Congestion Management Process

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1.0 Introduction

1.1 Foreword/Background

A Congestion Management Process (CMP) is an analytical process that measures the operational effectiveness of major transportation facilities located within a Transportation Management Area (TMA), an urban area with a population greater than 200,000 people. A CMP proposes strategies required to address congested areas identified within a TMA.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required each TMA to develop a Congestion Management System (CMS). Subsequent legislation that has continued this requirement include:

- The Transportation Equity Act for the 21st Century (TEA-21) in 1998
- Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005
- Moving Ahead for Progress in the 21st Century Act (MAP-21) in 2012
- Fixing America's Surface Transportation Act (FAST Act) in 2015
- Infrastructure Investment and Jobs Act (IIJA) in 2021

The CMS became the CMP with the SAFETEA-LU legislation. Prior to becoming the CMP, the CMS was often treated as a stand-alone data analysis exercise or report on congestion. Since then, the CMP has been intended to be an on-going process, fully integrated into the metropolitan transportation planning process[1]. This CMP effort for the Clarksville Urbanized Area Metropolitan Planning Organization (CUAMPO) is the MPO's first as the population of the Clarksville Metropolitan Planning Area (MPA) exceeded the 200,000-person threshold between with Census 2020. This CMP effort for the Clarksville MPA will:

- Analyze the Clarksville MPA's transportation system.
- Determine which areas experience the greatest mobility and maneuverability issues associated with traffic congestion.
- Identify a wide range of congestion reduction strategies that, if implemented, can aid in improving free flow traffic conditions.

[1] https://www.fhwa.dot.gov/planning/congestion_management_process/cmp_guidebook/cmpguidebk.pdf

1.2 Defining Congestion

Congestion is defined as the delay compared to normal free-flow traffic conditions on major transportation systems that impedes traffic mobility and maneuverability. Traffic congestion has several negative side effects, such as an increase in goods transportation costs, increased fuel consumption, and lost work productivity. It also contributes to air pollution, negatively impacting the health of the MPA's residents, workers, and the environment.

A CMP is an effective tool that assists in the management of new and existing transportation facilities. It does so using travel demand reduction scenarios and supply management strategies that promote traffic mobility and accessibility in the MPA.

1.3 Federal Guidance/Federal Legislation

Section 450.322 (a) of Subpart C (Metropolitan Transportation Planning and Programming), 23 CFR (Final Rule), states that:

> "The transportation planning process in a Transportation Management Area (TMA) shall address congestion management through a process that provides for safe and effective integrated management and operation of the multimodal transportation system, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities eligible for funding under title 23 U.S.C. and title 49 U.S.C. Chapter 53 through the use of travel demand reduction (Including Intercity bus operators, employer-based commuting programs such as a carpool program, vanpool program, transit benefit program, parking cash-out program, shuttle program, or telework program), job access projects and operational management strategies."

Section 500.109 (a) of Subpart A (Management Systems), 23 CFR (Final Rule), states that:

> "For purposes of this part, congestion means the level at which transportation system performance is unacceptable due to excessive travel times and delays. Congestion management means the application of strategies to improve system performance and reliability by reducing the adverse impacts of congestion on the movement of people and goods in a region. A congestion management system or process is a systematic and regionally accepted approach for managing congestion that provides

accurate, up-to- date information on transportation system operations and performance and assesses alternative strategies for congestion management that meet State and local needs."

Section 500.109 (b) of Subpart A (Management Systems), 23 CFR (Final Rule), states that:

"The development of a congestion management system or process should result in performance measures and strategies that can be integrated into transportation plans and programs. The level of system performance deemed acceptable by State and local officials may vary by type of transportation facility, geographic location (metropolitan area or subarea and/or non-metropolitan area), and/or time of day. In both metropolitan and non-metropolitan areas, consideration needs to be given to strategies that manage demand, reduce Single Occupant Vehicle (SOV) travel, and improve transportation system management and operations. Where the addition of general-purpose lanes is determined to be an appropriate congestion management strategy, explicit consideration is to be given to the incorporation of appropriate features into the SOV project to facilitate future demand management strategies and operational improvements that will maintain the functional integrity of those lanes."

1.4 Causes and Types of Congestion

Within urban areas across the United States, people are migrating from the core areas to the "outer rings" and suburbs. This out-migration trend has placed a strain on the existing infrastructure. This has affected other public facilities including transit, rental cars, bicycle lanes, and taxis.

The Clarksville MPA is the fifth largest metropolitan area in Tennessee; also, a portion of the Clarksville MPA extends into Kentucky. Situated on the Cumberland River in Middle Tennessee, the MPA encompasses Montgomery County, Tennessee and a portion of Christian County, Kentucky.

The MPA is situated along the I-24 corridor, which connects the Midwestern United States with the Southeastern United States, connecting the MPA to Paducah, Kentucky, Chicago, Illinois, and St. Louis, Missouri to the northwest and to Nashville, Tennessee, Chattanooga, Tennessee, and Atlanta, Georgia to the southeast. The MPA's location along the I-24 corridor results in additional through traffic as travelers head from one major metropolitan area to another. These additional trips have led to increased traffic not only on I-24, but also on US 41A, US 79, SR 12, SR 13, SR 48, SR 76, SR 237, and SR 374.

Congestion can generally be classified as either recurring or non-recurring, as summarized below. The sources of congestion based on a Federal Highway Administration (FHWA) summary is shown in **Figure 1.1**.

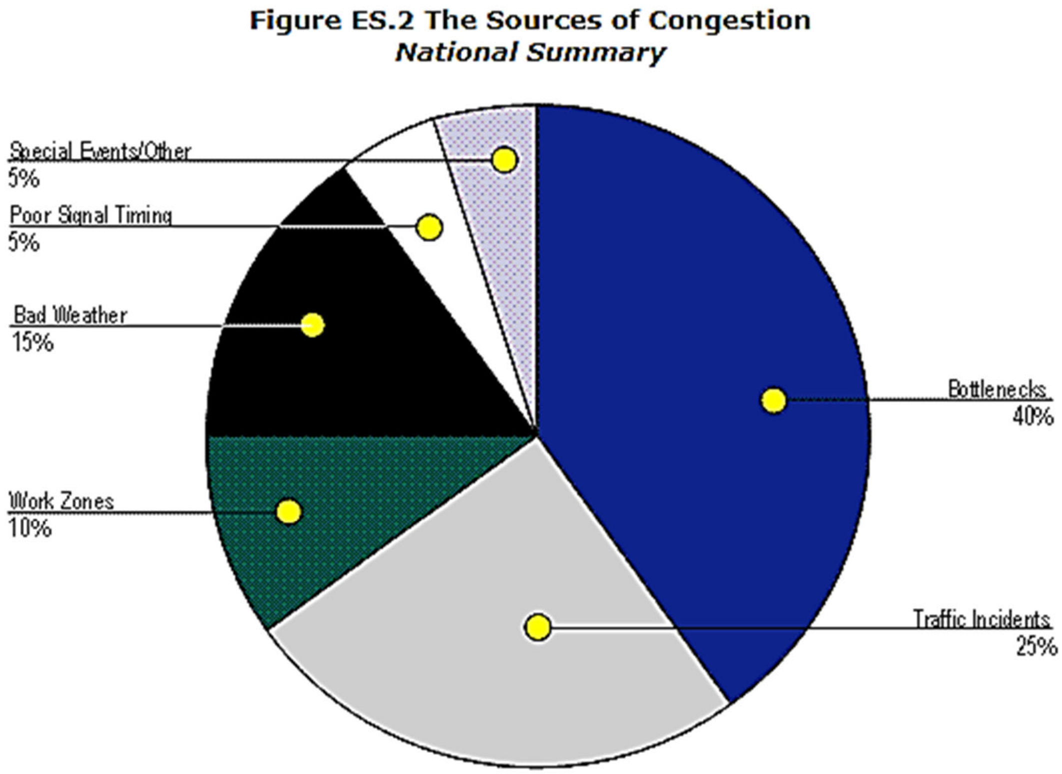
Recurring Congestion

- Recurring congestion is regularly occurring traffic congestion that happens at the same time every day during peak hours. This congestion occurs due to traffic demand exceeding roadway capacity.

Non-Recurring Congestion

- Non-recurring congestion occurs due to accidents, adverse weather, special events, work zones, and other factors that do not follow a predictable pattern. As such, non-recurring congestion is caused by non-standard or random events.

Figure 1.1: The Sources of Congestion – National Summary



Source: https://ops.fhwa.dot.gov/congestion_report/executive_summary.htm

1.5 Previous Congestion Management Strategies

Across the nation, there is a push to reduce Single Occupancy Vehicle (SOV) travel to reduce congestion. These efforts were guided by proposed alternative travel methods and travel demand strategies, such as carpooling/vanpooling and transit park-and-ride facilities. However, motorists preferred the convenience that SOVs provide, and the strategies proved ineffective. According to the Census Bureau, the percentage of workers in Clarksville that drove to work alone has been steady at approximately 85 percent in the last decade (2010 to 2019)[2,3].

This CMP effort, which will be the first for Clarksville, will identify alternative strategies to projects that increase SOV capacity which could alleviate congestion on congested corridors. Those strategies are shown in *2.6 Step 6: Congestion Management Strategies*.

1.6 Multimodal Mobility

The traditional understanding of congestion has been focused largely, if not solely, on automobiles. Typically, the standard solution for congestion reduction has been increasing roadway capacity (i.e. "building our way out of congestion"). However, this solution usually induces more automobile travel, which may worsen the level of congestion that existed before the capacity expansion. By understanding congestion from a multimodal perspective, all modes can be considered potential sources and remedies for congestion. Several studies have indicated that transit[4], walking, and cycling[5,6] can be tools to relieve automobile congestion.

Congestion also affects economic productivity. Growing freight demand increases congestion on the highway system as trucks and automobiles compete for space on the highway system while commuter trains and freight trains compete for space on the railroad network. This congestion affects both businesses and consumers as businesses require more

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[2] https://data.census.gov/table/ACSDT5Y2010.B08101?t=Commuting&g=160XX00US4715160
[3] https://data.census.gov/table/ACSDT5Y2019.B08101?t=Commuting&g=160XX00US4715160
[4] Nakamura, K., Hayashi, Y. (2013). Strategies and instruments for low-carbon urban transport: An international review on trends and effects. Transport Policy. 29, pp. 264–274
[5] Litman, T. (2014). Congestion Evaluation Best Practices. In: International Transportation Economic Development Conference. Sheraton Dallas Hotel, Dallas, USA. Apr. 09-11, 2014. pp. 1–20.
[6] Litman, T. (2018). Smart Congestion Relief - Comprehensive Evaluation of Traffic Congestion Costs and Congestion Reduction Strategies. Victoria Transport Policy Institute, Victoria, Canada

operators and equipment to deliver goods while consumers wait longer for inventory deliveries[7].

Freight

The Clarksville MPA is home to several freight facilities, including one (1) Class 1 railroad and 13 highways on the Tennessee and Kentucky state freight networks. The major freight network within the Clarksville MPA includes:

- Major freight roads, including I-24, US 41, US 41A, US 79, SR 12, SR 13, SR 48, SR 76, SR 149, SR 236, SR 237, SR 374, and KY 115. The freight highway network and conditions are summarized in *4.3 Trucking* of *Techical Report #2: State of Current System*[8].
- Railroads, including the CSX Transportation railroad, which parallels US 41, and the RJ Corman Railroad Company, which parallels SR 149 and the Cumberland River southwest of Clarksville and US 79 northeast of Clarksville. The freight railroad network and conditions are summarized in *4.4 Railways* of *Techical Report #2: State of Current System*[8].
- Airports, including Clarksville Regional Airport. The freight airport conditions are summarized in *4.5 Air Cargo* of *Techical Report #2: State of Current System*[8].
- Waterways and Ports, including the Cumberland River. The water network, ports, and their conditions are summarized in *4.6 Waterway Network* of *Techical Report #2: State of Current System*[8].

The economic consequences of congestion-delayed freight goods are significant to the Clarksville MPA. Data from the Clarksville MPO TDM indicates that, without additional roadway projects and strategies on the CMP Network beyond the Existing + Committed network projects discussed in *Technical Report #5: Plan Development*, the auto Vehicle Hours Delay (VHD) and auto congestion costs will increase by 242 percent from 2019 to 2050 and that truck VHD and truck congestion costs will increase by 358 percent during the same period. ***Figure 4.3*** of *Technical Report #2: State of Current System*[8] identifies locations that currently experience freight reliability issues. Segments currently experiencing freight congestion (in 2019), or are expected to experience freight congestion in 2050, are

[7] https://ops.fhwa.dot.gov/freight/freight_analysis/freight_story/congestion.htm
[8] http://www.cuampo.com/wp-content/uploads/2024/01/Clarksville_2050_MTP_Tech_Report_2_State_of_Current_System_122223.pdf

identified in ***Figure 5.3*** and ***Figure 5.4*** of *Technical Report #4: Needs Assessment*[9], respectively.

Transit

Transit can provide people with mobility and access to employment, shopping, medical care, and other destinations and opportunities. For some, transit is a lifeline service for those who have no other choice due to economic and/or physical limitations. For others, transit serves as an alternative to driving as well as a cheaper method of travel. Using transit removes SOVs from the roadway network and reduces overall network congestion, which can also improve the reliability for transit. Projects that promote the use of transit help reduce congestion and eliminate the need for costly capacity improvements while reducing induced demand.

Clarksville Transit System (CTS) is the primary public transit provider in the City of Clarksville; there are no current fixed route public transportation providers serving the Christian County portion of the MPA. CTS offers both fixed route bus service and on-demand service within the city limits. The CTS fixed route service operates from Monday through Saturday. Additionally, CTS and the Regional Transit Authority (RTA) operate a regional commuter bus route between Clarksville and Nashville. Intercity bus service is provided by private bus companies (e.g. Greyhound).

The current transit conditions in the MPA can be found in Chapter 6 of *Technical Report #2: State of Current System*[8], and the transit needs can be found in Chapter 7 of *Technical Report #4: Needs Assessment*[9].

Bicycle and Pedestrian

Although bicycling and walking currently accounts for a relatively small portion of commuting patterns in Tennessee and Kentucky, a seamless bicycle and pedestrian network would provide the MPA with a viable alternative to motor vehicle transportation and reduce the level of congestion by removing SOVs from the roadway network. Additionally, this network would produce benefits for the health of the MPA's residents and workers while improving regional air quality. Examples of bicycle and pedestrian facilities are shown in **Table 1.1**.

[9] http://www.cuampo.com/wp-content/uploads/2024/01/Clarksville_2050_MTP_Tech_Report_4_Needs_Assessment_122223.pdf

Table 1.1: Examples of Bicycle and Pedestrian Facilities

	Types of Facilities
Bicycle Facilities	• Bicycle lanes • Paved shoulders • Marked shared lanes • Shared use paths • Cycle tracks • End of trip facilities
Pedestrian Facilities	• Sidewalks • Crosswalks • Enhanced pedestrian treatments • Pedestrian amenities • Shared used paths • Curb ramps • Transit stops • Pedestrian signals

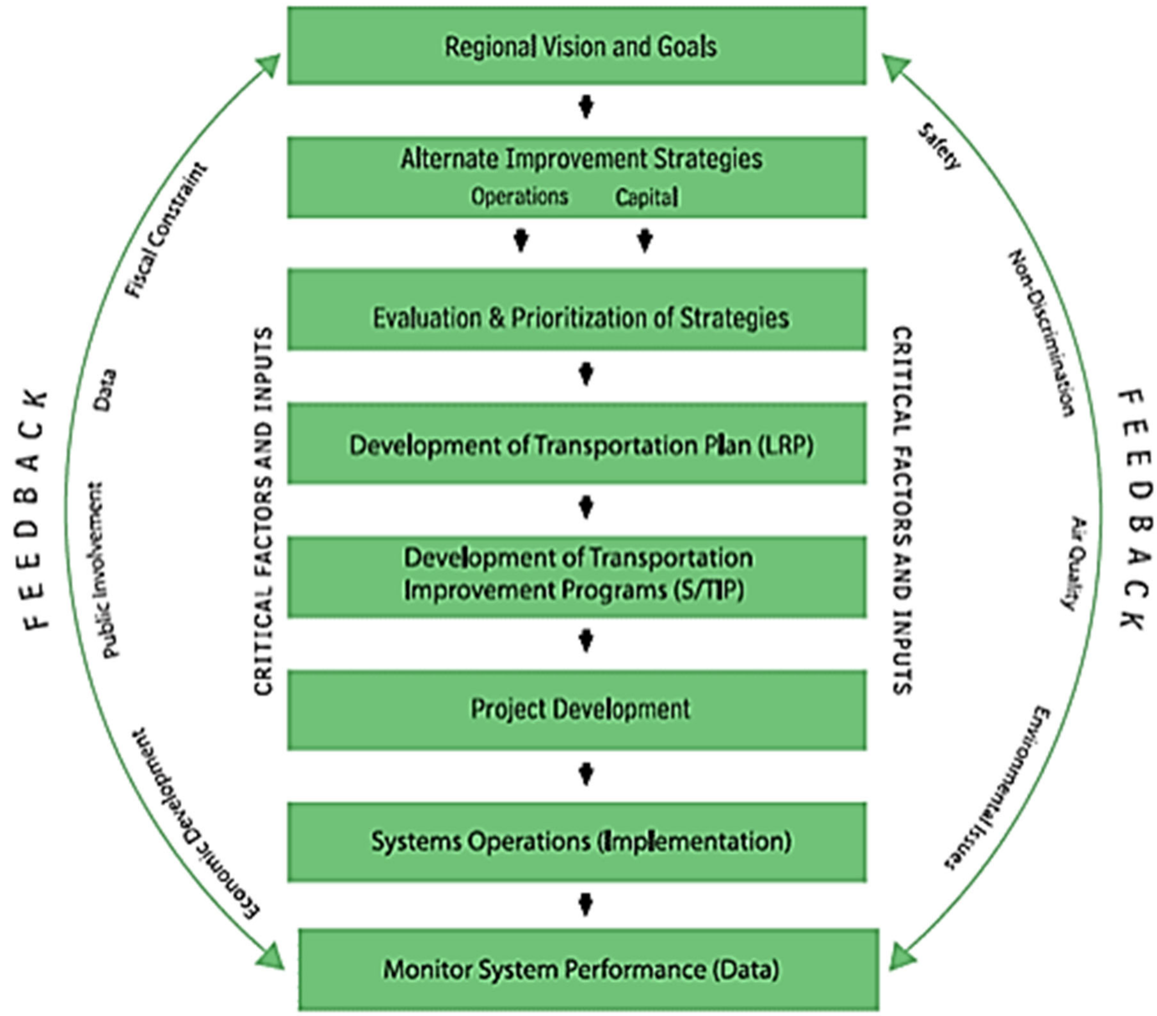
The current bicycle and pedestrian conditions in the MPA can be found in Chapter 5 of *Technical Report #2: State of Current System*[8], and the bicycle and pedestrian needs can be found in Chapter 6 of *Technical Report #4: Needs Assessment*[9].

1.7 The CMP Framework

Figure 1.2 Illustrates where the congestion management process fits within the broader planning perspective. The CMP is integrated into the development of the MTP goals and objectives, identification and evaluation of alternative strategies and final development of the MTP and TIP. In addition, the CMP could be utilized by regional stakeholders to:

- Develop numerous solutions for congestion mitigation and select the optimum alternative that addresses each issue
- Creating data driven analysis mechanisms that utilizes historical and real-time congestion data to continuously monitor and analyze congestion problems and needs
- Adopting other successful plans and strategies from other metropolitan areas nationwide

Figure 1.2: CMP and the Overall Planning Process



Source: https://www.fhwa.dot.gov/planning/congestion_management_process/cmp_guidebook/cmpguidebk.pdf

2.0 The Clarksville MPO Eight-Step Process

2.1 Step 1: CUAMPO Congestion Management Objectives

Several key transportation goals guided the development of the 2050 Metropolitan Transportation Plan (MTP) to work towards the vision of the Clarksville MPA's future transportation network. The following goals of the 2050 MTP are applicable for the CMP.

- Provide a safe transportation system
- Provide a well-maintained transportation system
- Provide a multimodal transportation system
- Provide a reliable and resilient transportation system
- Develop an economically and environmentally sustainable transportation system that provides equitable participation and beneftis across the diversity of the MPA

To achieve these goals, the following CMP objectives are established:

- Improve the following elements of the transportation system
    - Mobility
    - Connectivity
    - Accessibility
    - Reliability
    - Travel times
    - Safety
- Provide various modes of travel options in the Clarksville MPA

Segments that experience significant congestion can have a negative impact on the system performance, as well as the safety performance, of the MPA's roadway network. Actions that improve these segments can potentially improve regional performance to satisfy the established CUAMPO targets. More information on transportation performance measures can be found in *Technical Report #3: Transportation Performance Management*[10].

[10] http://www.cuampo.com/wp-content/uploads/2024/01/Clarksville_2050_MTP_Tech_Report_3_TPM_122223.pdf

2.2 Step 2: CMP Network

The MPA's overall roadway network consists of five facility types. The facility types are:

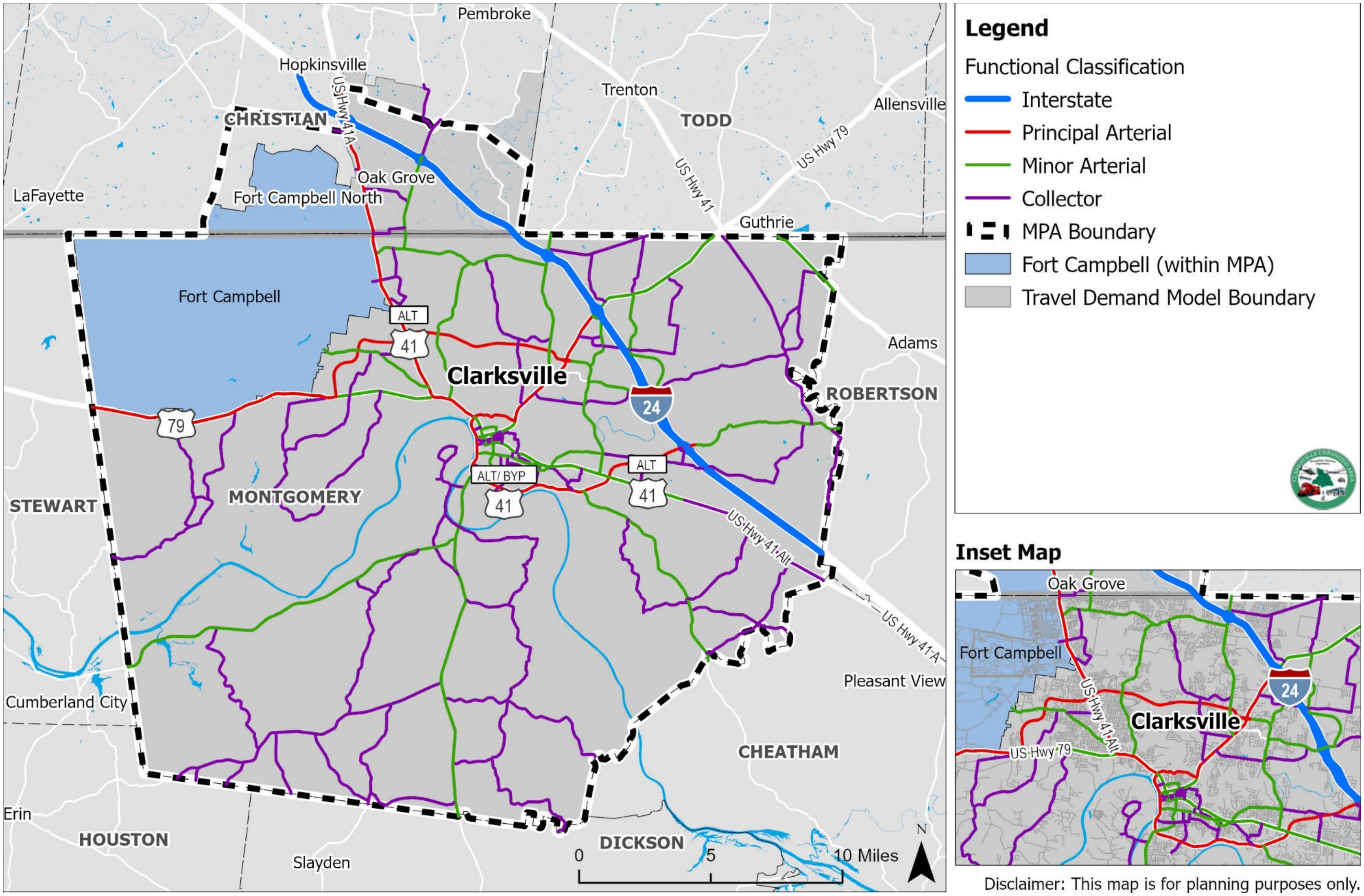
- Interstates
- Principal Arterials
- Minor Arterials
- Collectors
- Local Roads

Each facility type provides separate and distinct traffic service functions, which are described in *3.2 The Roadway Network* of *Technical Report #2: State of Current System*[8]. Their designs vary in accordance with the characteristics of traffic to be served by the facility.

The CMP network includes all roadways within the TDM network that are functionally classified as a Collector or above.

The boundaries of the MPA, and its CMP network, are shown in **Figure 2.1**.

Figure 2.1: MPA and CMP Network



Disclaimer: This map is for planning purposes only.

Source: TDOT, KYTC

2.3 Step 3: CMP Data

This section describes the data sources used to conduct the congestion analysis within the MPA.

Probe Data Analytics (PDA) Suite/The National Performance Management Research Data Set (NPMRDS)

The PDA Suite[11], which can be accessed from the Regional Integrated Transportation Information System (RITIS) website, allows agencies to support operations, planning, analysis, research, and performance measures generation using probe data mixed with other agency transportation data.

The suite consists of a collection of data visualization and retrieval tools. These web-based tools allow users to download reports, visualize data on maps or in other interactive graphics, and even download raw data for offline analysis. Each tool has its own unique purpose. Among many other uses, the PDA Suite can provide insight on:

- Real-time Speed Data
- Travel Time Index
- Travel Time Reliability metrics
- Queue Measurements
- Statewide bottleneck ranking
- Corridor Congestion Charts

For this CMP effort, the *Bottleneck Ranking Tool* was used. This tool gathers all bottlenecks found within a specified range of dates along a corridor and ranks the congested portions of the road based on either the number of occurrences found, the queue size, or the duration of the bottlenecks. This tool allows for quick and easy identification of regularly congested roads.

Travel Demand Model (TDM)

The Metropolitan Planning Organization's (MPO) TDM predicts trip-making behavior such as the number of trips, their origins and destinations, and most probable trip routes. The TDM used for this CMP has an existing (base) year of 2019 and a horizon year of 2050. The TDM contains data on existing conditions, socioeconomic forecasts, and anticipated growth in external trips to replicate current travel demand and develop forecast travel demand on

[11] https://www.cattlab.umd.edu/?portfolio=vehicle-probe-project-suite

the MPA's roadway network. It can also be used to conduct a congestion analysis for future conditions.

Google Traffic

A feature in Google Maps, Google Traffic displays traffic data using colored overlays on top of roads to represent the observed speed of traffic. It uses crowdsourcing from Google users to obtain the GPS locations of cellphone users and generates live traffic maps along roadway segments. This data, shown on a scale from fast (representing minimal or no congestion) to slow (representing heavy congestion), is displayed on a map. The data displays traffic conditions along a particular section of roads at specific times on specific days. Google Traffic was used to corroborate the congested segment results obtained from the PDA and NPMRDS data, which uses data from third-party vendors INRIX, TomTom, and HERE.[12]

Crash Data

Crash data obtained from the Tennessee Department of Transportation (TDOT) and the Kentucky Transportation Cabinet (KYTC) was used to identify non-recurring congestion, since incidents along a roadway may result in excessive delays. The crash records included latitude and longitude data, as well as the:

- Time
- Location (Intersection or roadway segment)
- Severity
- Crash Type
- Location conditions (e.g. Pavement condition, weather)

2.4 Step 4: Performance Measures

Performance measures are the essential instruments to properly quantify and monitor the regional transportation system in general and traffic congestion in specific. They help identify and track congestion development, intensity, and impacts. Thus, the adequacy of congestion mitigation strategies could be evaluated and recalibrated.

