Gulf Regional Planning Commission

2050 Metropolitan Transportation Plan | GRPC MPO

DRAFT Technical Report #1

Model Development Report

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Gulf Regional Planning Commission

2050 Metropolitan Transportation Plan

This Plan was prepared as a cooperative effort of the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Mississippi Department of Transportation (MDOT), and local governments in partial fulfillment of requirements in Title 23 USC 134 and 135, amended by the IIJA, Sections 11201 and 11525, October 1, 2021. The contents of this document do not necessarily reflect the official views or policies of the USDOT.

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1.0 Introduction

This report includes a description of the procedures used in developing the updated demographics and travel estimates used in the 2050 Metropolitan Transportation Plan (MTP) for the Gulf Region Planning Commission (GRPC). It also describes the relationship between planning data and trip making, and the calibration and testing of the model. Instructions on how to operate the model are not contained within this report.

The GRPC Travel Demand Model (TDM) serves as an updated version of the MPO's model for use in the MTP. The updated model was calibrated and validated to meet the requirements established by the Federal Highway Administration (FHWA) and uses the calibration and validation parameters described in the latest Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee.

The State of Tennessee modeling guidelines are better defined and slightly more stringent than FHWA minimums. As such, they were used within the MTP.

The TDM is based upon the conventional trip-based four-step modeling approach. Broadly, the main model components fall within the following four categories:

- **Trip Generation** - The process of estimating trip productions and attractions at each TAZ.
- **Trip Distribution** - The process of linking trip productions to trip attractions for each TAZ pair.
- **Mode Choice** - The process of estimating the number of trips by mode for each TAZ pair. This process allows the model to calculate transit trips.
- **Trip Assignment** - The process of assigning auto and truck trips onto specific highway facilities in the region.

The updated TDM has an established base year of 2022. Updates include:

- **updated master roadway network**
- **updated Traffic Analysis Zones**
- **updated socioeconomic data and trip rates**
- **updated turn penalties, capacity factors, and external trip data**

Due to a limited number of transit trips, the TDM focuses on the region's highway network. As a result, a transit element has not been included, eliminating the mode choice step. The TDM was developed in TransCAD 9.0 Build 32950 64-bit travel demand forecasting software, and the model interface was developed using GISDK macros.

2.0 Traffic Analysis Zones and Socioeconomic Data

2.1 Study Area and Traffic Analysis Zones

The accuracy necessary for generating trips from planning data requires it to be aggregated by small geographic areas. These areas are called Traffic Analysis Zones (TAZs).

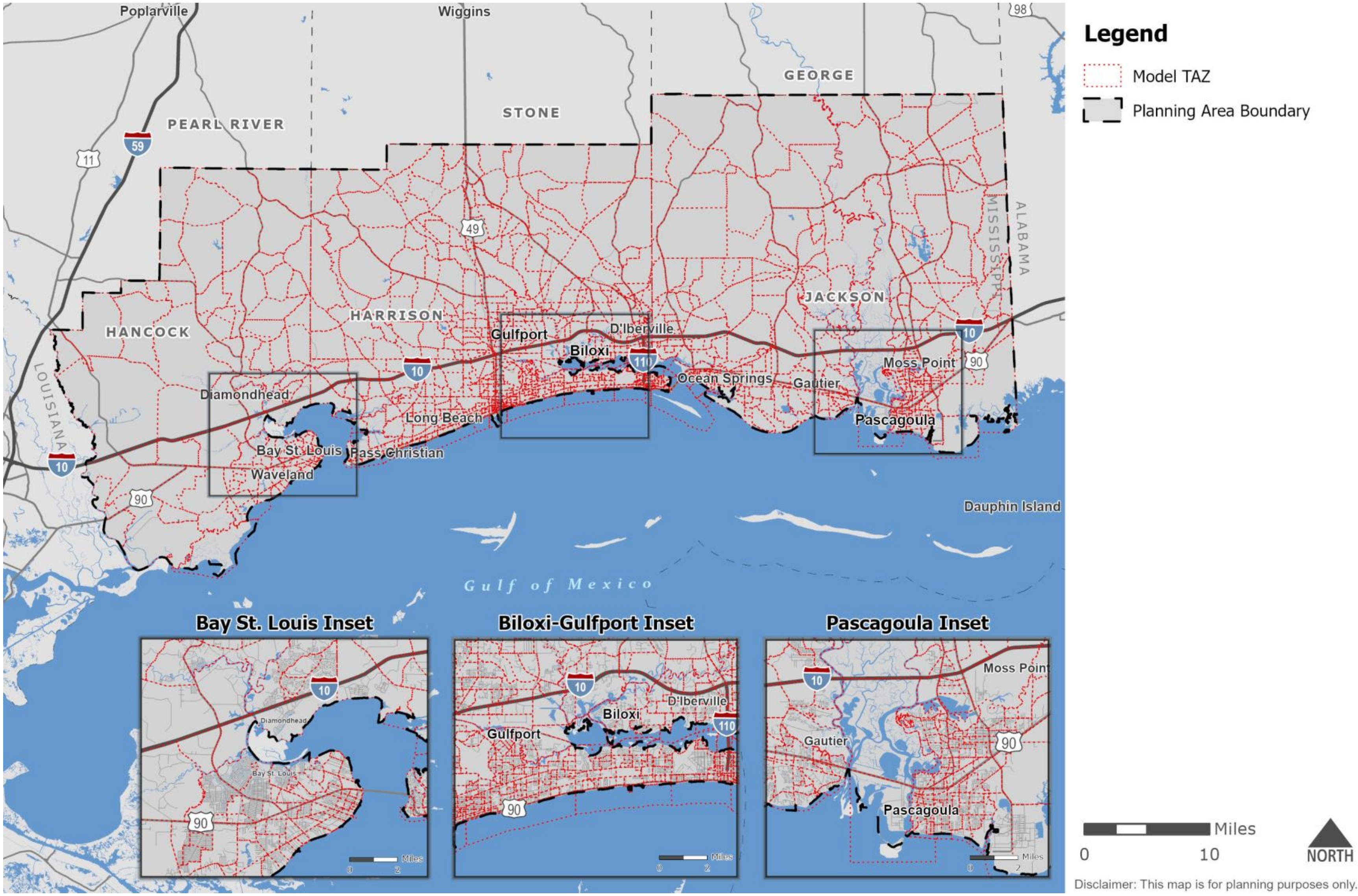
The GRPC TAZ structure were updated using 2020 Census geography and based on development patterns since the last plan update. The model study area is comprised of the entirety of Hancock County, Harrison County, and Jackson County.

These TAZs are generally homogeneous areas and were delineated based on:

- **population**
- **land use**
- **census geography**
- **physical landmarks**
- **governmental jurisdictions**

The study area is divided into 1,438 internal TAZs with 144 in Hancock County, 857 in Harrison County, and 421 in Jackson County. The study area also contains 16 external stations. A map of the TAZs is shown in **Figure 2.1**.

Figure 2.1: MTP 2050 Model TAZs



Source: GRPC TDM

2.2 Base Year (2022) Model Socioeconomic Data Update

This TDM effort uses a 2022 base year that includes housing, employment, and school attendance data as model inputs. This section describes the procedures used to update the model files to create the updated base year socioeconomic data.

Household Data Update

Household data for the model's TAZs were developed using:

- Census 2020 block data

Each TAZ within the model study area is comprised of one (1) or more Census blocks. Using Geographic Information Systems (GIS) mapping, a layer stores the blocks and their information, including:

- TAZ,
- 2020 Total Dwelling Units (DU),
- Households (A.K.A. Occupied Dwelling Units, OCCDU),
- Group Quarter Population (POPGQ)
- Household Population (POP), And
- Total Population (TOTPOP)

This data was aggregated to the TAZ level, resulting in 2020 DU, OCCDU, POP, and TOTPOP by TAZ and then used to develop each TAZ's percent of dwelling units that are occupied and the zone's average household size.

TOTPOP was then scaled up using the American Community Survey (ACS) 2022 5-year estimates to obtain year 2022 population data by TAZ. POPGQ was subtracted from TOTPOP to obtain the 2022 POP values. Using the 2022 POP values and the 2020 average household size, year 2022 OCCDU totals were calculated. 2022 DU values were obtained by dividing the 2022 OCCDU by the 2020 percent occupied.

Table 2.1 displays the updated household data within the model study area by county.

Table 2.1: Study Area Households and Population, Base Year 2022

Variable	Hancock County	Harrison County	Jackson County	Model Study Area Total
Dwelling Units	21,813	90,487	61,746	174,046
Occupied Dwelling Units	18,965	81,635	55,829	156,429
Household Population	45,783	204,212	142,573	392,568

Source: Census, GRPC TDM, NSI, 2022

Employment Data Update

For this effort, Quarterly Census of Employment and Wages (QCEW) data was used as it represents an accurate number of employees in the area with some minor exceptions and represents what has been reported to the Bureau of Labor Statistics.

It should be noted that the MTP 2045 Mississippi statewide model's control total, which used Woods & Poole, estimates produces a significant increase in employment when compared to the Mississippi statewide model estimates for MTP 2050 base year. This may be a result of the differences in the historical data from QCEW and Woods and Poole estimates.

The employment by TAZ and type was calculated, then adjusted proportionately by TAZ to meet each county's control totals. The control totals for the model area were calculated by analyzing the QCEW employment data in each county for year 2022 and taking the proportion of employment within the model area compared to the county total, based on the 2045 MTP.

Table 2.2 displays the study area employment by type. For modeling purposes, employment variables were differentiated into the following categories:

- Agriculture, Mining, and Construction (NAICS 11, 21, 23)
- Manufacturing, Transportation/Communications/Utilities, and Wholesale Trade (NAICS 31-33, 48-49, 22, 42)
- Retail Trade (NAICS 44-45, NAICS 722)
- Government, Office, and Services (NAICS 51-56, 61, 62, 71, 721, 81, 92)
- Other Employment (NAICS 99)

Table 2.2: Study Area Employment Classifications, Base Year 2022

Variable	Description	Hancock County	Harrison County	Jackson County	Model Study Area Total
TOT_EMP	Total Employment	16,790	94,169	59,677	170,636
AMC_EMP	Agriculture, Mining, and Construction	498	3,384	2,790	6,672
MTCUW_EMP	Manufacturing, Transportation/ Communications/ Utilities, and Wholesale Trade	1,573	6,080	14,825	22,478
RET_EMP	Retail Trade	2,314	22,039	11,213	35,566
OS_EMP	Government, Office, and Services	12,259	62,000	30,502	104,761
OTH_EMP	Other Employment	146	666	347	1,159

Source: QCEW, Bureau of Labor Statistics, GRPC TDM, NSI, 2022

School Enrollment Data Update

The MTP 2050 TDM obtained school attendance data from the U.S. Department of Education through the National Center for Education Statistics data tool[1]. School attendance figures include:

- Public and private elementary, middle, and high schools.
- Colleges and universities.
- Vocational and business schools.

The total school attendance in the study area in 2022 was 6,704 in Hancock County, 33,602 in Harrison County, and 23,437 in Jackson County. For modeling purposes, the school attendance is measured by the number of students attending a school in a TAZ and not by the number of students residing in that TAZ.

[1] National Center for Education Statistics (NCES) - Data & Tools - Most Popular Tools

TAZ Data

The socioeconomic data for each TAZ is included in the TDM files. This data has been updated for the new 2022 base year. The fields used in the TAZ layer are shown in **Table 2.3**.

Table 2.3: TAZ Field Attributes

Attribute Name	Description
ID	Integer (4 bytes) TAZ ID
AREA	Real (8 bytes) TAZ Area in Map Units
TAZ _22	Integer (4 bytes) 2022 TAZ Number
STATEFP	Character State ID Code
COUNTYFP	Character County ID Code
TRACTCE	Character Tract ID Code
BLKGRPGEOID	Character Block Group ID Code
PUMA10	Character Public Use Microdata Area ID
OCCROOM	Integer (4 bytes) Occupied hotel rooms
GAME_SQFT	Integer (4 bytes) Square feet of Casino game rooms
GAME_SEATS	Integer (4 bytes) Number of Casino seats in game rooms

3.0 Roadway Network

3.1 Network Line Layer

The simulation of travel patterns in a computer model requires a representation of the street and highway system in digital format. The TransCAD model creates such a network from a geographic line layer in GIS. The line layer dataview records contain descriptive information for each link and its properties. Turn prohibitions are also coded into the network at locations where certain movements are not allowed or physically cannot be made.

