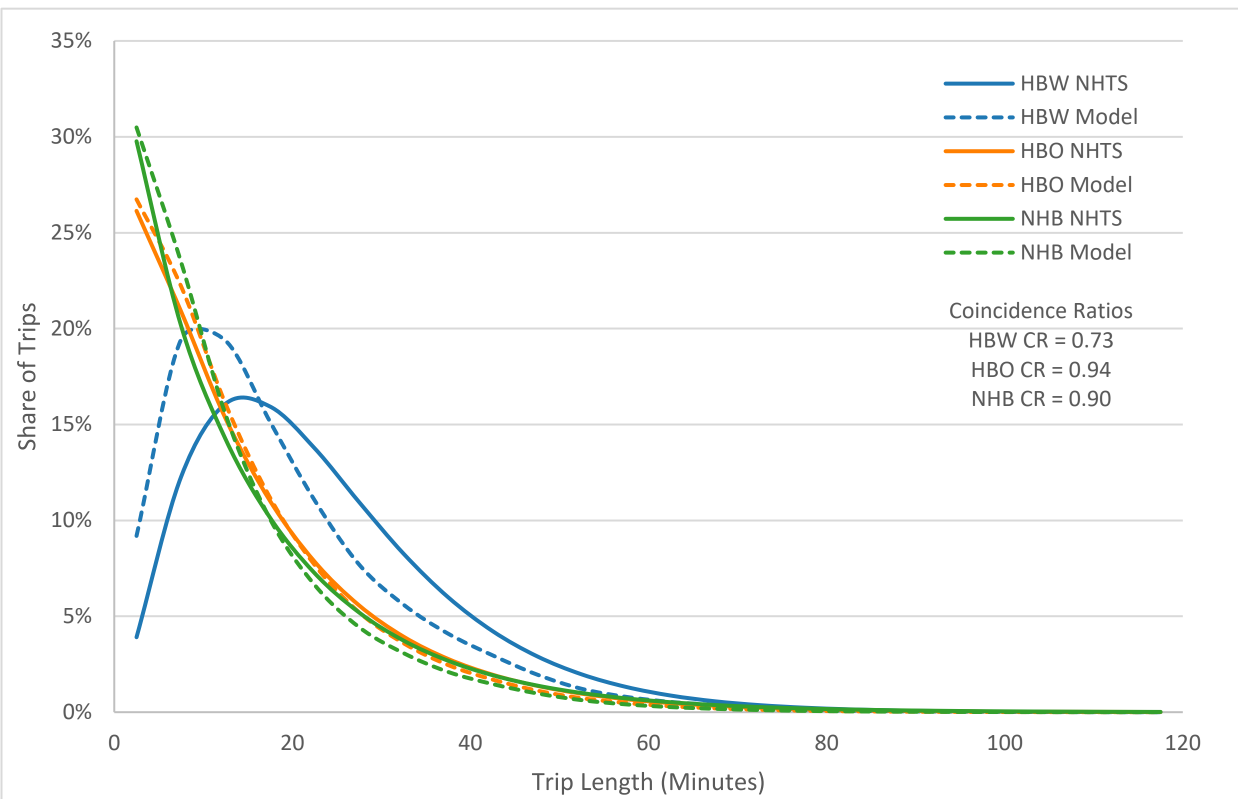
The resulting trip length distribution outputs in time and distance compared with NHTS data and benchmarks are summarized in **Table 3.10**. While average trip lengths fall within benchmark ranges, the model underestimates trip lengths compared to the NHTS congested travel times (based on 2017 NHTS data for the ACOG region).

The trip length distribution curves for each trip purpose for the model and NHTS data are illustrated in **Figure 3.1**. The plots include a coincidence ratio metric, understood as the area under both curves divided by the area under at least one of the curves, which is a measure of the percent of the area that overlaps between the modeled and NHTS distributions. All three trip purposes have a coincidence ratio above FHWA's preferred minimum threshold of 0.70.

Table 3.10 Average Trip Length Distributions for Person Trips

Purpose	Average Trip Length (minutes)			Average Trip Length (miles)		
	Model	NHTS	Benchmark	Model	NHTS	Benchmark
HBW	19.1	23.6	12-35	13.3	14.8	N/A
HBO	14.1	15.2	8 - 20	9.4	8.4	N/A
NHB	12.9	14.9	6 - 19	8.7	8.7	N/A

Figure 3.1 Travel Time Distribution for Passenger Trips (NHTS)



County-to-county HBW trips compared to ACS data are presented in **Table 3.11.** Overall, the model provides a reasonable representation of intra- and inter-county work trips relative to ACS data, with a notable underestimation (-7%) for trips from Laurens County to Greenville County and an overestimation (+7%) from Laurens County to Spartanburg County.

The trip distribution calibration achieves an acceptable balance between NHTS trip lengths and ACS county-level flows. Future refinements should focus on reducing reliance on K-factors and further adjusting friction factors to improve HBW trip length representation.

Table 3.11 Distribution of County-to-County Trips – Model vs ACS

Model								
County	**Anderson**	**Cherokee**	**Greenville**	**Laurens**	**Oconee**	**Pickens**	**Spartanburg**	**Total**
Anderson	64%	0%	19%	1%	3%	9%	3%	100%
Cherokee	0%	68%	5%	1%	0%	0%	26%	100%
Greenville	3%	0%	82%	1%	0%	3%	10%	100%
Laurens	4%	1%	23%	57%	0%	2%	14%	100%
Oconee	10%	0%	6%	0%	65%	18%	1%	100%
Pickens	12%	0%	26%	1%	6%	52%	4%	100%
Spartanburg	1%	3%	16%	2%	0%	1%	77%	100%
Total	**7%**	**5%**	**13%**	**5%**	**5%**	**6%**	**10%**	
ACS Commuting Flows 2016 – 2020								
County	**Anderson**	**Cherokee**	**Greenville**	**Laurens**	**Oconee**	**Pickens**	**Spartanburg**	**Total**
Anderson	68%	0%	19%	0%	2%	8%	2%	100%
Cherokee	0%	73%	3%	0%	0%	0%	24%	100%
Greenville	2%	0%	86%	1%	0%	1%	9%	100%
Laurens	2%	0%	30%	61%	0%	0%	6%	100%
Oconee	8%	0%	5%	0%	71%	15%	1%	100%
Pickens	9%	0%	28%	0%	5%	56%	2%	100%
Spartanburg	0%	2%	17%	1%	0%	0%	80%	100%
Total	**4%**	**3%**	**8%**	**3%**	**3%**	**4%**	**5%**	
Difference Model vs ACS								
County	**Anderson**	**Cherokee**	**Greenville**	**Laurens**	**Oconee**	**Pickens**	**Spartanburg**	**Total**
Anderson	-4%	0%	0%	1%	0%	2%	1%	0%
Cherokee	0%	-4%	2%	1%	0%	0%	1%	0%
Greenville	1%	0%	-4%	0%	0%	2%	1%	0%
Laurens	2%	1%	-7%	-5%	0%	1%	7%	0%
Oconee	2%	0%	0%	0%	-6%	3%	0%	0%
Pickens	3%	0%	-2%	1%	1%	-4%	2%	0%
Spartanburg	1%	2%	-1%	1%	0%	1%	-3%	0%
Total	**3%**	**2%**	**5%**	**2%**	**2%**	**3%**	**5%**	

3.3 Mode Choice and Auto Occupancy Model Update

The mode choice step estimates the number of trips by mode of transportation. The ARM uses a simplified mode choice model to estimate the number of person trips for auto, transit, and non-motorized travel. The approach is outlined as follows:

- This approach starts by factoring the person trip tables based on observed mode split data from the NHTS for urban and rural area types, shown in **Table 3.12**.
- Next, the auto person trips are further segmented into the following categories using a multinomial logit model:
  - Drive alone
  - Shared ride with two people
  - Shared ride with three or more people
- Lastly, the person trips are converted into vehicle trips based on vehicle occupancy rates, also derived from NHTS data, and shown in **Table 3.15**.

Table 3.12 Person Trip Mode Choice Inputs (2017 NHTS)

	Urban			Rural		
Mode	HBW	HBO	NHB	HBW	HBO	NHB
Auto	95.2%	84.7%	89.6%	97.1%	87.2%	91.9%
Transit	2.0%	4.9%	3.5%	0.5%	6.1%	4.0%
Other	2.8%	10.3%	6.9%	2.4%	6.7%	4.1%

The auto mode choice multinomial logit model is formulated as follows:

$$P_i = \frac{e^{u_i}}{\sum_{i=1}^{k} e^{u_i}}$$

where:
P_i = the probability of a travel choosing mode i
u_i = the utilitiy function of mode i
k = available mode choices

with the utility function defined as:

$$u_i = a_i + b * IVTT_i + b * \frac{AOC}{VOT} * DIS_i$$

where:
u_i = the utilitiy function of mode i
a_i = the mode specific constant
$IVTT_i$ = the in-vehicle travel time for mode i
b = the coefficient for IVTT
AOC = the auto operating cost for mode i
VOT = the value of time for mode i
DIS_i = distance traveled in mode i

Table 3.13 lists the mode choice parameters used in the multinomial logit model, chosen primarily to achieve NHTS auto mode share data, and **Table 3.14** shows the auto mode shares output from the model compared to NHTS data, with the modeled mode shares within one percent of the NHTS data for each mode and purpose.