[12] The National Performance Management Research Data Set (NPMRDS) and Application for Work Zone Performance Measurement - FHwA Office of Operations

Federal Guidelines for Measuring Congestion

Section 450.322 (d)(3) of Subpart C (Congestion Management Process in Transportation Management Areas), 23 CFR (Final Rule) states that a Congestion Management Process shall include:

> "Establishment of a coordinated program for data collection and system performance monitoring to define the extent and duration of congestion, to contribute in determining the causes of congestion, and evaluate the efficiency and effectiveness of implemented actions. To the extent possible, this data collection program should be coordinated with existing data sources (including archived operational/ITS data) and coordinated with operations managers in the metropolitan area."

The FHWA recommended that effective performance measures should incorporate the following characteristics:

- Include quantifiable data that are simple to present and interpret and have professional credibility,
- Describe existing conditions and can be used to identify problems and to predict changes,
- Can be calculated easily and with existing field data, uses techniques available for estimating the measure, and achieves consistent results,
- Applicable to multiple modes and is meaningful at varying scales and settings.

Congestion Metrics

The following performance metrics are used in this CMP effort. They serve as indicators to characterize the usage of a transportation facility or the characteristics of travelers using the system. These metrics were used to determine which roadway segments are congested, with the methodology described in later sections.

Bottleneck Ranking Tool Metrics

The Bottleneck Ranking Tool allows users to identify, rank, and explore bottleneck locations on the roadway. The following metrics provided in the Bottleneck Ranking Tool are summarized in **Table 2.1**.

Table 2.1: Bottleneck Ranking Metrics

Metric		Description
Bottleneck Profile	Average Max Length (miles)	The average maximum length (in miles) of queues formed by congestion originating at each location.
	Average Daily Duration	The average amount of time per day that congestion is identified originating at each location.
	Total Duration	The total amount of time each location congestion was identified originating at each location.
Influences	All Events/Incidents	The number of traffic events and incidents that occurred within the space of the bottleneck at any time during the time period that was searched.
Base Impact	Base Impact	The aggregation of queue length over time for congestion originating at each location in mile-minutes.
Weight Base Impact	Speed Differential	Raw speed drop weighted by queue lengths.
	Congestion	Speed drop adjusted by bottleneck activation threshold, weighted by queue length.
	Total Delay	Raw speed drop weighted by VMT Factor.

Source: RITIS Bottleneck Ranking Tool

The table provided in the Bottleneck Ranking Tool is, by default, sorted by the ***Total Delay***. The ranking of the bottlenecks was based on the ***Total Delay*** that is calculated using the observed travel time data provided by the Probe Data Analytics (PDA) suite.

Travel Time Index (TTI)

The TTI measures the amount of time delay that occurs when travelling a roadway segment. It is calculated by dividing the highest peak travel time (morning, midday, or afternoon) by the free-flow travel time. The TTI represents the increased travel time drivers experienced when travelling compared to the free-flow travel time.

The TTI was measured by:

- Calculating the average travel time for three (3) different time periods
    - Morning "AM" Peak Period (6:00 AM - 9:00 AM)
    - Midday “MD” Peak Period (9:00 AM – 3:00 PM)
    - Afternoon "PM" Peak Period (3:00 PM - 6:00 PM)

  - The nighttime “NT” travel times (6:00 PM and 6:00 AM) were not calculated due to the lower traffic volumes.
- Calculating the free-flow travel time of a segment using its free-flow speed
- Dividing the highest of the three peak travel times (AM, MD, or PM) by the free-flow travel time.

The equation used to calculate the TTI is shown below:

$$TTI = \frac{Highest\ Peak\ Period\ Travel\ Time}{Freeflow\ Travel\ Time}$$

Where:

- TTI – Travel Time Index
- Highest Peak Period Travel Time – the highest of the three peak period travel times (AM, MD, or PM)
- Free-flow Travel Time – the travel time at free-flow speed (typically the posted speed in the Travel Demand Model; however, these values were adjusted during model calibration using reasonableness checks and additional datasources such as INRIX probe data.)

TTI Example

- *The highest peak period travel time on A Street between B Avenue and C Avenue is three (3) minutes.*
- *The free-flow travel time on this segment is one (1) minute.*
- *Divide three (3) minutes, the highest peak period travel time, by one (1) minute, the free-flow travel time.*
- *This results in a TTI of 3.0, which implies that it takes three (3) times longer to travel this segment during the peak period.*

The results from the TTI study for each peak travel time (AM, MD, or PM) are shown in **Appendix A**.

Vehicle Hours Delay (VHD)

The annual vehicle hours of delay (VHD) are calculated by subtracting the estimated vehicle-hours traveled (VHT) if all travel demand were at free-flow speed from the VHT at the actual travel speed. The existing (2019) and future (2050) daily VHD can be obtained from the TDM to forecast the projected change in VHD between 2019 and 2050. The results of the VHD study are shown in **Appendix B**.

Volume-to-Capacity (V/C) Ratios

The V/C ratio is defined as the demand flow rate over the capacity available for a traffic facility. For this CMP effort, the TDM volumes and capacities for each network link were used to develop the V/C ratio, which compares the existing traffic volumes to the capacity the roadways were designed to handle. The time of day (Morning, Midday, Afternoon, and Night) capacity factors developed in the TDM are discussed in *Technical Report #1: Transportation Modeling and Forecasting*[13]. The model volumes and capacities can be found in the TDM's network files.

Segments with a V/C ratio greater than 1.00 are considered over capacity. The results of the V/C ratio study for each peak travel time (AM, MD, PM, or NT) are shown in **Appendix C**.

Many corridors in the MPA have received capacity improvements between 2016, the base year of the previous Metropolitan Transportation Plan (MTP), and 2019, the base year of the current MTP. **Table 2.2** displays the corridors in the CMP network that have received capacity improvements between 2016 and 2019.

Table 2.2: Roadways with Improved Capacity between 2016 and 2019

Roadway	Limits	Previous Facility Type (2016)	New Facility Type (2019)
US 41A/SR 112 (Madison St)	SR 76 to McAdoo Road/Sango Road	2 lanes	5 lanes
Oakland Road	US 79/SR 13 to Oakland Road	2 lanes	2 lanes realigned
US 79/SR 13 (Guthrie Highway)	Cracker Barrel Drive to International Boulevard	2/3 lanes	5 lanes
SR 374 (Warfield Boulevard)	Dunbar Cave Road to Stokes Road	2 lanes	5 lanes

[13] http://www.cuampo.com/wp-content/uploads/2024/01/Clarksville_2050_MTP_Tech_Report_1_Model_Development_122223.pdf

2.5 Step 5: Congestion Analysis

Recurring Congestion

Prioritization of Recurring Congested Segments

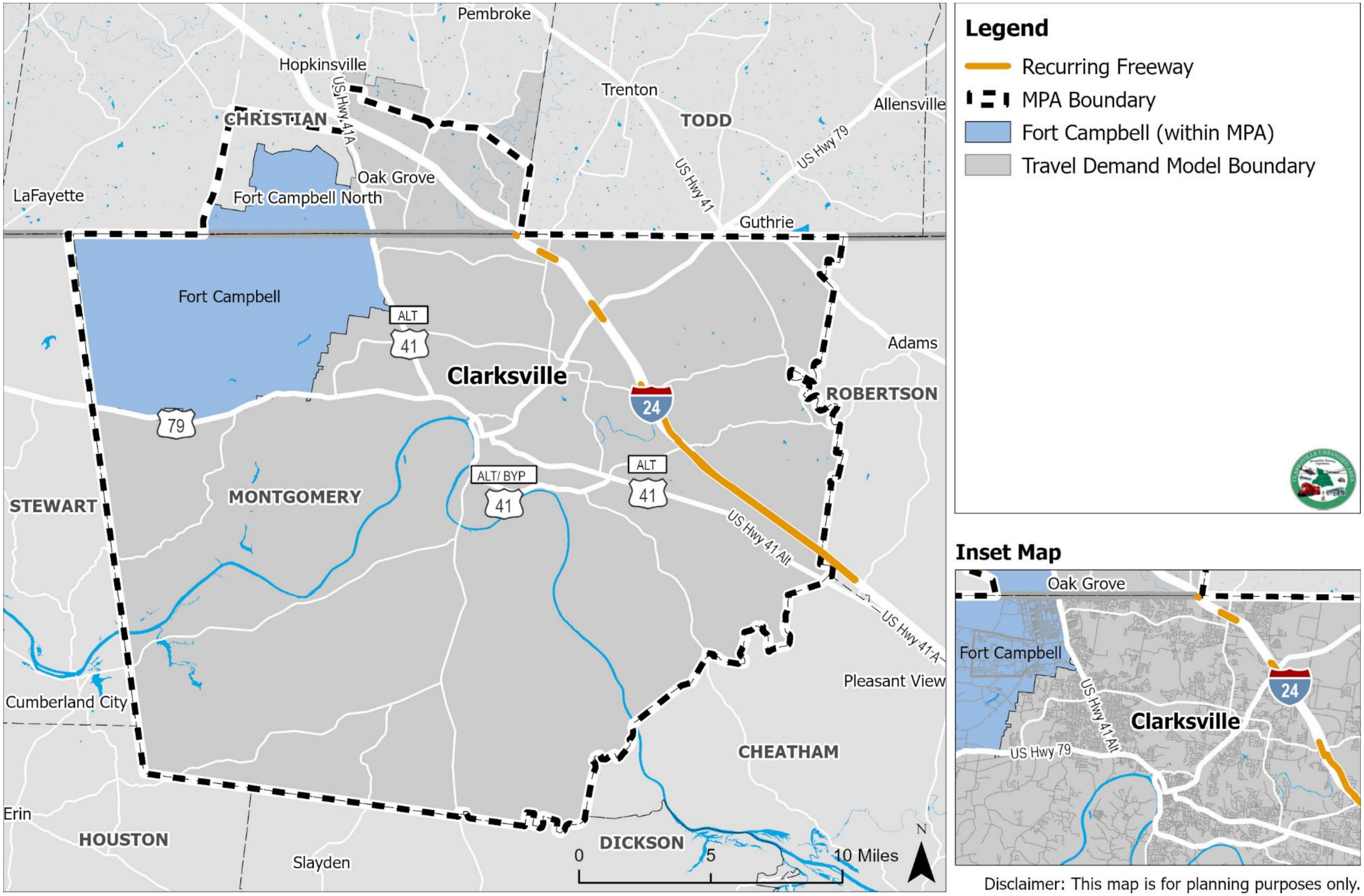
As mentioned in *2.3 Step 3: Performance Measures*, the ***Total Delay*** from the Bottleneck Ranking Tool is used to rank and compare the bottlenecks. The ranking of the bottlenecks was based on the ***Total Delay*** that is calculated using the observed travel time data provided by the PDA suite.

The duration of congestion, type of congestion, traffic volumes, and potential solutions to reduce congestion are different between freeways and arterials. Also, in the Clarksville MPA, three (3) out of the top ten (10) bottlenecks are on freeways (I-24). Therefore, separate rankings for freeways (I-24) and arterials are presented in this document.

The Bottleneck Ranking Tool indicated that there were 11 bottlenecks on I-24 and 103 bottlenecks on arterials in the Clarksville MPA in 2023. Of note, the ***Total Delay*** for the 11th ranked I-24 bottleneck is substantially lower than the ***Total Delay*** for 10th ranked I-24 bottleneck. Therefore, for this analysis, the top 10 freeway (I-24) bottlenecks and the top 25 arterial bottlenecks based on the highest ***Total Delays*** were used. **Table 2.3 and Table 2.4** show the Top 10 congested freeway and Top 25 arterial segments based on the PDA Bottleneck Ranking Tool, respectively. These segments are also presented in **Figure 2.2 and Figure 2.3**.

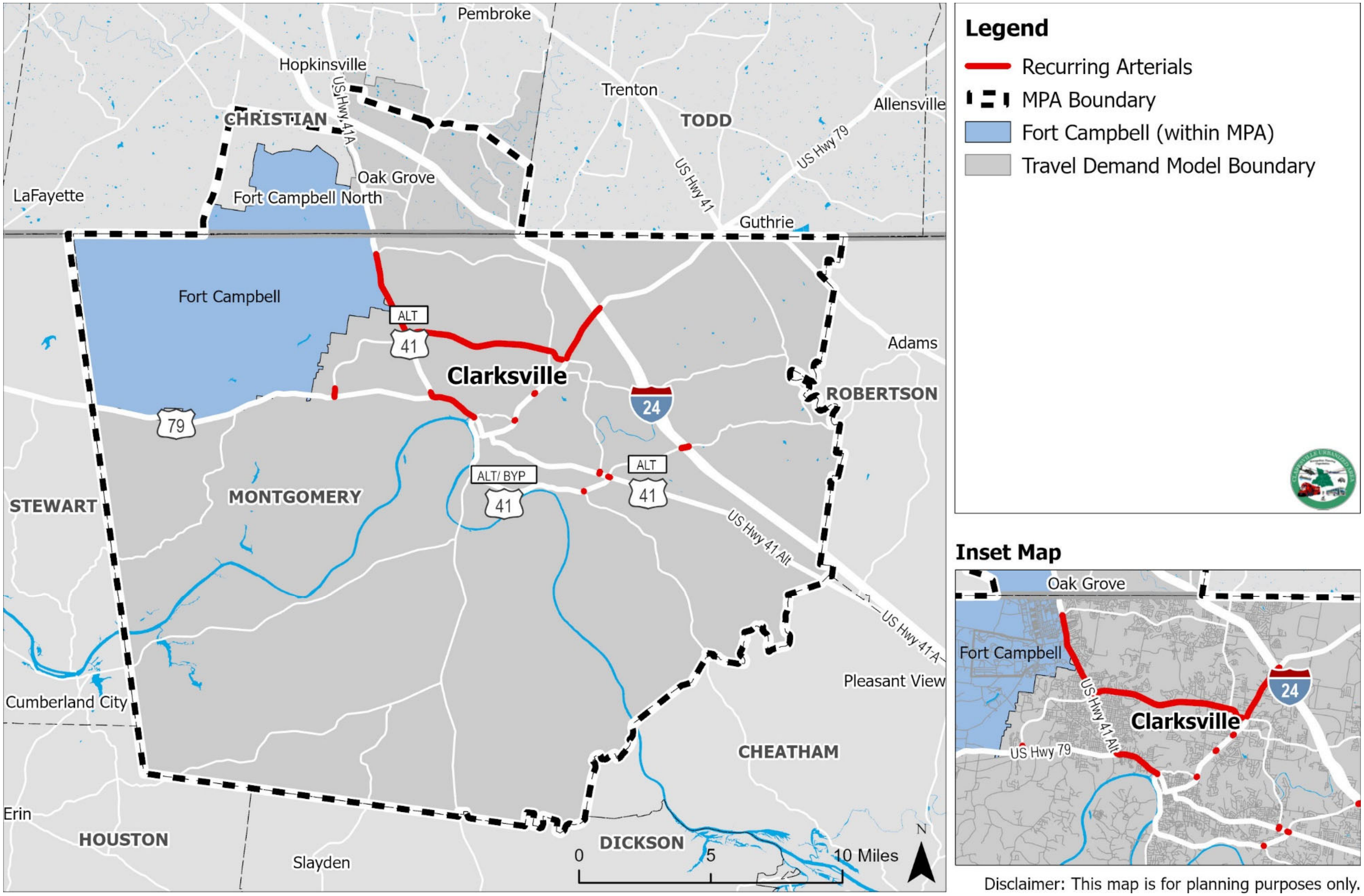
Tables 2.3 and 2.4 also display the TTI and V/C ratios for each corridor. Of the top 10 congested freeway segments, one (1) segment has a maximum peak period TTI of at least 1.50, and three (3) segments have a maximum peak period V/C ratio of greater than 1.00. Of the top 25 congested arterial segments, all 25 segments have a maximum peak period TTI of at least 1.50, and 15 segments have a maximum peak period V/C ratio greater than 1.00.

Figure 2.2: Top 10 Recurring Freeway (I-24) Bottlenecks



Source: Probe Data Analytics

Figure 2.3: Top 25 Recurring Arterial Bottlenecks



Source: Probe Data Analytics

Table 2.3: Top 10 Recurring Congested Freeway (I-24) Segments

Rank	Roadway	Segment	Average Maximum Bottleneck Length (miles)	Average Daily Duration of Congestion	Total Duration of Congestion	Total Delay (Vehicle Hours)	Maximum Peak Period TTI[1]	TTI Peak Period	Maximum Peak Period V/C[2]
1	I-24 Eastbound	SR 76 On-Ramp to Montgomery/Robertson County Line	9.46	15 m	3 d 19 h 20 m	41,580,608	1.20	AM	1.11
2	I-24 Westbound	Robertson/Montgomery County Line to SR 76 Off-Ramp	9.35	15 m	3 d 21 h 31 m	37,037,583	1.23	PM	1.13
3	I-24 Westbound	At Tennessee/Kentucky State Line	3.19	21 m	5 d 10 h 27 m	25,310,395	1.29	MD	0.91
4	I-24 Westbound	SR 76 On-Ramp to SR 237 (Rossview Road) Off-Ramp	5.81	5 m	1 d 9 h 2 m	8,242,528	1.19	PM	1.18
5	I-24 Eastbound	Between SR 237 (Rossview Road) Ramps	2.69	3 m	23 h 32 m	4,169,469	1.73	PM	0.84
6	I-24 Eastbound	Between SR 76 Ramps	3.15	4 m	1 d 2 h 7 m	3,684,409	1.26	PM	0.78
7	I-24 Westbound	Between SR 48 Ramps	7.86	0 m	5 h 50 m	1,675,265	1.36	MD	0.78
8	I-24 Westbound	Between US 79 (SR 13) Ramps	8.52	0 m	4 h 14 m	1,269,439	1.20	PM	0.66
9	I-24 Eastbound	Between US 79 (SR 13) Ramps	2.30	1 m	11 h 32 m	1,174,669	1.28	MD & PM	0.73
10	I-24 Eastbound	Between SR 48 Ramps	1.39	0 m	5 h 46 m	171,962	1.18	MD	0.78

NOTE 1: The following color codes were used for the Maximum Peak Period TTI.

- Green: TTI less than 1.50
- Yellow: TTI between 1.50 and 1.99
- Orange: TTI between 2.00 and 2.99
- Red: TTI greater than or equal to 3.00

NOTE 2: The following color codes were used for the Maximum Peak Period V/C.

- Green: V/C less than to equal to 0.50
- Yellow: V/C between 0.51 and 0.75
- Orange: V/C between 0.76 and 1.00
- Red: V/C between 1.01 and 1.20
- Purple: V/C greater than 1.20

Table 2.4: Top 25 Recurring Congested Arterial Segments

Rank	Roadway	Segment	Average Maximum Bottleneck Length (miles)	Average Daily Duration of Congestion	Total Duration of Congestion	Total Delay (Vehicle Hours)	Maximum Peak Period TTI[1]	TTI Peak Period	Maximum Peak Period V/C[2]
1	US 41A (SR 12) Northbound/US 79 (SR 76) Southbound/Providence Boulevard	US 41A/US 79 (SR 12/SR 13)/Riverside Drive to Peachers Mill Road	1.37	1 h 55 m	29 d 3 h 59 m	46,924,962	2.88	PM	1.69
2	US 41A (SR 12)/Fort Campbell Boulevard Northbound	US 79 (SR 76)/Dover Road to Dover Crossing Road	0.54	2 h 42 m	41 d 2 h 53 m	15,875,240	2.62	PM	0.68
3	SR 374/101st Airborne Division Parkway Westbound	SR 48/Trenton Road to Peachers Mill Road	4.66	21 m	5 d 13 h 31 m	15,305,093	2.23	PM	1.25
4	SR 374/101st Airborne Division Parkway Westbound	US 79 (SR 13)/Wilma Rudolph Boulevard to SR 48/Trenton Road	0.71	1 h 37 m	24 d 19 h 54 m	14,390,881	4.76	PM	1.02
5	US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	SR 374 to I-24 Eastbound	2.03	38 m	9 d 16 h 57 m	12,522,166	2.77	PM	1.09
6	US 79 (SR 76)/Dover Road Northbound	At US 41A (SR 12)/Providence Boulevard	0.10	11 h 12 m	170 d 12 h 44 m	9,591,152	2.67	PM	0.85
7	US 41A (SR 12)/Fort Campbell Boulevard Southbound	Dover Crossing Road to US 79 (SR 76)/Dover Road	0.21	4 h 46 m	72 d 16 h 20 m	8,417,762	3.05	MD	0.69
8	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	I-24 Westbound to I-24 Eastbound	0.36	2 h 4 m	31 d 15 h 56 m	8,413,519	3.62	PM	1.53
9	SR 374 (Richview Road) Southbound	At US 41A (SR 112)/Madison Street	0.21	5 h 49 m	88 d 15 h 19 m	7,404,997	4.05	MD	0.97
10	SR 374/101st Airborne Division Parkway Eastbound	Peachers Mill Road to SR 48/Trenton Road	4.56	7 m	1 d 21 h 51 m	6,921,302	1.74	AM	1.28

Rank	Roadway	Segment	Average Maximum Bottleneck Length (miles)	Average Daily Duration of Congestion	Total Duration of Congestion	Total Delay (Vehicle Hours)	Maximum Peak Period TTI[1]	TTI Peak Period	Maximum Peak Period V/C[2]
11	US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	Peachers Mill Road to US 41A/US 79 (SR 12/SR 13)/Riverside Drive	1.99	15 m	3 d 21 h 6 m	6,889,408	1.96	AM	1.77
12	SR 374/101st Airborne Division Parkway Eastbound	US 41A (SR 12)/Fort Campbell Boulevard On-Ramp to Peachers Mill Road	1.05	22 m	5 d 18 h 51 m	6,680,057	2.68	PM	1.13
13	SR 76 Eastbound	I-24 Eastbound to I-24 Westbound	0.60	1 h 33 m	23 d 15 h 42 m	5,536,896	4.43	AM	1.02
14	US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	At Dunbar Cave Road	0.11	4 h 27 m	67 d 19 h 21 m	4,236,472	3.10	PM	1.43
15	US 41A Bypass (SR 12/SR 13)/Riverside Drive Northbound	At US 41A/US 79 (SR 12/SR 76/SR 112)/Providence Boulevard	0.11	4 h 45 m	72 d 7 h 24 m	4,180,667	3.27	PM	0.90
16	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At SR 48/Trenton Road	0.10	5 h 20 m	81 d 6 h 56 m	4,033,467	3.05	PM	1.09
17	US 41A (SR 12)/Fort Campbell Boulevard Southbound	SR 236/Tiny Town Road to SR 374	3.46	4 m	1 d 4 h 9 m	3,689,194	1.52	PM	0.99
18	US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	US 79 (SR 76)/Dover Road to Peachers Mill Road	0.76	16 m	4 d 2 h 49 m	3,569,566	2.69	AM	1.32
19	SR 12/Ashland City Road Northbound	At US 41A Bypass (SR 12/SR 76)	0.03	14 h 54 m	226 d 17 h 5 m	3,170,423	4.35	AM	0.95
20	US 41A (SR 112)/Madison Street Eastbound	At US 41A Bypass (SR 76)	0.16	3 h 21 m	50 d 23 h 26 m	2,978,230	3.36	PM	1.48

Rank	Roadway	Segment	Average Maximum Bottleneck Length (miles)	Average Daily Duration of Congestion	Total Duration of Congestion	Total Delay (Vehicle Hours)	Maximum Peak Period TTI[1]	TTI Peak Period	Maximum Peak Period V/C[2]
21	US 79 (SR 13/SR 48)/Wilma Rudolph Boulevard Southbound	At US 79 (SR 13)/Kraft Street)	0.23	1 h 15 m	19 d 5 h 26 m	2,805,298	2.39	PM	1.77
22	SR 76 Westbound	I-24 Westbound to I-24 Eastbound	0.29	1 h 51 m	28 d 4 h 51 m	2,740,603	3.02	PM	0.85
23	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At Dunbar Cave Road	0.12	1 h 26 m	21 d 19 h 49 m	2,720,705	2.61	PM	1.14
24	US 41A (SR 12)/Fort Campbell Boulevard Northbound	SR 374 to SR 236/Tiny Town Road	3.41	4 m	1 d 26 m	2,584,617	1.52	MD	0.97
25	SR 374 (Paul B Huff Memorial Parkway) Southbound	At US 79 (SR 76)/Dover Road	0.38	1 h 26 m	21 d 20 h 10 m	2,335,828	3.77	PM	0.46

NOTE 1: The following color codes were used for the Maximum Peak Period TTI.

- Green: TTI less than 1.50
- Yellow: TTI between 1.50 and 1.99
- Orange: TTI between 2.00 and 2.99
- Red: TTI greater than or equal to 3.00

NOTE 2: The following color codes were used for the Maximum Peak Period V/C.

- Green: V/C less than to equal to 0.50
- Yellow: V/C between 0.51 and 0.75
- Orange: V/C between 0.76 and 1.00
- Red: V/C between 1.01 and 1.20
- Purple: V/C greater than 1.20

<u>Bottleneck Ranking Tool Limitations</u>

Figures 2.2 and 2.3, along with **Tables 2.3 and 2.4**, show the top 10 congested freeway and top 25 congested arterial segments based on the PDA Bottleneck Ranking Tool, respectively. However, some of the segments that are in between two congested segments are not shown in **Table 2.3, Table 2.4, Figure 2.2, or Figure 2.3**. This does not indicate that the segment is not congested, but rather that it is not in the top lists. An example screenshot of this bottleneck ranking limitation is shown in **Figure 2.4**.

Additionally, there were no bottlenecks found in the Bottleneck Ranking Tool for the Christian County, Kentucky portion of the MPA. This does not indicate that there are no bottlenecks in the Christian County, Kentucky portion of the MPA, just that the Bottleneck Ranking Tool did not find any bottlenecks.

Finally, the Bottleneck Ranking Tool coverage is limited to NHS roads and **Tables 2.3 and 2.4** only show the top 10 congested freeway and top 25 congested arterial segments based on the PDA Bottleneck Ranking Tool. Therefore, locations where the Daily TDM V/C ratio exceeds 1.00 during at least one peak period were compared with the bottleneck locations shown in **Tables 2.3 and 2.4**. The locations where the Daily TDM V/C ratio exceed 1.00 but are not shown in **Tables 2.3 and 2.4** are shown in **Table 2.5**.