Adjustments were made to the model network to update it to the new base year. These adjustments included:

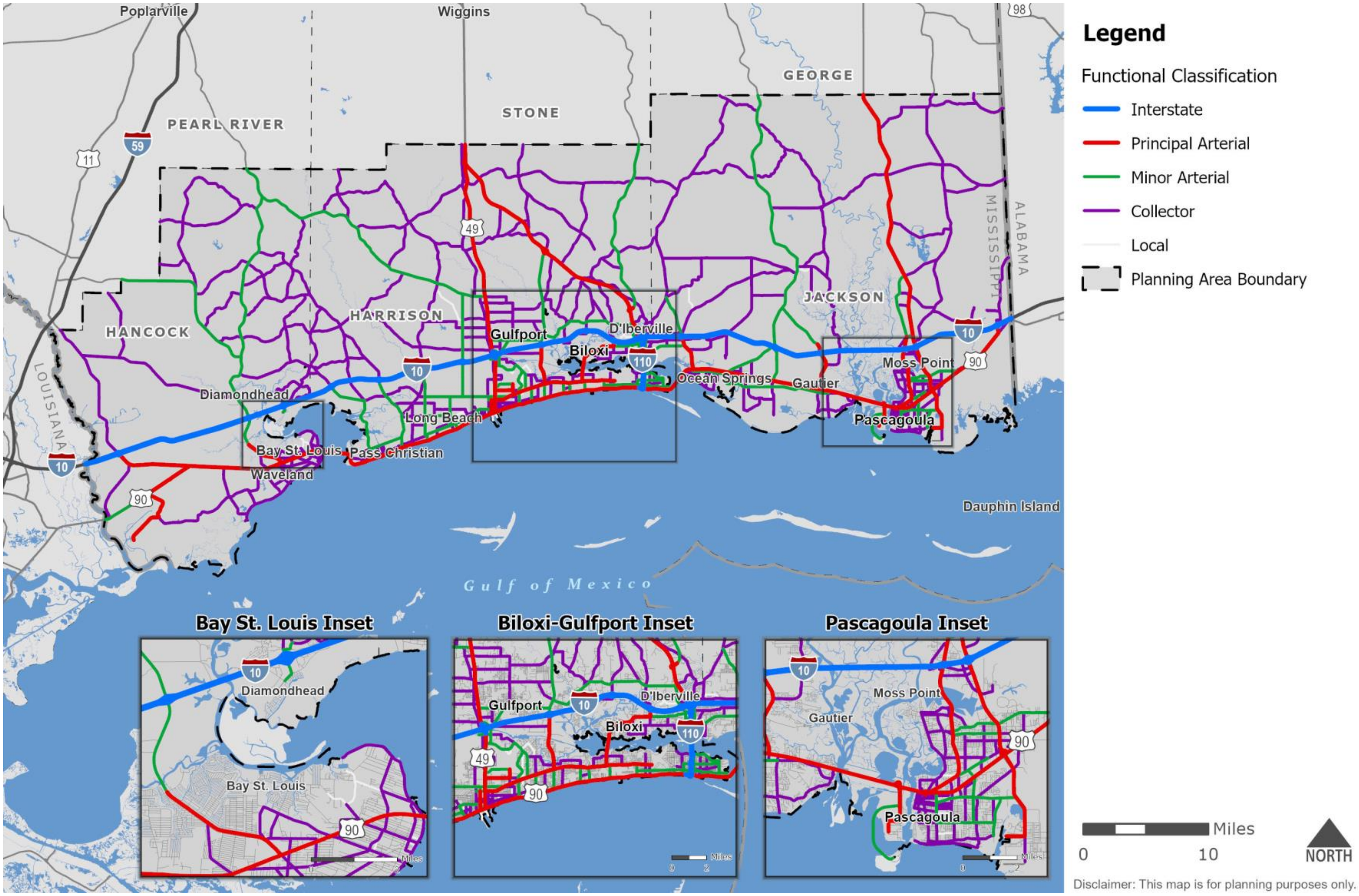
- number of lanes,
- speeds,
- functional classification,
- roadway capacity and capacity factors,
- volume-delay function parameters (alpha and beta values), and
- daily traffic counts and traffic stations (to 2022 where possible)

In addition to the changes listed above, the updated TDM features a master network in the model's setup folder. This line layer contains the records for all roadway links used in the TDM process. The master network contains the data for the base year, Existing Plus Committed network, and all roadway test projects. **Figure 3.1** displays the 2022 base year roadway network used in the TDM.

3.2 Functional Classification

Each link in the model's roadway network was assigned a functional classification based on the federal functional classification system. This system is also maintained by MDOT. The functional classifications used in the TDM are shown in **Table 3.1**. **Table 3.2** and **Table 3.3** show the model link classes and model functional classifications, respectively, that were developed for the TDM.

Figure 3.1: 2022 Roadway Functional Classification



Source: MDOT, GRPC TDM, NSI

Table 3.1: MDOT Functional Classifications Used in GRPC Model

Code	Description
00	Centroid Connector
01	Rural Interstate
02	Rural Principal Arterial
03	Rural Minor Arterial
04	Rural Major Collector
05	Rural Minor Collector
06	Rural Local
11	Urban Interstate
12	Urban Expressway
14	Urban Principal Arterial
16	Urban Minor Arterial
17	Urban Collector
18	Urban Local

Source: FHWA, MDOT

Table 3.2: Model Link Classes Used in GRPC Model

Code	Description
11	One lane, one way
12	One lane (each dir.), two way
14	One lane (each dir.), two way with left turn lanes, median, or boulevard
16	One lane (each dir.), two way with center turn lane
21	Two lanes, one way
22	Two lanes (each dir.), two way
24	Two lanes (each dir.), two way with left turn lanes, median, or boulevard
26	Two lanes (each dir.), two way with center turn lane
31	Three lanes, one way
34	Three lanes (each dir.), two way with left turn lanes, median, or boulevard
36	Three lanes (each dir.), two way with center turn lane
41	Four lanes, one way
44	Four lanes (each dir.), two way with left turn lanes, median, or boulevard

Source: NSI

Table 3.3: Model Functional Classifications Used in GRPC Model

Code	Description
001	Rural Interstate
002	Rural Principal Arterial Divided
021	Rural Principal Arterial Undivided
003	Rural Minor Arterial Divided
031	Rural Minor Arterial Undivided
004	Rural Major Collector
041	Rural Major Collector Undivided
005	Rural Minor Collector
051	Rural Minor Collector Divided
006	Rural Local
061	Rural Local Undivided
010	Rural On/Off Ramp
011	Urban Interstate
012	Urban Expressway
014	Urban Principal Arterial Divided
141	Urban Principal Arterial Undivided
016	Urban Minor Arterial Divided
161	Urban Minor Arterial Undivided
017	Urban Collector
171	Urban Collector Undivided
018	Urban Local
181	Urban Local Undivided
020	Rural On/Off Ramp
099	Centroid Connector

Source: NSI

3.3 Free Flow Speed and Capacity

Free flow speeds and capacities are important TDM inputs that affect the traffic assignment model. The link speed calculations are the same as those used in the previous TDM. The model uses the same capacity factors as the previous update, which are shown in **Figure 3.2**. These were deemed acceptable since GRPC is within the same geographic region and state. These key model inputs were assigned to each individual network link. These inputs consider factors such as:

- Free flow speed
- Roadway posted speed
- Roadway functional classification
- Location of roadway in urban or rural area
- Link capacity
- Number of lanes
- Width of travel lanes
- Presence of a median or dividing feature
- Presence and width of shoulder on roadway

Figure 3.2: Model Capacity Factors

Link Capacity (LOS D)

Vehicles per lane per hour - vphpl

Functional Class		vphpl Directional
All Interstate		
2 Lanes		2,300
>2 Lanes		2,400
Principal Arterial		
Rural	Divided	1,700
Rural	Undivided	1,500
Urban	Divided	1,500
Urban	Undivided	1,300
Minor Arterial		
Rural	Divided	1,600
Rural	Undivided	1,350
Urban	Divided	1,400
Urban	Undivided	1,150
Collector		
Rural	Divided	1,350
Rural	Undivided	1,150
Urban	Divided	1,150
Urban	Undivided	950
Local		
Rural	2 Lane	900
Rural	>2 Lane	1,000
Urban	2 Lane	800
Urban	>2 Lane	900
Ramps		1,000
Centroid Connectors		9,999

SF = c x N x Fw x Fhv x Fp x Fe x Fd x Fctl x Fpark X (V/C)i

SF = Model vphpl for desired level of service
c = Ideal vphpl
N = Number of Lanes
(V/C)I = Rate of service flow for level of service D

Adjustment Factors

Acronym	Name	Facility Type	Lane	Shoulder	Factor
Fw	Lane & Shoulder Width	Interstate & Sys Ramp	<=10'	0-<2'	0.78
		Interstate & Sys Ramp	<=10'	2'-5'	0.83
		Interstate & Sys Ramp	<=10'	>5'	0.88
		Interstate & Sys Ramp	>10'	0-<2'	0.90
		Interstate & Sys Ramp	>10'	2'-5'	0.95
		Interstate & Sys Ramp	>10'	>5'	1.00
		Principal Arterial Div	<=10'	0-<2'	0.78
		Principal Arterial Div	<=10'	2'-5'	0.83
		Principal Arterial Div	<=10'	>5'	0.88
		Principal Arterial Div	>10'	0-<2'	0.92
		Principal Arterial Div	>10'	2'-5'	0.96
		Principal Arterial Div	>10'	>5'	1.00
		Principal Arterial Undiv	<=10'	0-<2'	0.78
		Principal Arterial Undiv	<=10'	2'-5'	0.82
		Principal Arterial Undiv	<=10'	>5'	0.86
		Principal Arterial Undiv	>10'	0-<2'	0.90
		Principal Arterial Undiv	>10'	2'-5'	0.95
		Principal Arterial Undiv	>10'	>5'	1.00
		Minor Arterial Div	<=9'	0-<2'	0.81
		Minor Arterial Div	<=9'	2'-5'	0.86
		Minor Arterial Div	<=9'	>5'	0.93
		Minor Arterial Div	>9'	0-<2'	0.94
		Minor Arterial Div	>9'	2'-5'	1.00
		Minor Arterial Div	>9'	>5'	1.05
		Minor Arterial Undiv	<=9'	0-<2'	0.77
		Minor Arterial Undiv	<=9'	2'-5'	0.83
		Minor Arterial Undiv	<=9'	>5'	0.88
		Minor Arterial Undiv	>9'	0-<2'	0.89
		Minor Arterial Undiv	>9'	2'-5'	0.95
		Minor Arterial Undiv	>9'	>5'	1.00
		Collector Div	<=9'	0-<2'	0.81
		Collector Div	<=9'	2'-5'	0.86
		Collector Div	<=9'	>5'	0.93
		Collector Div	>9'	0-<2'	0.96
		Collector Div	>9'	2'-5'	1.00
		Collector Div	>9'	>5'	1.05
		Collector Undiv	<=9'	0-<2'	0.81
		Collector Undiv	<=9'	2'-5'	0.85
		Collector Undiv	<=9'	>5'	0.90
		Collector Undiv	>9'	0-<2'	0.94
		Collector Undiv	>9'	2'-5'	1.00
		Collector Undiv	>9'	>5'	1.04
		Local 2 Lane	<=9'	0-<2'	0.65
		Local 2 Lane	<=9'	2'-5'	0.78
		Local 2 Lane	<=9'	>5'	0.90
		Local 2 Lane	>9'	0-<2'	0.85
		Local 2 Lane	>9'	2'-5'	1.00
		Local 2 Lane	>9'	>5'	1.04
		Local >2 Lane	<=9'	0-<2'	0.81
		Local >2 Lane	<=9'	2'-5'	0.85
		Local >2 Lane	<=9'	>5'	0.92
		Local >2 Lane	>9'	0-<2'	0.96
		Local >2 Lane	>9'	2'-5'	1.00
		Local >2 Lane	>9'	>5'	1.10
Fhv	Heavy Vehicle	Interstate			0.88
		Principal Arterial			0.90
		Minor Arterial			0.90
		Collector			0.92
		Local			0.97
Fp	Driver Population	Rural Interstate			0.90
		Urban Interstate			0.92
		System Ramp			0.92
		Principal Arterial			0.95
		Minor Arterial			0.98
		Collector			NA
		Local			NA
Fe	Driving Environment	Interstate			NA
		Rural Prin Art	Divided		1.00
		Rural Prin Art	Undivided		0.90
		Urban Prin Art	Divided		0.90
		Urban Prin Art	Undivided		0.80
		Rural Minor Art	Divided		1.00
		Rural Minor Art	Undivided		0.90
		Urban Minor Art	Divided		0.90
		Urban Minor Art	Undivided		0.80
		Rural Collector	Divided		1.00
		Rural Collector	Undivided		0.90
		Urban Collector	Divided		0.90
		Urban Collector	Undivided		0.80
		Rural Local	2 Lane		0.90
		Rural Local	>2 Lane		0.90
		Urban Local	2 Lane		0.80
		Urban Local	>2 Lane		0.80
Fd	Directional Distribution (Local only)	2 Lane	Divided		0.94
		>2 Lane	Divided		1.16
		2 Lane	Undivided		0.94
		>2 Lane	Undivided		1.10
Fctl	Center Turn Lane	Interstate			NA
		All Other			1.08
Fpark	On Street Parking	Any			0.95

Source: Highway Capacity Manual, GNRC/Nashville MPO Model

3.4 Network Attributes

Table 3.3 displays the network attributes used on the links in the TDM, while **Table 3.4** displays the attributes used in the node layer.

Table 3.4: GRPC Model Link Attributes

Attribute Name	Description	Input Type
ID	Integer (4 bytes) TransCAD Automatic Field ID	Automatic, but user can override
Dir	Integer (2 bytes) 0 = Two-way link 1= One-way link, AB fields will be used -1= One-way link, BA fields will be used	Automatic, but user can override
Length	Real (8 bytes) Map unit length of link	Automatic
STREET_NAME	Character Roadway name	User
CITY	Character City name	User
COUNTY_ID	Integer (4 bytes) County ID	User
COUNTY_NAME	Character County name	User
EXT	Integer (4 bytes) External station link	User
COSQ_22	Character Traffic (AADT) count station ID	User
TRUCK_PCT	Real (8 bytes) 2022 Average Daily Truck Percent	User
AADT_22	Real (8 bytes) 2022 Total Annual Average Daily Traffic Count	User
DIR_22	Integer (2 byte) 0 = Two-way link 1= One-way link, AB fields will be used -1= One-way link, BA fields will be used	User*
NETWORK_22	Integer (2 bytes) 1= Model Network Road link 2= Centroid Connector 0 or null = Link will not be included in the model run	User*

Attribute Name	Description	Input Type
MDOT_FC_22	Integer (4 bytes) Refer to **Table 3.1**	User*
MDOT_FC_DESC_22	Character Roadway Functional Class Name	User*
AB_MDOT_FC_22	Integer (2 bytes) Refer to **Table 3.1**	User*
BA_MDOT_FC_22	Integer (2 bytes) Refer to **Table 3.1**	User*
MODEL_FC_22	Integer (4 bytes) Refer to **Table 3.3**	User*
MODEL_FC_DESC_22	Integer (4 bytes) Roadway Functional Class Name	User*
AB_CLASS_22	Integer (4 bytes) Refer to **Table 3.2**	User*
BA_CLASS_22	Integer (4 bytes) Refer to **Table 3.2**	User*
POSTED_SPEED_22	Integer (4 bytes) Posted link speed (MPH)	User
AB_SPEED_22	Real (4 bytes) Link speed (MPH) in AB direction	User*
BA_SPEED_22	Real (4 bytes) Link speed (MPH) in BA direction	User*
LANES_22	Integer (4 bytes) Number of lanes of the roadway	User*
AB_LANES_22	Integer (4 bytes) Number of lanes in AB direction	User*
BA_LANES_22	Integer (4 bytes) Number of lanes in BA direction	User*
ALPHA_22	Real (4 bytes) BPR Volume-Delay Function Parameter	User*
BETA_22	Real (4 bytes) BPR Volume-Delay Function Parameter	User*
AB_TT_22	Real (4 bytes) Link travel time in AB direction, minutes	Model
BA_TT_22	Real (4 bytes) Link travel time in BA direction, minutes	Model
AB_TT_AM_22	Real (4 bytes) Morning Link travel time in AB direction	Model
BA_TT_AM_22	Real (4 bytes) Morning Link travel time in BA direction	Model