Table 3.13 Auto Mode Choice Logit Model Parameters

Purpose	a_i			b	AOC (cents per mile)	VOT (dollars per hour)
	Drive Alone	Shared Ride 2	Shared Ride 3+			
HBW	0.0	-1.90	-2.80	-0.025	25	16
HBO	0.0	-0.42	-0.47	-0.010	25	13
NHB	0.0	-0.62	-0.98	-0.020	25	13

Table 3.14 Auto Person Mode Shares (Model vs NHTS)

Mode	Model			NHTS		
	HBW	HBO	NHB	HBW	HBO	NHB
Drive Alone	82.6%	43.8%	52.3%	82.5%	44.7%	52.2%
Shared Ride 2	12.4%	28.8%	28.1%	12.7%	28.3%	28.1%
Shared Ride 3+	5.0%	27.4%	19.6%	4.8%	27.0%	19.7%

Table 3.15 Vehicle Occupancy Rates

Auto Mode	HBW	HBO	NHB
Drive Alone	1.00	1.00	1.00
Shared Ride 2	2.00	2.00	2.00
Shared Ride 3+	3.83	3.61	3.72

3.4 Truck Model Update

The ARM includes three categories of truck trips:

- External trucks
- Local medium trucks
- Local heavy trucks

External truck trips represent trucks with a trip end outside of the seven-county ARM model area. These trips are derived from the SCSWM through a sub-area extraction procedure and used as an input origin-destination matrix to the ARM. The basis for this approach is SCSWM's use of the IHS-Global Insight Transearch database to develop truck trip estimates for the 2022 base year and the 2050 forecast year.

The local medium and heavy trucks are modeled using trip generation rates from the Quick Response Freight Manual (QRFM)[8] and adjusted during calibration to match truck counts. These trip rates, assumed to be the same for productions and attractions, are presented in **Table 3.16**.

[8] *Quick Response Freight Manual*, Second Edition, FHWA, 2007

Table 3.16 Local Truck Trip Generation Rates

TAZ Socioeconomic Variable	Medium Trucks	Heavy Trucks
Household Population	0.025	0.010
Dwelling Units	-	-
Agriculture, Forestry, Fishing	0.072	0.044
Mining	0.072	0.044
Construction	0.072	0.044
Manufacturing	0.061	0.026
Transportation & Public Utilities	0.061	0.026
Wholesale	0.061	0.026
Retail	0.063	0.016
Finance, Insurance, Real Estate	-	0.002
Services	0.017	0.002
Public Administration	-	0.002
School Enrollment	-	-
Total Employment	-	-

In the trip distribution step of the model, truck trips are modeled using an impedance function that differs from the gamma function used for auto trips. The parameters for this impedance function, derived from the QRFM[9], vary by trip distances, and are presented in **Table 3.17.** The impedance function for local trips is formulated as follows:

$$P_t = e^{a_t - b_t * T}$$

where:
P_t = the impedance for local truck trips
a_t, b_t = the coefficients for local truck trips
T = the travel time during off-peak time period

Table 3.17 Local Truck Impedance Parameters

Truck Type	Trip distance	a_t	b_t
Medium Truck Trips	< 27 miles	4.750	-0.005
	≥ 27 miles	3.200	-0.003
Heavy Truck Trips	< 7.5 miles	1.000	0.000
	≥ 7.5 miles	3.000	-0.009

[9] *Quick Response Freight Manual*, Second Edition, FHWA, 2007

3.5 External Trip Update

The ARM models external trips in two categories:

- External-to-Internal (EI) and Internal-to-External (IE) – these are trips with one end outside the model area.
- External-to-External – these are trips with both trip ends outside the model area.

To estimate the EI and IE trips, EI trips are first calculated using the trip generation rates shown in **Table 3.18.** These trips are transposed to derive the IE trips.

The EE trips are estimated using two sources:

1. A seed trip table for the seven-county ARM model area, derived from the SCSWM through a sub-area extraction process.
2. A Fratar method applied to adjust the trip table based on traffic count data at the external stations.

Table 3.18 External-to-Internal Trip Generation Rates

TAZ Socioeconomic Variable	EIIE Trip Rate
Household Population	-
Dwelling Units	0.3
Agriculture, Forestry, Fishing	0.17
Mining	0.17
Construction	0.17
Manufacturing	0.17
Transportation & Public Utilities	0.17
Wholesale	0.17
Retail	0.61
Finance, Insurance, Real Estate	0.17
Services	-
Public Administration	0.17
School Enrollment	-
Total Employment	-

3.6 Time-of-Day Update

The ARM incorporates time-of-day factors by hour for each trip purpose to account for variations in typical weekday travel patterns. These factors, shown in **Table 3.19**, were developed using NHTS data for internal trips by trip purpose and hourly traffic count data provided by SCDOT for external and truck trips. The hourly factors are aggregated to produce outputs for the following three time periods of the typical weekday:

- AM Peak Period: 6 AM to 9 AM
- PM Peak Period: 4 PM to 7 PM
- Off Peak Periods: 9 AM to 4 PM and 7 PM to 6 AM

Table 3.19 Time-of-Day Factors

Hour Start	HBW PA	HBW AP	HBO PA	HBO AP	NHB PA	NHB AP	EIIE PA	EIIE AP	EE PA	EE AP	Truck PA	Truck AP
12:00 AM	0.0%	0.4%	0.1%	0.2%	0.0%	0.0%	0.6%	0.7%	0.5%	0.5%	0.4%	0.4%
1:00 AM	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.3%	0.4%	0.3%	0.3%	0.3%	0.3%
2:00 AM	0.0%	0.3%	0.0%	0.1%	0.0%	0.0%	0.2%	0.2%	0.2%	0.2%	0.4%	0.2%
3:00 AM	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.3%	0.2%	0.2%	0.5%
4:00 AM	1.5%	0.2%	0.2%	0.1%	0.1%	0.1%	0.3%	0.2%	0.3%	0.3%	1.1%	0.5%
5:00 AM	4.7%	0.0%	0.6%	0.1%	0.2%	0.2%	0.6%	0.5%	0.7%	0.7%	1.0%	0.9%
6:00 AM	10.8%	0.1%	2.6%	0.4%	0.9%	0.9%	1.8%	1.5%	1.7%	1.9%	2.2%	1.5%
7:00 AM	14.8%	0.6%	8.0%	1.8%	3.2%	3.2%	2.7%	3.0%	2.2%	3.7%	2.0%	2.7%
8:00 AM	7.9%	0.3%	3.7%	1.3%	2.5%	2.5%	3.7%	3.6%	2.7%	4.0%	3.1%	3.7%
9:00 AM	3.0%	0.4%	3.5%	1.6%	2.2%	2.2%	2.7%	2.6%	2.4%	2.7%	4.3%	3.6%
10:00 AM	1.2%	0.5%	4.0%	2.1%	3.4%	3.4%	2.6%	2.4%	2.6%	2.7%	4.5%	4.9%
11:00 AM	1.0%	0.9%	3.2%	2.9%	4.3%	4.3%	2.4%	2.5%	2.5%	2.7%	3.6%	4.5%
12:00 PM	1.0%	1.2%	2.3%	3.0%	5.1%	5.1%	2.6%	2.6%	2.8%	2.9%	3.9%	3.2%
1:00 PM	1.9%	1.5%	1.9%	3.1%	4.5%	4.5%	2.8%	2.8%	3.1%	2.9%	3.2%	3.3%
2:00 PM	1.6%	2.0%	2.9%	4.6%	4.2%	4.2%	3.1%	2.9%	3.4%	3.2%	4.0%	3.7%
3:00 PM	1.3%	4.6%	2.6%	5.5%	4.9%	4.9%	3.2%	3.4%	3.5%	3.5%	3.1%	3.4%
4:00 PM	1.1%	8.3%	2.1%	4.5%	3.9%	3.9%	3.8%	3.8%	4.3%	3.7%	3.5%	3.1%
5:00 PM	0.6%	11.9%	3.2%	4.7%	4.2%	4.2%	4.0%	4.0%	4.3%	3.3%	2.6%	3.1%
6:00 PM	0.4%	4.8%	3.1%	4.7%	2.7%	2.7%	4.1%	4.1%	3.9%	3.5%	2.4%	2.5%
7:00 PM	0.2%	1.8%	1.9%	3.9%	1.5%	1.5%	3.0%	3.2%	2.7%	2.9%	0.8%	1.7%
8:00 PM	0.3%	1.6%	0.8%	3.8%	1.1%	1.1%	2.1%	1.8%	2.1%	1.6%	1.3%	1.2%
9:00 PM	0.4%	1.2%	0.3%	2.8%	0.5%	0.5%	1.7%	1.5%	1.6%	1.2%	0.4%	1.0%
10:00 PM	0.3%	1.7%	0.0%	1.1%	0.2%	0.2%	1.1%	1.0%	0.9%	0.9%	0.6%	0.5%
11:00 PM	0.1%	1.3%	0.1%	0.4%	0.1%	0.1%	0.7%	0.8%	0.6%	0.7%	0.4%	0.5%
Total	**54.1%**	**45.8%**	**47.1%**	**52.8%**	**49.8%**	**49.8%**	**50.2%**	**49.8%**	**49.9%**	**50.1%**	**49.1%**	**50.9%**

3.7 Highway Assignment Update

The ARM highway assignment step determines the routes for auto and combined truck trips for the three modeled time periods (AM peak, PM peak, and off-peak). The process begins by assigning trips between TAZs based on the shortest travel-time paths and then iteratively reallocates trips along alternate paths based on the congested travel times until an “equilibrium” condition is reached. The ARM uses a multi-modal multi-class assignment (MMA) using a Bi-Conjugate (N-Conjugate) Frank Wolfe User Equilibrium technique. A maximum of 500 iterations is allowed, with a convergence criterion of 0.001 (measured as the relative difference in travel times between iterations) to ensure stable results.