Figure 2.4: Bottleneck Limitation Example

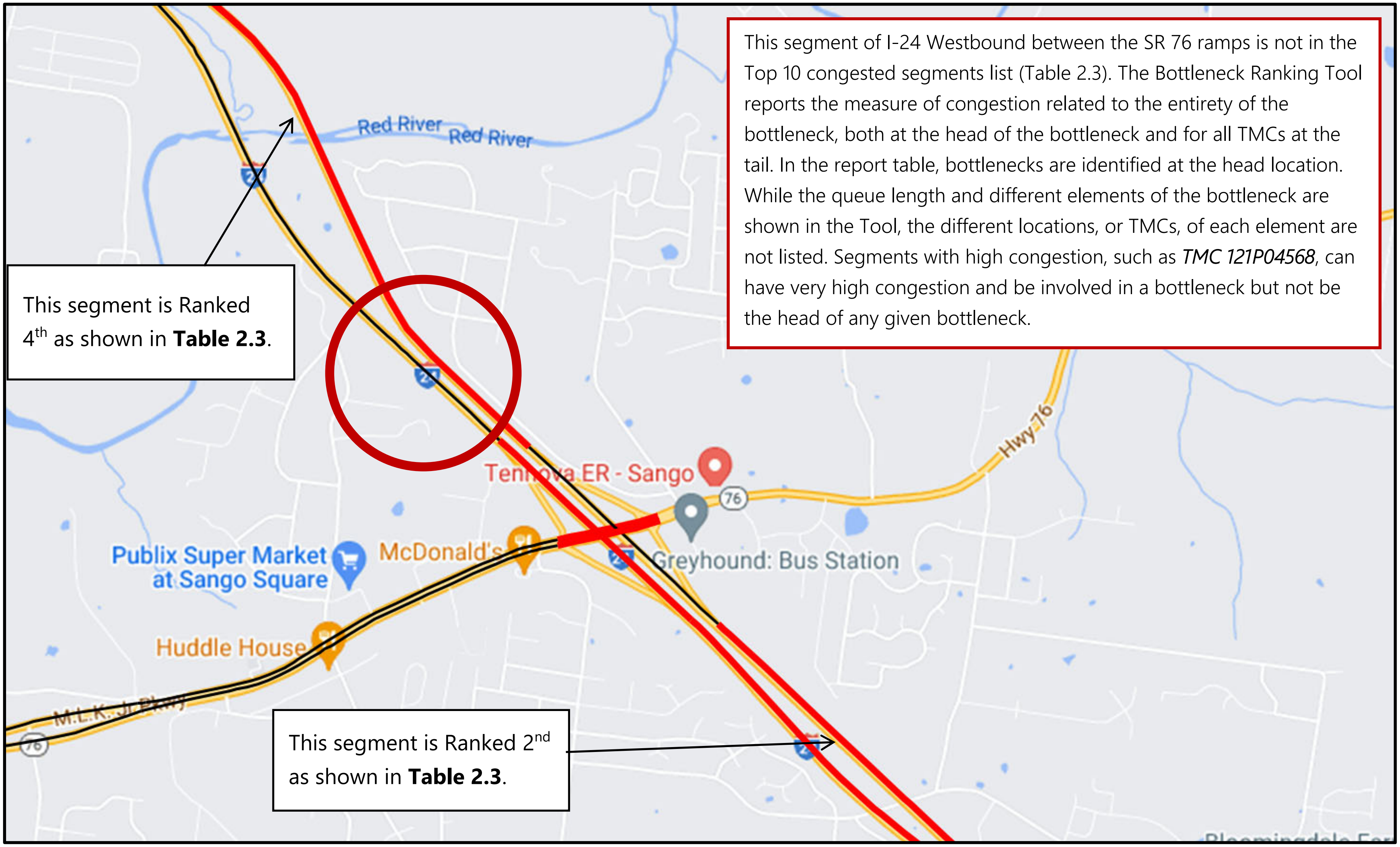


Table 2.5: Daily TDM V/C Greater than 1.00 Locations

Roadway	Segment	Length (miles)	Daily TDM V/C[1]
I-24 Eastbound	Off-Ramp to US 79 (SR 13)	0.37	1.25
I-24 Eastbound	On-Ramp from SR 237	0.24	1.20
I-24 Eastbound	Off-Ramp to SR 76	0.25	1.48
I-24 Eastbound	On-Ramp from SR 76	0.42	1.13
I-24 Westbound	Off-Ramp to SR 76	0.34	1.13
I-24 Westbound	On-Ramp from SR 76	0.33	1.48
I-24 Westbound	Off-Ramp to SR 237	0.26	1.09
I-24 Westbound	On-Ramp from US 79 (SR 13)	0.35	1.34
SR 48/College Street US 79 (SR 13)/College Street/Wilma Rudolph Boulevard	Hornberger Lane to Old Trenton Road	1.04	1.12
US 79 (SR 13)/Wilma Rudolph Boulevard	Summit Lane to Dunbar Cave Road	0.19	1.00
US 79 (SR 13)/LG Highway	I-24 Westbound to Alfred Thun Road/Cracker Barrel Drive	0.09	1.15
US 79 (SR 13)/Guthrie Highway	Boolean Drive/International Boulevard to 0.87 miles east of Hampton Station Road	2.38	1.23
US 41A Bypass (SR 12)/Ashland City Road	Old Ashland City Road to SR 12/Ashland City Road	0.46	1.13
US 41A (SR 112)/Madison Street	SR 374/Richview Road to SR 76/M.L.K. Jr Parkway	0.39	1.07
SR 13/SR 48	SR 149 to US 41A Bypass (SR 12)/Riverside Drive	2.48	1.12
SR 48/Trenton Road	SR 374 to Lowes Dr	0.12	1.08
SR 48/Trenton Road	Needmore Road to Branson Way	2.64	1.12
SR 48/Trenton Road	I-24 Eastbound to Tylertown Road	0.40	1.26
SR 374 Eastbound	Off-Ramp to US 79 (SR 13)/Wilma Rudolph Boulevard	0.07	1.08
SR 374 Westbound	On-Ramp from US 79 (SR 13)/Wilma Rudolph Boulevard	0.12	1.07
SR 374/Warfield Boulevard	Stokes Road to SR 237/Rossview Road	1.00	1.23
SR 374/Warfield Boulevard	Dunbar Cave Road to Memorial Drive	2.07	1.28
SR 236/Tiny Town Road	Peachers Mill Road to Needmore Road	0.68	1.04
SR 237/Rossview Road	Dunbar Cave Road to Powell Road	0.43	1.05
SR 76	Sango Road to I-24 Eastbound	0.07	1.10
Tylertown Road	McClain Drive to Suiter Road	0.55	1.05
Meriwether Road	Glenhurst Way to Oakland Road	0.76	1.19
Needmore Road	SR 48/Trenton Road to US 79 (SR 13)/Wilma Rudolph Boulevard	0.95	1.26
Peachers Mill Road	Mill Creek Road to SR 374	0.57	1.25
Whitfield Road	SR 374 to Needmore Road	0.22	1.11
Dunlop Lane	Alexander Boulvard to International Boulevard	0.36	1.18
Evans Road	Garrettsburg Road to Lafayette Road	0.04	1.01

Roadway	Segment	Length (miles)	Daily TDM V/C[1]
Hornberger Lane	SR 48/College Street to Franklin Street	0.10	1.16
Zinc Plant Road	River Road to SR 13/SR 48	0.53	1.15

NOTE 1: The following color codes were used for the Daily TDM V/C.

- Red: V/C between 1.01 and 1.20
- Purple: V/C greater than 1.20

Public and Stakeholder Meeting Identification

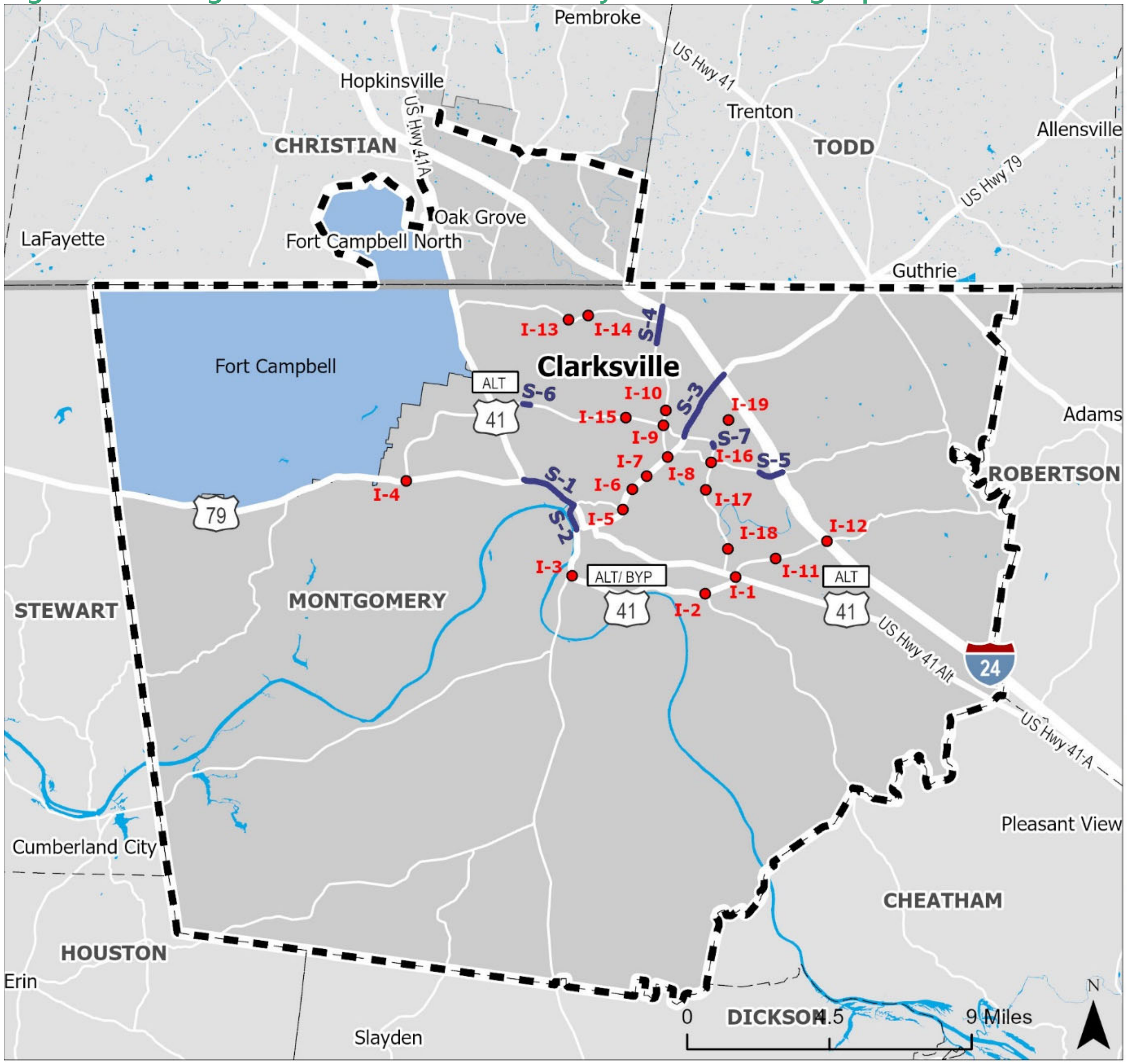
Public input was gathered from a series of in-person and online surveys, the latter of which using the MetroQuest platform. The first round of online engagement was in September 2023 that saw input from nearly 1,000 unique users to help identify driver behavior in the Clarksville area, infrastructure needs, and overall issues on the roadway. A second round of surveys were conducted in June/July of 2024 to assist in identifying goals and strategies to implement in the plan, which saw nearly 5,000 maps makers by citizens to detect known congestion and safety issues.

All feedback from the public and stakeholders' meetings are considered in the CMP and the locations identified by the public are listed in **Table 2.6** and shown in **Figure 2.5**.

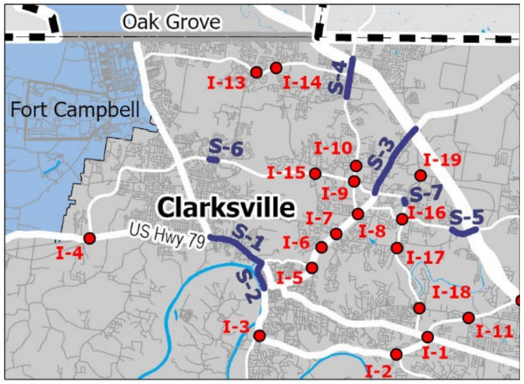
Table 2.6: Congested Locations Identified by Public Meeting Input

Segments		
ID	**Roadway**	**Segment**
S-1	US 41A (SR 12)/US 79 (SR 76)/Providence Boulevard	US 79 (SR 76)/Dover Road to US 79 (SR 13)/Kraft Street/Riverside Drive
S-2	US 41A Bypass (SR 12/SR 13)/Riverside Drive	SR 48/College Street to US 41A (SR 12)/Providence Boulevard
S-3	US 79 (SR 13)/Wilma Rudolph Boulevard	SR 374 to I-24
S-4	SR 48/Trenton Road	Hazelwood Road to I-24
S-5	SR 237/Rossview Road	Dunbar Cave Road to I-24
S-6	SR 374	Ringgold Road to Peachers Mill Road
S-7	SR 374	Ted A Crozier Sr. Boulevard to Bellamy Lane
Intersections		
ID	**Roadway**	**Intersection**
I-1	US 41A (SR 112)/Madison Street	At SR 76/M.L. King Jr. Parkway
I-2	US 41A Bypass (SR 76)/Ashland City Road	At SR 12/Ashland City Road
I-3	US 41A Bypass (SR 12)/Ashland City Road	At SR 12/SR 13 (Cumberland Drive)
I-4	US 79 (SR 76)/Dover Road	At SR 374
I-5	US 79 (SR 48)/College Street	At US 79 (SR 13)/Kraft Street
I-6	US 79 (SR 13)/Wilma Rudolph Boulevard	At Old Trenton Road
I-7	US 79 (SR 13)/Wilma Rudolph Boulevard	At West Dunbar Cave Road
I-8	US 79 (SR 13)/Wilma Rudolph Boulevard	At SR 48/Trenton Road
I-9	SR 48/Trenton Road	At SR 374
I-10	SR 48/Trenton Road	At Needmore Road
I-11	SR 76/M.L. King Jr. Boulevard	At Old Farmers Road
I-12	SR 76/M.L. King Jr. Boulevard	At I-24
I-13	SR 236/Tiny Town Road	At Peachers Mill Road
I-14	SR 236/Tiny Town Road	At Needmore Road
I-15	SR 374	At Whitfield Road
I-16	SR 374	At SR 237/Rossview Road
I-17	SR 374	At Dunbar Cave Road
I-18	SR 374	At Memorial Drive
I-19	Ted A Crozier Sr. Boulevard	At Dunlop Lane

Figure 2.5: Congested Locations Identified by Public Meeting Input



Inset Map



Disclaimer: This map is for planning purposes only.

Source: Neel-Schaffer, Inc.
Note: Boundaries reflected in this map are from the MTP 2050 public outreach.

<u>Summary</u>

Due to the limited scope of this study, location-specific recommendations for the identified top recurring segments have not been developed. Nonetheless, detailed corridor studies should be done for the identified top recurring segments to identify and validate the causes of recurring congestion as well as improvements to address these deficiencies.

Non-Recurring Congestion

Non-recurring congestion represents a greater influence on total congestion. As the physical capacity of our roadways is consumed by the growth in traffic that has been seen over the past 20 years, they also become more vulnerable to disruptions caused by traffic-influencing events such as traffic incidents, bad weather, and work zones. Further, these events can occur at any time and in places that don't usually experience congestion, thereby spreading congestion to more roadways and more times of the day.

The methodology[14] used to determine the roadway segments experiencing nonrecurring congestion was to:

- Group speed data into one-hour periods for a year and calculate the annual average speed and the annual standard deviation by hour for each segment.
- Group speed data into one-hour periods by hour and day and calculate the average speeds by hour.
- Tabulate the average speeds calculated in the previous steps, side by side, for all the speeds collected over the year 2023, for a specific time period (hour and day).
- Calculate the Standard Normal Deviate (SND) for each time period (hour and day) using the equation below.

$$SND_{i,j} = \frac{Speed_{i,j} - Annual\ Average\ Speed_i}{Annual\ Standard\ Deviation_i}$$

  Where
    - SND – Standard Normal Deviate
    - i – Hour
    - j – Day

Negative SND values that are greater than a selected threshold would indicate congestion beyond average levels. This indicates a high likelihood of non-recurring congestion. For this CMP effort, a threshold value of -1.5 was selected based on the research's sensitivity

[14] Andrew J. Sullivan, Virginia P. Sisiopiku, Bharat R. Kallem, "Measuring Non-Recurring Congestion in Small to Medium Sized Urban Areas" Prepared by the University Transportation Center for Alabama.

analysis. SND values which deviated by more than -1.5 (i.e., lower than -1.5) are indicative of non-recurring congestion speeds. Additionally, the delays for the time period (hour and day) where the SND deviated by more than -1.5 were calculated using the equation below.

$$Time\ Delay = \frac{Segment\ Length}{Segment\ Speed_i} - \frac{Segment\ Length}{Segment\ Annual\ Average\ Speed_i}$$

Where

- Segment length is in miles
- Segment speeds are in MPH
- Time delay is in hours
- i = Hour

With the methodology established, the following process was used to locate segments that experienced excessive non-recurring congestion in 2023:

- Calculate the SND and the time delay (in hours) for each segment
  - Any segments that had a calculated maximum delay of at least half an hour (30 minutes) in 2023 were considered to experience excessive non-recurring congestion.
- Calculate the five-year crash trends using the 2018-2022 TDOT and KYTC crash data for both total and fatality/serious injury crash frequencies.
  - The average yearly crash frequency was used to prioritize the segments experiencing excessive non-recurring congestion.

Crashes, especially those that result in a fatality or life-threatening injury or involve hazardous materials, can result in significant congestion and dramatically reduce the available capacity and reliability of the entire transportation system. Additionally, congestion can result in additional crashes.

The TDOT and KYTC crash data was used to identify trends in total crash frequency and those that resulted in a fatality or life-threatening injury. The high crash frequency and high crash rate locations within the Clarksville MPA are shown in *3.7 Roadway Safety* of *Technical Report #2: State of Current System*[8]. These locations were identified in ***Tables 3.9 through 3.13***, as well as ***Figures 3.11 through 3.13***, of that report. The MPA's safety needs, as well as ways to reduce the number of crashes, are summarized in *4.3 Roadway Safety Needs* of *Technical Report #4: Needs Assessment*[9].

Figure 2.6 displays the segments that experienced excessive non-recurring congestion in the year 2023. The non-recurring congestion trends for each segment are shown in **Table 2.7**.

Limitations

To develop a reliable methodology that identifies non-recurring congestion, a consistent and reliable travel time database is necessary. Speed data and travel times for each time interval (5-minute, 10-minute, 15-minute, or 1-hour) throughout an entire year is essential. However, the RITIS database contains several time intervals where speed and travel time data is unavailable or missing, making it difficult to perform an accurate and reliable non-recurring congestion analysis.

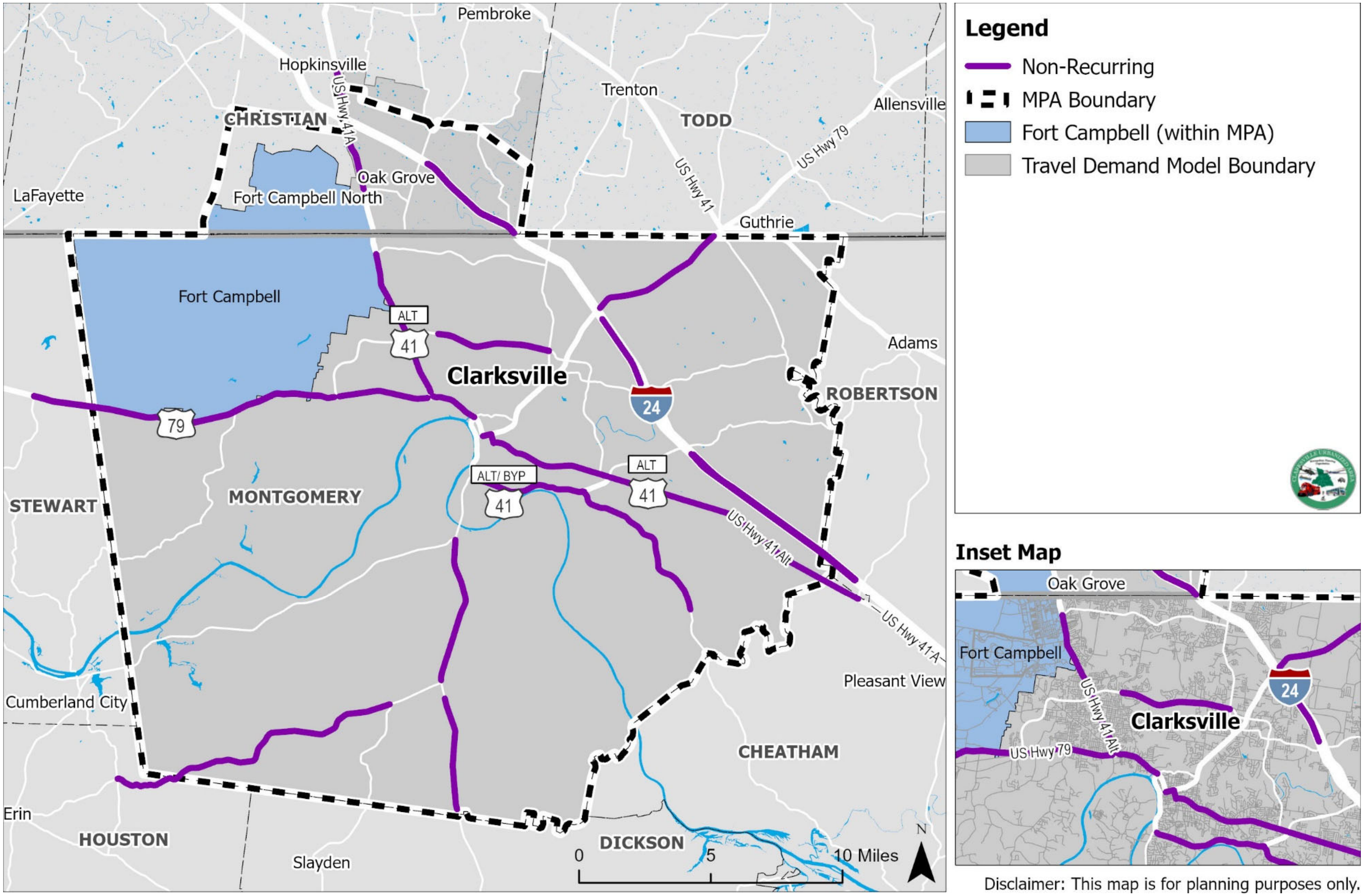
Additionally, the RITIS database travel time data is not available for each individual travel lane for multi-lane highways. However, with minor incidents, there is a chance that the impacts from the incident would negatively impact only the travel lane experiencing the incident and not the other travel lanes. This indicates that the incident would not be reflected in the RITIS database even though an incident had occurred.

Segment Prioritization

The segments displayed in **Figure 2.6** were ranked based on the five-year average crash frequency. **Table 2.7** shows the following:

- Frequency of non-recurring congestion incidents
- The maximum delay for a non-recurring congestion incident
- The 5-year trends for total crash frequency and fatal and life-threatening injury crash frequency for each segment.

Figure 2.6: Non-Recurring Congestion Segments



Source: Probe Data Analytics

Table 2.7: Non-Recurring Congestion Segments

Roadway	Segment	Length (miles)	2023 Non-Recurring Incidents	2023 Maximum Delay (Hours)	5-Year Annual Average Crash Frequency	5-Year Annual Average Fatal/Serious Injury Crash Frequency	5-Year Total Crash Trend	5-Year Fatal/Serious Injury Crash Frequency
SR 13 Westbound	SR 235/Marion Road to Tarsus Road	5.61	160	1.76	10.2	0.8	Decrease	Decrease
I-24 Westbound	Robertson/Montgomery County Line to SR 76 Off-Ramp	7.79	287	1.68	69.2	2.6	Increase	Neutral
US 79 (SR 13)/Guthrie Highway Southbound	Kentucky/Tennessee State Line to I-24 Westbound	5.28	177	1.62	54.0	2.0	Decrease	Decrease
US 41A (SR 112) Southbound	North 2nd Street to SR 76/ML King Jr Parkway	5.28	160	1.60	240.0	2.8	Decrease	Increase
US 41A (SR 112)/Madison Street Northbound	Robertson/Montgomery County Line to Durham Road	4.96	222	1.56	15.8	1.6	Increase	Decrease
SR 13 Westbound	Tarsus Road to Montgomery/Houston County Line	6.08	108	1.40	4.0	0.0	Decrease	Neutral
SR 48 Northbound	Little Barton Creek Road to Southside Road	4.30	357	1.34	18.2	0.2	Decrease	Decrease
SR 13 Eastbound	Tarsus Road to SR 235/Marion Road	5.61	165	1.30	10.2	0.8	Decrease	Decrease
US 41A (SR 112)/Madison Street Southbound	SR 76/ML King Jr Parkway to Durham Road	5.63	142	1.29	62.8	0.4	Increase	Increase
US 41A (SR 112)/Madison Street Northbound	Durham Road to SR 76/ML King Jr Parkway	5.63	136	1.28	62.8	0.4	Increase	Increase
SR 13/SR 48 Southbound	SR 149 to SR 13	5.55	226	1.28	68.8	3.0	Decrease	Decrease
I-24 Eastbound	SR 76 On-Ramp to Montgomery/Robertson County Line	7.85	270	1.25	84.8	3.0	Increase	Decrease
US 79 (SR 13)/Guthrie Highway Northbound	I-24 Westbound to Kentucky/Tennessee State Line	5.29	199	1.19	54.0	2.0	Decrease	Decrease
US 79 (SR 76)/Dover Road Eastbound	Stewart/Montgomery County Line to SR 233/Lylewood Road	7.75	263	1.17	21.6	1.8	Decrease	Decrease
US 41A (SR 112) Northbound	SR 76/ML King Jr Parkway to North 2nd Street	5.28	121	1.15	240.0	2.8	Decrease	Increase
US 41A/Fort Campbell Boulevard Southbound	KY 1453/Elmo Road to I-24 Westbound	7.86	183	1.12	10.6	0.4	Increase	Decrease

Roadway	Segment	Length (miles)	2023 Non-Recurring Incidents	2023 Maximum Delay (Hours)	5-Year Annual Average Crash Frequency	5-Year Annual Average Fatal/Serious Injury Crash Frequency	5-Year Total Crash Trend	5-Year Fatal/Serious Injury Crash Frequency
SR 12/Ashland City Road Southbound	McAdoo Creek Road to Old Clarksville Pike	3.51	218	1.10	22.8	1.4	Increase	Decrease
SR 13 Eastbound	Montgomery/Houston County Line to Tarsus Road	6.08	124	1.10	4.0	0.0	Decrease	Neutral
SR 13/SR 48 Northbound	SR 13 to SR 149	5.55	185	1.05	68.8	3.0	Decrease	Decrease
US 79 (SR 76)/Dover Road Westbound	Dover Crossing Road to SR 374/Paul B Huff Memorial Parkway	3.39	196	1.05	48.2	2.0	Decrease	Increase
US 41A (SR 12)/Fort Campbell Boulevard Northbound	SR 374/101st Airborne Division Parkway to SR 236/Tiny Town Road	3.34	217	1.02	87.2	2.2	Decrease	Decrease
SR 48 Southbound	Southside Road to Little Barton Creek Road	4.30	329	0.98	18.2	0.2	Decrease	Decrease
SR 12/Ashland City Road Northbound	Old Clarksville Pike to McAdoo Creek Road	3.51	258	0.81	22.8	1.4	Increase	Decrease
US 41A/Fort Campbell Boulevard Southbound	I-24 Eastbound to KY 911	2.55	165	0.78	56.0	0.8	Increase	Neutral
US 79 (SR 76)/Dover Road Eastbound	SR 374/Paul B Huff Memorial Parkway to Dover Crossing Road	3.39	226	0.76	48.2	2.0	Decrease	Increase
US 79 (SR 76)/Dover Road Eastbound	SR 233/Lylewood Road to SR 374/Paul B Huff Memorial Parkway	3.97	236	0.72	27.4	1.2	Decrease	Decrease
US 79 (SR 76)/Dover Road Westbound	SR 233/Lylewood Road to Stewart/Montgomery County Line	7.75	254	0.71	21.6	1.8	Decrease	Decrease
SR 12/Ashland City Road Northbound	McAdoo Creek Road to US 41A Bypass (SR 76)/Ashland City Road	3.08	212	0.71	36.2	1.8	Decrease	Decrease
US 41A (SR 12)/Fort Campbell Boulevard Northbound	Dover Crossing Road to SR 374/101st Airborne Division Parkway	2.21	152	0.68	190.2	6.6	Decrease	Decrease
US 79 (SR 76)/Dover Road Westbound	SR 374/Paul B Huff Memorial Parkway to SR 233/Lylewood Road	3.98	268	0.67	27.4	1.2	Decrease	Decrease
US 41A/Fort Campbell Boulevard Northbound	KY 911 to I-24 Eastbound	2.43	151	0.64	56.0	0.8	Increase	Neutral

Roadway	Segment	Length (miles)	2023 Non-Recurring Incidents	2023 Maximum Delay (Hours)	5-Year Annual Average Crash Frequency	5-Year Annual Average Fatal/Serious Injury Crash Frequency	5-Year Total Crash Trend	5-Year Fatal/Serious Injury Crash Frequency
US 41A Bypass (SR 12/SR 76)/Ashland City Road Eastbound	SR 13/SR 48/Cumberland Drive to SR 12/Ashland City Road	4.34	207	0.63	91.6	2.0	Increase	Decrease
US 41A (SR 12)/Fort Campbell Boulevard Southbound	SR 236/Tiny Town Road to SR 374/101st Airborne Division Parkway	3.28	220	0.58	87.2	2.2	Decrease	Decrease
SR 374/101st Airborne Division Parkway Westbound	SR 48/Trenton Road to Peachers Mills Road	4.34	245	0.57	211.6	2.6	Decrease	Decrease
US 41A/US 79 (SR 12/SR 76)/Providence Boulevard Westbound	SR 12/SR 13/Riverside Drive to US 79 (SR 76)/Dover Road	1.82	281	0.56	146.6	3.2	Increase	Neutral
SR 12/Ashland City Road Southbound	US 41A Bypass (SR 76)/Ashland City Road to McAdoo Creek Road	3.08	232	0.55	36.2	1.8	Decrease	Decrease
US 41A/Fort Campbell Boulevard Northbound	I-24 Westbound to KY 1453/Elmo Road	7.97	257	0.55	10.6	0.4	Increase	Decrease
I-24 Eastbound	US 79 (SR 13) On-Ramp to SR 237/Rossview Road Off-Ramp	2.90	272	0.53	67.6	1.0	Decrease	Decrease
SR 374/101st Airborne Division Parkway Eastbound	Peachers Mills Road to SR 48/Trenton Road	4.34	222	0.53	211.6	2.6	Decrease	Decrease
US 41A Bypass (SR 12/SR 76)/Ashland City Road Westbound	SR 12/Ashland City Road to SR 13/SR 48/Cumberland Drive	4.34	218	0.52	91.6	2.0	Increase	Decrease
I-24 Eastbound	KY 115 On-Ramp to Kentucky/Tennessee State Line	4.27	247	0.50	29.2	0.2	Decrease	Decrease
I-24 Westbound	Tennessee/Kentucky State Line to KY 115 Off-Ramp	4.25	315	0.50	31.0	0.2	Increase	Increase

Summary

Based on the Non-Recurring Congestion Analysis, the following conclusions were drawn:

- There were 42 segments that experienced excessive non-recurring congestion, with maximum delays of at least half an hour; the maximum delay was nearly two (2) hours.
- Six (6) segments that experienced excessive non-recurring congestion also experienced excessive recurring congestion.
- Non-recurring congestion predominantly occurs on I-24, US 41A, US 79, SR 12, SR 13, SR 48, and SR 374.