Attribute Name	Description	Input Type
AB_TT_MD_22	Real (4 bytes) Mid-day Link travel time in AB direction	Model
BA_TT_MD_22	Real (4 bytes) Mid-day Link travel time in BA direction	Model
AB_TT_PM_22	Real (4 bytes) Afternoon Link travel time in AB direction	Model
BA_TT_PM_22	Real (4 bytes) Afternoon Link travel time in BA direction	Model
AB_TT_NT_22	Real (4 bytes) Nighttime Link travel time in AB direction	Model
BA_TT_NT_22	Real (4 bytes) Nighttime Link travel time in BA direction	Model
DIVIDED_22	Integer (2 bytes) 0 = Roadway not divided 1 = Divided roadway	User
PARKING_22	Integer (2 bytes) 0 = No On-Street Parking Present 1 = On-Street Parking Present	User
CTL_22	Integer (2 bytes) 0 = No Center Turn Lane Present 1 = Center Turn Lane Present	User
LW_CODE_22	Integer (2 bytes) Width of Lane Code	User
SW_CODE_22	Integer (2 bytes) Width of Shoulder Code	User
Fw_22	Real (8 bytes) Capacity factor for lane and shoulder width	User*
Fhv_22	Real (8 bytes) Capacity factor for heavy vehicles	User*
Fp_22	Real (8 bytes) Capacity factor for driver population	User*
Fe_22	Real (8 bytes) Capacity factor for driving environment	User*
Fd_22	Real (8 bytes) Capacity factor for directional distribution	User*

Attribute Name	Description	Input Type
Fctl_22	Real (8 bytes) Capacity factor for center turn lanes	User*
Fpark_22	Real (8 bytes) Capacity factor for on-street parking	User*
Fall_22	Real (8 bytes) Overall capacity factor	User*
IDEAL_VPHPL_22	Real (8 bytes) Maximum capacity in vehicles/hour/lane	User
AB_VPHPL_22	Real (8 bytes) Capacity in AB direction in vehicles/hour/lane	User*
BA_VPHPL_22	Real (8 bytes) Capacity in BA direction in vehicles/hour/lane	User*
IS_MANUAL_CAP_22	Integer (2 bytes) Manual Capacity input	User
AB_CAPACITY_22	Real (8 bytes) Daily Capacity in AB direction	User
BA_CAPACITY_22	Real (8 bytes) Daily Capacity in BA direction	User
AB_CAP_AM_22	Integer (4 bytes) Morning peak period capacity in AB direction	Model
BA_CAP_AM_22	Integer (4 bytes) Morning peak period capacity in BA direction	Model
AB_CAP_MD_22	Integer (4 bytes) Mid-day capacity in AB direction	Model
BA_CAP_MD_22	Integer (4 bytes) Mid-day capacity in BA direction	Model
AB_CAP_PM_22	Integer (4 bytes) Afternoon peak period capacity in AB direction	Model
BA_CAP_PM_22	Integer (4 bytes) Afternoon peak period capacity in BA direction	Model
AB_CAP_NT_22	Integer (4 bytes) Nighttime capacity in AB direction	Model

Attribute Name	Description	Input Type
BA_CAP_NT_22	Integer (4 bytes) Nighttime capacity in BA direction	Model
DAILY_FLOW	Real (4 bytes) Total daily model volume	Model
AB_DAILY_FLOW	Real (4 bytes) AB directional daily model volume	Model
BA_DAILY_FLOW	Real (4 bytes) BA directional daily model volume	Model
DAILY_TOT_VMT	Real (4 bytes) Total daily vehicle miles travelled	Model
DAILY_AB_VMT	Real (4 bytes) AB directional daily vehicle miles travelled	Model
DAILY_BA_VMT	Real (4 bytes) BA directional daily vehicle miles travelled	Model
DAILY_TOT_VHT	Real (4 bytes) Total daily vehicle hours travelled	Model
DAILY_AB_VHT	Real (4 bytes) AB directional daily vehicle hours travelled	Model
DAILY_BA_VHT	Real (4 bytes) BA directional daily vehicle hours travelled	Model
DAILY_TOT_VHD	Real (4 bytes) Total daily vehicle hours of delay	Model
DAILY_AB_VHD	Real (4 bytes) AB directional daily vehicle hours of delay	Model
DAILY_BA_VHD	Real (4 bytes) BA directional daily vehicle hours of delay	Model
DAILY_MAX_VOC	Real (4 bytes) Higher of AB and BA volume/capacity	Model
DAILY_AB_VOC	Real (4 bytes) AB directional volume/capacity	Model
DAILY_BA_VOC	Real (4 bytes) BA directional volume/capacity	Model
DAILY_TRK_FLOW	Real (4 bytes) Total daily model truck volume	Model

Attribute Name	Description	Input Type
AB_DAILY_TRK_FLOW	Real (4 bytes) AB directional daily model truck volume	Model
BA_DAILY_TRK_FLOW	Real (4 bytes) BA directional daily model truck volume	Model
DAILY_TOT_TRK_VMT	Real (4 bytes) Total daily truck miles travelled	Model
DAILY_AB_TRK_VMT	Real (4 bytes) AB directional daily truck miles travelled	Model
DAILY_BA_TRK_VMT	Real (4 bytes) BA directional daily truck miles travelled	Model
DAILY_TOT_TRK_VHT	Real (4 bytes) Total daily truck hours travelled	Model
DAILY_AB_TRK_VHT	Real (4 bytes) AB directional daily truck hours travelled	Model
DAILY_BA_TRK_VHT	Real (4 bytes) BA directional daily truck hours travelled	Model
DAILY_TOT_TRK_VHD	Real (4 bytes) Total daily truck hours of delay	Model
DAILY_AB_TRK_VHD	Real (4 bytes) AB directional daily truck hours of delay	Model
DAILY_BA_TRK_VHD	Real (4 bytes) BA directional daily truck hours of delay	Model

Note:
1. Each of the suffix “22” fields should be repeated for EC, VIS, and SCE suffixes as well.
2. Volume-delay function parameter fields Alpha_22 and Beta_22 is based on BPR function.
3. In addition to the base year fields, each planned year should have a field called “PROJECT_[suffix]” of type Integer. This field should have a unique project number for each committed or planned project.
4. * : These values are required when adding and/or modifying a roadway link.
5. User does not need to input values of fields whose “INPUT TYPE” is ‘Model’. Model interface will calculate the values of these fields.

Table 3.5: GRPC Model Node Attributes

Attribute Name	Description
ID	Integer (4 bytes) For centroids keep the ID the same as TAZ number.
LONGITUDE	Integer (4 bytes) TCAD automatic field
LATITUDE	Integer (4 bytes) TCAD automatic field
Elevation	Real (8 bytes) TCAD automatic field
CENTROID	Integer (4 bytes) TAZ number for centroid

3.5 Centroid Connectors

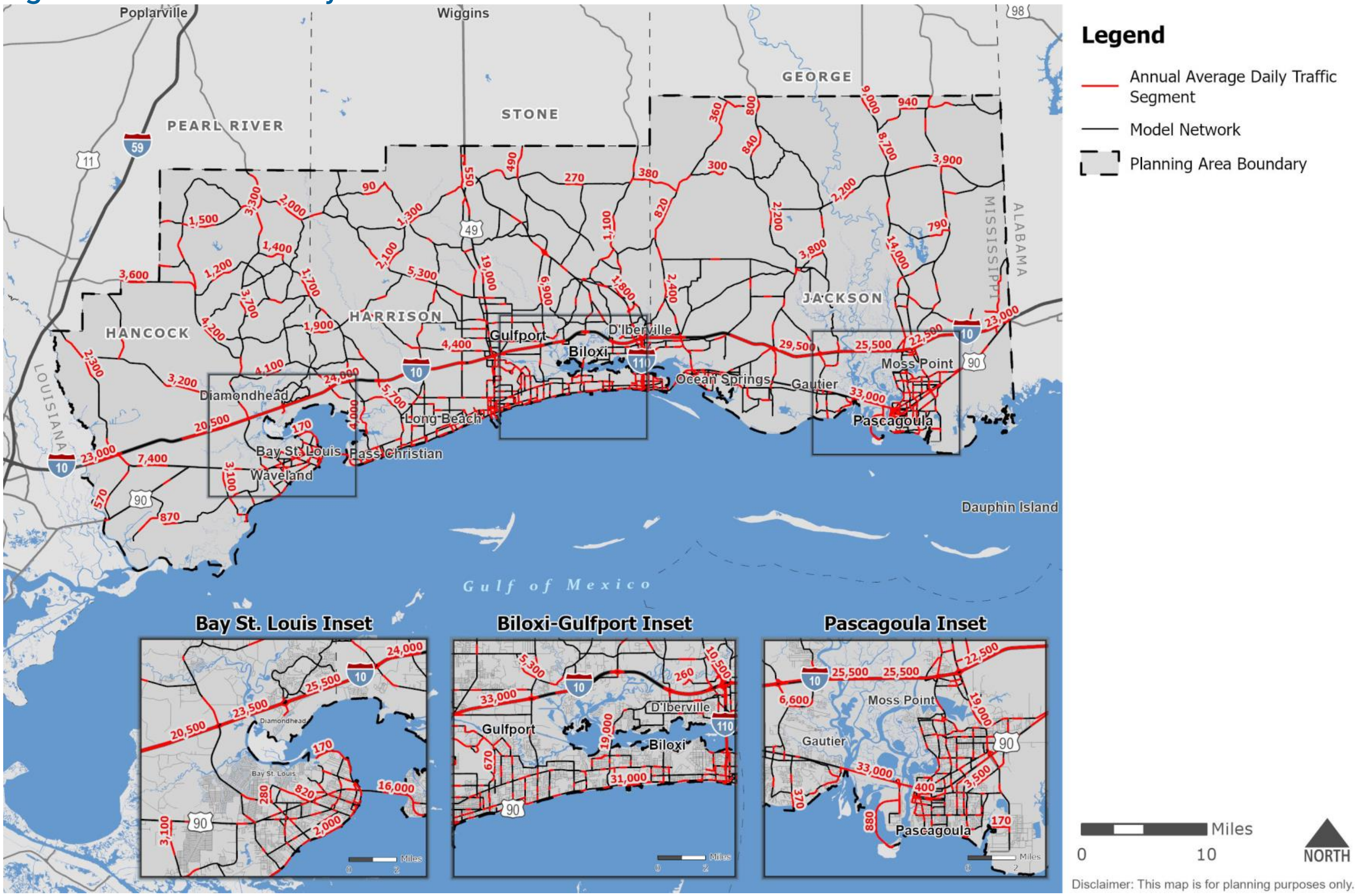
Centroid connectors are imaginary roadway network links that connect the TAZ centroid to the adjacent roadway network at nodes. These links represent the local streets on the street and highway system that are not in the model network. Centroid connectors provide the model the ability to move trips generated from individual TAZs to the roadway network. The locations where centroid connectors access the model network are based on features such as neighborhood roadway entrances, driveways and parking lots.

During the TDM update, the centroid connectors were adjusted to match locations where traffic is most likely to access the model's roadways. This was accomplished by relocating the centroid for the TAZ to reflect the "center of mass" of developed land and/or moving the centroid connector roadway network access points to a location where trips generally enter or leave the TAZ. This changes the length of the centroid connectors and the travel times on the links to encourage modeled traffic to use certain access points to reflect the observed traffic.

3.6 Traffic Counts

The updated model also contains updated traffic counts in the roadway network. These counts come from MDOT and are the most recent available. The update process included the verification of count stations upon the existing TDM links and ensuring that the AADTs are assigned to the correct link. Where a 2022 AADT was not available for a count station, the most recent count was factored to the base year using growth rate data from historical counts. The traffic AADTs used in the TDM are shown in **Figure 3.3**.

Figure 3.3: 2022 Roadway Traffic Counts



Source: MDOT, GRPC TDM, NSI

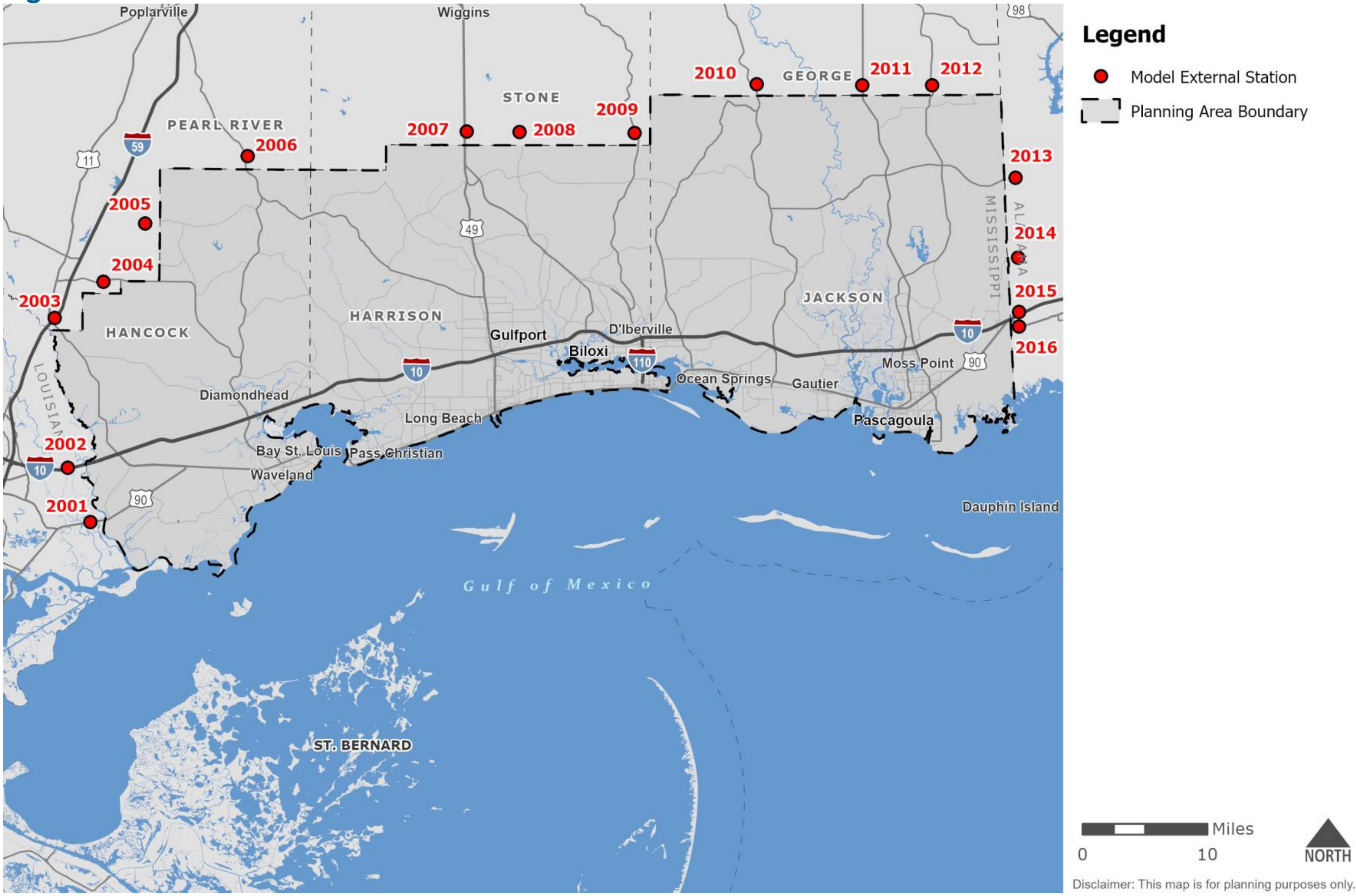
4.0 External Travel

There are two types of external travel trips: external-internal (EI) trips and external-external (EE) trips. These trips are further described as follows:

- EI trips have one end of the trip inside the study area and the other outside. This can apply to trips originating within the study area and leaving, or can be trips originating outside of the study area and stopping within.
- EE trips pass through the study area. They have no origin or destination within the study area itself.