Additionally, the ARM includes a “feedback loop” between the trip distribution and traffic assignment steps. In this loop, the travel times produced during the traffic assignment step (which simulate real-world congestion) are iteratively fed back into the trip distribution step. This process improves the reasonableness of the trip distribution estimates and the model’s ability to account for the effects of congestion on travel behavior. The feedback loop is implemented using the Method of Successive Averages (MSA), with convergence reached when root-mean-square-error (RMSE) of peak-period travel times between consecutive iterations is less than 0.1. For the base year 2022 model, convergence was reached after seven feedback iterations.

Roadway link travel times during assignment are computed using a volume-delay function (VDF), which predicts congested travel time (or delay) on a link as a function of its capacity and assigned traffic volume. The ARM uses the following VDF formulation:

$$T_c = T_0 * \left(1 + \alpha * \left(\frac{v}{c}\right)^{\beta}\right)$$

where:
$T_c =$ congested travel time on the link
$T_0 =$ free-flow travel time on the link
$\frac{v}{c} =$ volume-to-capacity ratio on the link
$\alpha, \beta =$ VDF coefficients

Link capacities and VDF coefficients for each roadway functional class were updated based on SCDOT input, a review of peer regional models, and iterative sensitivity testing. The ARM uses daily per-lane capacities as an input, derived from accepted hourly capacities and hour-to-period scaling factors. The factors consider that travel is not uniformly distributed throughout the day, and that off-peak and overnight demand is low relative to the peak period or peak hour. The scaling factors are listed below, and the resulting capacities are shown in **Table 3.20**. The calibrated VDF parameters are presented in **Table 3.21**.

- Daily factor of 10.0, typically between 8.0 and 12.0. For a freeway lane with a capacity of 2,000 vehicles per hour, this results in a daily capacity of 20,000 vehicles per day.
- AM or PM peak-factor of 2.5, which is slightly below the theoretical maximum of 3.0 for the three-hour period.
- Off-peak (midday or nighttime) factor of 6.25.

Table 3.20 Roadway Link Capacities (Directional and Per-Lane)

Functional Class	Hourly	Daily (10 x Hourly)	AM and PM Peak Periods (2.5 x Hourly)	Off-Peak Period (6.25 x Hourly)
Freeway	2,100	21,000	5,250	13,125
Expressway	1,800	18,000	4,500	11,250
Divided Principal Arterial	1,780	17,825	4,456	11,141
Undivided Principal Arterial	1,550	15,500	3,875	9,688
Divided Minor Arterial	1,495	14,950	3,738	9,344
Undivided Minor Arterial	1,300	13,000	3,250	8,125
Divided Major Collector	1,035	10,350	2,588	6,469
Undivided Major Collector	9,000	9,000	2,250	5,625

Table 3.21 Volume Delay Function Coefficients

Functional Class	α	β
Freeway	1.30	7.00
Expressway	1.20	4.00
Divided Principal Arterial	0.50	5.00
Undivided Principal Arterial	0.50	5.00
Divided Minor Arterial	1.00	5.00
Undivided Minor Arterial	1.00	5.00
Divided Major Collector	1.00	6.00
Undivided Major Collector	1.00	6.00

3.7.1 Highway Assignment Validation

During the calibration process, the model's input parameters were adjusted with a primary focus on matching modeled volumes to observed daily traffic count data. This section presents a series of outputs from the base year 2022 ARM highway assignment and evaluates the model's performance against benchmark criteria, including:

- **Percent Root-Mean-Square-Error (RMSE):** The square root of the difference between modeled and observed volumes, divided by the number of observations. This metric is similar to a standard deviation, assessing overall model reasonableness.
- **Percent Volume Error:** The percent deviation between modeled and observed volumes, providing a general context for whether model volumes are higher or lower than the counts.
- **Percent Vehicle Miles Traveled (VMT) Error:** The percent deviation between modeled and observed VMT.
- **Scatterplot of Modeled vs Observed Volume with R-squared (R^2) Statistic:** The R-squared value measures the proportion of variance in observed volumes explained by the model's estimated volumes. Values range from 0 to 1, with higher values signifying a better model fit.
- **Vehicle Miles Traveled (VMT), Vehicle Hours Traveled (VHT), and Average Speeds:** A summary of overall network performance.

Considering the regional scope of the ARM, these validation checks have been done for links with daily counts greater than 1,000 vehicles per day. **Table 3.22** presents %RMSE and volume error by volume class. The %RMSE falls in the acceptable range model-wide and for most volume classes, though volume classes between 5,000 and 20,000 are marginally outside the acceptable range. Percent volume error is acceptable model-wide and across nearly all volume classes, except for the 60,000+ class, where the model underestimates observed counts by 16%. This discrepancy is based on a limited sample of only 10 count locations.

Table 3.22 Percent RMSE and Volume Error by Volume Class

Volume Class	Number of Counts	% RMSE		Sum of Volumes			
		Model	Benchmark	Observed	Modeled	% Error	Benchmark
>1,000-4,999	769	72%	<= 100%	2,060,896	2,081,702	1%	+/-25%
5,000-9,999	492	54%	<= 45%	3,517,436	3,462,503	-2%	+/-25%
10,000-14,999	225	37%	<=35%	2,747,927	2,671,996	-3%	+/-20%
15,000-19,999	96	36%	<=30%	1,682,950	1,579,996	-6%	+/-20%
20,000-29,999	164	25%	<=27%	4,066,750	3,994,325	-2%	+/-15%
30,000-49,999	108	17%	<=25%	4,328,100	4,176,422	-4%	+/-15%
50,000-59,999	22	13%	<=20%	1,175,650	1,115,166	-5%	+/-10%
60,000+	10	16%	<=19%	622,700	525,933	-16%	+/-10%
Overall	**1886**	**38%**	**<=45%**	**20,202,409**	**19,608,043**	**-3%**	**+/-5%**

Table 3.23 shows the volume error and VMT error by functional class, all within acceptable ranges.

Table 3.23 Volume Error and VMT Error by Functional Class

Functional Class	Number of Counts	Sum of Counts	Sum of Volumes	% Volume Error	Observed VMT	Modeled VMT	% VMT Error	Benchmark
Freeway	200	6,588,300	6,502,434	-1%	7,151,485	7,310,898	2%	+/-7%
Expressway	27	365,950	381,731	4%	143,628	143,593	0%	+/-7%
Principal Arterial	253	4,403,050	4,253,914	-3%	2,170,675	2,271,304	5%	+/-15%
Minor Arterial	560	5,008,600	5,144,704	3%	2,708,945	2,943,094	9%	+/-15%
Major Collector	152	682,950	709,166	4%	604,968	671,344	11%	+/-25%
Collector	694	2,851,100	2,315,820	-19%	1,634,624	1,385,819	-15%	+/-25%
Total	**1886**	**19,899,950**	**19,307,769**	**-3%**	**14,414,324**	**14,726,052**	**2%**	**+/-5%**

Table 3.24 summarizes the VMT, VHT, and average speeds by functional class. Modeled average speeds range from 38 mph on collector streets to 56 mph on freeways, with an overall network average speed of 47 mph. **Figure 3.2** illustrates a scatterplot of modeled versus observed daily volumes, with an R-squared value of 0.88, indicating an acceptable fit.

Figure 3.3 and **Figure 3.4** display the modeled highway assignment results for the 2022 base year, including volumes and volume-to-capacity (V/C) ratios, respectively. The ARM calculates level-of-service (LOS) for each link based on the V/C ratios in **Table 3.25**. LOS D or worse corresponds to a V/C ratio greater than one, indicating that the estimated demand volume exceeds the available roadway capacity for that link.