Reliability

According to the FHWA, travel time reliability is defined as how much travel times vary over the course of time. This lack of consistency in travel time occurs due several factors which are essentially the seven key sources of congestion happing separately or interacting. The contribution of these factors to the regional congestion transforms trip durations into unreliable travel times on a day-to-day basis which impedes appropriate travel planning and increases inconvenience for transportation system users. During the AM, MD, and PM peaks, commuters on the following corridors could anticipate unpredictable variability in trip durations as shown in **Table 2.8**.

Accordingly, arriving to work 'on time' requires adding a factor of safety or a buffer to their travel time while planning for their daily commute. This buffer is commonly used to quantify travel time reliability in terms of *Buffer Index*, which is the size of the buffer as a percentage of the average (95th percentile minus the average, divided by the average). **Figures 2.7 through 2.9** show the average Buffer Index values during the AM, MD, and PM peaks for 2023.

The Buffer Time Index (BTI) expresses the amount of extra "buffer of cushion" time needed to reach a destination on-time 95 percent of the time (late one working day per month). It is the ratio of the buffer or cushion time to the average travel time under regular traffic conditions. A buffer index of 1.0 indicates that for a 30-minute trip during regular traffic conditions, an extra 100 percent (or 30-minutes) buffer time is needed to reach the destination on time 95 percent of the time regardless of uncertainties.

Table 2.8: Unpredictable Variability in Trip Duration

Peak	Corridors
AM	• US 79 Northbound from SR 374 to US 41A and from I-24 to the Tennessee/Kentucky State Line • US 79 Southbound from the Tennessee/Kentucky State Line to SR 374 • US 41A Northbound from Durham Road to SR 76 • US 41A Southbound from SR 374 to Peachers Mill Road and from SR 12/SR 13/Riverside Road to SR 48/College Street • SR 374 Eastbound and Westbound from US 41A to Peachers Mill Road
MD	• US 79 Northbound and Southbound from I-24 to the Tennessee/Kentucky State Line • US 79 Northbound from US 41A to SR 48/College Street • US 41A Northbound and Southbound from Durham Road to SR 76 • US 41A Southbound from US 79/Dover Road to Peachers Mill Road and from SR 12/SR 13/Riverside Road to SR 48/College Street • US 41A Bypass Southbound from SR 12 to US 41A • SR 76 Westbound at I-24 • SR 374 Southbound from Dunbar Cave Road to Memorial Drive
PM	• I-24 Eastbound at SR 237 • US 79 Northbound from SR 374 to the Tennessee/Kentucky State Line • US 79 Southbound from the Tennessee/Kentucky State Line to I-24 and from Dunbar Cave Road to US 41A • US 41A Northbound from SR 48/College Street to SR 12/SR 13/Riverside Road • US 41A Southbound from US 79/Dover Road to Peachers Mill Road, from SR 12/SR 13/Riverside Road to SR 48/College Street, and from SR 76 to Durham Road • US 41A Bypass Northbound from US 41A to SR 12 and from SR 48/College Street to US 41A • US 41A Bypass Southbound from SR 12 to US 41A • SR 76 Eastbound and Westbound from Memorial Drive to I-24 • SR 374 Eastbound from US 41A to Peachers Mill Road and from Dunbar Cave Road to Memorial Drive • SR 374 Westbound from US 41A to Dunbar Cave Road and from US 79 to Peachers Mill Road

Source: NPMRDS

Figure 2.7: Average Buffer Index Values – AM Peak – 2023

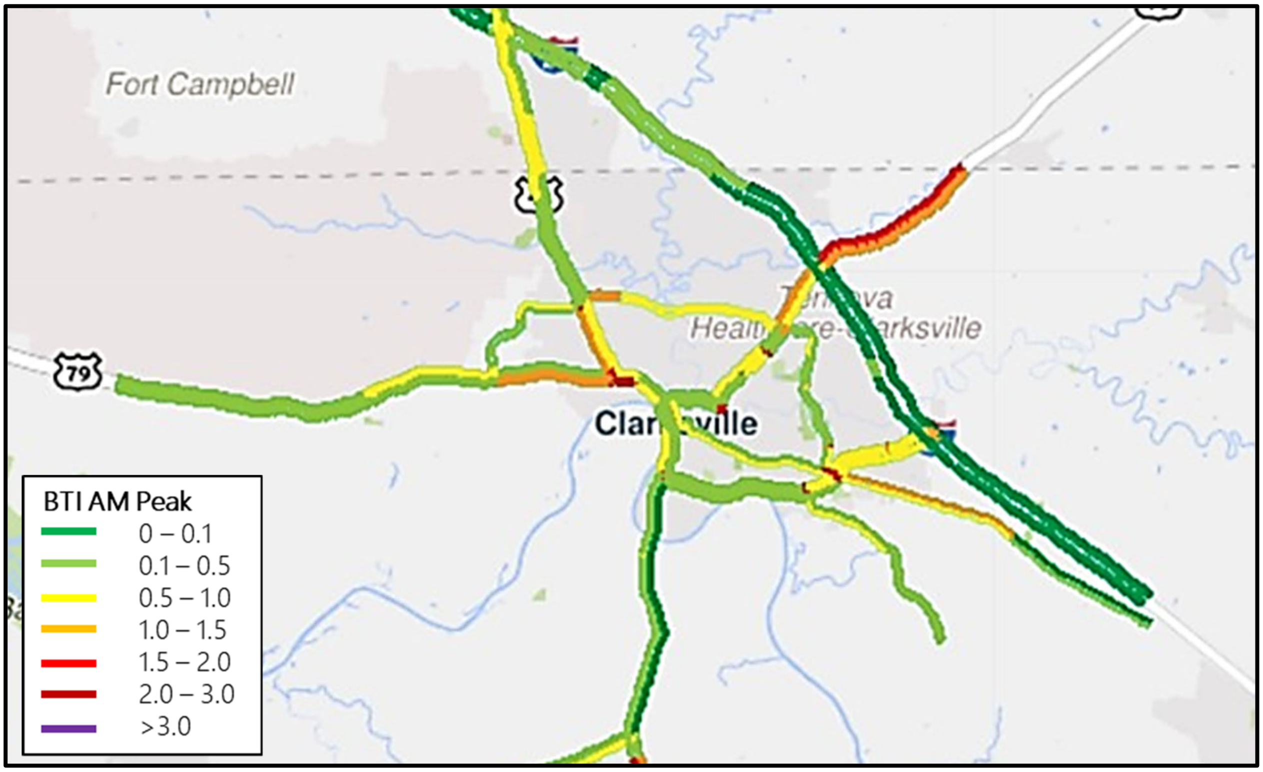


Figure 2.8: Average Buffer Index Values – MD Peak – 2023

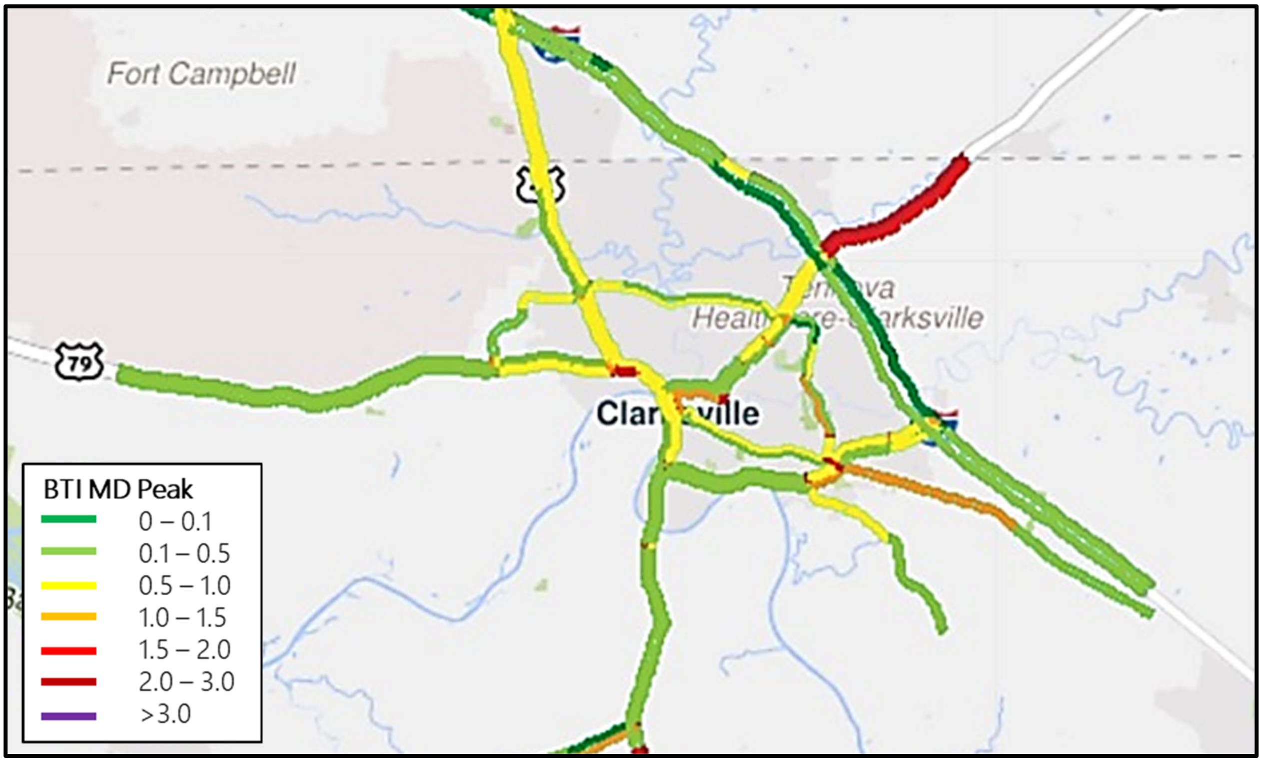
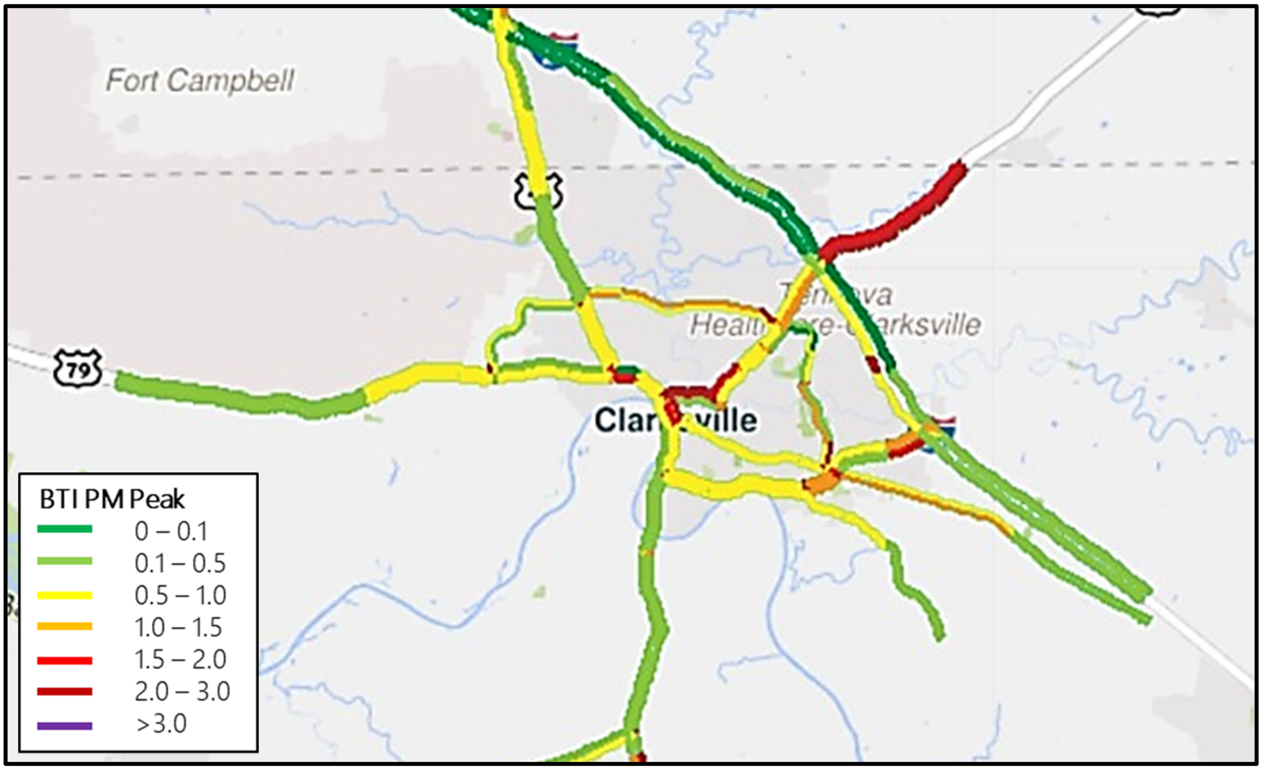


Figure 2.9: Average Buffer Index Values – PM Peak – 2023



In addition to determining the Top 10 Freeway and Top 25 Arterial bottlenecks using the highest observed **Total Delays**, the roadway's Level of Travel Time Reliability (LOTTR) was used to determine any additional bottlenecks that were not identified in the analysis shown in *2.5 Step 5: Congestion Analysis*. **Figures 2.10 and 2.11** show monthly distributions as well as yearly average for LOTTR during 2023. As shown in the figures, the Interstate NHS LOTTR is above the target of having a LOTTR less than 1.50 for all 12 months; however, the Non-Interstate NHS LOTTR is below the target of having a LOTTR less than 1.50 for four (4) months.

Figure 2.12 displays the 2023 LOTTR of the monitored segments on the National Highway System (NHS) routes within the MPA. The high LOTTR segments (greater than 1.50) that were not identified in the analysis are listed in **Table 2.9**. More information on LOTTR can be found in *3.4 Roadway Reliability* of *Technical Report #2: State of Current System*[8].

Figure 2.10: Monthly Distribution of LOTTR – Interstate System – 2023

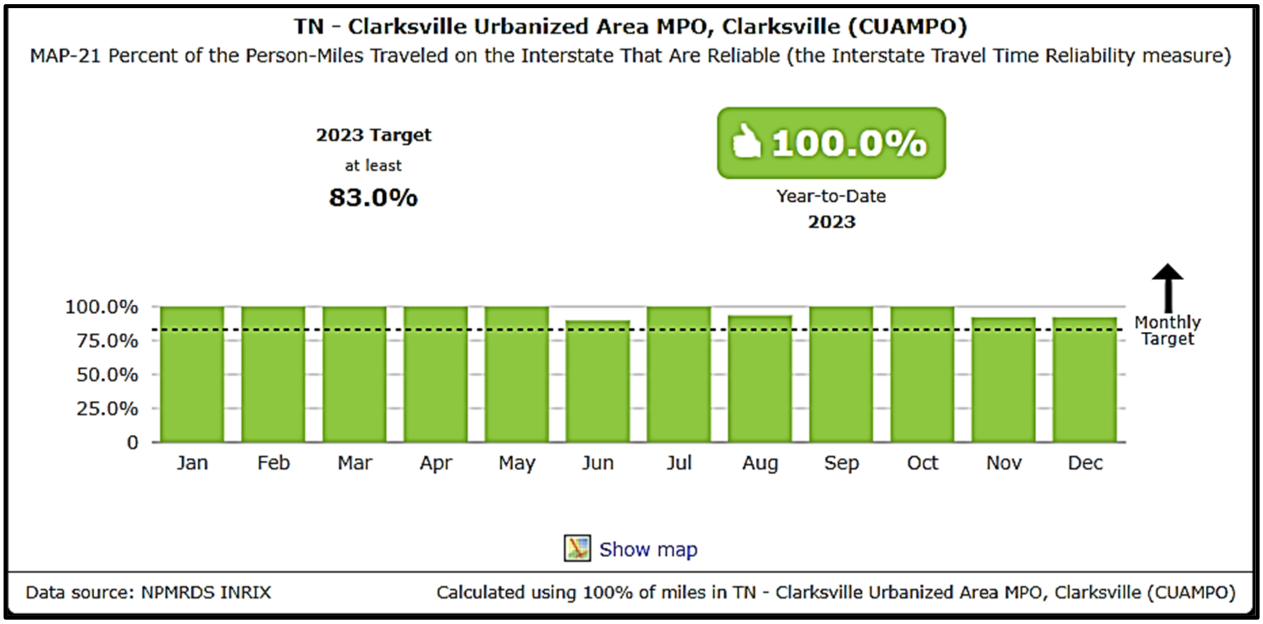


Figure 2.11: Monthly Distribution of LOTTR – Non-Interstate System – 2023

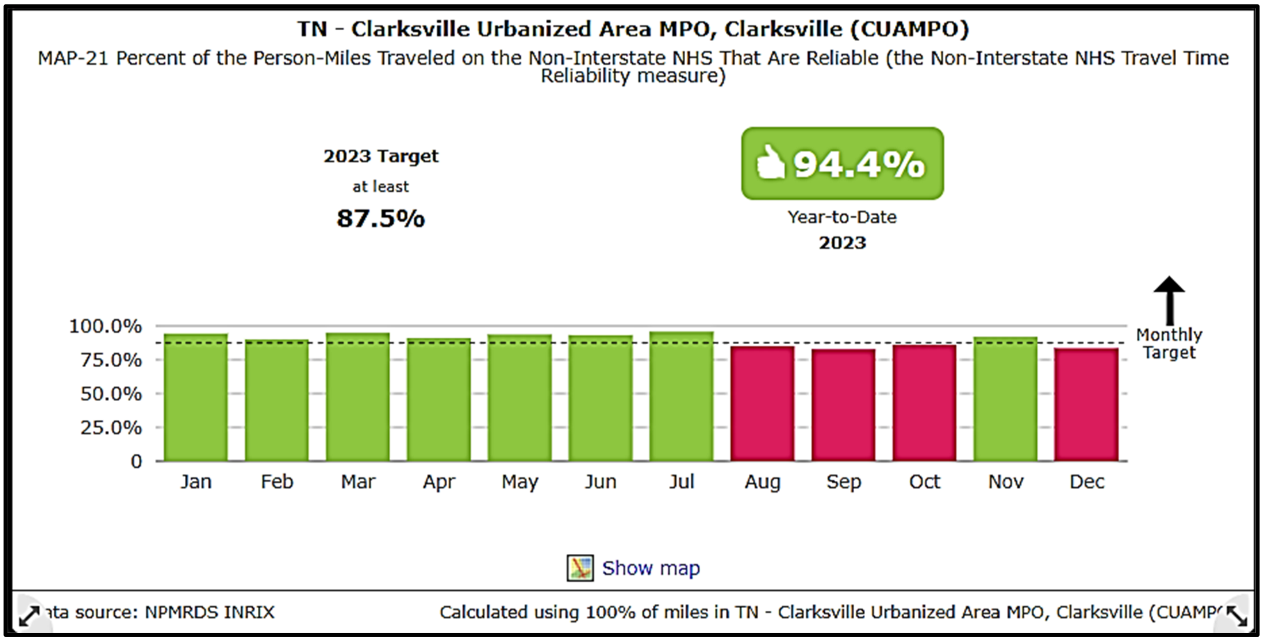
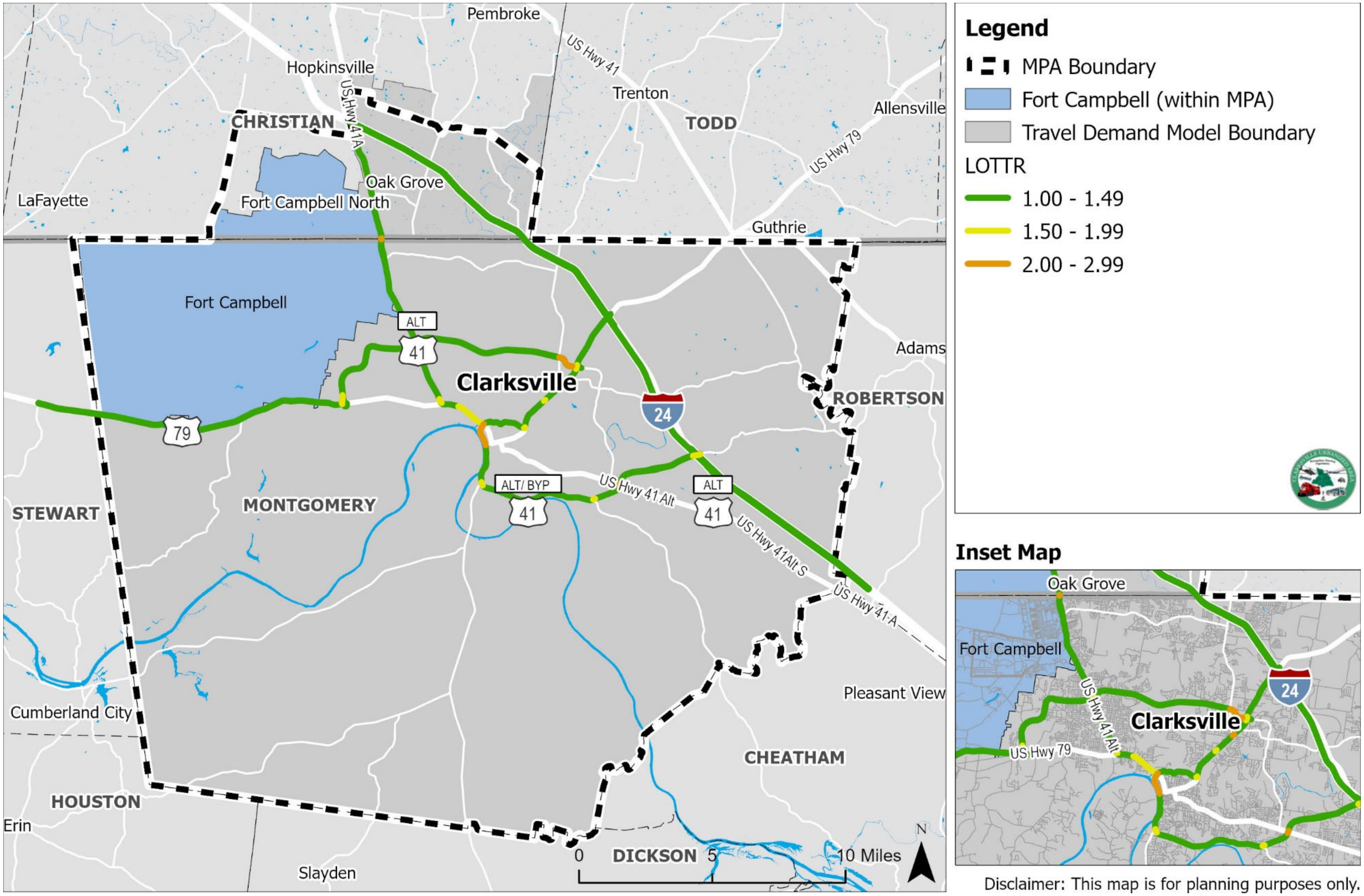


Table 2.9: High LOTTR Roadways Not Identified in Bottleneck Analysis

State and County	Route	Segment
Montgomery, Tennessee	US 41A (SR 12)/Fort Campbell Boulevard Northbound	At SR 374/101st Airborne Division Parkway
		At KY 400/State Line Road
	US 41A (SR 12)/Fort Campbell Boulevard Southbound	At SR 374/101st Airborne Division Parkway
	US 41A Bypass (SR 76)/Ashland City Road Northbound	At SR 12/Ashland City Road
		At SR 13/SR 48/Cumberland Road
	US 41A Bypass (SR 76)/Ashland City Road Southbound	At SR 12/Ashland City Road
		At US 41A (SR 112)/Madison Street
	US 41A Bypass (SR 12/SR 13)/Riverside Drive Northbound	SR 48/College Street to US 41A (SR 12/SR 76)/North Second Street
	US 41A Bypass (SR 12/SR 13)/Riverside Drive Southbound	At SR 13/SR 48/Cumberland Road
	US 79 (SR 13)/Kraft Street Northbound	At SR 48/College Street
	US 79 (SR 13)/Kraft Street Southbound	At US 41A (SR 12/SR 76)/North Second Street
	US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	At SR 48/Trenton Road
		At SR 374/Warfield Boulevard
	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At SR 374/Warfield Boulevard
	SR 76/M.L.K. Jr Parkway	At US 41A (SR 112)/Madison Street

Figure 2.12: 2023 LOTTR on the National Highway System (NHS) Routes



Disclaimer: This map is for planning purposes only.

Source: NPMRDS

2.6 Step 6: Congestion Management Strategies

Federal Guidelines for Congestion Reduction Strategies

Section 500.109 (a) of Subpart A (Management Systems), 23 CFR (Final Rule) states:

> "…A congestion management system or process is a systematic and regionally accepted approach for managing congestion that provides accurate, up-to-date information on transportation system operations and performance and assesses alternative strategies for congestion management that meet State and local needs."