Both trip types are assigned at external stations located on significant roadways that are at the periphery of the study area. These stations represent most trips that are crossing the study area boundary. Since there were no changes to the study area, the external stations remained the same as the previous model. The locations of the TDM's external stations are shown in **Figure 4.1**.

Figure 4.1: MTP 2050 Model External Stations



Source: GRPC TDM, NSI

4.1 Development of EE Trips

The EE trips that pass through the study area are represented by a matrix in the model. This matrix represents the daily vehicle trips going from one external station to the other external stations of the study area.

The percentage of EE and EI trips, as well as the auto and truck trip percentages, were created for this TDM using the data obtained from Replica Platform. This created an initial seed matrix for EE distribution. The Fratar Method was used to grow the EE trips to current AADT counts.

The external travel trips at each station are shown in **Table 4.1**. The full distribution of the EE trips can be found in the model input files.

Table 4.1: Study Area External-External Trips

Station ID	Description	Station Count	% EE Trips	% EE AUTO	% EE TRK	EE AUTO Trips	EE TRK Trips
2001	US 90	2,600	0.4%	0.3%	0.0%	9	1
2002	I-55	46,000	23.2%	17.6%	5.6%	8,112	2,562
2003	MS 607	4,700	3.1%	2.8%	0.3%	130	16
2004	MS 43	3,600	1.1%	0.9%	0.2%	34	5
2005	Caesar Necaise Rd	1,600	1.1%	1.0%	0.1%	16	2
2006	MS 53	3,200	1.4%	1.2%	0.2%	37	8
2007	US 49	21,000	4.3%	3.8%	0.5%	804	110
2008	Airey Tower Rd	490	1.1%	1.0%	0.1%	5	1
2009	MS 15	550	6.0%	5.4%	0.6%	30	3
2010	MS 57	800	3.6%	3.3%	0.4%	26	3
2011	MS 63	9,000	8.3%	7.6%	0.8%	683	68
2012	MS 613	1,200	12.5%	11.1%	1.4%	133	16
2013	Airport Blvd	4,500	9.0%	8.1%	0.9%	365	41
2014	Fort Lake Rd	2,600	10.5%	9.7%	0.8%	252	22
2015	I-10	46,000	23.9%	18.4%	5.5%	8,457	2,526
2016	US 90	5,500	4.8%	4.3%	0.5%	236	29

Source: MDOT, GRPC TDM, NSI, 2022

4.2 Development of EI Trips

During model development, EI trips (which include both internal-external and external-internal) were separated into auto and truck trips based on the vehicle classification counts at external stations. However, for this update the following EI attraction equations were used in the travel demand model for EIAUTO and EITRK trips.

EIAUTO Attractions = (0.4978 * OCCDU) + (0.3356 * RET_EMP) + (0.3356 * RET_EMP2) + (0.0606 * OS_EMP) + (0.4464 * OTH_EMP) + (0.4464 * AMC_EMP) + (0.4464 * MTCUW_EMP) + (0.1541 * OCCROOM)

EITRK Attractions = (0.0878 * RET_EMP) + (0.0878 * RET_EMP2) + (0.2667 * AMC_EMP) + (1.4250 * MTCUW_EMP)

Since these equations are new for this model update, and origin-destination data was available, EITRK and EIAUTO attractions were derived from Replica data.

Table 4.2 displays the EI trips at each external station.

Table 4.2: Study Area External-Internal Trips

Station ID	Description	Station Count	% EI Trips	% EI AUTO	% EI TRK	EI AUTO Trips	EI TRK Trips
2001	US 90	2,600	99.6%	92.7%	7.0%	2,409	181
2002	I-55	46,000	76.8%	58.4%	18.4%	26,848	8,478
2003	MS 607	4,700	96.9%	86.2%	10.7%	4,053	501
2004	MS 43	3,600	98.9%	85.1%	13.8%	3,062	499
2005	Caesar Necaise Rd	1,600	98.9%	88.0%	10.9%	1,408	174
2006	MS 53	3,200	98.6%	81.8%	16.8%	2,619	536
2007	US 49	21,000	95.7%	84.2%	11.5%	17,676	2,410
2008	Airey Tower Rd	490	98.9%	88.0%	10.9%	431	53
2009	MS 15	550	94.0%	84.6%	9.4%	465	52
2010	MS 57	800	96.4%	86.7%	9.6%	694	77
2011	MS 63	9,000	91.7%	83.4%	8.2%	7,507	742
2012	MS 613	1,200	87.5%	77.9%	9.6%	935	116
2013	Airport Blvd	4,500	91.0%	81.9%	9.1%	3,685	409
2014	Fort Lake Rd	2,600	89.5%	82.3%	7.2%	2,140	186
2015	I-10	46,000	76.1%	58.6%	17.5%	26,963	8,054
2016	US 90	5,500	95.2%	84.7%	10.5%	4,659	576

Source: MDOT, GRPC TDM, NSI, 2022

5.0 Trip Generation

This section describes the procedures used to determine the number of trips that begin or end in a given traffic zone. Trip generation is the estimation of the amount of person trips that are produced and attracted to each TAZ. Trip rates for the various types of trips are based upon the land use properties and demographic characteristics of each TAZ.

The model considers the following internal trip purposes:

- Home-Based Work (HBW)
- Home-Based Other (HBO)
- Not Home-Based (NHB)
- Commercial Vehicle (CMVEH)
- Freight or Truck (FRT)

5.1 Internal Travel Mode

For home-based trips, the productions refer to the home end, and the attractions refer to the non-home end of the trip. For NHB, CMVEH, and FRT trips, productions and attractions refer to the origin and destination respectively. The model uses cross-classification trip production models for the home-based and non-home-based trip purposes. This means that trip rates that vary by household type are applied at the zonal level. The trip attraction models are linear regression equations that relate zonal employment and households to trip attractions. For the commercial vehicle and freight vehicle trip purposes, the model applies a linear regression equation that relates zonal employment and households to trip productions and attractions. These equations are based on the Quick Response Freight Manual.

The trip production and attraction models were developed based on the NCHRP 716 methodology and adjusted to meet the minimum calibration guidelines. These trip models were refined again for this update as needed during the calibration process and adjusted to meet the guidelines based on the updated socioeconomic data. The final trip generation production and attraction models for HBW, HBO, and NHB trips are shown **Tables 5.1** and **5.2** respectively. The trip rates for CMVEH and TRK (FRT) trips are shown in **Table 5.3**.

Table 5.1: Trip Production Rates

Trip Purpose	HH Size	Vehicle Ownership (Number of Vehicles)			
		0 VEH	1 VEH	2 VEH	3+ VEH
HBW	1 HH	0.4137	0.6986	0.8161	0.8440
	2 HH	0.8682	1.1771	1.1374	1.4081
	3 HH	1.1329	1.5517	1.6913	2.0130
	4 HH	1.3217	2.0035	2.1002	2.4181
	5+ HH	1.3583	2.1410	2.2880	2.6129
HBO	1 HH	1.1340	2.3220	2.3220	2.3220
	2 HH	2.1600	3.4020	4.0500	4.0500
	3 HH	3.3600	4.9280	5.9360	7.2800
	4 HH	4.0600	6.4960	7.5400	8.8740
	5+ HH	4.9600	8.1840	9.5480	11.3460
NHB	1 HH	0.5496	1.2101	1.1430	1.1272
	2 HH	0.9647	1.5959	2.0059	1.8972
	3 HH	1.5041	2.2703	2.8386	3.5171
	4 HH	1.6141	2.6376	3.1729	3.7608
	5+ HH	1.6809	2.8251	3.4040	4.0996

Source: GRPC TDM, NSI

Table 5.2: Trip Attraction Rates

Trip Purpose	Employment Type						
	RET	OS	OTH	AMC	MTCUW	SCHATT	OCCDU
HBW	1.2800	1.2800	1.2800	1.2800	1.2800	0.0000	0.0000
HBO	10.1126	1.8169	0.5029	0.5029	0.5029	0.7416	0.9489
NHB	3.5346	1.0573	0.4928	0.4928	0.4928	0.2478	0.4630

Source: GRPC TDM, NSI

Table 5.3: Commercial Vehicle and Freight Vehicle Trip Rates

Trip Purpose	Employment Type					
	RET	OS	OTH	AMC	MTCUW	OCCDU
CMVEH	0.6660	0.3278	0.3278	0.8325	0.7035	0.1883
FRT	0.0867	0.0210	0.0210	0.1263	0.0944	0.0373

Source: GRPC TDM, NSI

5.2 Special Generators

A special generator is a land use with unusually low or high trip generation characteristics when compared to the established trip generation rates. For the GRPC TDM, there were 18 locations identified as a special generator with the majority of these trips resulting from beach trips and casino trips.

The rates developed for the TDM's special generators are in vehicle trips. These trips were then converted to person trips using the model's vehicle occupancy rates. This makes the special generator trips consistent with the trip rates developed in the above section.

5.3 Balancing Productions and Attractions

Productions and attractions are balanced at the study area level for all trip purposes. This means that the area-wide trip attractions match the amount of area-wide trip productions. HBW and HBO trips are balanced by holding the productions as a constant since household data is typically considered to be more accurate than employment data. The NHB trips are balanced by holding the attractions as a constant. This reflects that the trips produced at the households or trip origins must be equal to the total number of trips attracted to the non-home ends or destinations. **Table 5.4** shows the daily trips by trip purpose before and after balancing.

Table 5.4: Balanced Productions and Attractions

Trip Purpose	Before Balancing		After Balancing		% Dev	Target
	Productions	Attractions	Productions	Attractions		
HBW	216,445	218,414	216,445	216,445	0.9%	+/- 10%
HBO	735,480	771,955	735,480	735,480	5.0%	+/- 10%
NHB	346,262	363,234	346,262	346,262	4.9%	+/- 10%
CMVEH	102,331	102,331	102,444	102,444	-0.1%	+/- 10%
FRT	14,157	14,157	14,157	14,157	0.0%	+/- 10%
GAME	3,749	3,747	3,749	3,749	-0.1%	+/- 10%

Source: GRPC TDM, NSI

5.4 Summary

As a member of the Tennessee Model Users Group (TNMUG), MDOT has adopted a set of guidelines that help with TDM development. These guidelines are contained in two documents. The first is the *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee*[2], which was last updated in 2016. The second is the *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition*.[3] Using these guidelines, several key statistics for trip generation were monitored, which are shown in **Table 5.5**.

Table 5.5: Modeled vs Benchmark Trip Rates

Trip Rate	Modeled	Low Benchmark	High Benchmark
Person Trips per Person	3.3	3.3	4.0
Person Trips per Household	8.3	8.0	10.0
HBW Person Trips per Employee	1.27	1.20	1.55
HBW Trips	16.7%	12.0%	24.0%
HBO Trips	56.7%	45.0%	60.0%
NHB Trips	26.7%	20.0%	33.0%

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; GRPC TDM, NSI, 2022

As shown in **Table 5.5**, trip generation statistics are within the allowable limits. No further adjustments were made since the model was performing well within all benchmark ranges.

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[2] https://tnmug.utk.edu/wp-content/uploads/sites/10/2022/11/Guidelines-Updated-2016.pdf

[3] Travel Model Validation and Reasonableness Checking Manual, 2nd Edition. Travel Model Improvement Program.

6.0 Trip Distribution

The next step in travel demand modeling is the trip distribution process. This function determines the destinations of trips produced in the trip generation model, and conversely, where the attracted trips originated.

6.1 Gravity Model

Many models are available for this process; however, the GRPC TDM effort used the traditional gravity model.

This model employs two relationships, the first of which is indirect:

> The shorter the travel time to the destination zone, the greater the number of trips will be distributed to it from the origin zone.

The second relationship is direct:

> The more attractions there are in a destination zone, the more trips will be distributed to it from the origin zone.

The generalized equation for this model is:

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

Where:
- T_{ij} = Trips distributed between zones i and j
- P_i = Trips produced at zone i
- A_j = Trips attracted to zone j
- F_{ij} = Relative distribution rate (friction factors or impedance function) reflecting impedance between zone i and zone j
- K_{ij} = Calibration parameter. This parameter is not used in the GRPC TDM
- n = Total number of zones in study area

6.2 Impedance Matrix

The TDM uses a travel time impedance matrix for each zonal pairing within the study area. This matrix traced the shortest free-flow travel time path from zone i (the start of the trip) to zone j (the end of the trip). These values are placed in what is called a skim matrix. Intrazonal trips are unable to build a path for calculation purposes since i and j are the same zone in this case. When this occurred, the travel time in the skim matrix was computed by taking half of the average of travel time from zone i to its three closest zones.