Table 3.24 VMT, VHT, and Average Speed – 2022 Base Year

Functional Class	Number of Links	Sum of Length	VMT	VHT	Average Speed (mph)
Freeway	671	455	12,649,874	224,596	56
Expressway	104	24	314,167	5,962	53
Ramp	568	121	395,620	11,640	34
Direct Connector	49	17	102,958	2,443	42
Divided Principal Arterial	343	127	2,684,108	56,522	47
Undivided Principal Arterial	903	356	4,925,600	109,770	45
Divided Minor Arterial	206	62	1,321,690	28,775	46
Undivided Minor Arterial	2,314	1,086	8,447,767	187,676	45
Divided Major Collector	8	2	6,382	154	42
Undivided Major Collector	607	584	2,209,859	48,929	45
Divided Collector	126	31	236,501	6,257	38
Undivided Collector	4,351	2,535	5,455,327	138,326	39
Total	**10,250**	**5,401**	**38,749,852**	**821,049**	**47**

Figure 3.2 Base Year 2022 Traffic Assignment – Modeled vs Observed Volumes Scatterplot

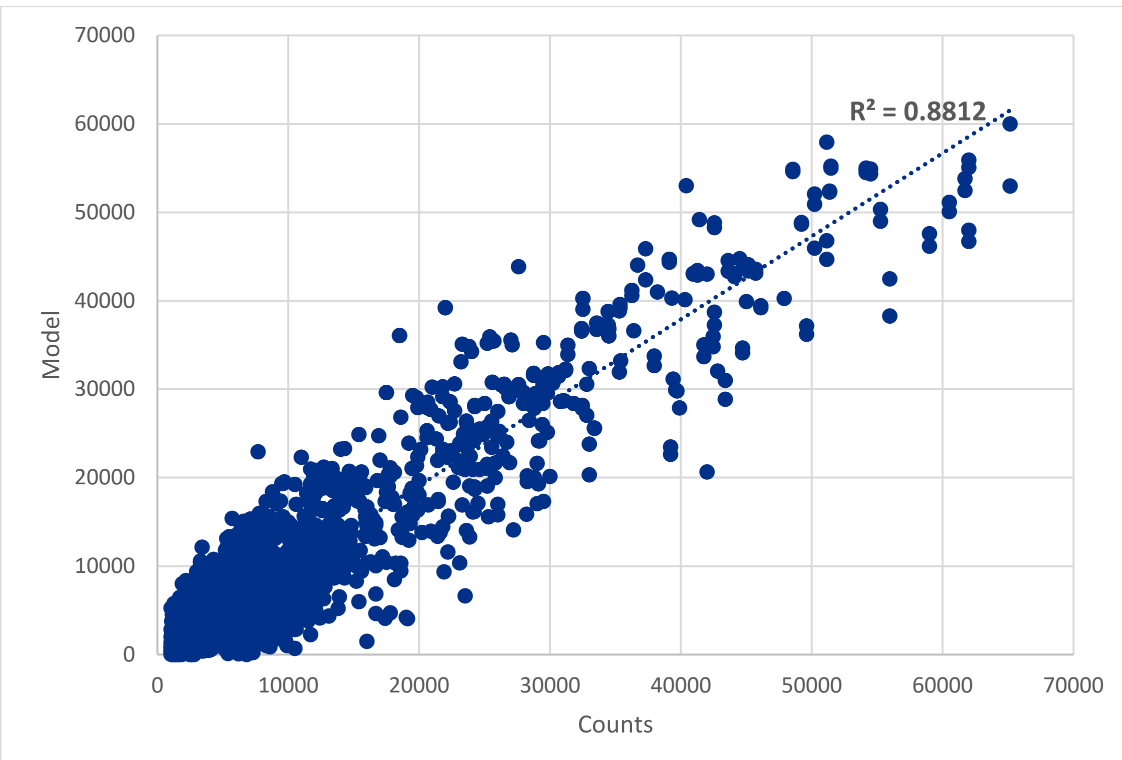


Table 3.25 Level-of-Service (LOS) Thresholds

Level of Service	V/C Ratio Range
A	0.00 – 0.50
B	> 0.50 – 0.74
C	> 0.74 – 1.00
D	> 1.00 – 1.15
E	> 1.15 – 1.34
F	> 1.34

Figure 3.3 Base Year 2022 Traffic Assignment – Volumes Map

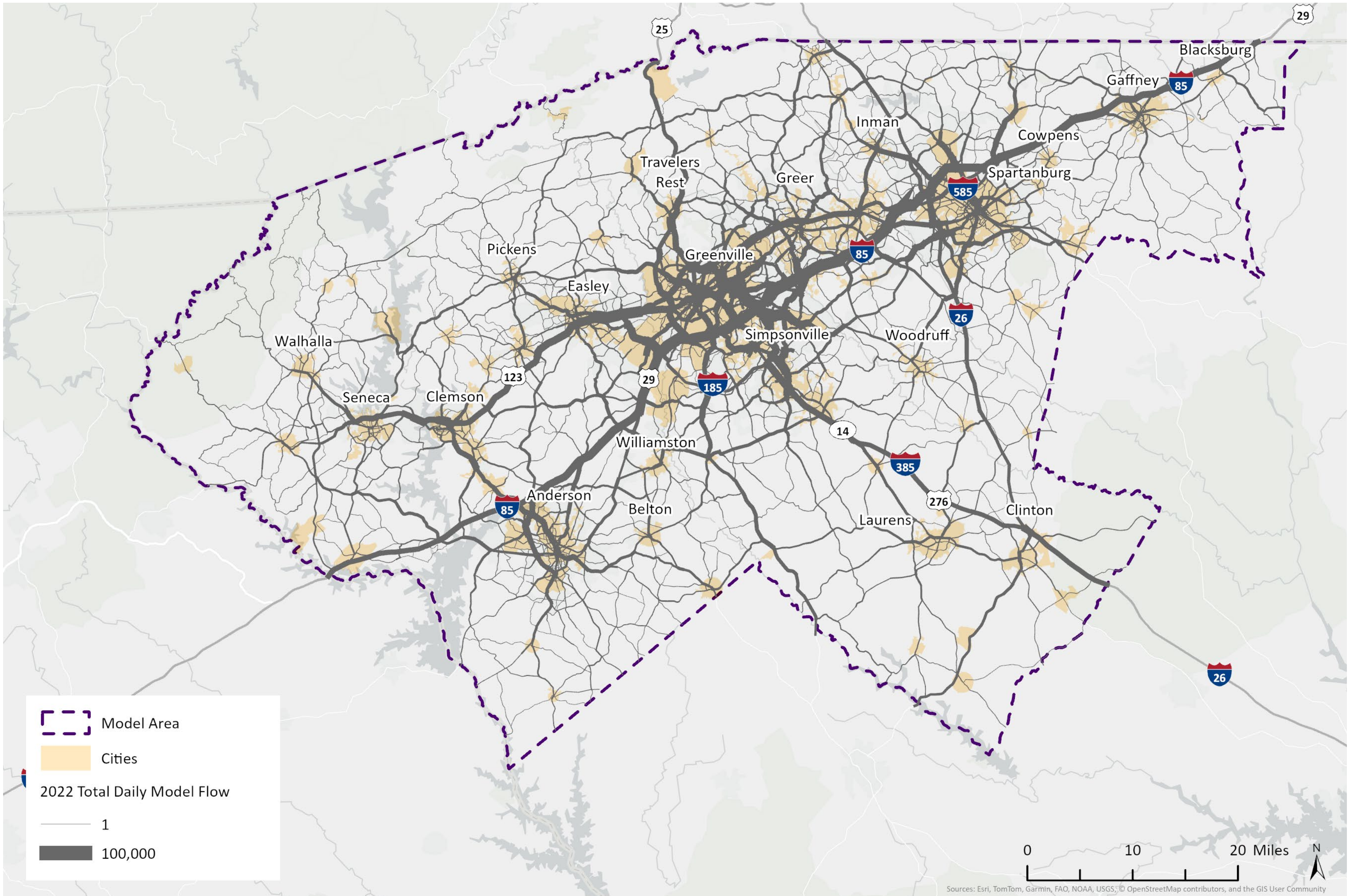
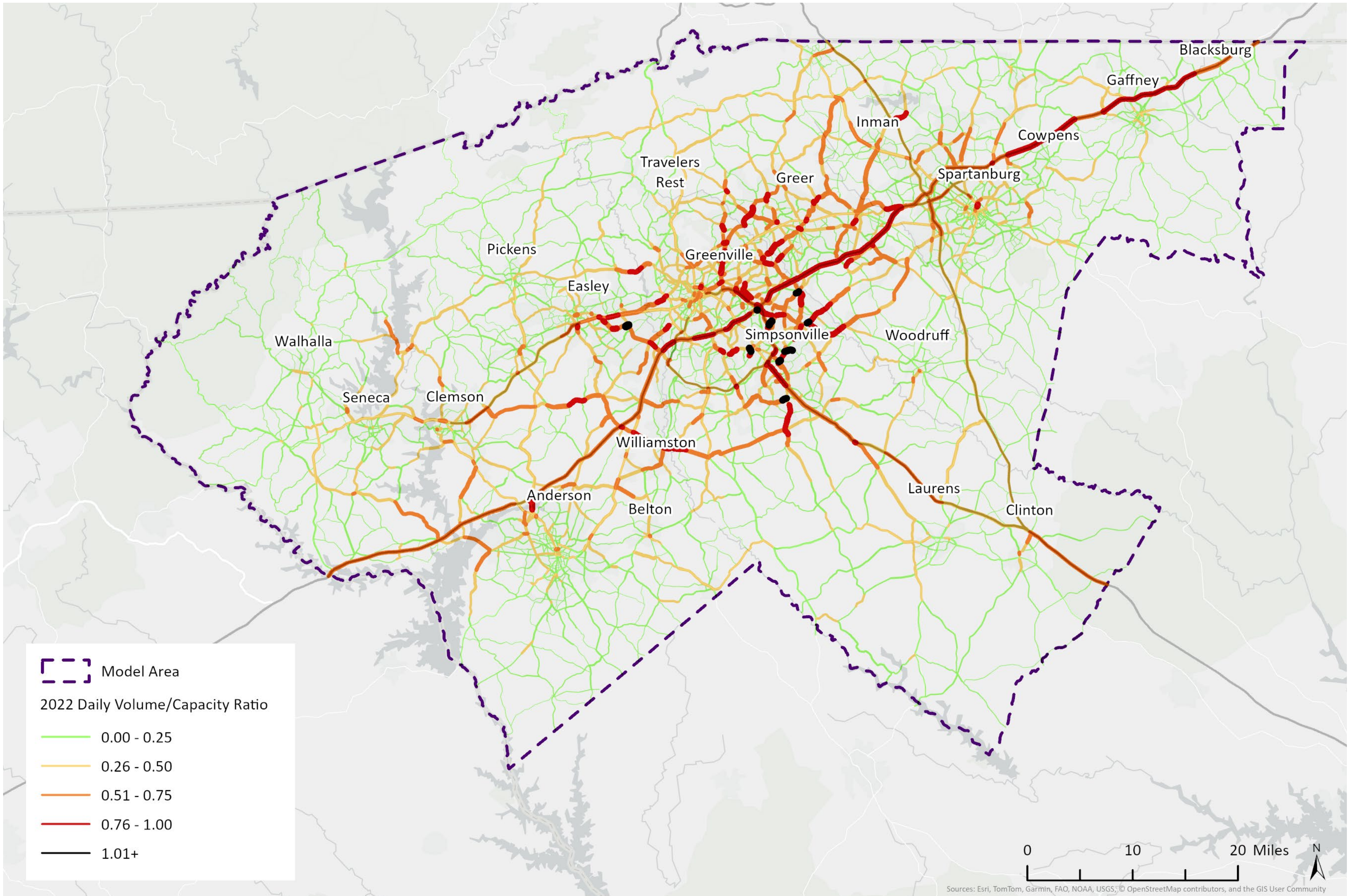