Section 450.322 (d)(4) of Subpart C (Metropolitan Transportation Planning and Programming), 23 CFR (Final Rule) further states that a Congestion Management Process shall include:

> "identification and evaluation of the anticipated performance and expected benefits of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems based on the established performance measures. The following categories of strategies, or combination of strategies, are some examples of what should be appropriately considered for each area:
>
> - Demand management measures, including growth management and congestion pricing;
> - Traffic operational improvements;
> - Public transportation improvements;
> - ITS technologies as related to the regional ITS Architecture; and
> - Where necessary, additional system capacity."

Section 450.322 (d)(5) of Subpart C (Metropolitan Transportation Planning and Programming) 23 CFR (Final Rule) also states that a CMP shall include "identification of an implementation schedule, implementation responsibilities, and possible funding sources for each strategy (or combination of strategies) proposed for implementation."

Identifying Congestion Reduction Strategies Using CMP Toolbox

There are constant changes in the way our society and economy operate. With increased commercial, residential, and industrial development, there is also increased transportation demand on existing transportation facilities. To address this increase in demand and ensuing congestion, appropriate strategies must be formulated to prevent deterioration in free flow traffic conditions. These strategies can include upgrading existing transportation facilities, creating additional facilities, and exploring the use of alternative travel methods. The CMP proposes the following four (4) management strategies that provide a variety of measures that can be implemented to reduce traffic congestion[15]:

- Demand Management Strategies
- Traffic Operations Strategies
- Public Transportation Strategies
- Road Capacity Strategies

Demand Management Strategies

Demand Management, or Travel Demand Management (TDM), nonautomotive travel modes, and land use management can provide travelers with more options and reduce the number of vehicles of trips during congested periods. These include strategies, summarized in **Table 2.10**, that substitute communication for travel or encourage regional cooperation to change development patterns and/or reduce sprawl.

Traffic Operations Strategies

These strategies, summarized in **Table 2.11**, focus on getting more out of the existing infrastructure. Rather than building new infrastructure, many transportation agencies have embraced strategies that deal with operation of the existing network of roads. Many of these operations-based strategies are supported by the use of enhanced technologies or Intelligent Transportation Systems (ITS).

Public Transportation Strategies

Improving transit operations, improving access to transit, and expanding transit service can help reduce the number of vehicles on the road by making transit more attractive or accessible. These strategies, summarized in **Table 2.12**, may be closely linked to Demand Management and Traffic Operations Strategies. As with traffic operations, transit operations are often enhanced by ITS.

Road Capacity Strategies

This category of strategies addresses adding more base capacity to the road network, including additional lanes and building new highways, as well as redesigning specific bottlenecks (such as interchanges and intersections) to increase their capacity. Given the expense and possible adverse environmental impacts of new single-occupant vehicle

[15] https://www.fhwa.dot.gov/planning/congestion_management_process/cmp_guidebook/cmpguidebk.pdf

capacity, management and operations strategies, summarized in **Table 2.13**, should be given due consideration before additional capacity is considered.

Tables 2.14 and 2.15 present potential strategies that can be employed to alleviate or reduce congestion on the freeways and arterials identified in **Figures 2.2, 2.3, and 2.6** that experience the highest levels of traffic congestion in the MPA. Priorities gathered from public input is also reflected in the table.

Table 2.10: Demand Management Strategies

Strategy Group	Strategy	Description
Promoting Alternatives	Programs that encourage transit use	These programs give travelers that have the option of driving reasons to choose transit. Some programs can use: • Improving transit service (more service, faster service, and more comfortable service) • Improved stops and stations • Reduced fares and more convenient fare structures and payment systems • Marketing
	Pedestrian and bicycle improvements, and other strategies that promote nonmotorized travel	Pedestrian and bicycle improvements ensure that a network of infrastructure is in place to make bicycling or walking viable modes of travel. Some examples of infrastructure improvement to pedestrian and bicycle facilities include: • Bicycle lanes • Bicycle parking and storage facilities • Curb extensions • Intersection treatments • Paved shoulders and/or sidewalks • Shared-lane markings ("sharrows") • Signage and signalization • Trails and shared-use paths
Managing and Pricing Assets	Congestion pricing strategies	Congestion pricing works by shifting some rush hour highway travel to other transportation modes or to off-peak periods. Some strategies include: • High Occupancy Toll (HOT) and Express Toll Lanes • Roadway facility-based pricing • Zone-based pricing • Parking pricing
	Parking management	Parking management refers to strategies that result in a more efficient use of parking resources.
	Pricing fees for parking spaces	Efficient pricing fees for parking spaces can provide numerous benefits including increase turnover and therefore improved user convenience, parking facility cost savings, reduced traffic congestion, and increased revenues.
	Pricing fees for use of travel lanes	Pricing fees for use of travel lanes, or congestion pricing, works by shifting some rush hours traffic to over transportation modes or to off-peak periods.
	Increasing intercity freight rail or port capacity	Increasing freight rail or port capacity can reduce the number of trucks, thus reducing congestion.
Work Patterns	Flexible work hours programs	The organization has varying starting and ending working hours for employees, which can include: • Staggered hours are where employees arrive and depart work at different times in shifts, which may be staggered anywhere from 15 minutes to two (2) hours. • Flextime is where employees work specified hours each week but are given flexibility on where they arrive to work, take lunch, and leave work. • Compressed work weeks are where employees work more hours daily but work fewer days per week or pay period. (e.g. four ten-hour days instead of five eight-hour days)
	Telecommuting programs	Work is performed wherever the employee chooses. This is a system where employees do not commute or travel to a central place of work.
Land Uses	Land use controls or zoning	Land use controls consist of government ordinances, codes, and permit requirements that restrict the private use of land and natural resources, to conform to public policies. These controls can provide a blueprint for sustainable growth and manage traffic.

Strategy Group	Strategy	Description
	Growth management restrictions	Growth management restrictions often stem from concerns about the compatibility of new growth with surrounding uses and/or the need to minimize the costs associated with supplying public services, such as roads and streets, to support new development.
	Development policies that support transit-oriented designs	The utilization of effective and predictable transit encourages surrounding development which, in turn, supports transit. The basic principle is that convenient access to transit can be a key attraction that fosters mixed-use development, and the increased density in station areas not only support transit but also may accomplish other goals, including reducing congestion and urban sprawl, increasing pedestrian activity and economic development potential, and realizing environmental benefits.
	Incentives for high-density development	Incentives such as tax abatements and streamlined permitting processes can be used to stimulate the development of housing types which can reduce congestion.

Table 2.11: Traffic Operations Strategies

Strategy Group	Strategy	Description
Highway/Freeway Operations	Metering traffic onto freeways	Ramp meters are signals installed on freeway on-ramps to control the frequency at which vehicles enter the flow of traffic on the freeway. These signals reduce overall freeway congestion by managing the amount of traffic entering the freeway and by breaking up platoons that make it difficult to merge onto the freeway.
	Reversible commuter lanes	Reversible commuter lanes add peak-direction capacity to a two-way road and decrease congestion by borrowing available lane capacity from the other (off-peak) direction. This strategy can also be used for situations of non-recurring congestion, such as special events, construction, or evacuations.
	Access management	Access management strategies for highways include: • Left-turn restrictions • Intersection/signal spacing • Frontage Roads • Turn lanes • Roadway modifications (geometry, medians, sight distance)
	Movable median barriers	These barriers can be transferred between lanes to increase capacity in the peak direction. These barriers can also be used in work zones to prevent opposing traffic flow collisions.
	Automated toll collection improvements	Improving automated toll collections can improve traffic flow, decrease emissions, and are less expensive to build and operate than traditional toll collection methods.
	Conversion of HOV lanes to High Occupancy Toll (HOT) lanes	In many cases, HOV lanes may be underutilized and do not meet expectations about congestion relief benefits. Converting HOV lanes to HOT lanes is an innovative concept that can better utilize HOV lanes.
	Bus-only shoulder lanes	These shoulders can permit buses to bypass congestion.
Arterial and Local Roads Operations	Optimizing traffic signal timings	Optimizing traffic signal timing reduces idling and the acceleration of vehicles, as well as reducing stops and delay, leading to less fuel being burned and less emissions.
	Restricting turns at key intersections	Turning movement restrictions are a type of access management strategy used to improve the safety of intersections and driveways. Restricted and prohibited turn movements reduce the number of turning conflict points at intersections, which are generally known to reduce crash risk.
	Geometric improvements	Geometric improvements can include adding raised medians near intersections, adding bicycle lanes, and improved skew angles. Adding turn lanes are another intersection improvement. However, right-of-way restrictions need to be considered.
	Converting streets to one-way operations	One-way streets manage traffic patterns and reduce vehicle conflicts. These conversions work best in downtown or very congested areas, and they can offer improved signal timing.
	Transit signal priority (TSP)	TSP adjusts the timing of a traffic signal's red and green cycles to reduce the amount of time a transit vehicle spends waiting at a red light.
	Access management	Access management strategies for arterial and local roads include: • Driveway consolidation • Driveway spacing/design • Left-turn restrictions • Elimination of on-street parking • Intersection/signal spacing • Turn lanes

Strategy Group	Strategy	Description
		• Roadway modifications (geometry, medians, sight distance)
	Traffic calming	Traffic calming refers to a full range of methods to slow cars through commercial and residential neighborhoods. This can benefit pedestrians and bicyclists since cars are driving at speeds that are safer and more compatible to walking and bicycling.
	Road Diets	Road Diets remove travel lanes from a roadway and utilize space for other uses and travel modes. The most common Road Diet reconfiguration is converting a four-lane undivided roadway to a three-lane roadway with a Two-Way Left-Turn Lane (TWLTL).
Other Operations Strategies	Incident management	Traffic incident management (TIM) consists of a planned and coordinated multi-disciplinary process to detect, respond to, and clear traffic incidents and restore traffic flow as safely and quickly as possible.
	Traveler information systems	These systems update drivers on current roadway conditions, including delays, incidents, weather-related messages, travel times, emergency alerts, and alternate routes. These systems allow drivers to make more effective travel decisions.
	Improved management of work zones	Managing traffic during construction is necessary to minimize traffic delays, maintain motorist and worker safety, complete roadwork in a timely manner, and maintain access for businesses and residents.
	Identifying weather and road surface problems	Weather can have impact traffic flow due to reduced visibility and or wet roadway surface conditions.
	Special events management	Special events such as sporting events, concerts, fairs, and conventions cause high levels of congestion due to an overload of the street and highway networks adjacent to the venue. However, agencies and organizers can easily coordinate a mitigation plan and deploy the proper resources to minimize the effects on normal traffic operation.
	Freight management	Congestion can be caused by restrictions on freight movement, such as the lack of space for trucks in urban areas.

Table 2.12: Public Transportation Strategies

Strategy Group	Strategy	Description
Operations Strategies	Realigned transit service schedules and stop locations	Realigning transit service schedules and stop locations eliminate non-productive route segments, reduce route mileage and/or increase speed, or ensure that major activity centers are served.
	Providing real-time information	Real-time transit information systems provide transit riders with up-to-the-minute information on bus arrivals via the internet, phone, and display boards at key bus stops. The information is based on real-time bus locations using GPS rather than a set schedule of arrival and departure times. Access to real-time travel information reduces actual and perceived wait times and increase the reliability of transit, which can encourage a mode shift.
	Providing travel conditions information	Travel conditions information can allow users to make proper mode and route choices.
	Monitoring security	Enhancing the security, and safety, of transit customers, personnel, equipment, and facilities can alert officials of possible delays or closures as well as warn officials of possible intentional acts of crime or violence.
	Enhanced transit amenities and safety	Enhanced transit amenities and safety can make transit more attractive while bringing immense benefits to accessibility and performance.
	Universal farecards	Users can access multiple modes of travel, such as trains, buses, and taxis, with one card.
	Transit Signal Priority (TSP)	TSP tools modify signal timing or phasing when transit vehicles are present either conditionally for late runs or unconditionally for all arriving transit.
	Bus Rapid Transit (BRT)	BRT is a term used for a set of transit service improvements that include: • Grade-separated right-of-way • High-quality vehicles • Frequent service • Convenient user information • Efficient pre-paid fare collection • Efficient operations
Capacity Strategies	Reserved travel lanes	Reserved lanes help buses pass congested traffic. These lanes can include curbside lanes, median lanes, or contraflow lanes.
	More frequent transit or expanded hours of service	Expanded transit can reduce motor vehicles miles driven and traffic congestion.
	Expanded transit network	Expanding the transit network can increase the mode's attractiveness.
Accessibility Strategies	Bicycle and pedestrian facilities improvements	Improved bicycle and pedestrian facilities can reduce traffic congestion and pollution by providing alternate means of vehicular travel, as well as recreational opportunities which encourage healthy lifestyles.
	Provisions for bicycles	Transit vehicles with bikeracks mounted on buses allow a bicycle to be used at both ends of the journey, and helps cyclists who experience a mechanical failure, unexpected bad weather, or sudden illness. It also allows cyclists to pass major barriers where cycling is prohibited or particularly difficult.

Table 2.13: Road Capacity Strategies

Strategy Group	Strategy	Description
All	Construct new HOV or HOT lanes	High Occupancy Vehicle (HOV) lanes are lanes that have occupancy restrictions on usage to encourage ridesharing. High Occupancy Toll (HOT) lanes are available to HOV users without a toll. SOV users can use these lanes for a toll, which adjusts based on demand.
	Removing bottlenecks	Some strategies that can remove or fix bottlenecks include: • Use a short section of traffic bearing shoulder as a peak-hour lane • Restriping • Modifying weaving areas • Ramp metering or closing entrance ramps • Improving traffic signal timing • Access management • Providing traffic diversion information (ITS).
	Intersection improvements	Intersection improvements can include adding raised medians near intersections, adding bicycle lanes, improved skew angles, reconfiguring signal timings, and adding advanced warning devices. Adding turn lanes are another intersection improvement. However, right-of-way restrictions need to be considered.
	Center turn lanes	These lanes, also known as Two-Way Left Turn Lanes (TWLTL), remove left-turning vehicles from the through lanes and store those vehicles in the median area until an acceptable gap in opposing traffic is available.
	Overpasses or underpasses at congested locations	Intersections handling a high volume of traffic and pedestrians (and possibly railroads) limit the capacity of the approaching roads. Grade separating these conflict points using overpasses and underpasses allows traffic to flow freely. This in turn makes conditions safer for vehicles, pedestrians, and trains.
	Closing gaps in the street network	Closing gaps in the street network by constructing new roads can mitigate congestion on existing roads. These new roads can also incorporate complete streets.
	Adding travel lanes	Increasing the number of lanes is not always possible due to physical and fiscal constraints. However, it remains an important approach to addressing congestion.

Table 2.14: Proposed Strategies for Alleviating Congestion on Freeway Segments

Roadway	Segment	Congestion Recurring or Non-Recurring	Proposed Congestion Alleviation Strategy
I-24 Eastbound	SR 76 On-Ramp to Montgomery/Robertson County Line	Recurring and Non-Recurring	Additional capacity - widening four lanes to six lanes and extending SR 76 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Westbound	Robertson/Montgomery County Line to SR 76 Off-Ramp	Recurring and Non-Recurring	Additional capacity - widening four lanes to six lanes and extending SR 76 Off-Ramp deceleration lane; implementing ITS; improving incident management and freight management
I-24 Westbound	At Tennessee/Kentucky State Line	Recurring	Additional capacity - widening four lanes to six lanes; implementing ITS; improving incident management and freight management
I-24 Westbound	SR 76 On-Ramp to SR 237 (Rossview Road) Off-Ramp	Recurring	Additional capacity - widening four lanes to six lanes and extending SR 76 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	Between SR 237 (Rossview Road) Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending SR 237 Off-Ramp deceleration lane and SR 237 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	Between SR 76 Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending SR 76 Off-Ramp deceleration lane and SR 76 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Westbound	Between SR 48 Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending SR 48 Off-Ramp deceleration lane and SR 48 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Westbound	Between US 79 (SR 13) Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending US 79 Off-Ramp deceleration lane and US 79 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	Between US 79 (SR 13) Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending US 79 Off-Ramp deceleration lane and US 79 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	Between SR 48 Ramps	Recurring	Additional capacity - widening four lanes to six lanes and extending SR 48 Off-Ramp deceleration lane and SR 48 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	US 79 (SR 13) On-Ramp to SR 237/Rossview Road Off-Ramp	Non-Recurring	Additional capacity - widening four lanes to six lanes and extending SR 237 Off-Ramp deceleration lane and US 79 On-Ramp acceleration lane; implementing ITS; improving incident management and freight management
I-24 Eastbound	KY 115 On-Ramp to Kentucky/Tennessee State Line	Non-Recurring	Additional capacity - widening four lanes to six lanes; improving ITS, incident management, and freight management (Road work occurred on this segment in 2023.)
I-24 Westbound	Tennessee/Kentucky State Line to KY 115 Off-Ramp	Non-Recurring	Additional capacity - widening four lanes to six lanes; improving ITS, incident management, and freight management (Road work occurred on this segment in 2023.)

Table 2.15: Proposed Strategies for Alleviating Congestion on Arterial Segments

Roadway	Segment	Congestion Recurring or Non-Recurring	Proposed Congestion Alleviation Strategy
US 41A (SR 12) Northbound/US 79 (SR 76) Southbound/Providence Boulevard	US 41A/US 79 (SR 12/SR 13)/Riverside Drive to Peachers Mill Road	Recurring	Optimize signal timings; safety improvements; bicycle and pedestrian improvements; access management
US 41A (SR 12)/Fort Campbell Boulevard Northbound	US 79 (SR 76)/Dover Road to Dover Crossing Road	Recurring	Optimize signal timings; safety improvements; bicycle and pedestrian improvements; access management
SR 374/101st Airborne Division Parkway Westbound	SR 48/Trenton Road to Peachers Mill Road	Recurring and Non-Recurring	Optimize signal timings
SR 374/101st Airborne Division Parkway Westbound	US 79 (SR 13)/Wilma Rudolph Boulevard to SR 48/Trenton Road	Recurring	Optimize signal timings; extend turn lanes
US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	SR 374 to I-24 Eastbound	Recurring	Optimize signal timings; access management; bicycle and pedestrian improvements
US 79 (SR 76)/Dover Road Northbound	At US 41A (SR 12)/Providence Boulevard	Recurring	Optimize signal timings; access management
US 41A (SR 12)/Fort Campbell Boulevard Southbound	Dover Crossing Road to US 79 (SR 76)/Dover Road	Recurring	Optimize signal timings; safety improvements; bicycle and pedestrian improvements; access management
US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	I-24 Westbound to I-24 Eastbound	Recurring	Optimize signal timings; extend left turn lane or construct second left turn lane
SR 374 (Richview Road) Southbound	At US 41A (SR 112)/Madison Street	Recurring	Optimize signal timings; extend left turn lane
SR 374/101st Airborne Division Parkway Eastbound	Peachers Mill Road to SR 48/Trenton Road	Recurring and Non-Recurring	Optimize signal timings; extend left turn lane at SR 48
US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	Peachers Mill Road to US 41A/US 79 (SR 12/SR 13)/Riverside Drive	Recurring	Optimize signal timings; safety improvements; bicycle and pedestrian improvements; access management
SR 374/101st Airborne Division Parkway Eastbound	US 41A (SR 12)/Fort Campbell Boulevard On-Ramp to Peachers Mill Road	Recurring	Optimize signal timings; extend turn lanes at intersections
SR 76 Eastbound	I-24 Eastbound to I-24 Westbound	Recurring	Optimize signal timings; extend left turn lane
US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	At Dunbar Cave Road	Recurring	Optimize signal timings
US 41A Bypass (SR 12/SR 13)/Riverside Drive Northbound	At US 41A/US 79 (SR 12/SR 76/SR 112)/Providence Boulevard	Recurring	Optimize signal timings
US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At SR 48/Trenton Road	Recurring	Optimize signal timings; access management for SR 48 at Covington Street

Roadway	Segment	Congestion Recurring or Non-Recurring	Proposed Congestion Alleviation Strategy
US 41A (SR 12)/Fort Campbell Boulevard Southbound	SR 236/Tiny Town Road to SR 374	Recurring and Non-Recurring	Optimize signal timings; access management; safety improvements
US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	US 79 (SR 76)/Dover Road to Peachers Mill Road	Recurring	Optimize signal timings; safety improvements; bicycle and pedestrian improvements; access management
SR 12/Ashland City Road Northbound	At US 41A Bypass (SR 12/SR 76)	Recurring	Optimize signal timings; access management for SR 12 at East Old Ashland City Road
US 41A (SR 112)/Madison Street Eastbound	At US 41A Bypass (SR 76)	Recurring	Optimize signal timings; extend right turn lane (Other intersection improvements under construction as of 2023)
US 79 (SR 13/SR 48)/Wilma Rudolph Boulevard Southbound	At US 79 (SR 13)/Kraft Street	Recurring	Optimize signal timings
SR 76 Westbound	I-24 Westbound to I-24 Eastbound	Recurring	Optimize signal timings; extend left turn lane
US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At Dunbar Cave Road	Recurring	Optimize signal timings; construct right turn lane
US 41A (SR 12)/Fort Campbell Boulevard Northbound	SR 374 to SR 236/Tiny Town Road	Recurring and Non-Recurring	Optimize signal timings; access management; safety improvements
SR 374 (Paul B Huff Memorial Parkway) Southbound	At US 79 (SR 76)/Dover Road	Recurring	Install signal (if warranted)
SR 13 Westbound	SR 235/Marion Road to Tarsus Road	Non-Recurring	Safety improvements
US 79 (SR 13)/Guthrie Highway Southbound	Kentucky/Tennessee State Line to I-24 Westbound	Non-Recurring	Safety improvements
US 41A (SR 112) Southbound	North 2nd Street to SR 76/ML King Jr Parkway	Non-Recurring	Safety improvements; access management
US 41A (SR 112)/Madison Street Northbound	Robertson/Montgomery County Line to Durham Road	Non-Recurring	Safety improvements
SR 13 Westbound	Tarsus Road to Montgomery/Houston County Line	Non-Recurring	Safety improvements
SR 48 Northbound	Little Barton Creek Road to Southside Road	Non-Recurring	Safety improvements
SR 13 Eastbound	Tarsus Road to SR 235/Marion Road	Non-Recurring	Safety improvements
US 41A (SR 112)/Madison Street Southbound	SR 76/ML King Jr Parkway to Durham Road	Non-Recurring	Safety improvements; access management; additional capacity - widen two lanes to four lanes from Durham Road to Sango Drive
US 41A (SR 112)/Madison Street Northbound	Durham Road to SR 76/ML King Jr Parkway	Non-Recurring	Safety improvements; access management; additional capacity - widen two lanes to four lanes from Durham Road to Sango Drive
SR 13/SR 48 Southbound	SR 149 to SR 13	Non-Recurring	Safety improvements
US 79 (SR 13)/Guthrie Highway Northbound	I-24 Westbound to Kentucky/Tennessee State Line	Non-Recurring	Safety improvements

Roadway	Segment	Congestion Recurring or Non-Recurring	Proposed Congestion Alleviation Strategy
US 79 (SR 76)/Dover Road Eastbound	Stewart/Montgomery County Line to SR 233/Lylewood Road	Non-Recurring	Safety improvements; access management (Road work occurred on this segment in 2023.)
US 41A (SR 112) Northbound	SR 76/ML King Jr Parkway to North 2nd Street	Non-Recurring	Safety improvements; access management
US 41A/Fort Campbell Boulevard Southbound	KY 1453/Elmo Road to I-24 Westbound	Non-Recurring	Safety improvements; access management
SR 12/Ashland City Road Southbound	McAdoo Creek Road to Old Clarksville Pike	Non-Recurring	Safety improvements
SR 13 Eastbound	Montgomery/Houston County Line to Tarsus Road	Non-Recurring	Safety improvements
SR 13/SR 48 Northbound	SR 13 to SR 149	Non-Recurring	Safety improvements
US 79 (SR 76)/Dover Road Westbound	Dover Crossing Road to SR 374/Paul B Huff Memorial Parkway	Non-Recurring	Safety improvements; access management
SR 48 Southbound	Southside Road to Little Barton Creek Road	Non-Recurring	Safety improvements
SR 12/Ashland City Road Northbound	Old Clarksville Pike to McAdoo Creek Road	Non-Recurring	Safety improvements
US 41A/Fort Campbell Boulevard Southbound	I-24 Eastbound to KY 911	Non-Recurring	Safety improvements; access management
US 79 (SR 76)/Dover Road Eastbound	SR 374/Paul B Huff Memorial Parkway to Dover Crossing Road	Non-Recurring	Safety improvements; access management
US 79 (SR 76)/Dover Road Eastbound	SR 233/Lylewood Road to SR 374/Paul B Huff Memorial Parkway	Non-Recurring	Safety improvements; access management (Road work occurred on this segment in 2023.)
US 79 (SR 76)/Dover Road Westbound	SR 233/Lylewood Road to Stewart/Montgomery County Line	Non-Recurring	Safety improvements; access management (Road work occurred on this segment in 2023.)
SR 12/Ashland City Road Northbound	McAdoo Creek Road to US 41A Bypass (SR 76)/Ashland City Road	Non-Recurring	Safety improvements
US 41A (SR 12)/Fort Campbell Boulevard Northbound	Dover Crossing Road to SR 374/101st Airborne Division Parkway	Non-Recurring	Safety improvements; access management
US 79 (SR 76)/Dover Road Westbound	SR 374/Paul B Huff Memorial Parkway to SR 233/Lylewood Road	Non-Recurring	Safety improvements; access management (Road work occurred on this segment in 2023.)
US 41A/Fort Campbell Boulevard Northbound	KY 911 to I-24 Eastbound	Non-Recurring	Safety improvements; access management
US 41A Bypass (SR 12/SR 76)/Ashland City Road Eastbound	SR 13/SR 48/Cumberland Drive to SR 12/Ashland City Road	Non-Recurring	Safety improvements; access management
US 41A/US 79 (SR 12/SR 76)/Providence Boulevard Westbound	SR 12/SR 13/Riverside Drive to US 79 (SR 76)/Dover Road	Non-Recurring	Safety improvements; access management
SR 12/Ashland City Road Southbound	US 41A Bypass (SR 76)/Ashland City Road to McAdoo Creek Road	Non-Recurring	Safety improvements

Roadway	Segment	Congestion Recurring or Non-Recurring	Proposed Congestion Alleviation Strategy
US 41A/Fort Campbell Boulevard Northbound	I-24 Westbound to KY 1453/Elmo Road	Non-Recurring	Safety improvements; access management
US 41A Bypass (SR 12/SR 76)/Ashland City Road Westbound	SR 12/Ashland City Road to SR 13/SR 48/Cumberland Drive	Non-Recurring	Safety improvements; access management

2.7 Step 7: Strategy Programming and Implementation

The strategy toolbox identified in the previous section is expected to be subject to a rigorous evaluation process by different stakeholders. The process will include additional and more detailed analysis of short-listed projects pertaining to potential operational, safety, and cost elements associated with the implementation phase. A number of these projects might include transportation policy modifications or demand restraints which might require additional collaboration and outreach from elected officials. The implementation process might also require allocation or redistribution of existing resources by the CUAMPO during the next Metropolitan Transportation Plan.

Potential funding buckets for such projects could be the following:

1. Dedicated MPO funding as a set-aside
2. Other funding programs (Safety, CMAQ, etc.)
3. High Priority Candidate Future Projects (MTP)
4. Other future projects

2.8 Step 8: Congestion Management Process Maintenance

Federal Guidelines for Maintaining the Congestion Management Process

Section 450.322 (d)(3) of Subpart C (Metropolitan Transportation Planning and Programming), 23 CFR (Final Rule) states that a Congestion Management Process shall include:

> "Establishment of a coordinated program for data collection and system performance monitoring to define the extent and duration of congestion, to contribute in determining the causes of congestion, and evaluate the efficiency and effectiveness of implemented actions. To the extent possible, this data collection program should be coordinated with existing data sources (including archived operational/ITS data) and coordinated with operations managers in the metropolitan area."

Section 450.322 (d)(6) of Subpart C (Metropolitan Transportation Planning and Programming), 23 CFR further states that the CMP shall include:

> "Implementation of a process for periodic assessment of the effectiveness of implemented strategies, in terms of the area's established performance measures. The results of this evaluation shall be provided to decision makers and the public to provide guidance on selection of effective strategies for future implementation."