6.3 Friction Factors

In a model of this type, friction factors determine the effect that spatial separation has on trip distribution between zones. This is the first relationship that was mentioned for the gravity model. These factors measure the probability of trip making at one-minute increments of travel time. Friction factors in the gravity model are an inverse function of travel time and each unique trip purpose has its own friction factors. This TDM effort uses the gamma function to derive the friction factors. Calibration of a gamma impedance function involves estimating the three parameters of the gamma function; a, b, and c. The gamma function parameter values used for each trip purpose are shown in **Table 6.1**.

The friction factors used in this effort are the same as the previous model which were derived from NCHRP 716 guidance and adjusted to match the trip length distribution observed in 2022 NHTS data and previous TDM modeling efforts.

Table 6.1: Gamma Function Parameter Values by Trip Purpose

Trip Purpose	a	b	c
HBO	70,374.3607	0.6241	0.1250
HBW	2,317.3833	0.3171	0.0900
NHB	17,427.5474	0.9035	0.1300
CMVEH	19,363.5199	1.3182	0.0250
EIAUTO	2.2692	-2.2451	0.1600
FRT	19,363.5199	1.3182	0.0250
EITRK	1.1209	-2.5131	0.1400
GAME	1,075,418.6894	1.8274	0.0629

Source: GRPC TDM, NSI

6.4 Terminal Times

Terminal times reflect additional travel that is associated with a trip. These can be events such as parking or walking to vehicles and/or facilities. This factor was added to the beginning and end of each trip, using a terminal time of one minute. This value has not been used in previous GRPC TDM model updates and has been changed for this effort.

6.5 Trip Length Frequency Distribution

As mentioned previously, the gravity model develops friction factors in one minute increments and accommodates various lengths of trips. The average trip lengths obtained from the model are displayed in **Table 6.2**. The average trip lengths that were estimated using NHTS data for 2022, and previous TDM modeling efforts, are included in the trip length table for comparison. **Figure 6.1** through **Figure 6.3** show the modeled trip length frequency distribution for HBW, HBO, and NHB trips. These curves were compared to those used in the previous model and determined to be within an acceptable level of consistency.

Table 6.2: Average Trip Length by Trip Purpose

Trip Purpose	2022 Model Average Trip Length (min)	Low Benchmark Average Trip Length (min)	High Benchmark Average Trip Length (min)
HBW	13.1	12.0	35.0
HBO	17.9	8.0	20.0
NHB	11.9	6.0	19.0

Source: GRPC TDM, NSI

Figure 6.1: Base Year 2022 Modeled HBW Trip Length Frequency Distribution

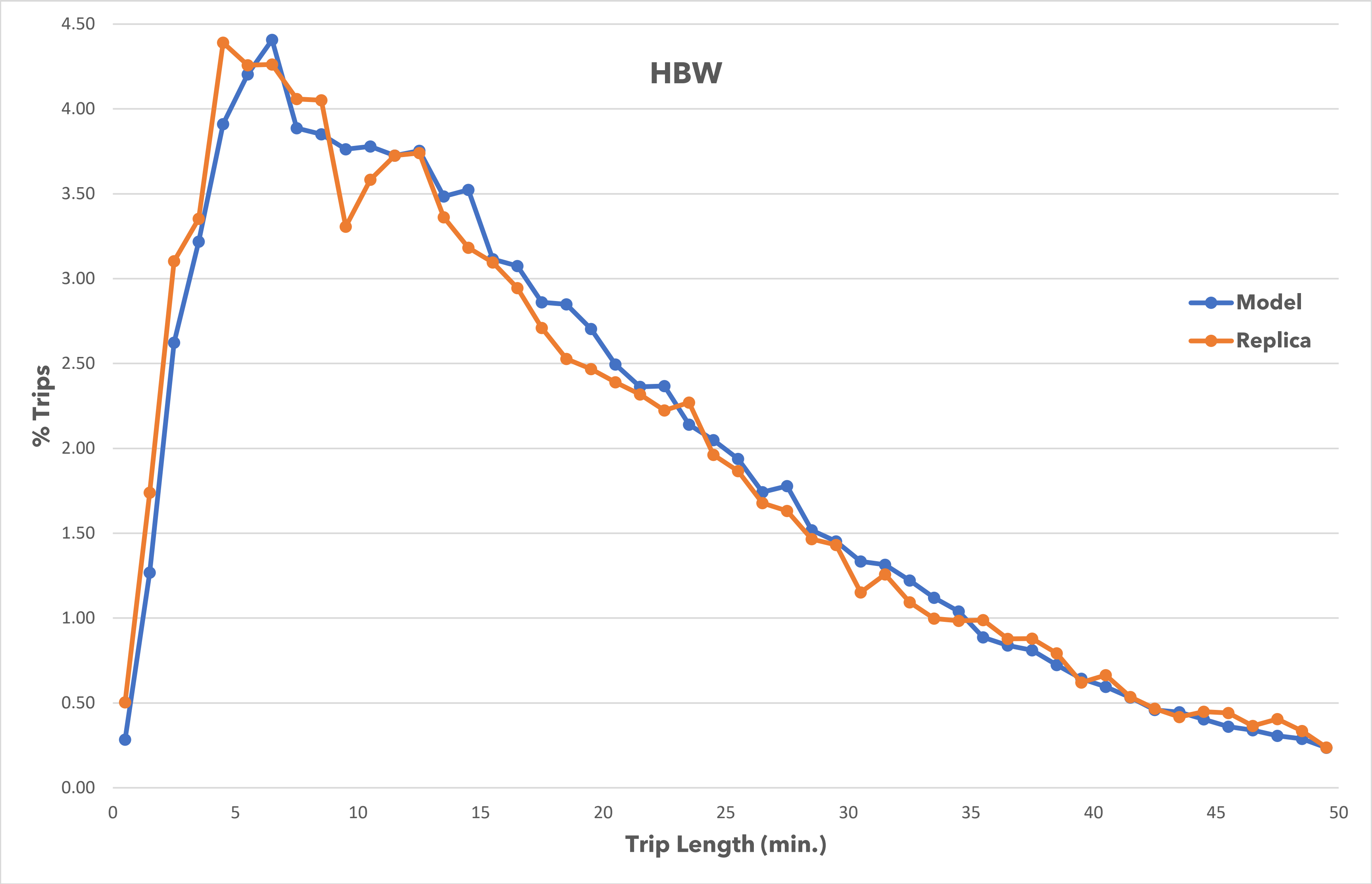


Figure 6.2: Base Year 2022 Modeled HBO Trip Length Frequency Distribution

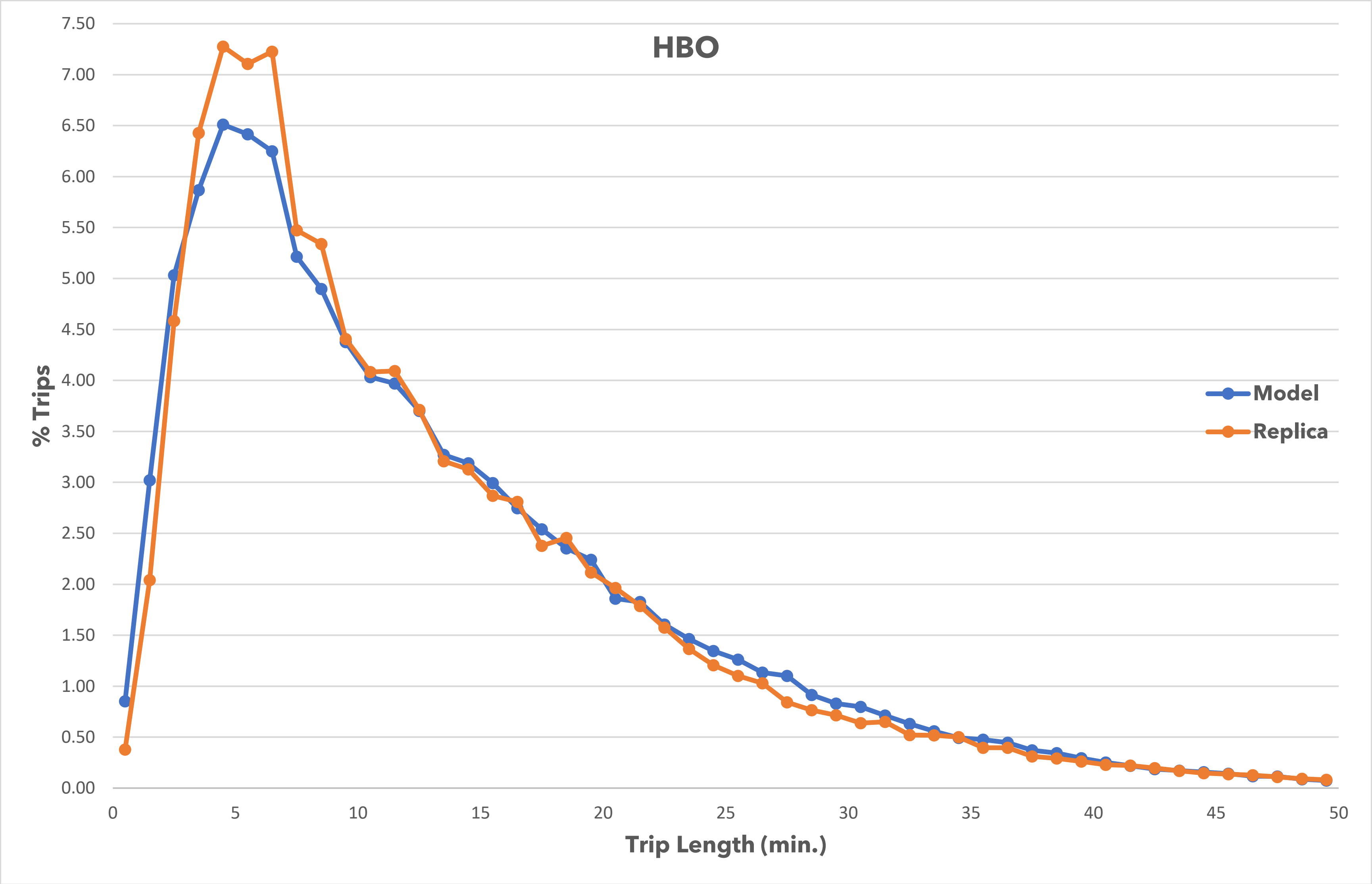
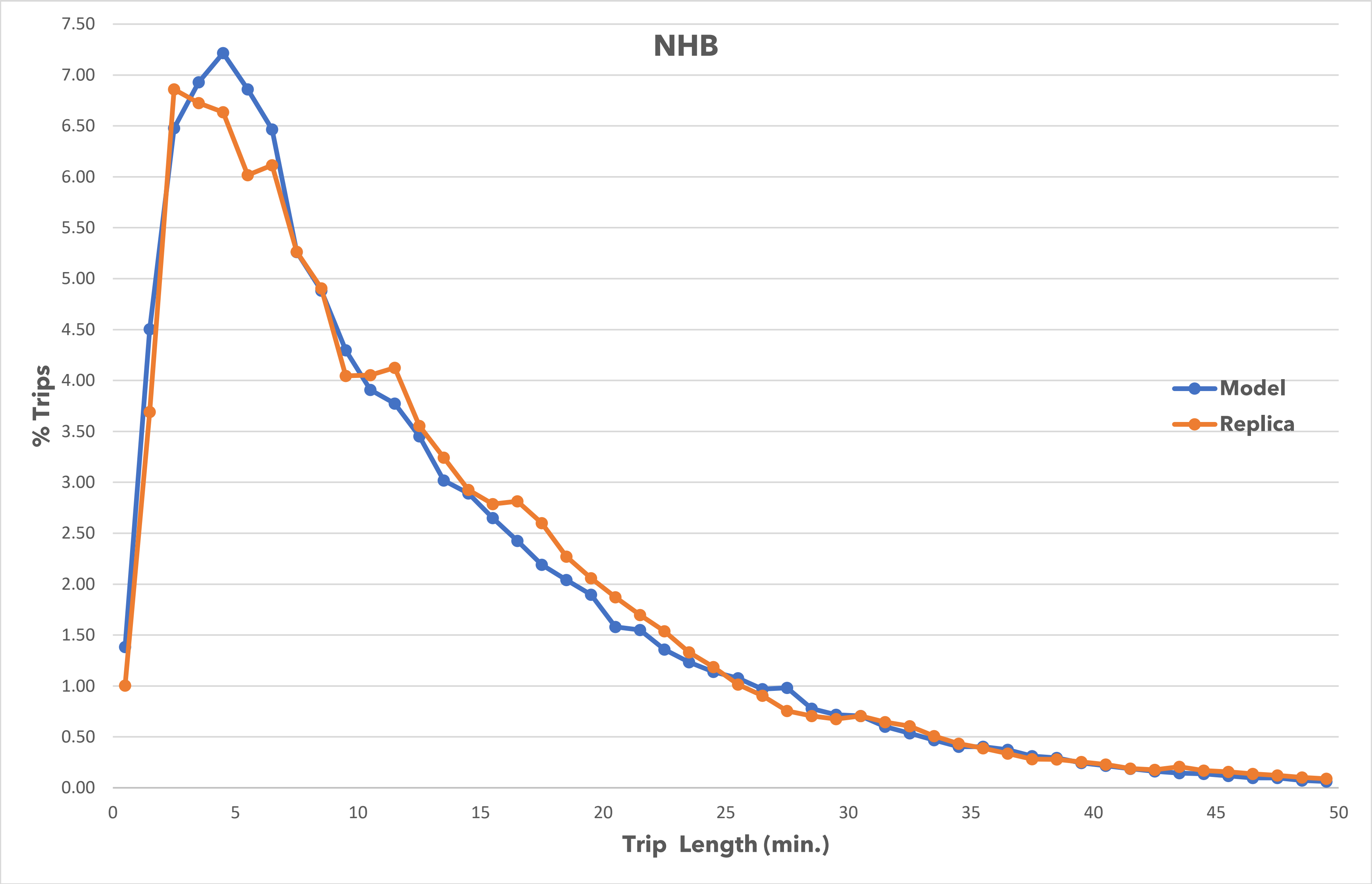


Figure 6.3: Base Year 2022 Modeled NHB Trip Length Frequency Distribution



6.6 Auto Occupancy Rates

The trip rates calculated in the Trip Generation step for HBW, HBO, and NHB trips are in person trips. In order for the TDM to assign vehicles to the roadway network, the number of trips assigned must be in vehicle trips. This process is done using auto occupancy factors. It divides the amount of person trips by the corresponding occupancy factors shown in **Table 6.3**.