Figure 3.4 Base Year 2022 Traffic Assignment – V/C Ratio Map



4.0 Future Year Model Update

The future forecast year for the ARM is 2050. This chapter outlines the data sources used to prepare the future year scenario inputs, including socioeconomic data, highway network, external trips, and truck trips assumptions. It also presents the future year model outputs.

4.1 Future Year Socioeconomic Data

The initial 2050 socioeconomic data for the ARM update was developed using the base year dataset and a simplified methodology based on growth rates derived from SCSWMv5 (base year 2019 and future year 2050). These growth rates were applied at the county level, consistent with the approach used for SCSWMv5, for key socioeconomic variables including households, population, and employment. For school enrollment, the ARM update retained the more granular approach from SCSWMv5, which allocated school enrollment based on population forecasts for each school district.

The initial future year dataset was submitted to ACOG for review. Following their feedback, revisions were incorporated into the final dataset.

Table 4.1 summarizes the key base and future year socioeconomic variables by county along with the corresponding compound annual growth rates (CAGR). The resulting future year TAZ-level population and employment densities are visualized in **Figure 4.1** and **Figure 4.2**, respectively.

Table 4.1 County-level Socioeconomic Data - Base Year 2022 and Future Year 2050

County	Population			Households			Total Employment			School Enrollment		
	2022	2050	CAGR	2022	2050	CAGR	2022	2050	CAGR	2022	2050	CAGR
Anderson	204,420	249,800	0.72%	79,348	96,957	0.72%	92,578	122,877	1.02%	32,664	39,913	0.72%
Cherokee	59,905	65,199	0.30%	22,081	24,032	0.30%	26,028	34,743	1.04%	8,299	9,033	0.30%
Greenville	530,212	708,345	1.04%	205,189	274,121	1.04%	286,600	399,819	1.20%	86,217	115,180	1.04%
Laurens	72,832	76,905	0.19%	27,790	29,347	0.19%	29,625	38,909	0.98%	8,930	9,429	0.19%
Oconee	81,049	92,827	0.49%	33,058	37,861	0.49%	35,432	50,129	1.25%	10,229	11,719	0.49%
Pickens	133,755	176,172	0.99%	50,477	66,488	0.99%	49,639	68,435	1.15%	16,651	21,933	0.99%
Spartanburg	311,924	446,907	1.29%	117,909	168,937	1.29%	168,550	289,258	1.95%	52,557	75,305	1.29%
Total	**1,394,097**	**1,816,155**	**0.95%**	**535,852**	**697,743**	**0.95%**	**688,452**	**1,004,170**	**1.36%**	**215,547**	**282,512**	**0.97%**

Figure 4.1 Future Year 2050 Population Density

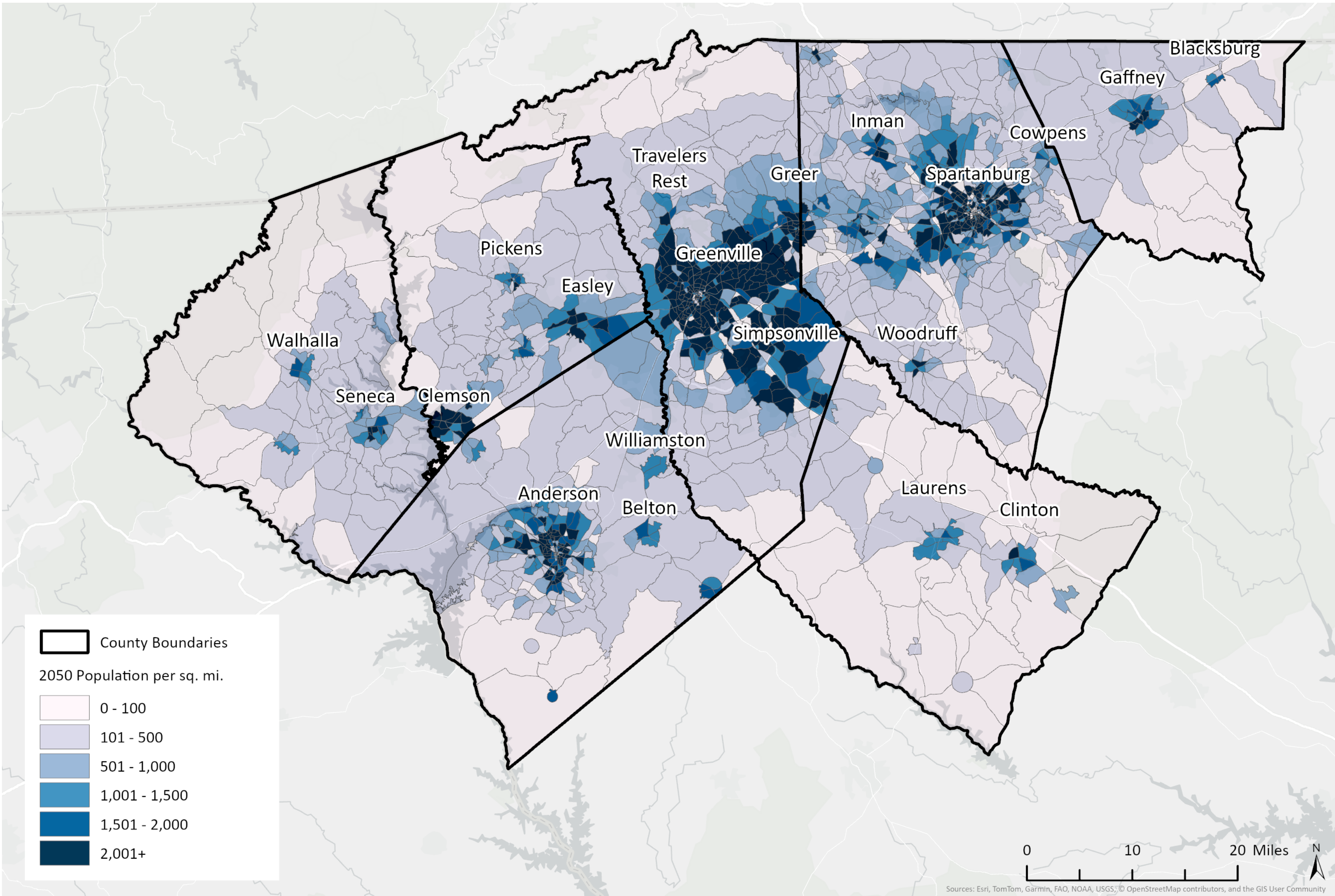
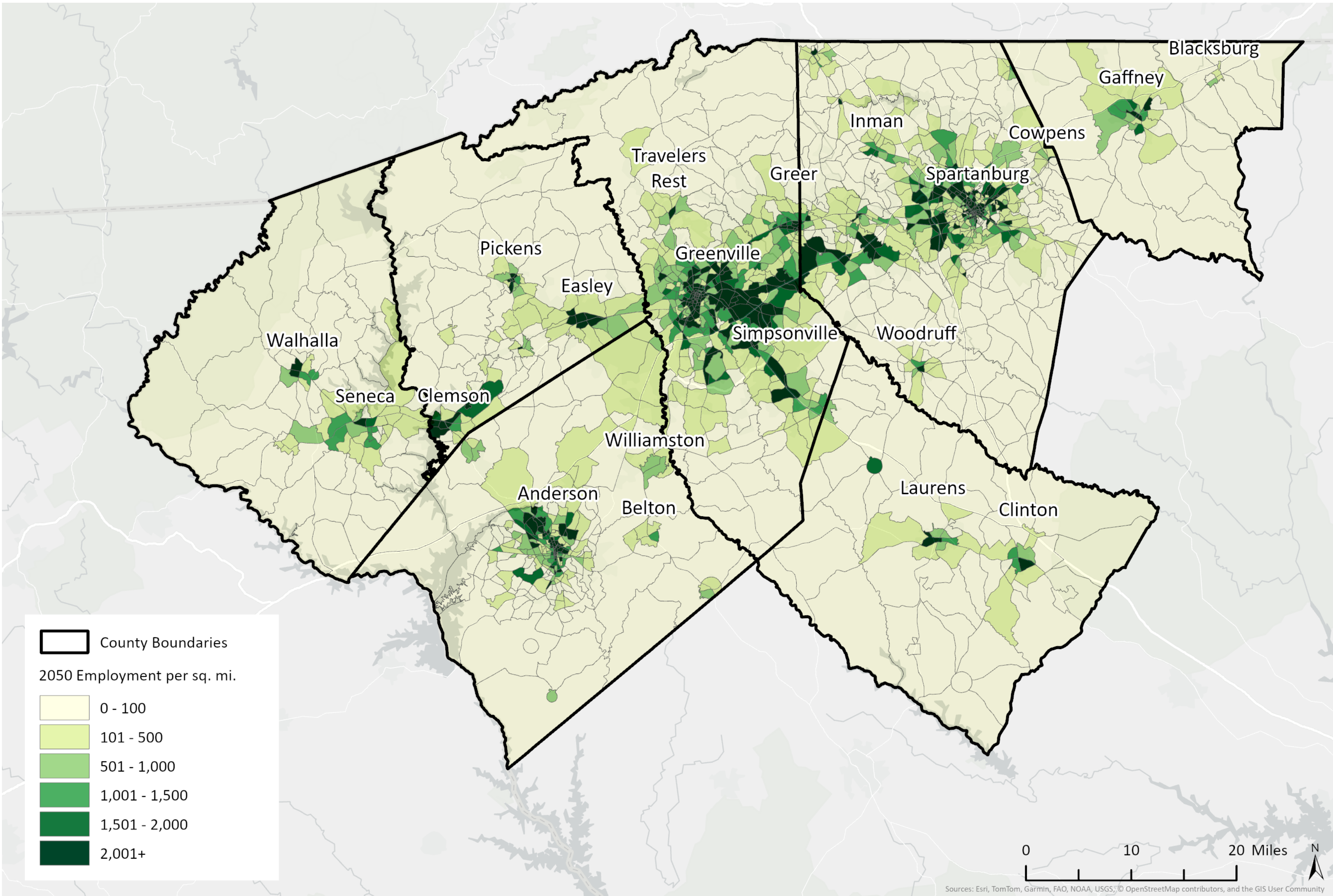