System Performance and Maintenance

The overall goal of the CMP is to reduce traffic congestion within the MPA and improve free-flow traffic conditions through the implementation of proposed congestion reduction strategies. Since this CMP effort is the first for the Clarksville MPA, a comparative analysis to a previous CMP was not conducted. However, the congested locations identified and proposed congestion reduction strategies for this CMP effort should be compared with the next CMP effort conducted for the Clarksville MPA at the time of the next MTP update to measure the effectiveness this CMP will have had on reducing traffic congestion in the MPA.

Future Actions

With the development of the CMP, and to meet 23 CFR, the CUAMPO will need to regularly collect data to monitor the effectiveness of the congestion management strategies implemented throughout the region. This will be done as part of the CMP update process, as well as the additional analysis conducted as part of the MTP. These efforts will include evaluation of the performance of the regional transportation system as part of the MTP, but also additional analysis of the corridors included in the existing CMP network and the CMP network as updated by the MTP. Additionally, the MPO can evaluate the anticipated congestion impacts of candidate projects using the MPO's Travel Demand Model.

To understand the impact of the CMP strategies, the MPO can begin collecting data on projects included in the TIP to determine the before and after impacts of these projects and if they are assisting with CMP efforts and how projects may need to be changed to align with the CMP strategies. The MPO will review the results of these before and after analyses to assist in the identification of effective and ineffective strategies and revise the CMP as needed. Additionally, the CMP will be available on the MPO's website, available for public commenting during the MTP update process, and be part of the input sought from the general public during the public outreach process.

3.0 Cost of Congested Travel

Since traffic congestion imposes substantial direct and indirect costs on transportation system users, including excess travel time, additional fuel consumption and emissions, decreased travel time reliability as well as delayed freight operations, the need of accurate quantification of congestion cost became urgent. Most approaches to estimate congestion costs on the national or regional levels focused mainly on direct costs pertaining to excess travel time and fuel consumption by the system user. The problem with these approaches is that they do not take into consideration additional costs accumulated due to the increased unreliability or decreased mobility, for example. Although the travel time cost represents the major cost category the system is expected to endure while making a trip from one origin to another destination, there are a few other types that needs to be considered including:

Unreliability Cost: The cost assumed by drivers in having to make necessary adjustments to account for the unpredictability of the total trip duration due to congestion. Travelers cope to some extent by leaving early for a destination or using alternative modes in anticipation of delays, which sometimes result in additional inconveniences.

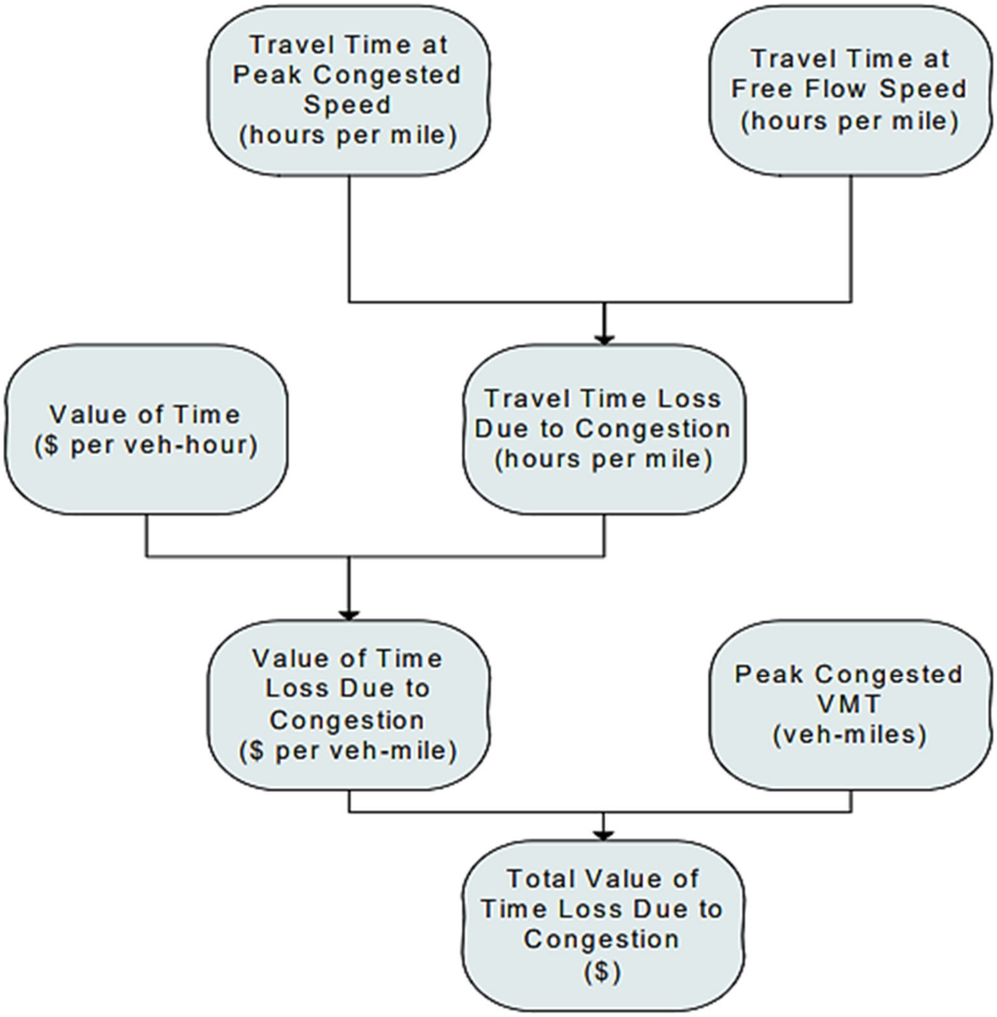
Vehicle Operating Cost: Traffic congestion leads to higher vehicle operating costs due to additional fuel consumption as well as extra wear-and-tear to the vehicle.

Mobility Cost: The mobility cost captures the productivity lost due to postponed or cancelled trips and is estimated as the consumer surplus derived from additional trips that would occur if congestion was alleviated or eliminated.

Emission Cost: The negative impacts of pollution depend not only on the quantity of emissions produced, but on the types of pollutants emitted, which has a direct contribution to the cost of travelling due to the operational and environmental tolls.

Appropriate estimation of excess travel time cost is extremely significant since it represents the largest fraction of the total cost of congestion. As mentioned before, travel time delay represents the value of the total amount of time that road users anticipate losing during congestion as compared to free flow travel. **Figure 3.1** illustrates the methodology of calculating excess travel time due to congestion.

Figure 3.1: Structure and Logic Diagram for Travel Time Cost



Source:
https://www.transportation.gov/sites/dot.gov/files/docs/Costs%20of%20Surface%20Transportation%20Congestion.pdf

Accordingly, the travel time per mile in the peak congested period is:

$$Peak\ Congested\ Travel\ Time = \frac{Peak\ Congested\ Period\ Daily\ VHT}{Peak\ Congested\ Period\ Daily\ VMT}$$

Where:

- Peak Congested Vehicle Hours Traveled (VHT) is the difference between the VHT in the entire peak period (8 hours) and the VHT in the uncongested portion of that period.

The value of excess travel time is the average differential cost of the extra travel time resulting from congestion according to the Texas Transportation Institute (TTI) Urban

Mobility Report[16] criteria which has two key components; time and fuels utilized during congestion periods. Both components are estimated separately from each other. The datum for estimating the value of delay time is the median Bureau of Labor Statistics (BLS) wage estimates for all occupations. Using a vehicle occupancy rate of 1.5 persons per vehicle and the median hourly wage for 2022 is $23.12 per person and the estimated value of delay time is $34.68 per personal vehicle.

The American Automobile Association (AAA) report included values for vehicle operating costs that was used as a basis to calculate the marginal cost per mile of travel for passenger vehicles, which are shown in **Table 3.1**. The individual costs associated with the different classes of vehicles were weighed to produce an acceptable approximation for the operating vehicle.

Table 3.1: 2020 Passenger Vehicle Operating Costs per Mile

Estimated Cost Per Mile	Average Cost
Fuel	$0.110
Maintenance, Repair, Tire	$0.090
Insurance	$0.100
License, Registration, Taxes	$0.071
Depreciation	$0.310
Finance Charges	$0.068
Total	**$0.749**

Source: American Automobile Association (AAA)

Table 3.2 below illustrates a breakdown of operational trucking costs according to the American Transportation Research Institute (ATRI) annual survey. Values are calculated on a per-mile and per-hour basis, which indicates an estimated average operating cost for commercial trucks of $0.900 per mile for 2020.

[16] https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2023-appx-c.pdf

Table 3.2: 2020 Estimates of Truck Operational Costs per Mile

Estimated Cost Per Mile	Average Cost
Fuel	$0.321
Truck/Trailer Lease or Purchase Payments	$0.267
Repair and Maintenance	$0.147
Truck Insurance Premiums	$0.070
Permits and Licenses	$0.024
Tires	$0.037
Tolls	$0.035
Total	$0.900

Source: American Transportation Research Institute (ATRI)

The annual excess fuel consumption within the Clarksville Metropolitan Area is shown in **Figure 3.2**. The annual hours of delay within the Clarksville Metropolitan Area are shown in **Figure 3.3**. The Annual Congestion Cost within the Clarksville Metropolitan Area are shown in **Figure 3.4**.

Figure 3.2: Annual Excess Fuel Consumption within the Clarksville Metropolitan Area

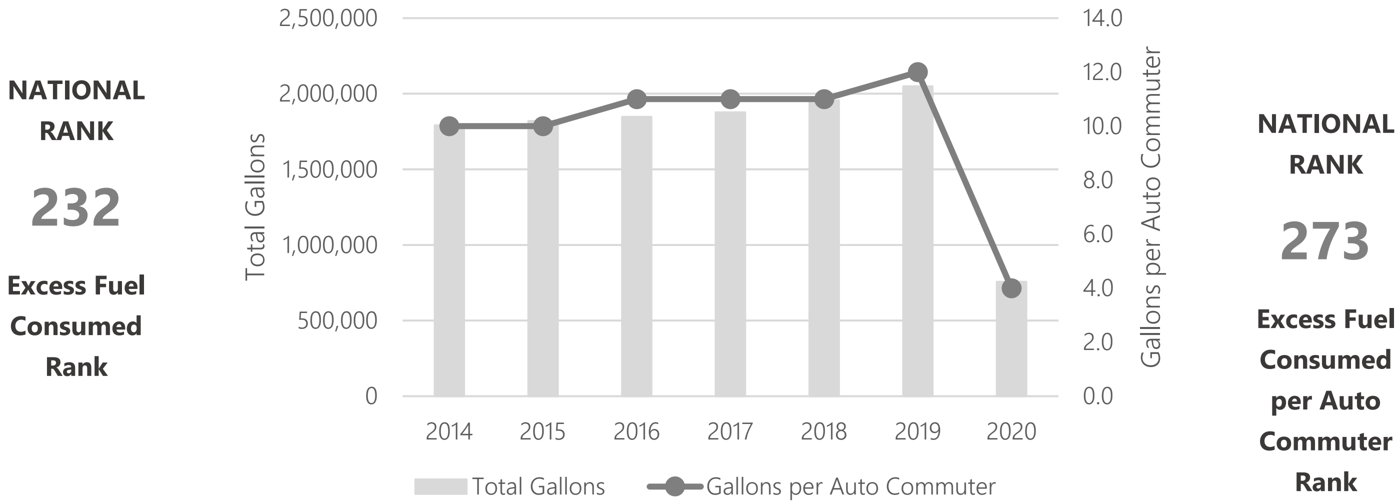
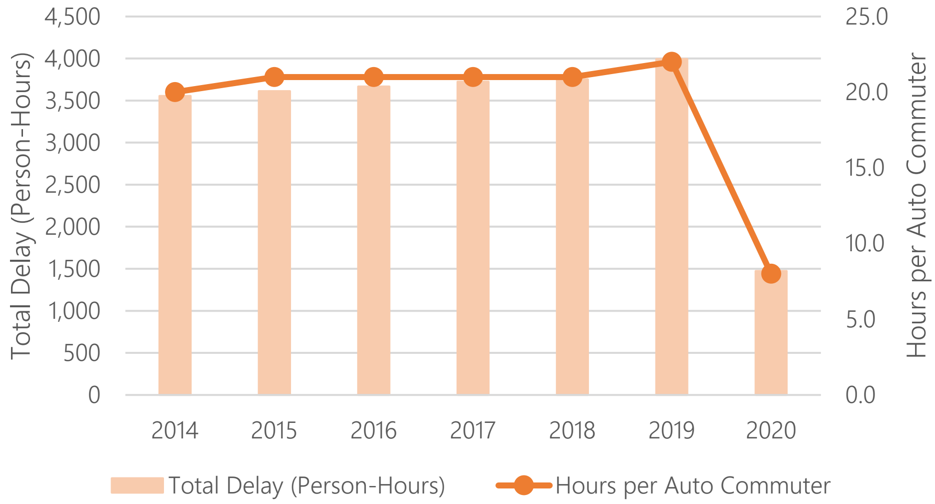


Figure 3.3: Annual Hours of Delay within the Clarksville Metropolitan Area

NATIONAL RANK

267

Delay Rank



NATIONAL RANK

331

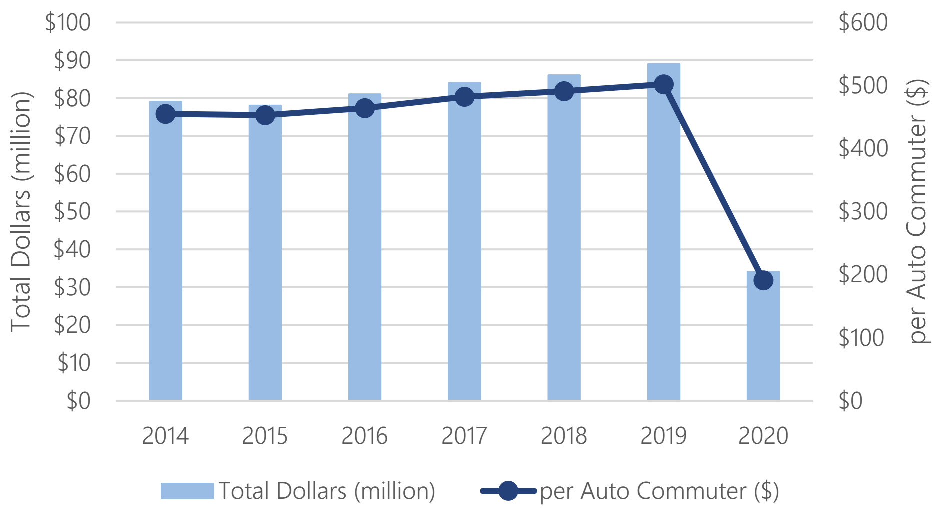
Delay per Auto Commuter Rank

Figure 3.4: Annual Congestion Cost within the Clarksville Metropolitan Area

NATIONAL RANK

263

Cost Rank



NATIONAL RANK

336

Cost per Auto Commuter Rank

Due to data access limitations, the focus of this CMP would be to estimate the travel time cost due to excessive delay and vehicle operating cost.

4.0 Future Congestion

Using the results from the 2050 TDM, with only the "Existing plus Committed" (E+C) Projects implemented, in the Clarksville MPA, the Vehicle Miles Traveled (VMT) will increase by 42 percent from 2019 to 2050, and the Vehicle Hours Traveled (VHT) will increase by 107 percent from 2019 to 2050. However, during this same time period, the Vehicle Hours Delay (VHD) will increase by 237 percent. This large increase in VHD is expected to result in increased congestion on the roadway network. Chapter 4 of *Technical Report #4: Needs Assessment*[9] further summarizes the congestion relief needs.

To calculate the projected change in Average Daily Duration of Congestion, Total Duration of Congestion, and Total Delay for the Top 10 freeway and Top 25 arterial segments shown in **Tables 2.3 and 2.4** between 2023 and 2050, the VHD for each segment was obtained from the TDM, and the percent change in VHD between 2019 and 2050 was applied to the 2023 Average Daily Duration of Congestion, Total Duration of Congestion, and Total Delay to calculate the 2050 values.

Non-recurring congestion analysis for the future was not conducted since the occurrence of random events such as crashes, road construction, or special events in the future cannot be determined. However, segments that currently experience non-recurring congestion due to crashes may experience longer delays in the future if no improvements are made. *2.5 Step 5: Congestion Analysis – Non-Recurring Congestion* identifies the segments that experienced significant non-recurring congestion.

4.1 Existing plus Committed (E+C) Scenario

This scenario includes only the projects that are committed for construction. A list of E+C projects can be found in *Technical Report #1: Transportation Modeling and Forecasting*[13]. According to this document, a project is considered committed if:

- Construction was either completed or begun since 2020,
- 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.

Table 4.1 presents the E+C projects. If only the E+C projects are implemented, the sum of the Total Delay of the Top 10 Freeway Segments is projected to increase by 557 percent between 2023 and 2050, and the sum of the Total Delay of the Top 25 Arterial Segments is projected to increase by 143 percent between 2023 and 2050. **Tables 4.2 and 4.3** shows the projected Average Daily Duration of Congestion, Total Duration of Congestion, and Total Delay for the Top 10 Freeway and Top 25 Arterial segments shown in **Tables 2.3 and 2.4**, respectively, in 2050, with only the E+C projects implemented.

Table 4.1: E+C Projects

Roadway	Location	Improvement	Opening Year
Dunbar Cave Road	0.07 miles south of Moss Road to Rossview Road	Realignment	2026
SR 237/Rossview Road	Keysburg Road to Cardinal Lane	Widen from 2 lanes to 3 lanes	2026
	Cardinal Lane to Powerll Road	Widen from 2 lanes to 5 lanes	2026
KY 911	US 41A to KY 115	Widen from 2 lanes to 5 lanes	2025
SR 374	South of Dunbar Cave Road to West of Stokes Road	Widen from 2 lanes to 5 lanes	Completed
SR 149/SR 13	SR 149 from River Road to SR 13	Widen from 2 lanes to 5 lanes	Completed
	SR 13 from SR 149 to Zinc Plant Road		Completed

Source: CUAMPO

Table 4.2: Changes in Total Delay for Top 10 Congested Freeway Segments, 2023 to 2050 E+C

2023 Rank	Roadway	Segment	2023 Average Daily Duration of Delay	2023 Total Duration of Congestion	2023 Total Delay (Vehicle Hours)	2019 TDM Daily VHD	2050 TDM Daily VHD	Change in TDM Daily VHD (2019 to 2050)	Percent Change in TDM Daily VHD (2019 to 2050)	2050 Average Daily Duration of Congestion	2050 Total Duration of Congestion	2050 Total Delay (Vehicle Hours)
1	I-24 Eastbound	SR 76 On-Ramp to Montgomery/Robertson County Line	15 m	3 d 19 h 20 m	41,580,608	3,005.0	23,738.3	20,733.3	690%	1 h 58 m	30 d 1 h 29 m	328,470,333
2	I-24 Westbound	Robertson/Montgomery County Line to SR 76 Off-Ramp	15 m	3 d 21 h 31 m	37,037,583	3,163.0	24,983.9	21,820.9	690%	2 h 1 m	30 d 18 h 40 m	292,552,318
3	I-24 Westbound	At Tennessee/Kentucky State Line	21 m	5 d 10 h 27 m	25,310,395	84.0	321.4	237.4	283%	1 h 22 m	20 d 19 h 10 m	96,851,667
4	I-24 Westbound	SR 76 On-Ramp to SR 237 (Rossview Road) Off-Ramp	5 m	1 d 9 h 2 m	8,242,528	1,371.0	5,694.6	4,323.6	315%	22 m	5 d 17 h 12 m	34,236,441
5	I-24 Eastbound	Between SR 237 (Rossview Road) Ramps	3 m	23 h 32 m	4,169,469	31.0	76.1	45.1	145%	9 m	2 d 9 h 43 m	10,228,679
6	I-24 Eastbound	Between SR 76 Ramps	4 m	1 d 2 h 7 m	3,684,409	31.0	298.0	267.0	861%	41 m	10 d 11 h 2 m	35,415,910
7	I-24 Westbound	Between SR 48 Ramps	0 m	5 h 50 m	1,675,265	24.0	84.8	60.8	253%	3 m	20 h 36 m	5,918,517
8	I-24 Westbound	Between US 79 (SR 13) Ramps	0 m	4 h 14 m	1,269,439	9.0	50.6	41.6	462%	3 m	23 h 47 m	7,133,038
9	I-24 Eastbound	Between US 79 (SR 13) Ramps	1 m	11 h 32 m	1,174,669	13.0	57.1	44.1	339%	8 m	2 d 2 h 41 m	5,162,539
10	I-24 Eastbound	Between SR 48 Ramps	0 m	5 h 46 m	171,962	18.0	68.1	50.1	278%	3 m	21 h 48 m	650,334

Table 4.3: Changes in Total Delay for Top 25 Congested Arterial Segments, 2023 to 2050 E+C

2023 Rank	Roadway	Segment	2023 Average Daily Duration of Delay	2023 Total Duration of Congestion	2023 Total Delay (Vehicle Hours)	2019 TDM Daily VHD	2050 TDM Daily VHD	Change in TDM Daily VHD (2019 to 2050)	Percent Change in TDM Daily VHD (2019 to 2050)	2050 Average Daily Duration of Congestion	2050 Total Duration of Congestion	2050 Total Delay (Vehicle Hours)
1	US 41A (SR 12) Northbound/US 79 (SR 76) Southbound/Providence Boulevard	US 41A/US 79 (SR 12/SR 13)/Riverside Drive to Peachers Mill Road	1 h 55 m	29 d 3 h 59 m	46,924,962	1,797.0	3,952.8	2,155.8	120%	4 h 13 m	64 d 3 h 44 m	103,219,704
2	US 41A (SR 12)/Fort Campbell Boulevard Northbound	US 79 (SR 76)/Dover Road to Dover Crossing Road	2 h 42 m	41 d 2 h 53 m	15,875,240	25.0	39.0	14.0	56%	4 h 13 m	64 d 3 h 46 m	24,769,131
3	SR 374/101st Airborne Division Parkway Westbound	SR 48/Trenton Road to Peachers Mill Road	21 m	5 d 13 h 31 m	15,305,093	2,076.0	5,918.7	3,842.7	185%	1 h 2 m	15 d 20 h 39 m	43,634,996
4	SR 374/101st Airborne Division Parkway Westbound	US 79 (SR 13)/Wilma Rudolph Boulevard to SR 48/Trenton Road	1 h 37 m	24 d 19 h 54 m	14,390,881	200.0	621.2	421.2	211%	5 h 4 m	77 d 2 h 56 m	44,700,057
5	US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	SR 374 to I-24 Eastbound	38 m	9 d 16 h 57 m	12,522,166	1,247.0	2,735.3	1,488.3	119%	1 h 24 m	21 d 6 h 59 m	27,467,839
6	US 79 (SR 76)/Dover Road Northbound	At US 41A (SR 12)/Providence Boulevard	11 h 12 m	170 d 12 h 44 m	9,591,152	24.0	65.9	41.9	175%	1 d 6 h 47 m	468 d 4 h 32 m	26,332,359
7	US 41A (SR 12)/Fort Campbell Boulevard Southbound	Dover Crossing Road to US 79 (SR 76)/Dover Road	4 h 46 m	72 d 16 h 20 m	8,417,762	25.0	39.0	14.0	56%	7 h 27 m	113 d 9 h 34 m	13,133,701
8	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	I-24 Westbound to I-24 Eastbound	2 h 4 m	31 d 15 h 56 m	8,413,519	501.0	1,343.8	842.8	168%	5 h 35 m	84 d 22 h 21 m	22,567,497
9	SR 374 (Richview Road) Southbound	At US 41A (SR 112)/Madison Street	5 h 49 m	88 d 15 h 19 m	7,404,997	49.0	135.7	86.7	177%	16 h 8 m	245 d 9 h 30 m	20,500,859
10	SR 374/101st Airborne Division Parkway Eastbound	Peachers Mill Road to SR 48/Trenton Road	7 m	1 d 21 h 51 m	6,921,302	2,076.0	5,918.7	3,842.7	185%	21 m	5 d 10 h 43 m	19,732,712

2023 Rank	Roadway	Segment	2023 Average Daily Duration of Delay	2023 Total Duration of Congestion	2023 Total Delay (Vehicle Hours)	2019 TDM Daily VHD	2050 TDM Daily VHD	Change in TDM Daily VHD (2019 to 2050)	Percent Change in TDM Daily VHD (2019 to 2050)	2050 Average Daily Duration of Congestion	2050 Total Duration of Congestion	2050 Total Delay (Vehicle Hours)
11	US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	Peachers Mill Road to US 41A/US 79 (SR 12/SR 13)/Riverside Drive	15 m	3 d 21 h 6 m	6,889,408	1,797.0	3,952.8	2,155.8	120%	33 m	8 d 12 h 47 m	15,154,464
12	SR 374/101st Airborne Division Parkway Eastbound	US 41A (SR 12)/Fort Campbell Boulevard On-Ramp to Peachers Mill Road	22 m	5 d 18 h 51 m	6,680,057	451.0	1,221.5	770.5	171%	1 h 1 m	15 d 16 h 4 m	18,092,834
13	SR 76 Eastbound	I-24 Eastbound to I-24 Westbound	1 h 33 m	23 d 15 h 42 m	5,536,896	61.0	163.9	102.9	169%	4 h 10 m	63 d 13 h 16 m	14,876,272
14	US 79 (SR 13)/Wilma Rudolph Boulevard Northbound	At Dunbar Cave Road	4 h 27 m	67 d 19 h 21 m	4,236,472	176.0	424.2	248.2	141%	10 h 44 m	163 d 9 h 58 m	10,210,078
15	US 41A Bypass (SR 12/SR 13)/Riverside Drive Northbound	At US 41A/US 79 (SR 12/SR 76/SR 112)/Providence Boulevard	4 h 45 m	72 d 7 h 24 m	4,180,667	32.0	61.2	29.2	91%	9 h 5 m	138 d 5 h 14 m	7,991,398
16	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At SR 48/Trenton Road	5 h 20 m	81 d 6 h 56 m	4,033,467	76.0	181.9	105.9	139%	12 h 47 m	194 d 12 h 11 m	9,651,279
17	US 41A (SR 12)/Fort Campbell Boulevard Southbound	SR 236/Tiny Town Road to SR 374	4 m	1 d 4 h 9 m	3,689,194	1,402.0	2,551.3	1,149.3	82%	8 m	2 d 3 h 13 m	6,713,416
18	US 41A (SR 12) Southbound/US 79 (SR 76) Northbound/Providence Boulevard	US 79 (SR 76)/Dover Road to Peachers Mill Road	16 m	4 d 2 h 49 m	3,569,566	565.0	1,106.8	541.8	96%	31 m	8 d 1 h 34 m	6,992,579
19	SR 12/Ashland City Road Northbound	At US 41A Bypass (SR 12/SR 76)	14 h 54 m	226 d 17 h 5 m	3,170,423	104.0	540.2	436.2	419%	3 d 5 h 25 m	1177 d 13 h 52 m	16,467,691
20	US 41A (SR 112)/Madison Street Eastbound	At US 41A Bypass (SR 76)	3 h 21 m	50 d 23 h 26 m	2,978,230	194.0	579.2	385.2	199%	10 h	152 d 4 h 25 m	8,891,187

2023 Rank	Roadway	Segment	2023 Average Daily Duration of Delay	2023 Total Duration of Congestion	2023 Total Delay (Vehicle Hours)	2019 TDM Daily VHD	2050 TDM Daily VHD	Change in TDM Daily VHD (2019 to 2050)	Percent Change in TDM Daily VHD (2019 to 2050)	2050 Average Daily Duration of Congestion	2050 Total Duration of Congestion	2050 Total Delay (Vehicle Hours)
21	US 79 (SR 13/SR 48)/Wilma Rudolph Boulevard Southbound	At US 79 (SR 13)/Kraft Street)	1 h 15 m	19 d 5 h 26 m	2,805,298	233.0	573.0	340.0	146%	3 h 6 m	47 d 6 h 48 m	6,899,069
22	SR 76 Westbound	I-24 Westbound to I-24 Eastbound	1 h 51 m	28 d 4 h 51 m	2,740,603	61.0	163.9	102.9	169%	4 h 58 m	75 d 18 h 31 m	7,363,323
23	US 79 (SR 13)/Wilma Rudolph Boulevard Southbound	At Dunbar Cave Road	1 h 26 m	21 d 19 h 49 m	2,720,705	117.0	297.0	180.0	154%	3 h 38 m	55 d 9 h 50 m	6,907,163
24	US 41A (SR 12)/Fort Campbell Boulevard Northbound	SR 374 to SR 236/Tiny Town Road	4 m	1 d 26 m	2,584,617	1,402.0	2,551.3	1,149.3	82%	7 m	1 d 20 h 27 m	4,703,360
25	SR 374 (Paul B Huff Memorial Parkway) Southbound	At US 79 (SR 76)/Dover Road	1 h 26 m	21 d 20 h 10 m	2,335,828	35.0	124.2	89.2	255%	5 h 5 m	77 d 11 h 39 m	8,287,133

5.0 Conclusions

High transportation demand in relatively populous metropolitan areas generates congestion which could vary in both intensity and extension depending on the relationship between supply and demand. The limited capacity of the existing road network within the Clarksville Metropolitan Area leads to substantial congestion repercussions along several travel corridors during different times of the day for both commuters and non-commuters. System users carry the burden of those repercussions through excess travel times, higher crash rates, travel unreliability, additional emissions, and personal frustration, as well as additional costs for goods and services.