Table 6.3: Model Auto Occupancy Factors

Trip Purpose	Modeled	Low Benchmark	High Benchmark
HBW	1.10	1.05	1.10
HBO	1.72	1.65	1.95
NHB	1.66	1.60	1.90

Source: NCHRP 716

7.0 Trip Assignment

Trip assignment is the final step in the traditional four-step planning model. Traffic assignment models are used to estimate the traffic flows on a network. The main input to these models is a matrix of flows that indicate the volume of traffic between origin-destination (O-D) pairs. The other inputs to these models are network topology, link characteristics, and link performance functions.

The trips between each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic. The 2050 MTP model is a user equilibrium model with a generalized cost assignment that uses travel time as the cost.

7.1 BPR Volume-Delay Functions

The TDM link travel time was estimated by the Bureau of Public Roads (BPR) Volume-Delay function. The values that were used in the BPR formula are determined by facility type. The TDM has updated alpha and beta values which are assigned by a roadway's functional classification. The assignment process used in the TDM analyzes link and intersection delay. For segments, as traffic volume increases on a roadway and approaches its maximum capacity, the average speed on the roadway declines. After a point, the roadway speed declines past that of the free flow speed and indicates congestion. The intersection delay is calculated using intersection volume/capacity (VOC) ratios and intersection capacities on the intersection links.

The generalized equation for the BPR formula is:

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

Where:

- T = Congested travel time
- T_0 = Free flow travel time
- v = Assigned link volume
- c = Capacity
- α, β = BRP coefficients

This allows for the calculation of the roadway's peak hour travel:

Peak Hour Travel Speed = (Free Flow Speed)/ $(1+\alpha*(\frac{v}{c})^{\beta}$

The BPR coefficients used in the TDM are shown in **Table 7.1**.

Table 7.1: BPR Volume-Delay Function Parameters

Model Functional Class	Alpha	Beta
Rural Interstate	0.83	5.50
Rural Principal Arterial	0.71	2.10
Rural Minor Arterial	0.71	2.10
Rural Major Collector	0.60	1.60
Rural Minor Collector	0.60	1.60
Rural Local	0.60	1.60
Rural Other	0.60	1.60
Rural On/Off Ramp	0.71	2.10
Urban Interstate	0.83	5.50
Urban Expressway	0.71	2.10
Urban Principal Arterial	0.71	2.10
Urban Minor Arterial	0.71	2.10
Urban Collector	0.60	1.60
Urban Local	0.60	1.60
Urban Other	0.60	1.60
Urban On/Off Ramp	0.71	2.10
Centroid Connector	0.15	4.00

Source: GRPC TDM, NSI

8.0 Model Validation

The purpose of model validation is to make the adjustments necessary to replicate the base-year traffic conditions as closely as possible. In practice, this means making the link assignment volumes approximate the traffic estimates, based on actual counts, within acceptable limits of deviation. Generally speaking, the lower the volume, the greater the relative deviation that is acceptable. Conversely, the greater the amount of traffic, the greater the degree of accuracy required. This is because the ultimate purpose of the model is to determine whether additional vehicular capacity will be needed on any given roadway at a designated future date.

Where existing volumes are low, the model assignment may deviate from actual conditions by 40 or 50 percent without affecting the projected need for additional capacity. On the other hand, in the case of a heavily traveled interstate route, a deviation of 20 percent may be significant (i.e., alter the projection of required capacity). The validation process is intended to ensure that the model is performing within the limits that define acceptable ranges of deviation from observed "real-world" values.

As stated previously, the Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee and the Travel Model Validation and Reasonableness Checking Manual, 2nd Edition were utilized as guidelines for the validation of TDMs. These guidelines, developed by the Tennessee Model Users Group, are commonly used in by state departments of transportation in southeastern United States as they are slightly more stringent and better defined than FHWA minimums.

The following criteria were used to validate the GRPC TDM:

- Percent Root Mean Square Error (RMSE) by Functional Class
- Percent RMSE by Volume Group
- Percent Error/Deviation by Roadway Facility
- Coefficient of Determination (R^2)
- Cordon Lines

8.1 Percent RMSE

The RMSE measure was chosen because when comparing model flows versus counts, sometimes a straight aggregate sum by link group can be misleading. The sum of all traffic counts for a particular link group may be close to the sum of the corresponding traffic flows, but individual link flows may still be very different than their corresponding link count. However, the RMSE statistic does not convey information about the magnitude of the error relative to that of the counts. Therefore, the Percent Root Mean Square Error (Percent RMSE or % RMSE) is often computed. This measure expresses the RMSE as a percentage of the average count value. The Percent RMSE is defined below:

$$\%RMSE = \frac{\sqrt{\sum_j (Model_j - Count_j)^2 / (Numberofcounts)}}{\left(\sum_j Count_j \middle/ Numberofcounts\right)} * 100$$

Validation results by AADT group and functional class are shown in **Table 8.1** and **Table 8.2** respectively.

Table 8.1: RMSE by AADT Group

AADT Range	Number of Observations	Total Count[1]	Total Model Volume[2]	% RMSE	% RMSE Limit[3]
AADT<5,000	539	1,201,554	1,070,008	68.8	45.0-100
5,000 <= AADT < 10,000	186	1,280,700	1,084,031	34.3	35.0-45.0
10,000 < =AADT < 15,000	68	826,500	805,015	24.9	27.0-35.0
15,000 < =AADT < 20,000	40	674,000	673,176	22.7	25.0-30.0
20,000 < =AADT < 30,000	68	1,643,000	1,719,635	21.3	15.0-27.0
30,000 < =AADT <50,000	38	1,383,000	1,327,048	14.5	15.0-25.0
AADT>=50,000	1	62,000	58,817	5.1	10.0-20.0
Areawide	940	7,070,754	6,737,729	34.6	35.0-45.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; GRPC TDM, NSI, 2022

Table 8.2: RMSE by Roadway Functional Class

Functional Class	Number of Observations	Total Count[1]	Total Model Volume[2]	% RMSE	% RMSE Limit[3]
Freeway/Interstate	45	1,166,500	1,273,355	18.5	20.0
Principal Arterial	144	2,933,970	2,902,302	20.9	30.0-35.0
Minor Arterial	186	1,277,660	1,050,775	36.7	40.0-50.0
Collector	424	1,172,004	913,005	58.5	60.0-70.0
Local	20	23,240	13,554	121.4	N/A
Ramps	121	497,380	584,739	43.9	N/A
Areawide	940	7,070,754	6,737,729	34.6	35.0-45.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; GRPC TDM, NSI, 2022

(1) Total Count represents the sum of average daily traffic estimates for all MDOT count locations (area wide), all count locations on principal arterials, all locations on minor arterials, all on major/minor collectors.

(2) Total Model Volume is the sum of model-generated traffic volumes for all network links associated with MDOT count locations (area wide), all links associated with count locations on principal arterials, all links associated with locations on minor arterials, and all links associated with count locations on collectors.

(3) % RMSE Limit is the maximum acceptable magnitude of the error relative to that of the counts conducted by MDOT.

8.2 Percent Error

The next measure of model validation is the percent error, or percent deviation, of the model's assigned traffic volumes to the observed traffic counts. **Table 8.3** and **Table 8.4** display the validation results by AADT group, AADT and lane group, and by facility category respectively.

Table 8.3: Percent Deviation by AADT Group

AADT Range	Number of Observations	Total Count[1]	Total Model Volume[2]	% Dev	% Dev Limit[3]
AADT<1,000	113	58,854	71,474	21.4	+/-200.0
1,000 < =AADT < 2,500	196	320,900	266,886	-16.8	+/-100.0
2,500 <= AADT < 5,000	230	821,800	731,648	-11.0	+/-50.0
5,000 <= AADT < 10,000	186	1,280,700	1,084,031	-15.4	+/-25.0
10,000 < =AADT <25,000	149	2,426,500	2,417,871	-0.4	+/-20.0
25,000 < =AADT < 50,000	65	2,100,000	2,107,002	0.3	+/-15.0
AADT>=50,000	1	62,000	58,817	-5.1	+/-10.0
Areawide	940	7,070,754	6,737,729	-4.7	+/-5.0

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; GRPC TDM, NSI, 2022

Table 8.4: Percent Deviation by Facility Type

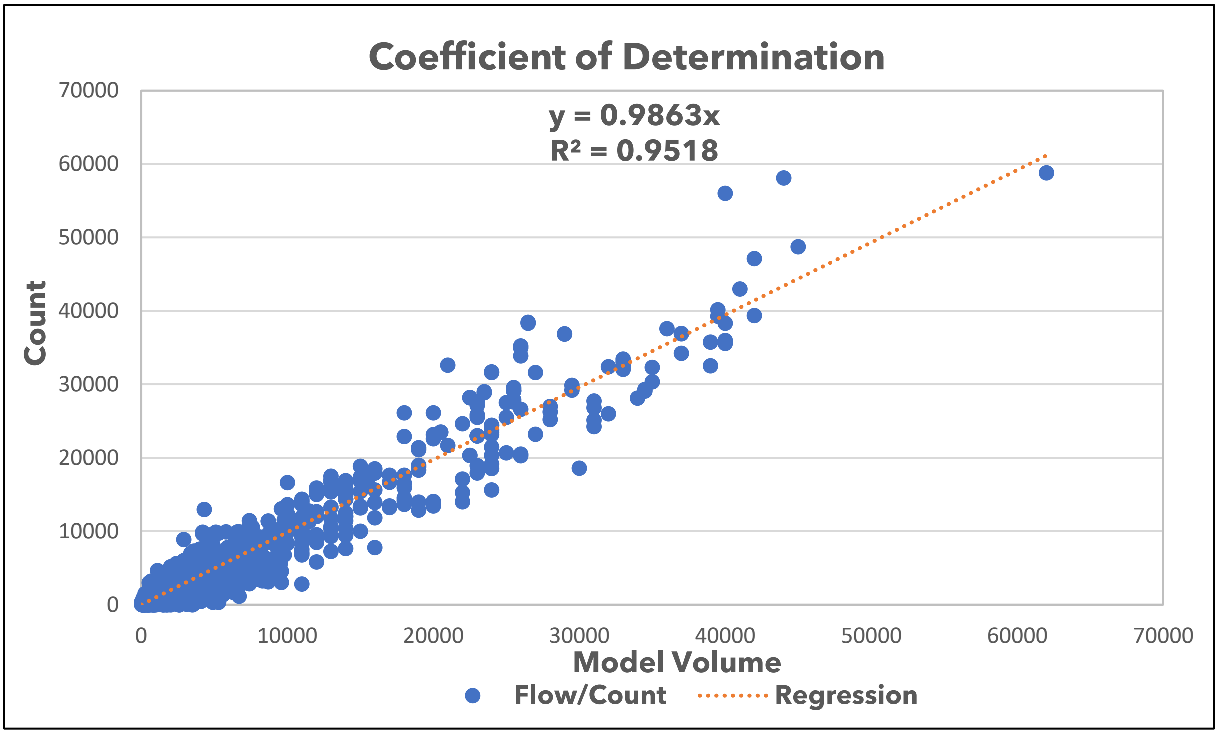
Facility Type	Number of Observations	Total Count[1]	Total Model Volume[2]	% Dev	% Dev Limit[3]
Freeway/Interstate	45	1,166,500	1,273,355	9.2	+/-7%
Principal Arterial	144	2,933,970	2,902,302	-1.1	+/-10%
Minor Arterial	186	1,277,660	1,050,775	-17.8	+/-15%
Collector	424	1,172,004	913,005	-22.1	+/-25%
Local	20	23,240	13,554	-41.7	N/A
Ramps	121	497,380	584,739	17.6	N/A
Areawide	940	7,070,754	6,737,729	-4.7	+/-5%

Source: Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee; GRPC TDM, NSI, 2022
(1) Total Count represents the sum of average daily traffic estimates for all MDOT count locations (area wide), all count locations on principal arterials, all locations on minor arterials, all on major/minor collectors.
(2) Total Model Volume is the sum of model-generated traffic volumes for all network links associated with MDOT count locations (area wide), all links associated with count locations on principal arterials, all links associated with locations on minor arterials, and all links associated with count locations on collectors.
(3) % Dev Limit is the maximum acceptable plus/minus percentage deviation from estimated base-year (2022) average daily traffic (AADT) based on counts conducted by MDOT.

8.3 Coefficient of Determination

The coefficient of determination (R^2) provides a correlation between the observed traffic volumes from MDOT and the estimated TDM volumes. The TNMUG guidelines recommend a minimum R^2 of 0.88. The areawide coefficient of this TDM effort was 0.95 and a scatter plot of the results is shown in **Figure 8.1**.

Figure 8.1: Base Year 2022 Modeled Volume vs Traffic Count Plot



8.4 Cordon Lines

An analysis of the study area boundary's cordon lines was also conducted in order to determine if the external station TDM volumes matched those of the traffic counts. Based on the TNMUG guidance, all external station link model volumes should be within +/- one percent of the observed traffic counts. The results of the cordon analysis are shown in **Table 8.5**.

Table 8.5: Cordon Analysis

External Station	Description	Model Volume	Count Volume	Volume/Count
2001	US 90	2,600	2,600	1.00
2002	I-55	46,000	46,000	1.00
2003	MS 607	4,700	4,700	1.00
2004	MS 43	3,600	3,600	1.00
2005	Caesar Necaise Rd	1,600	1,600	1.00
2006	MS 53	3,200	3,200	1.00
2007	US 49	21,000	21,000	1.00
2008	Airey Tower Rd	490	490	1.00
2009	MS 15	550	550	1.00
2010	MS 57	800	800	1.00
2011	MS 63	9,000	9,000	1.00
2012	MS 613	1,200	1,200	1.00
2013	Airport Blvd	4,500	4,500	1.00
2014	Fort Lake Rd	2,600	2,600	1.00
2015	I-10	46,000	46,000	1.00
2016	US 90	5,500	5,500	1.00

Source: GRPC TDM, NSI

The validation effort concluded that the GRPC MPO study area travel demand forecasting model performs within the established limits of acceptable deviation from base-year estimated volumes.

9.0 Future Year Model Development

Future year models were developed to forecast traffic that the study area will experience based on its anticipated growth. This includes forecast socioeconomic data, external travel, and special generator data. Forecast models also require updates to the roadway network based on projects that are expected to occur or have allocated funding in the near future.

9.1 Future Year Socioeconomic Data Development

To adequately forecast future transportation system needs, future projections of demographic variables were developed for each Traffic Analysis Zone (TAZ).