Figure 4.2 Future Year 2050 Employment Density



4.2 Future Year Roadway Network Data

The 2050 roadway network improvements were derived from the SCSWM and incorporated into the ARM after review by ACOG. Specific projects included in the future year scenario are listed in **Table 4.2** and displayed in **Figure 4.3**.

Table 4.3 Future Year Roadway Network Improvements

Project ID	Road Name	Project Limits		Project Description
401	I-85	S-42-57	SC 18	Widen to 6 lanes
402	I-85	SC-18/Shelby Hwy/Exit 96	SC-5/Exit 99	Widen to 6 lanes
403	I-85	SC-5/Exit 99	SC-198/Exit 102	Widen to 6 lanes
404	I-85	SC-198/Exit 102	Exit 104	Widen to 6 lanes
405	I-85	Exit 104	State Line	Widen to 6 lanes
406	I-26	US 176 (Exit 15)	SC 296 (Exit 22)	Widen to 6 lanes
407	I-85	Pelham Rd/Exit 54	SC 85-Exit 69	Widen 1 lane/direction
408	I-85	I-385/SC-146/Woodruff Rd/Exit 51	Pelham Rd/Exit 54	Widen 1 lane/direction
409	I-85	SC 146	SC 153	Widen to 8 lanes
410	Batesville Road (S-23-164/312)	Pelham Road (S-23-492)	The Parkway (S-23-1025)	3 Lane C&G
411	Batesville Road (S-23-164/312)	Roper Mountain Road (S-23-548)	Pelham Road (S-23-492)	3 Lane C&G
412	Woodruff Road Parallel	Miller Road (S-564)	Verdae Blvd	4 Lane raised median
413	I-385	I-385	mile 38	Widen one lane in either direction
414	S-23-547	S-23-492	S-23-548	Widen to 3 lanes
415	S-23-548/183	I-85	Blacks Drive (Local)	Widen to 3 lanes
416	Price Perry Rd/ Rock Springs Rd	Rolling Hills Circle	Dayton School Rd.	Change from Undivided to Divided Highway
417	I-385	mile 34	I-385	Widen one lane in either direction
418	I-85	GA State Line	Exit 19/US 76	4 to 6 Lanes
419	I-85	exit 19	mile 20	Widen one lane in either direction
113	Butler Road (S-107)	Mauldin High School	Bridges Rd	Reconstruct 3 Lanes to C&G
116	SC 153 Extension	US 123	S-39-221	New Location/Improve to 2 lanes
117	I-85/I-385 Interchange	I-85	I-385	Reconstruct interchange
118	SC 101/290	US 29	SC 290	Widen to 5 lanes
121	SC 14	SC 296	S-23-48	Widen to 3 lanes

4.3 Future Year External Truck Trips

The 2050 external auto and truck trips were modeled using a similar methodology to the base year, as outlined in Chapter 3. This approach involved extracting a sub-area from the SCSWM for the seven-county ACOG region to incorporate external auto and truck growth rates as an input to the ARM.

4.4 Future Year Person and Vehicle Trips

Table 4.4 summarizes the base-year and future-year person trips by purpose with associated compound annual growth rates (CAGR), while **Table 4.5** provides the same information for vehicle trips. Overall, trip growth averages about 1% annually, aligning with the projected socioeconomic growth. External and truck trips exhibit a higher growth rate of approximately 1.5 – 2.0%, driven primarily by SCSWM external station growth rates and Transearch-based truck forecasts.

Table 4.4 Person Trips – Base and Future Year

Person Trips	2022	2050	CAGR
HBW	748,187	979,216	1.0%
HBO	2,270,517	2,961,304	1.0%
NHB	1,599,757	2,094,962	1.0%
Total	**4,618,461**	**6,035,482**	**1.0%**

Table 4.5 Vehicle Trips – Base and Future Year

Vehicle Trips	2022	2050	CAGR
HBW	643,798	842,552	1.0%
HBO	1,278,901	1,667,541	1.0%
NHB	1,033,862	1,353,496	1.0%
External	205,931	353,347	1.9%
Medium Truck	58,854	80,609	1.1%
Heavy Truck	21,607	29,535	1.1%
External Truck	49,228	76,259	1.6%
Total Auto	3,162,491	4,216,937	1.0%
Total Truck	129,689	186,403	1.3%
Total	**6,584,360**	**8,806,679**	**1.0%**

4.5 Future Year Highway Assignment

The 2050 highway assignment was run using the same parameters as the base year. **Table 4.6** presents the summary VMT, VHT, and average speed statistics for the base and future years. **Figure 4.4** and **Figure 4.5** show the 2050 highway assignment volumes and V/C ratios, respectively. **Figure 4.6** shows the growth between base and future years.

While the VMT growth is as expected, the overall average speed only drops by about 2 mph, with the largest drops on expressways and freeways at approximately 5 mph and 4 mph, respectively. At a macro-level, these results indicate adequate network capacity in the future year scenario. However, the V/C ratio maps indicate several corridors with high V/C ratios compared to the base year, suggesting potential localized congestion that warrants further review. It is also recommended that link capacities and VDF parameters for freeways and expressways be further reviewed to ensure they reflect committed improvements and reasonable capacities.

Table 4.6 VMT, VHT, and Average Speeds – Base and Future Year

	Base Year 2022					Future Year 2050				
Functional Class	**No. of Links**	**Sum of Length (miles)**	**VMT (miles)**	**VHT (hours)**	**Avg. Speed (mph)**	**No. of Links**	**Sum of Length (miles)**	**VMT (miles)**	**VHT (hours)**	**Avg. Speed (mph)**
Freeway	671	455	12,649,874	224,596	56.3	671	455	16,331,005	312,697	52.2
Expressway	104	24	314,167	5,962	52.7	104	24	452,542	9,539	47.4
Ramp	568	121	395,620	11,640	34.0	566	121	489,166	14,924	32.8
Direct Connector	49	17	102,958	2,443	42.1	50	17	135,959	3,239	42.0
Divided Principal Arterial	343	127	2,684,108	56,522	47.5	343	127	3,823,348	82,389	46.4
Undivided Principal Arterial	903	356	4,925,600	109,770	44.9	902	356	7,106,923	159,498	44.6
Divided Minor Arterial	206	62	1,321,690	28,775	45.9	218	64	1,709,395	38,521	44.4
Undivided Minor Arterial	2,314	1,086	8,447,767	187,676	45.0	2,304	1,085	11,238,778	259,066	43.4
Divided Major Collector	8	2	6,382	154	41.5	8	2	9,867	237.84	41.5
Undivided Major Collector	607	584	2,209,859	48,929	45.2	607	584	3,048,933	70,310	43.4
Divided Collector	126	31	236,501	6,257	37.8	136	34	338,070	9,082	37.2
Undivided Collector	4,351	2,535	5,455,327	138,326	39.4	4,341	2,532	7,611,989	195,323	39.0
Total	**10,250**	**5,401**	**38,749,852**	**821,049**	**47.2**	**10,250**	**5,401**	**52,295,973**	**1,154,826**	**45.3**