Unfortunately, the relationship between transportation supply and demand involves a wide array of clear and underlaying elements that need continuous monitoring and data collection. Although the availability of new technologies is offering plenty of tools to tackle congestion problems and needs more aggressively, resulting congestion remedies need to be taken to the next level in terms of policy and implementation. Accordingly, success in tackling congestion problems requires cooperation between transportation agencies, law enforcement, public safety agencies, the private sector, and the public.

The eight-step congestion management process included robust data collection and analysis which illustrated:

- The recurring and non-recurring congestion analyses showed that excessive recurring and non-recurring congestion occurs on I-24, as well as several major arterials.
- The match with the current Long Range Transportation Plan (MTP) indicates that CUAMPO is already going in the direction of congestion mitigation. However, partial implementation of the MTP would essentially allow congestion problems to intensify and expand which would jeopardize the quality of life within the Clarksville metropolitan area.

Recommendations

- Continue to encourage utilizing alternative modes of transportation and/or car/vanpooling as means of decreasing the single-occupant vehicle travel demand. The two large scale wideing projects on I-24 are not proposed to start construction until the mid 2030’s, which only increases the need for alternative modes of travel.

- Enhance real-time communication with multi-modal travelers to provide them with information to help them with the decision-making process to avoid congestion before or during their trips.
- Enhance the interaction with the public to continuously obtain feedback about congestion problems and needs as well as the implemented strategies and policies.
- Continue to obtain data related to regional congestion. Variability of data nature and sources both public and private sector are becoming increasingly accessible and provide leverage in verifying and enhancing the analysis and findings.
- Monitor and analyze freight trends specially trucks. Freight movement dynamics have significantly different correlation with congestion than passenger travel trends.
- Encourage Traffic Incident Management (TIM). Continued TIM efforts will be beneficial for traffic incident monitoring and non- recurring congestion analysis.
- Continue to work with TDOT to identify opportunities that may exisit to promote the newly created Statewide Partnership Program. Additionally, continue to have regular conversations with the State to better understand challeges that face the CUAMPO.

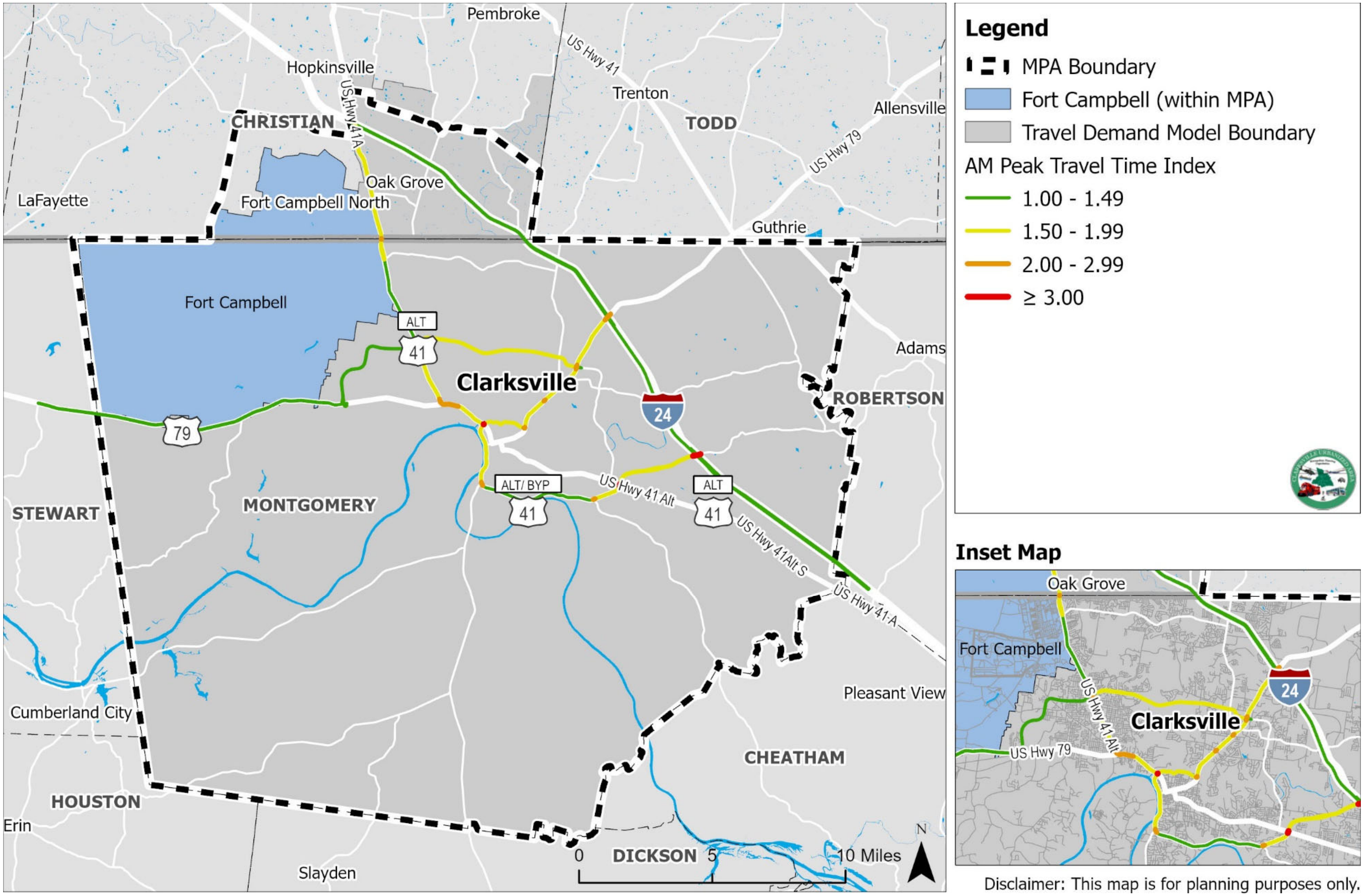
Appendices

Appendix A: Travel Time Index Study

Appendix B: Vehicle Hours Delay Study

Appendix C: Volume to Capacity Study

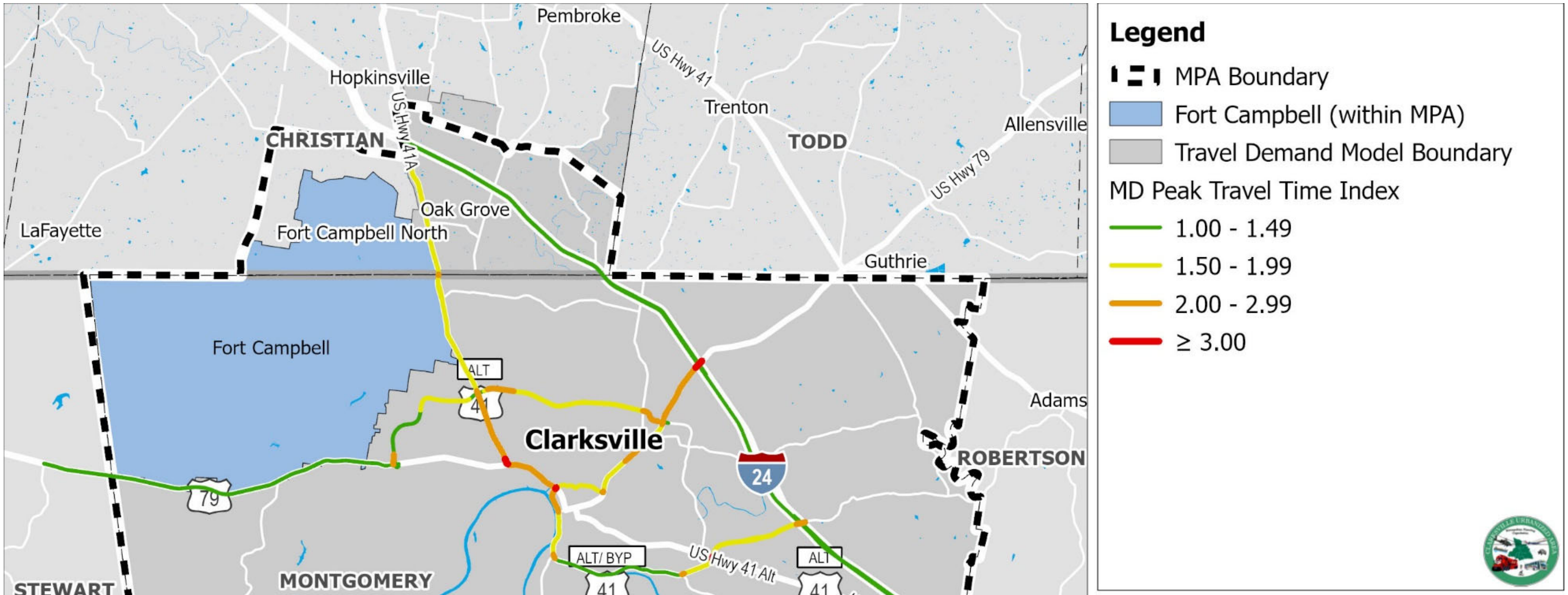
Appendix A.1: Travel Time Index Study – AM Peak



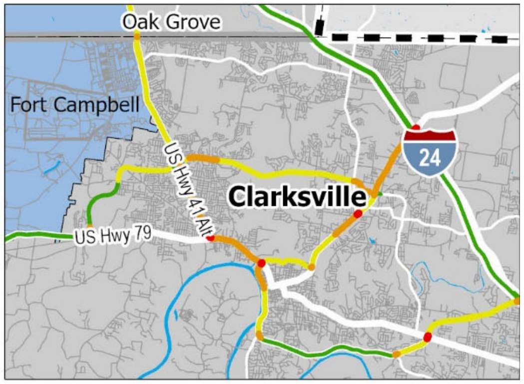
Disclaimer: This map is for planning purposes only.

Source: NPMRDS

Appendix A.2: Travel Time Index Study – MD Peak



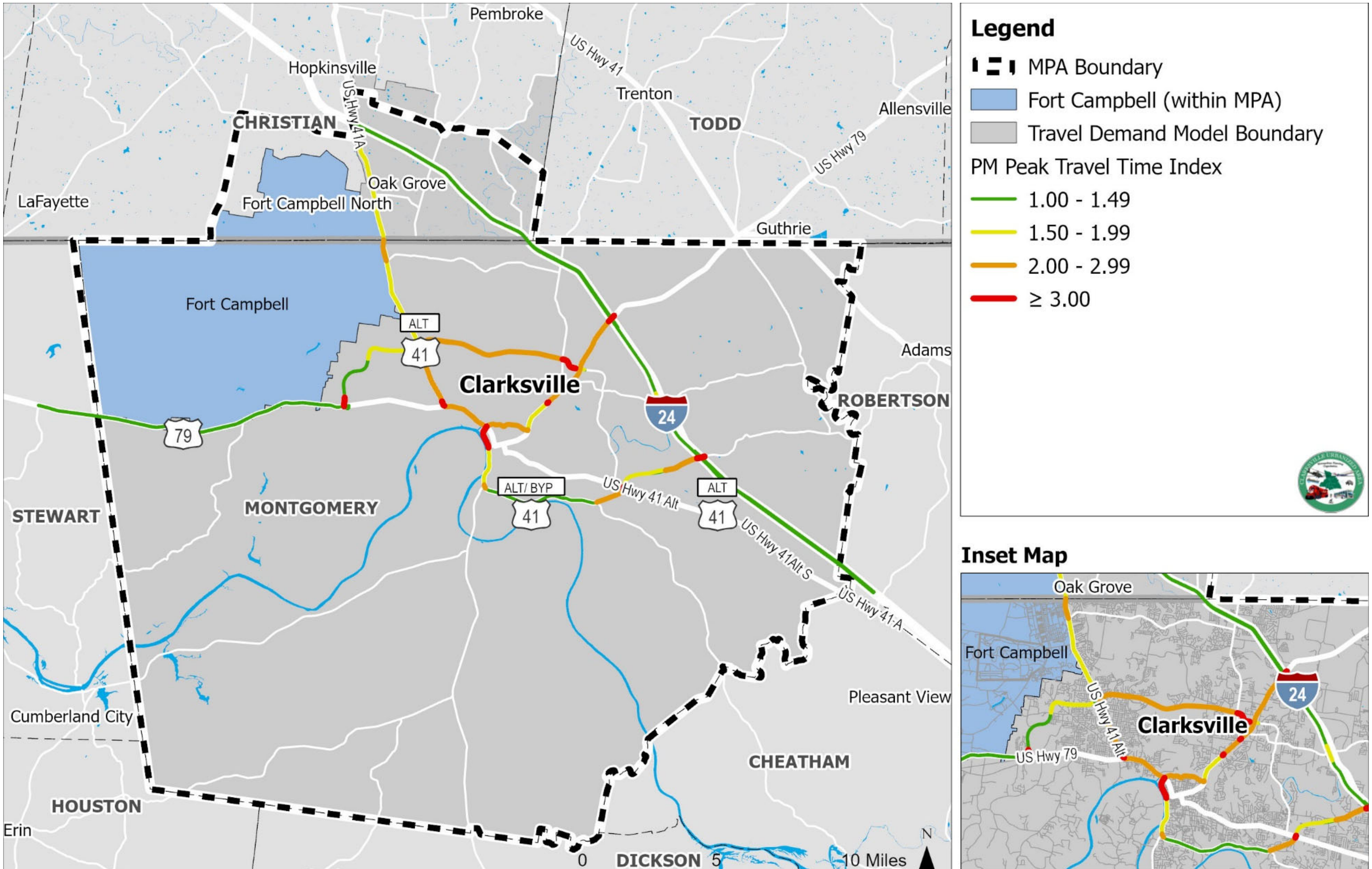
Inset Map



Disclaimer: This map is for planning purposes only.

Source: NPMRDS

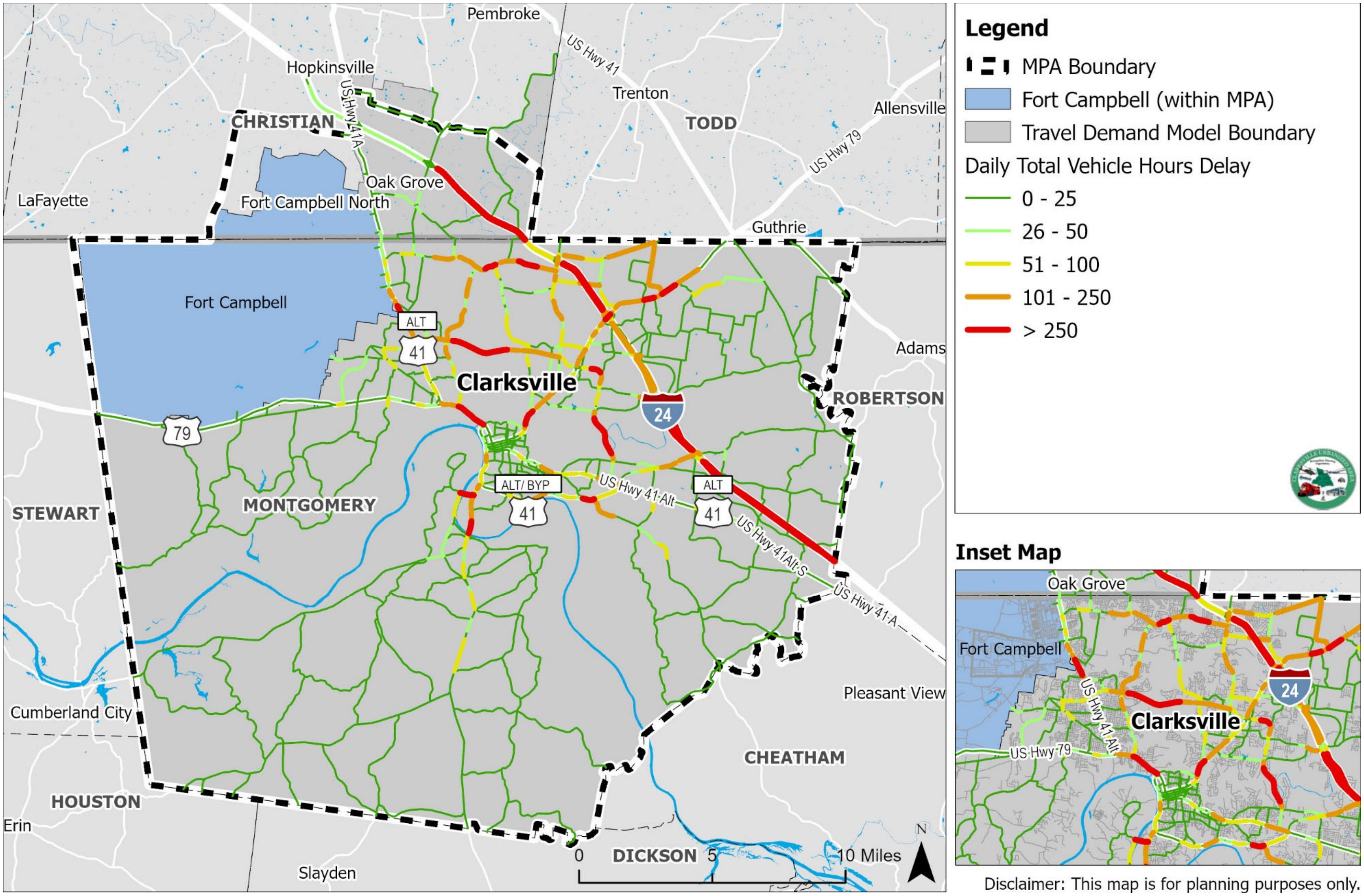
Appendix A.3: Travel Time Index Study – PM Peak



Disclaimer: This map is for planning purposes only.

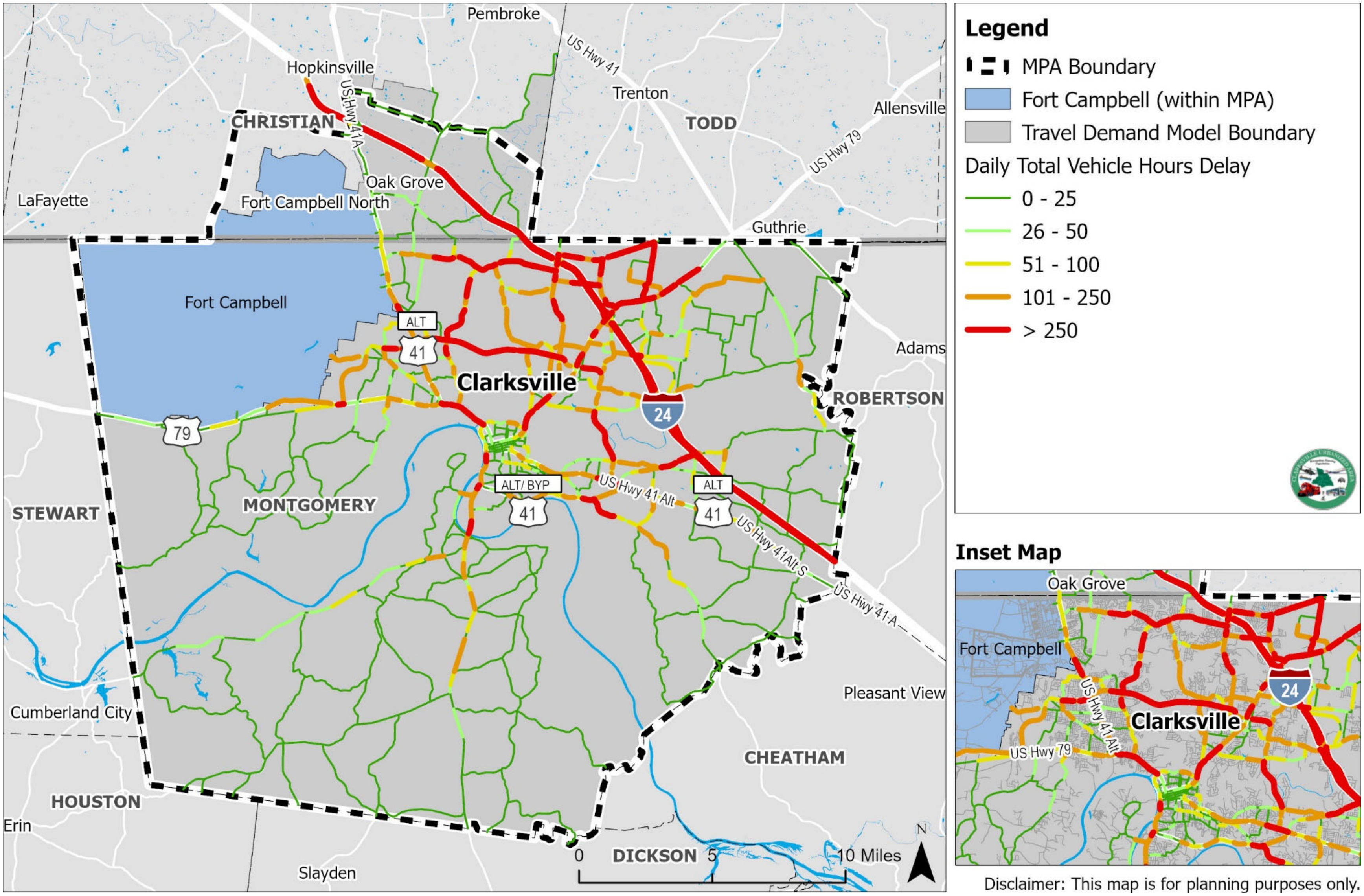
Source: NPMRDS

Appendix B.1: Vehicle Hours Delay Study – Base (2019) Daily



Source: Travel Demand Model

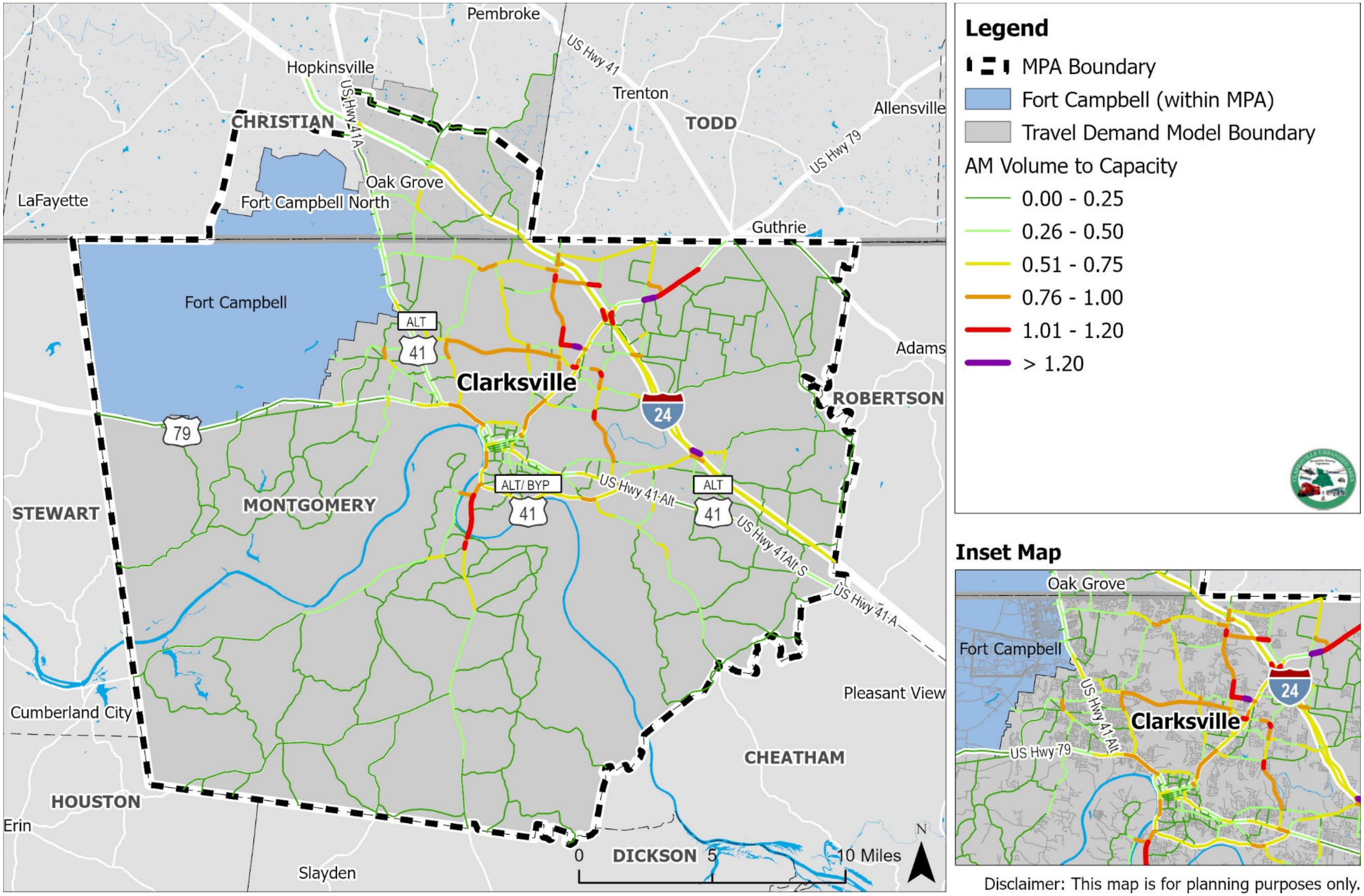
Appendix B.2: Vehicle Hours Delay Study – E+C (2050) Daily



Disclaimer: This map is for planning purposes only.