Population and Employment Growth

County-level growth rates and study area-level population and employment control totals for the year 2050 were developed in consultation with the GRPC MPO. These forecasts were developed based on a comparison of the previous MTP, historical trends, state projections, and third-party projections to determine the potential growth rates for the planning area. The potential growth rates are shown in **Table 9.1**.

Table 9.1: Population and Employment Growth Rates

Source	Forecast Population Annual Growth Rates			Forecast Employment Annual Growth Rates		
	Hancock County	Harrison County	Jackson County	Hancock County	Harrison County	Jackson County
ACS	0.87%	1.13%	1.06%	N/A	N/A	N/A
Historical BLS	N/A	N/A	N/A	0.98%	0.78%	1.10%

Source: GRPC TDM, NSI

Each of the growth rates was then applied to the base year population and employment to develop year 2050 data. From these, it was determined that the most reasonable population estimates came from the Historical 2000-2020 Census, while QCEW projections provided the most reasonable employment estimates. Interim control totals were derived using growth rates from the same data sources to determine Year 2030 and Year 2040 control totals. The interim and final horizon year control totals are displayed in **Table 9.2**.

Table 9.2: Planning Area Population and Employment Control Totals

Population					
County	Year				Total Change in Persons
	2022	2030	2040	2050	
Hancock County	46,010	50,193	54,381	58,564	12,554
Harrison County	208,748	234,411	260,087	285,750	77,002
Jackson County	143,721	160,220	176,717	193,216	49,495
Employment					
County	Year				Total Change in Employees
	2022	2030	2040	2050	
Hancock County	16,790	18,552	20,315	22,067	5,277
Harrison County	94,169	101,783	109,405	117,054	22,885
Jackson County	59,677	66,814	73,966	81,102	21,425

Source: GRPC TDM, NSI

Using these control totals, both population and employment growth were sub-allocated to each TAZ in the travel demand model. **Figure 9.1** displays the total population change by TAZ, while **Figure 9.2** displays the percent change of population. **Figure 9.3** displays the total employment change by TAZ, while **Figure 9.4** displays the percent change of employment.

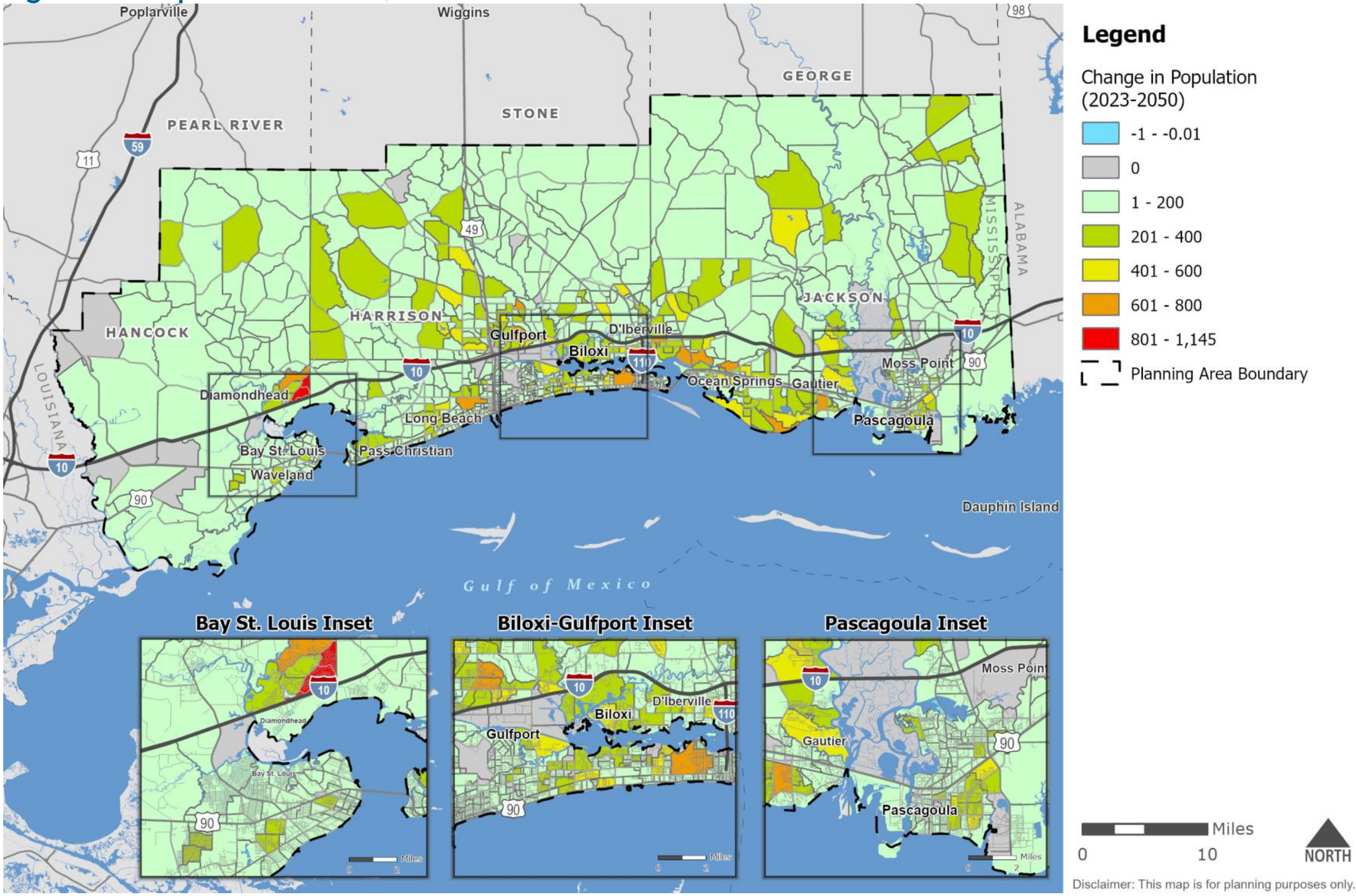
The following process was used:

- First, growth that has occurred since the base year was added, based upon local and MPO staff knowledge of recent or approved developments.
- The remaining available growth was allocated through 2050, with an emphasis on areas that were identified as growth areas in the 2045 MTP.
- Since the new control totals resulted in less population and employment than the 2045 MTP, growth to the remaining TAZs was proportionately allocated.
- Following that, some growth was "moved" and instead allocated to nearby zones that had not previously received it so as to produce more reasonable results.
- After approval of the year 2050 TAZ data, data for years 2030 and 2040 were created.

School Enrollment Growth

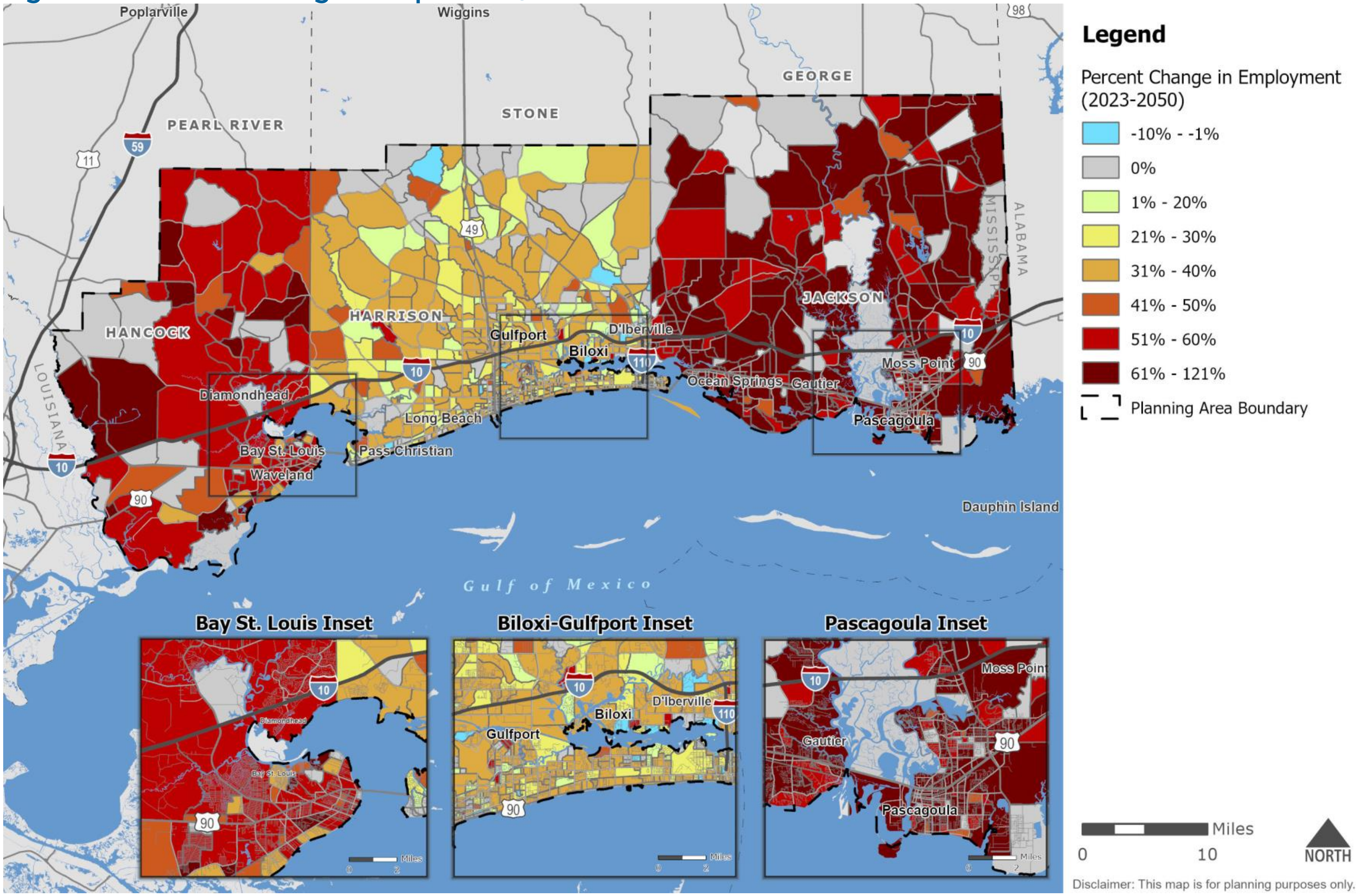
School enrollment growth was projected to grow at the same rate as the total population of the County it is located within until it reached the maximum school enrollment established by each County's School System.