Figure 4.3 Future Year 2050 Roadway Network Improvements

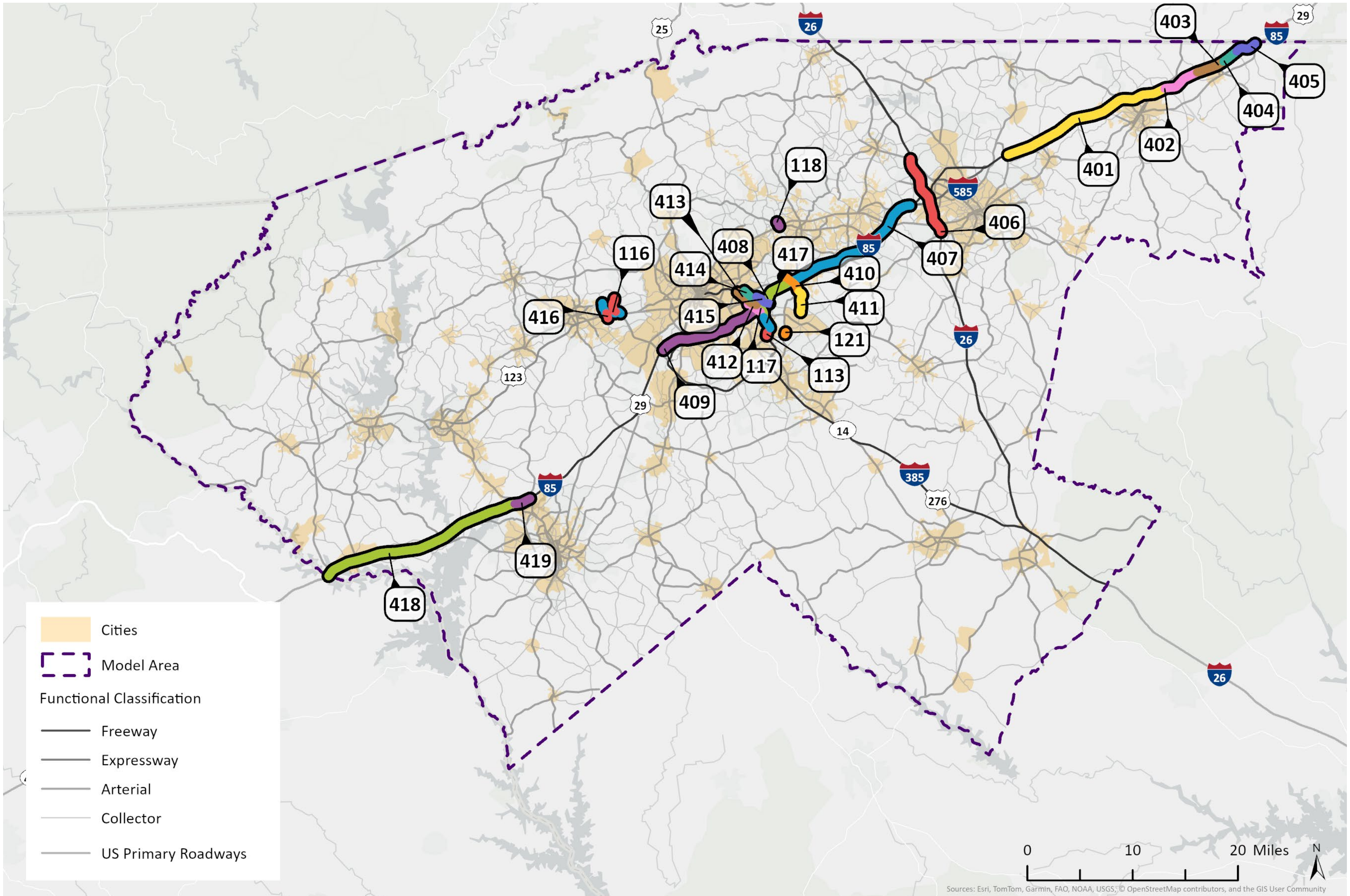


Figure 4.4 Future Year 2050 Traffic Assignment – Volumes Map

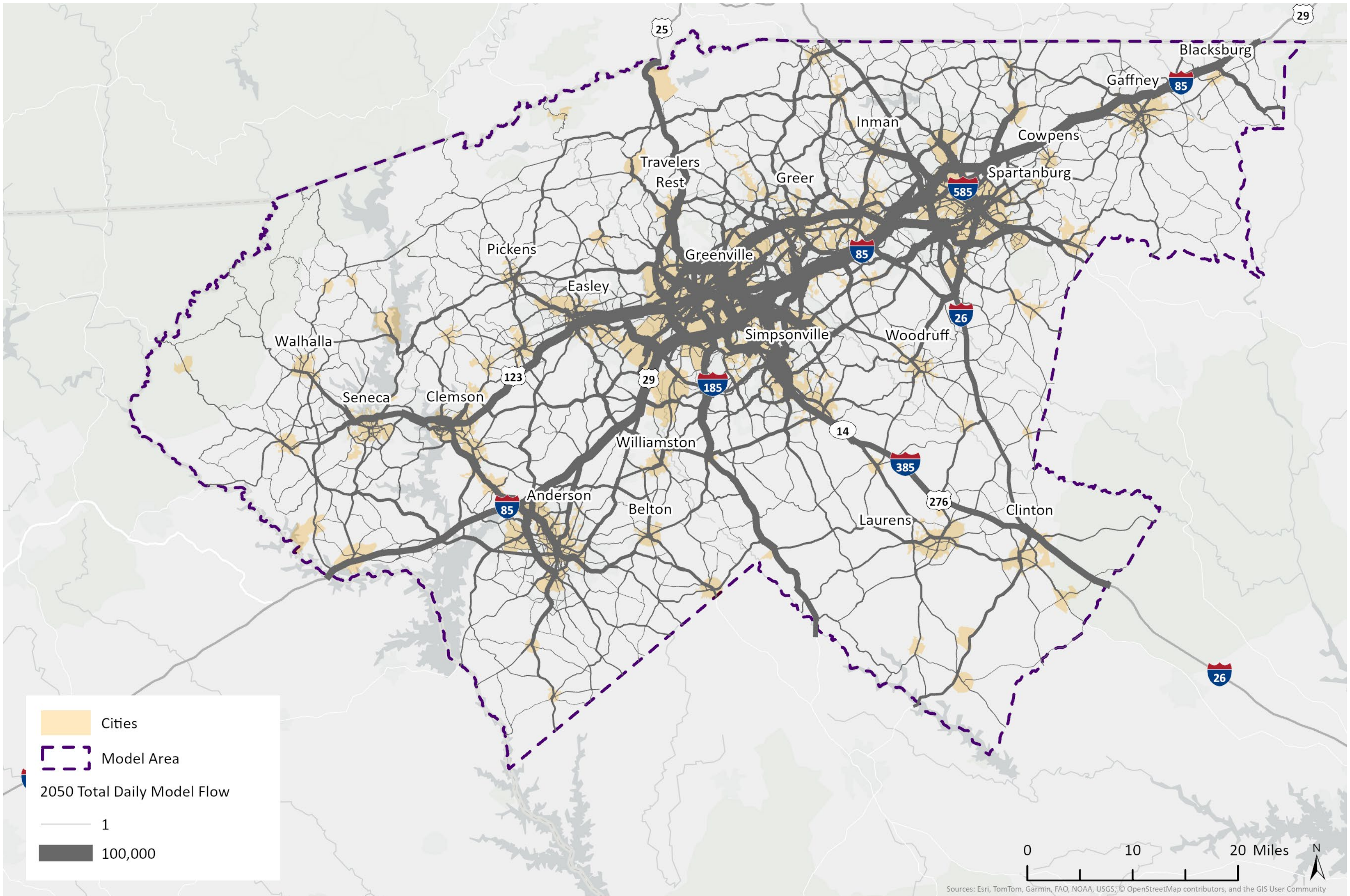


Figure 4.5 Future Year 2050 Traffic Assignment – V/C Ratio Map

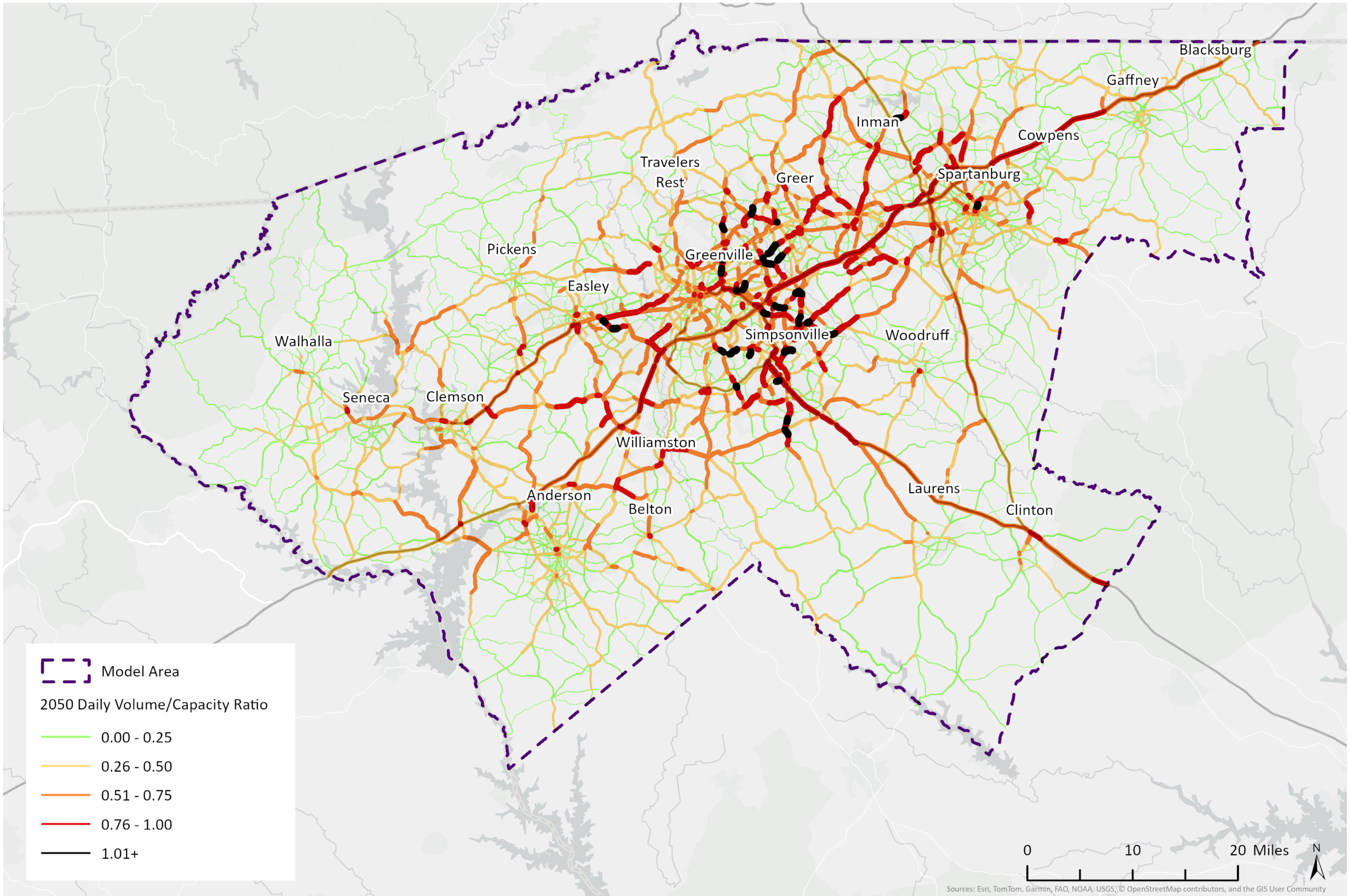
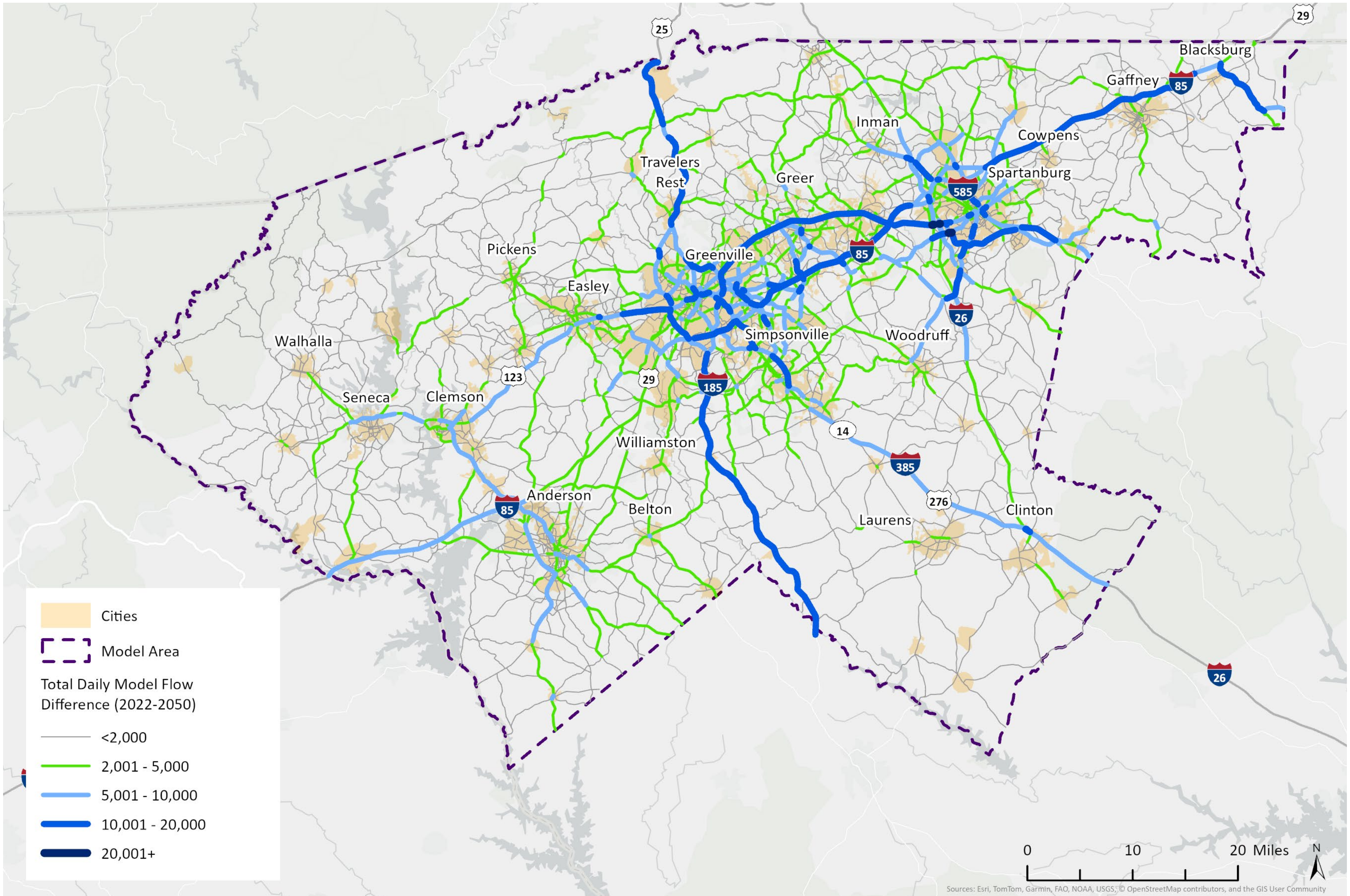


Figure 4.6 Future Year 2050 Traffic Assignment – Volume Growth Map



5.0 Model System Update

5.1 Model System Updates

The ARM was upgraded from TransCAD version 6.0 to version 9.0 to align with the current SCSWM and improve overall user-friendliness and reliability. Key enhancements include:

- Migration to TransCAD 9.0—leveraging the latest features and performance gains.
- Redesigned user interface with streamlined scenario management and robust file-path handling.
- Back-end code cleanup that improves stability, improves readability, and simplifies future upgrades.
- Simplified network and TAZ field names by removing redundancies, improving clarity.
- Enhanced master-network setup for easier tracking and management of planned roadway improvements.
- Standardized, intuitive file naming for inputs, parameters, and outputs, making file management straightforward.
- Refined parameter-file schemas for quicker edits and better code transparency.

5.2 Automated Land Use Importer Tool Development

The ARM update also includes an Automated Land Use Importer Tool designed to streamline the process of importing land-use changes into the model. Developed with input from SCDOT and ACOG, the tool ingests a shapefile of land use changes to automatically adjust population and employment figures within the model's socioeconomic data file. This design lets non-modelers, such