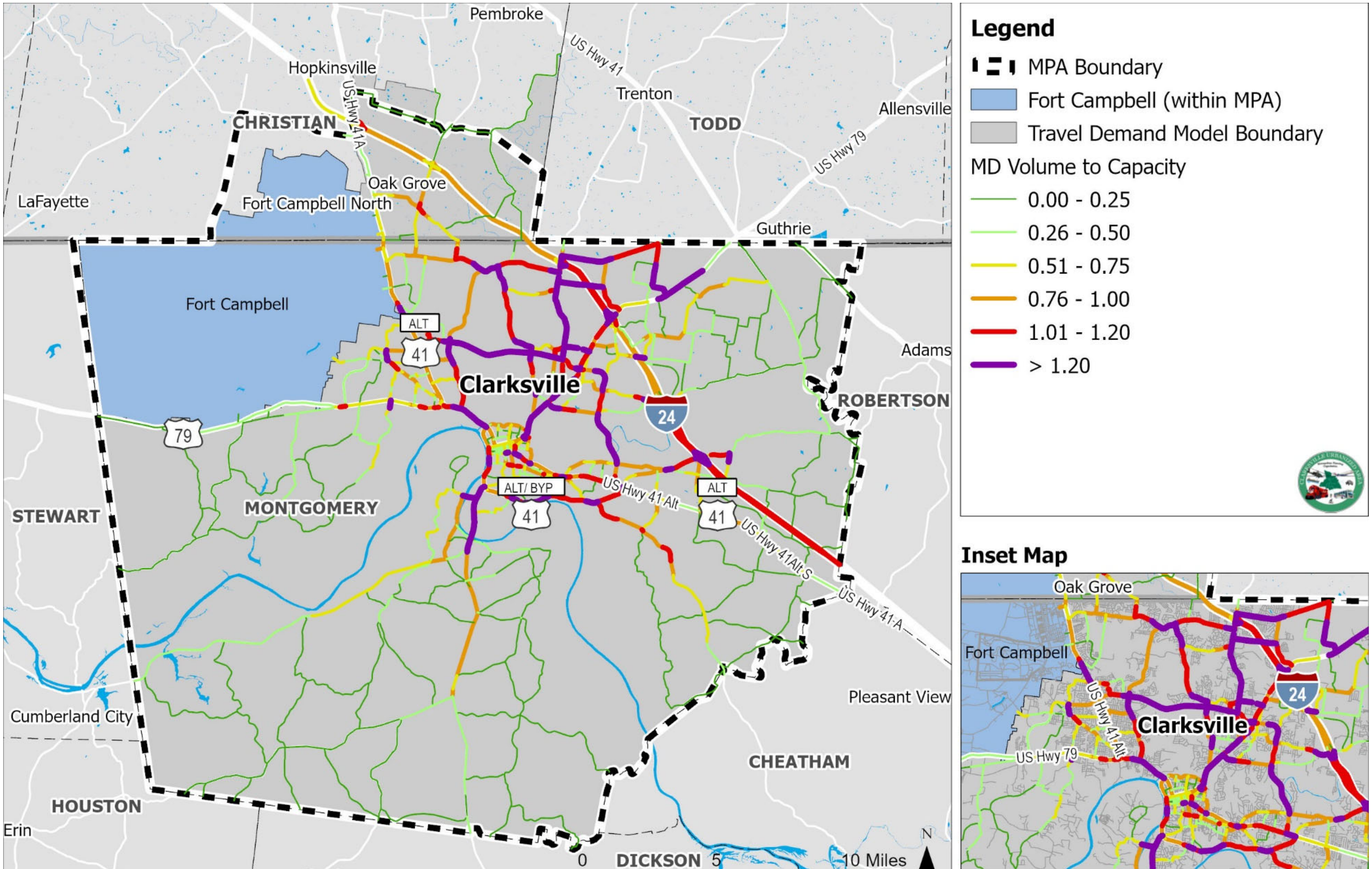
Source: Travel Demand Model

Appendix C.1: Volume to Capacity Study – Base (2019) AM



Source: Travel Demand Model

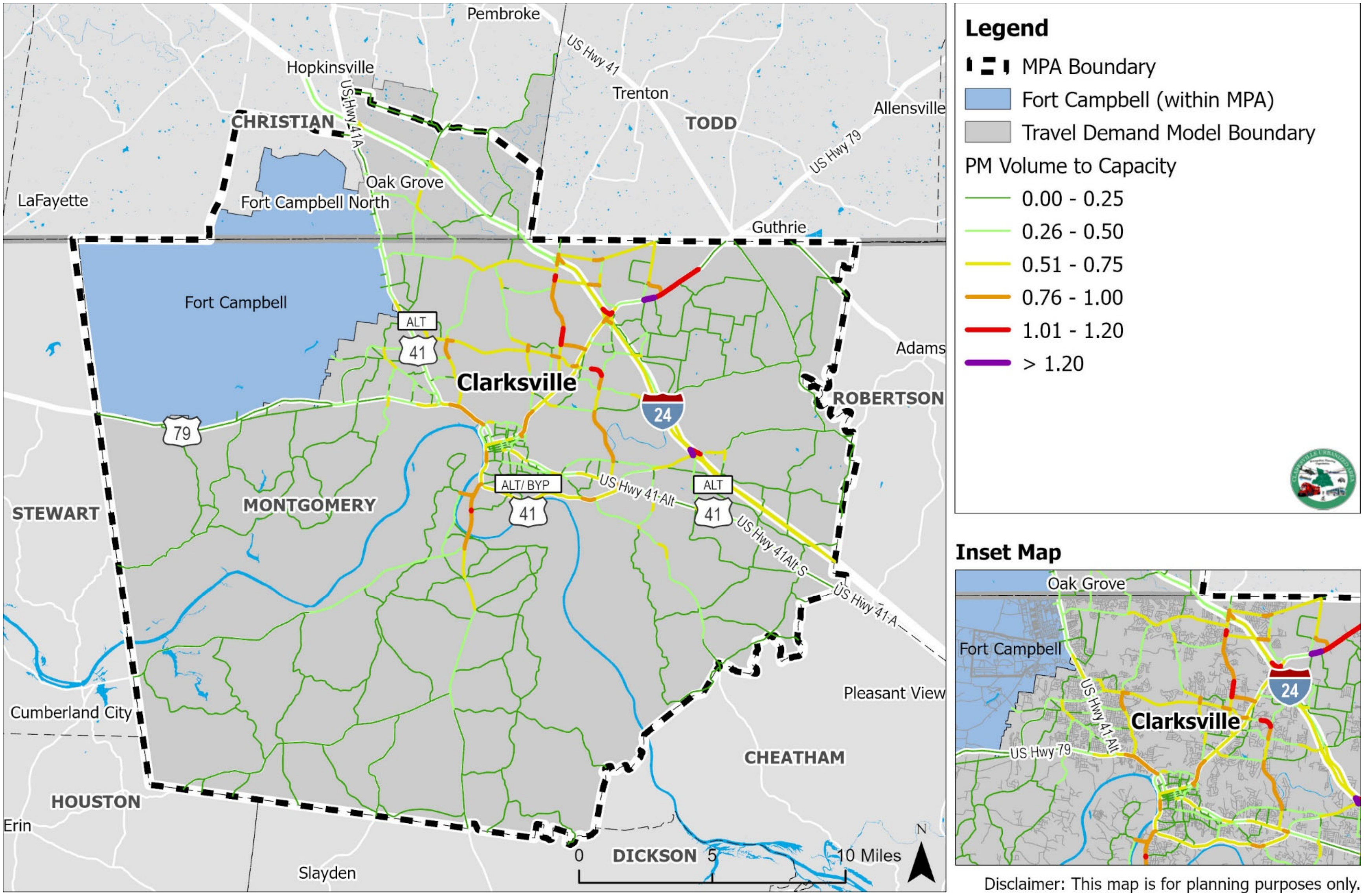
Appendix C.2: Volume to Capacity Study – Base (2019) MD



Disclaimer: This map is for planning purposes only.

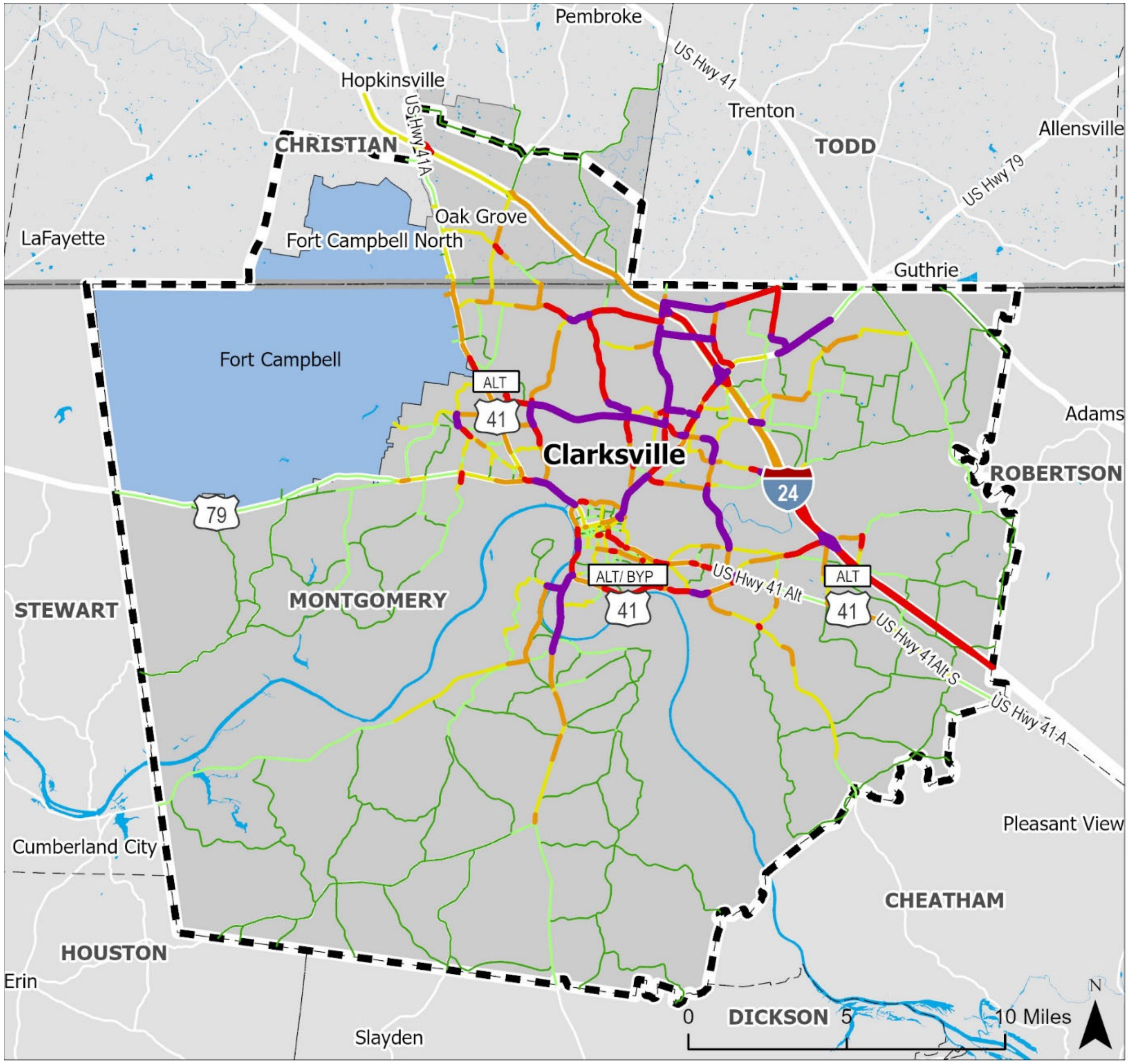
Source: Travel Demand Model

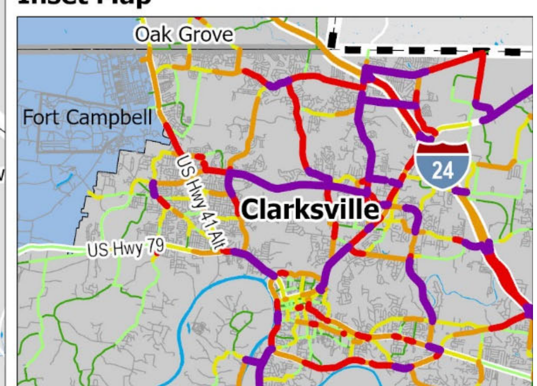
Appendix C.3: Volume to Capacity Study – Base (2019) PM



Source: Travel Demand Model

Appendix C.4: Volume to Capacity Study – Base (2019) NT

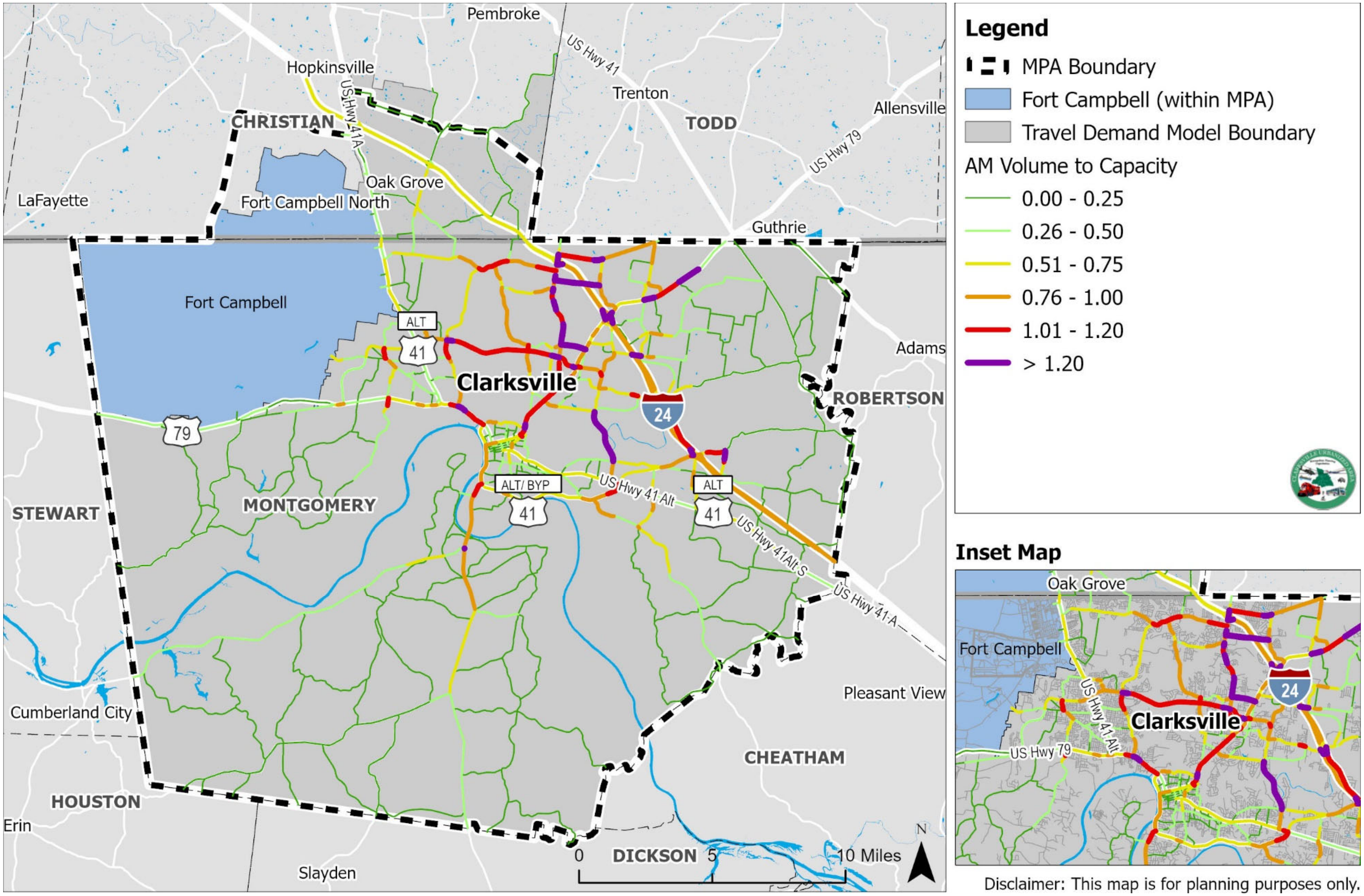




Disclaimer: This map is for planning purposes only.

Source: Travel Demand Model

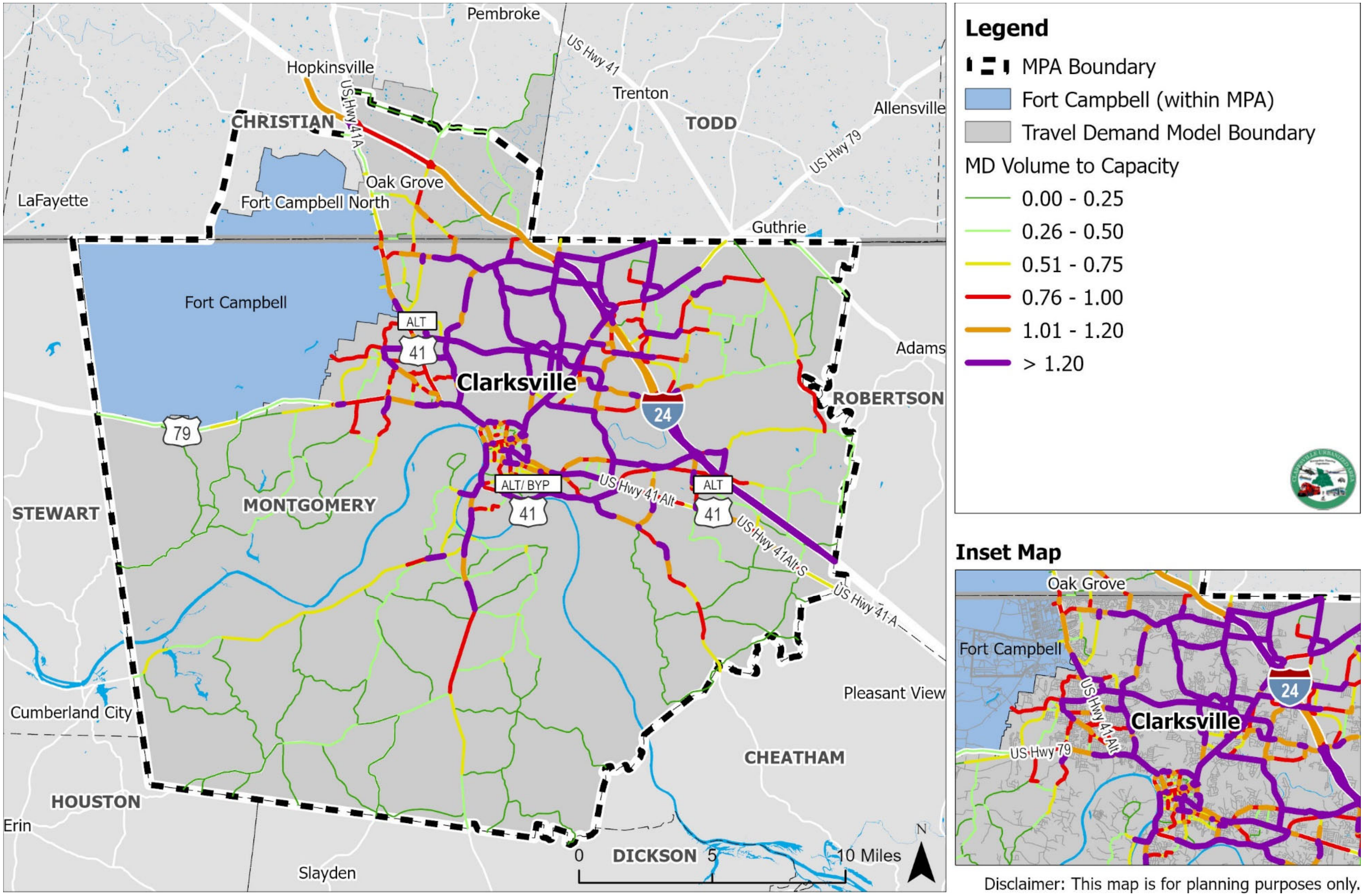
Appendix C.5: Volume to Capacity Study – E+C (2050) AM



Disclaimer: This map is for planning purposes only.

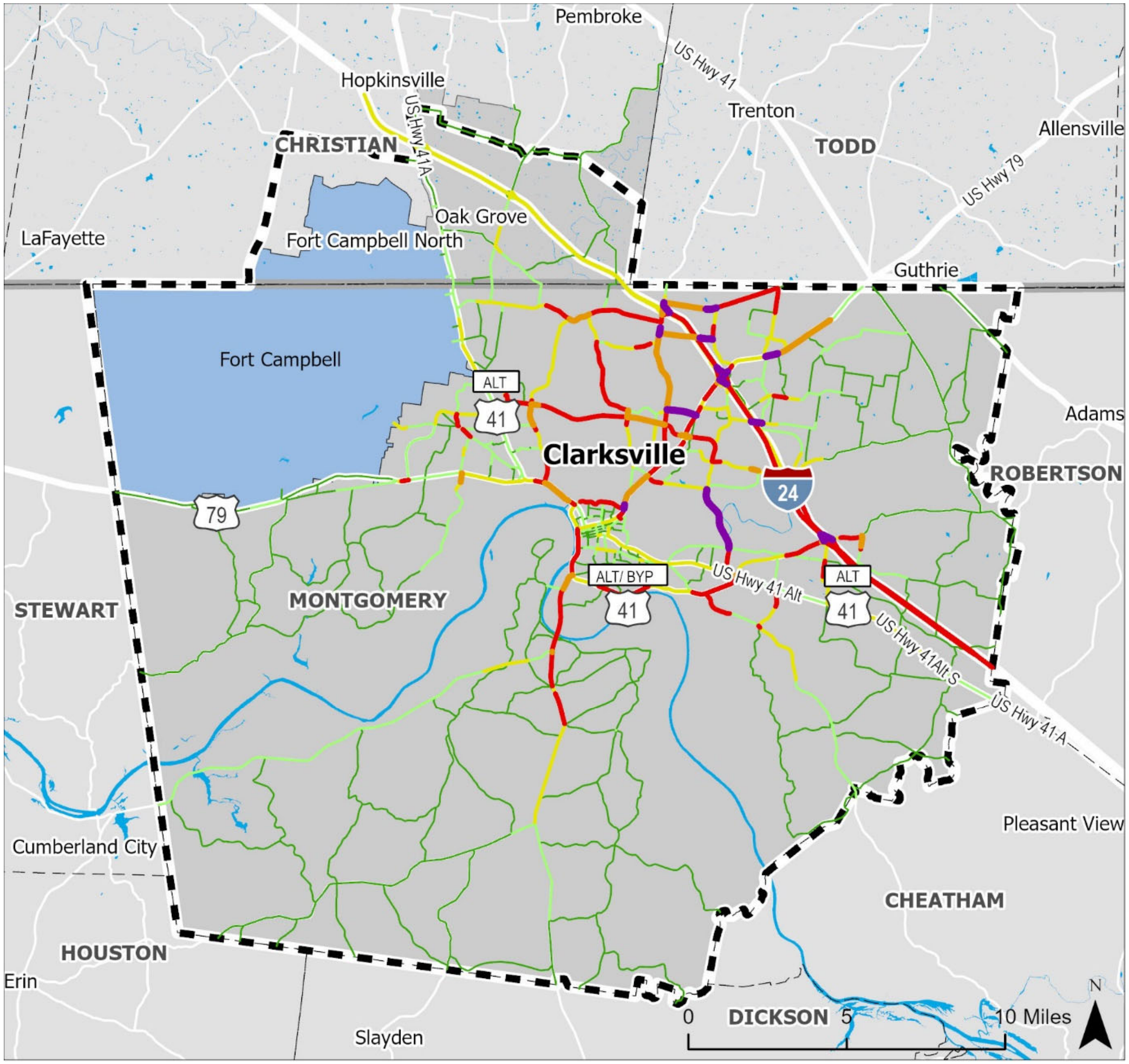
Source: Travel Demand Model

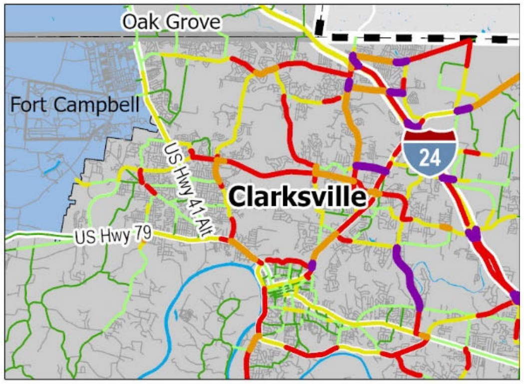
Appendix C.6: Volume to Capacity Study – E+C (2050) MD



Source: Travel Demand Model

Appendix C.7: Volume to Capacity Study – E+C (2050) PM

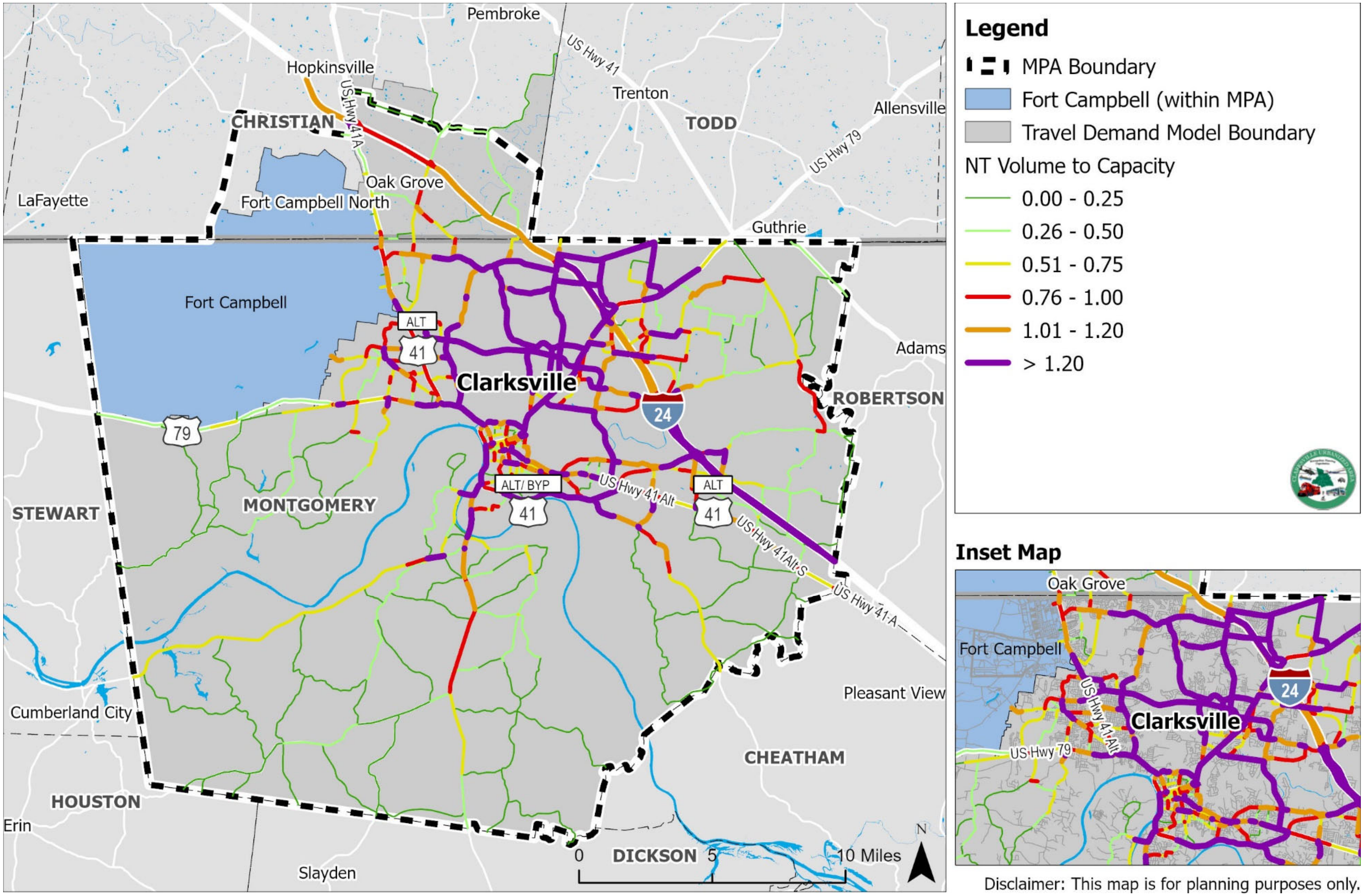




Disclaimer: This map is for planning purposes only.

Source: Travel Demand Model

Appendix C.8: Volume to Capacity Study – E+C (2050) NT



Source: Travel Demand Model