Figure 9.1: Population Growth, 2022-2050



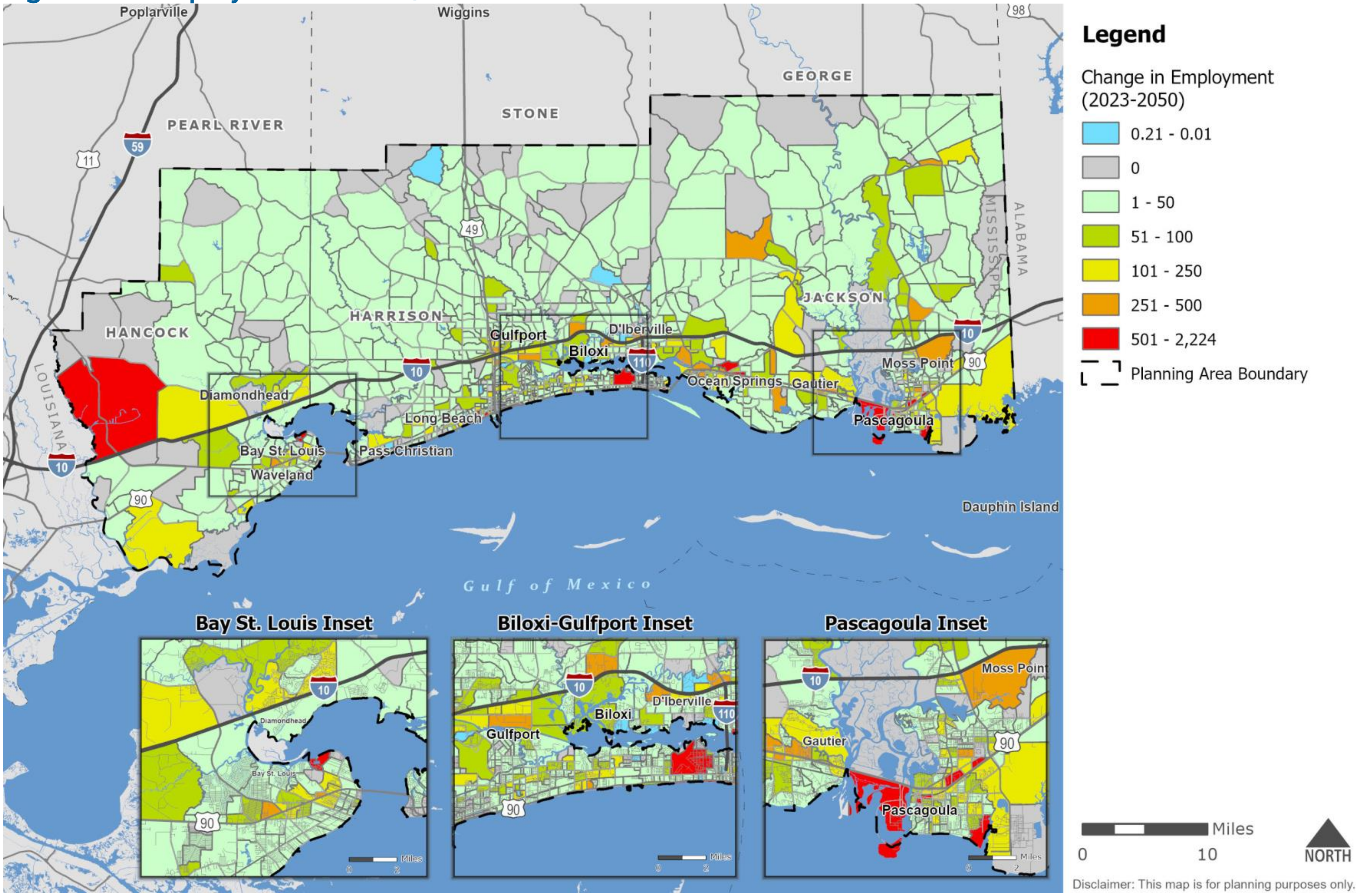
Source: GRPC TDM, NSI, 2022

Figure 9.2: Percent Change in Population, 2022-2050



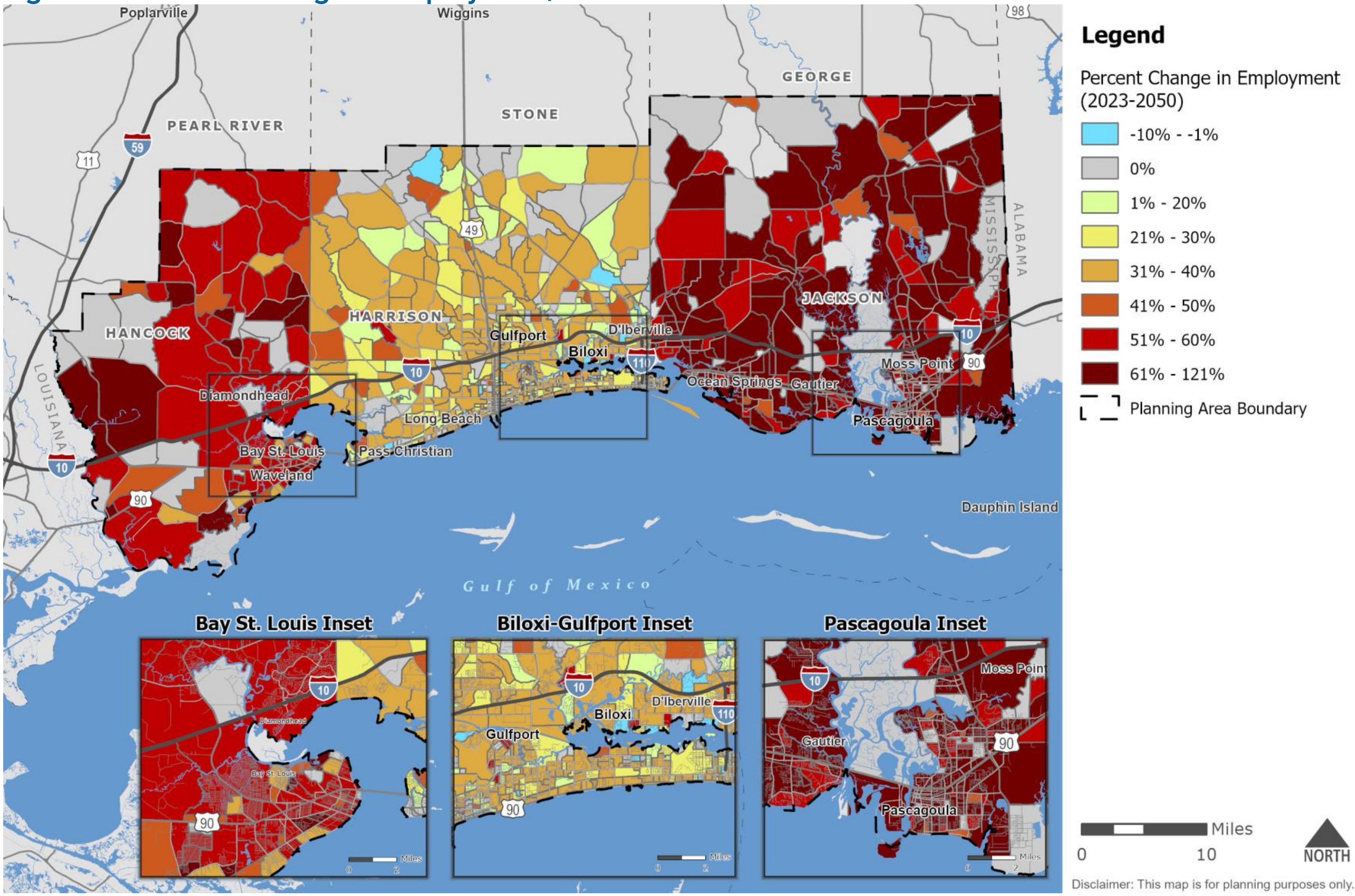
Source: GRPC TDM, NSI, 202

Figure 9.3: Employment Growth, 2022-2050



Source: GRPC TDM, NSI, 2022

Figure 9.4: Percent Change in Employment, 2022-2050



Source: GRPC TDM, NSI, 2022

9.2 Existing Plus Committed (E+C) Network

The base year network was defined as the street and highway system that existed in year 2022. Once the base year network was calibrated, the E+C network was developed, which included committed projects.

Committed projects are those improvements for which:

- **construction was either completed or begun since 2022,**
- **a contract for construction has been awarded,**
- **have completed the National Environmental Policy Act (NEPA) phase, or**
- **have funding for right-of-way and/or construction programmed in the MPO's Transportation Improvement Program.**

Committed projects were added to the base network using the following procedure:

- New routes were coded with the proposed number of lanes, and with the posted speed and volume-delay function attributes that reflect the project's functional classification.
- Widened roadways change the number of lanes to the appropriate amount in each direction as well as the lane configuration field required by the network.
- All E+C projects were flagged in the 'PROJECT_EC' field using a unique project ID.

The committed projects are listed in **Table 9.3** and shown in **Figure 9.5**.

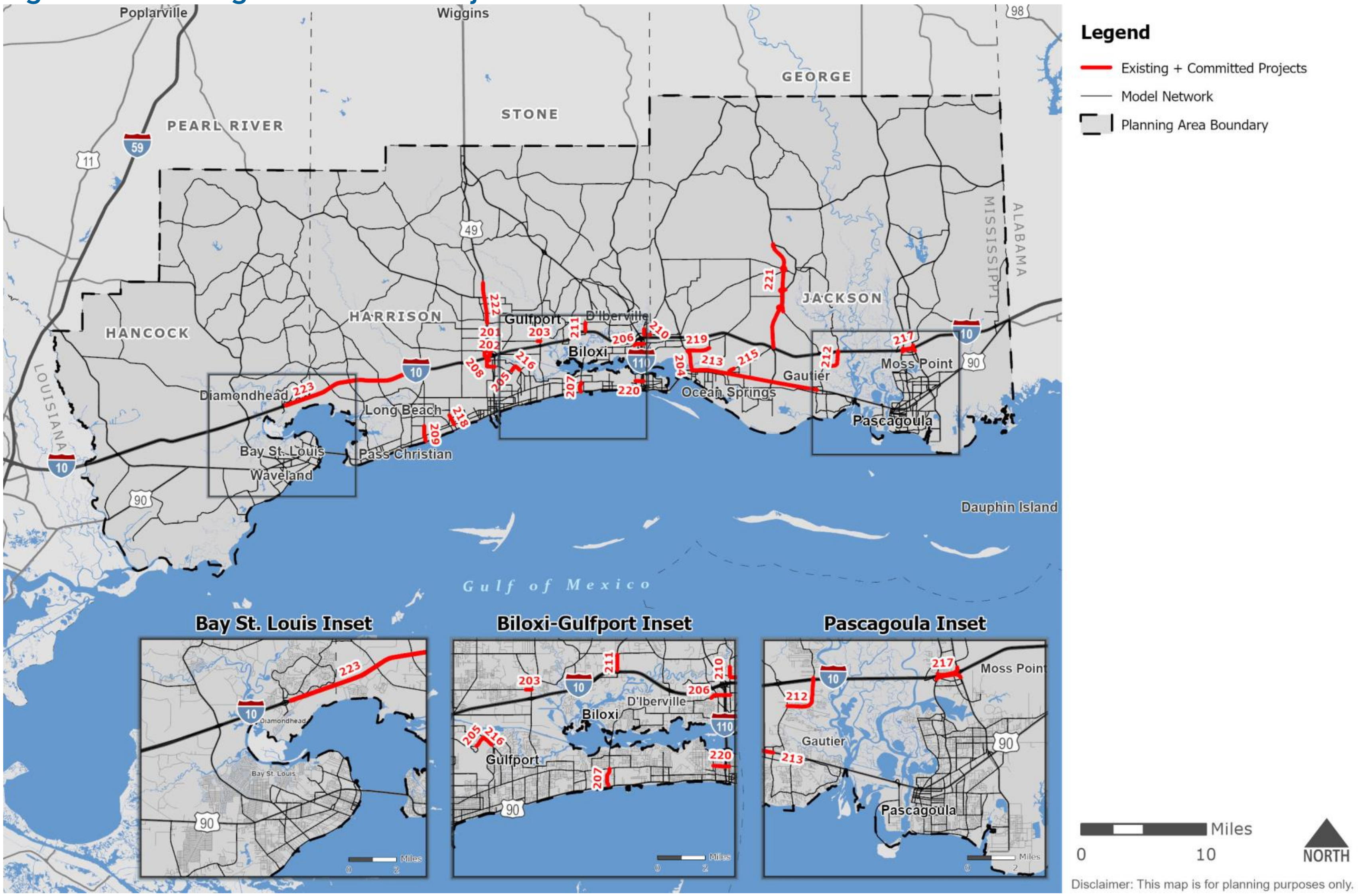
Table 9.3: Existing + Committed Projects

Project ID	Roadway	Location	Improvement	Opening Stage Year
201	Landon Rd	34th St to Coleman Rd	Widen from 2 lanes to 5 lanes	2030
202	Landon Rd	Coleman Rd to Hwy 49	Widen from 2 lanes to 5 lanes	2030
203	Dedeaux Rd	0.25 miles west of Hwy 605 to Hwy 605	Widen from 2 lanes to 4 lanes	2030
204	Washington Ave	Old Fort Bayou Rd to US 90	5 lane to 4 lane divided	2030
205	Airport Rd	Business Center Dr to Washington Ave	Widen from 2 lanes to 4 lanes	2030
206	Popps Ferry Rd	Popps Ferry Rd to Lamey Brg Rd	New roadway	2030
207	Popps Ferry Rd	US 90 to Pass Rd	Construct new 4-lane divided road	2030
208	Interconnecting Gulfport	Airport Rd to Daniel Blvd	New roadway	2030
209	Beatline Pkwy	US 90 to Johnson Rd	Widening and New 4 lane roadway	2030
210	Mallet Rd - Lamey Bridge Rd	Lamey Bridge Rd to Daisy Vestry Rd and I-110 to Cypress Creek Dr	Widen to 4 lanes	2030
211	Shriners Blvd	I-10 to Woolmarket Rd	Widen from 2 lanes to 4 lanes plus center turn lane	2030
212	Martin Bluff Rd	Gautier-Vancleave Rd to Frontage Rd	Addition of center turn lane	2030
213	US 90	SR 609 to Dolphin Dr	Widen to 6 lanes	2030
215	Ocean Springs Rd	0.13 miles west of Monticello Blvd to Culeoka Dr	Add center turn lane	2030
216	Washington Ave	Airport Rd to S Vista Dr	Widen from 2 lanes to 4 lanes	2030
217	I-10 Frontage Roads	MS 613 to MS 63	Build frontage roads	2030
218	Cleveland Ave	Klondyke Rd to Railroad St	2 lane to 2 lane with center turn lane	2030
219	Old Fort Bayou Rd	Washington Ave to Yellow Jacket Rd	Widen to 3 lanes	2030

Project ID	Roadway	Location	Improvement	Opening Stage Year
220	Division Street	Caillavet Street to Forrest Ave-KAFB	Widen to 4 lanes divided	2030
221	MS 57	Mariposa Lane to I-10 Frontage Rd	Widen to 4 lanes divided and realign	2030
222	US 49	School Rd to O'Neal Rd	Widen to 6 lanes divided	2030
223	I-10	Hancock Co Line to Wolf River	Widen to 6 lanes	2030

Source: MDOT, GRPC TDM, NSI

Figure 9.5: Existing + Committed Projects



Source: MDOT, GRPC TDM, NSI

9.3 External Station Growth

The base year traffic counts at each external station were projected to 2030, 2040, and 2050 using growth factors developed based on historic traffic counts at the external stations. Development of the growth rates used the following methodology:

- Used current AADT counts at the external stations as well as historical AADT counts to determine the six-year growth rate and three-year growth rate of traffic at each external station.
- Obtained the average of the growth rates and established that rate as the initial external station growth rate.
- If the external station rate exceeded three percent annually, the growth rate was adjusted to three percent.
    - External station growth above three percent annually is often indicative of short-term, explosive growth due to major developments or temporary changes in traffic patterns due to construction.
    - These growth rates are generally not sustainable in the long-term and often produce unreasonable results unless there is a known major development or roadway project expected in the future.
    - There are no known major developments or roadway projects at these external stations, therefore, annual growth rates have been capped to three percent.
- If the external station growth rate was less than one percent, including negative growth rates, the external growth rate was adjusted to one percent.
- For some stations, the average annual growth rate produced unrealistic results or reflects recent explosive growth that is not expected to continue into the future.
    - Stations where this occurred further had the growth rate adjusted to reflect more reasonable expected growth.

The final forecast growth rates for each external station and comparison of external travel forecast for the base year and target years is shown in **Table 9.4**.

The total traffic at each station was then divided into EI and EE trips with the assumption that there would not be a significant change in the distribution from the base year. In addition, both EI and EE forecast trips were also separated into auto and truck trips.

Table 9.4: External Station Forecast Growth

Station ID	Station Description	Forecast Growth Rate	2022 Volume	2030 Volume	2040 Volume	2050 Volume
2001	US 90	1.0%	2,600	2,808	3,068	3,328
2002	I-55	2.1%	46,000	53,742	63,421	73,099
2003	MS 607	1.0%	4,700	5,076	5,546	6,016
2004	MS 43	1.0%	3,600	3,888	4,248	4,608
2005	Caesar Necaise Rd	1.0%	1,600	1,728	1,888	2,048
2006	MS 53	2.1%	3,200	3,732	4,397	5,062
2007	US 49	2.2%	21,000	24,637	29,184	33,730
2008	Airey Tower Rd	1.0%	490	529	578	627
2009	MS 15	1.6%	550	619	705	791
2010	MS 57	1.0%	800	864	944	1,024
2011	MS 63	1.1%	9,000	9,766	10,724	11,681
2012	MS 613	1.0%	1,200	1,296	1,416	1,536
2013	Airport Blvd	2.9%	4,500	5,545	6,852	8,158
2014	Fort Lake Rd	1.6%	2,600	2,936	3,355	3,775
2015	I-10	1.0%	46,000	49,680	54,280	58,880
2016	US 90	1.0%	5,500	5,940	6,490	7,040

Source: MDOT, GRPC TDM, NSI, 2022

9.4 Future Year Model Runs

The TDM was used to forecast traffic for the future years using the E+C network and forecast socioeconomic, external station, and special generator data. Interpolation was used where necessary to obtain a future year scenario that occurred between the base year (2022), interim years (2030 and 2040), or the horizon year (2050).