as local planners, record land use changes in a manner commonly used in planning practice (e.g., square footage of different land use types), and relies on built-in conversion factors to translate those changes into the population and employment categories required by the model. The tool and its usage are described in detail in **Appendix A.**

5.2.1 Land Use Update Factors

The Automated Land Use Importer utilizes a set of configurable conversion factors to translate planner-oriented land-use metrics (such as square footage or housing units) into the socioeconomic data (SED) categories required by the travel demand model. The default mapping factors included with the model are summarized in **Table 5.1**. These rates are based on professional judgment, common practice, and guidance from NCHRP[10]. Users are encouraged to review these defaults and document any local adjustments made during model application or modification. Instructions for updating or modifying the land use update factors are provided in **Appendix A**.

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[10] *Travel Demand Forecasting: Parameters and Techniques, Chapter 4—Model Components*, NCHRP Report 716. Transportation Research Board, 2012.

Table 5.1: Default Land Use Update Factors

Model SED Variable	Model SED Units	Land Use (LU) Variable	LU Units	LU Units/1 SED Unit
Households	Housing Units	HU	Housing Units	1
Dwelling Units	Housing Units	HU	Housing Units	1
Household Population	Persons	HU	Housing Units	0.4
Manufacturing	Jobs	INDUST_SF	Square Feet	1000
Retail	Jobs	RETAIL_SF	Square Feet	400
FIRE	Jobs	OFFICE_SF	Square Feet	250
School	Enrollment	EDU_ENR	Enrollment	1

Appendix A Model User Guide

Appendix B ARM Version 1 Documentation