REGIONAL BICYCLE AND PEDESTRIAN STUDY

A Strategic Vision for Walking and Bicycling in the Greater Nashville Region

Needs Assessment

Technical Memorandum 2

November 2009

TABLE OF CONTENTS

1.0 Introduction 1

2.0 System Performance 2

2.1 Pedestrian & Bicycle Level of Service Analysis 2
2.1.1 Commuter Corridors 15
2.2 Bicycle and Pedestrian Crash Anaylsis 18

3.0 Travel Demands 21

3.1 Trip Model 21

4.0 Health Assessment 24

5.0 Opportunities & Challenges 27

5.1 Accommodation Provisions 28
5.1.1 Facilities 28
5.1.2 Design 28
5.1.3 Maintenance 29
5.2 Education, Awareness, and Enforcement 29
5.2.1 Sharing the Road 29
5.2.2 Safer Streets 29
5.3 Connectivity 30
5.3.1 Land Uses and Land Use Patterns 30
5.3.2 Crossing Major Features 30
5.4 Vehicular Traffic & Cultural Environment 31
5.5 Funding 31

APPENDIX

Appendix A Pedestrian & Bicycle Level of Service (PLOS/BLOS) Maps by County 1

Appendix B Nashville Area MPO Bicycle and Pedestrian Crash Assessment 1

Appendix C Nashville Regional Non-Motorized Trip Generator (Trip Model) 1

MAPS

Map 2.1 Pedestrian Level of Service (PLOS) – MPO Region 4

Map 2.2 Bicycle Level of Service (BLOS) – MPO Region 10

Map 2.3 Commuter Corridors – BLOS Assessment 16

Map 2.4 Nolensville Road Corridor - BLOS 17

Map 2.5 Bicycle and Pedestrian Crashes by Corridor – MPO Region 20

Map 2.6 Non-Motorized Demand – MPO Region 23

1.0 INTRODUCTION

In 2008, the Nashville Area Metropolitan Planning Organization (MPO), the regional transportation planning organization in the Middle Tennessee area, initiated the development of the region's first comprehensive Bicycle and Pedestrian Study for the greater Nashville region. The Regional Bicycle and Pedestrian Study is intended to establish a strategic vision for walking and bicycling in the region. This strategic vision will feed into the MPO's overall Long Range Transportation Plan and provide the basis by which future funding priorities of the MPO are established for bicycle and pedestrian accommodations within Davidson, Rutherford, Sumner, Wilson and Williamson counties, plus the cities of Spring Hill and Springfield.

Working with local governments, businesses, non-profit organizations, and the general public the Nashville Area MPO developed the Regional Bicycle and Pedestrian Study as a mechanism to foster a better understanding of bicycle and pedestrian needs within the region. The Study is also intended to serve as a means of guiding policies, programs, and investments intended to maximize opportunities for greater walking and biking activity now and in the future within the greater Nashville region.

In general, the Regional Bicycle and Pedestrian Study:

- Provides a comprehensive inventory of existing and currently proposed on and off-road bicycle and pedestrian facilities in the greater Nashville region
- Increases the region's understanding of how non-motorized modes add to system-wide capacity by improving connectivity between residential areas, employment centers, schools, retail centers, recreational centers, and other attractions
- Serves as a framework for identifying and selecting bicycle/pedestrian projects for the region's Long Range Transportation Plan and Transportation Improvement Program; and
- Provides guidance for engineering, education, enforcement, encouragement, and evaluation activities to help improve the safety of non-motorized travel modes.

This Technical Memorandum provides an assessment of walking and biking conditions in the greater Nashville region based on system conditions and non-motorized demand. Additionally, an assessment of high health risk areas and challenges and opportunities to walking and biking in the region are also discussed.

2.0 SYSTEM PERFORMANCE

Many factors influence one's decision to walk or bike when making a transportation choice. Many of these factors have to do with the physical environment, which includes the presence of adequate walking and biking accommodations. This section includes an assessment of walking and biking conditions based on existing facility conditions.

2.1 PEDESTRIAN & BICYCLE LEVEL OF SERVICE ANALYSIS

Various tools have been developed in recent years to assist engineers and planners in evaluating the ability of roads to serve pedestrians and bicyclists. Similar to the vehicular Level of Service, there are models that have been developed to evaluate the suitability of the roadway for walking and bicycling. The Level of Service for walking and bicycling is based on the comfort level of the pedestrian and bicyclist on the roadway. Both the Pedestrian Level of Service (PLOS) and the Bicycle Level of Service (BLOS) models were developed using input from actual pedestrians and bicyclists on various roadway segments. There are various factors used to evaluate the comfort level of the users which involve the roadway geometry, motor vehicles using the road, and the presence and condition of pedestrian and bicycle facilities.

PLOS

A Pedestrian Level of Service (PLOS) analysis was conducted for roadway segments inventoried in the Nashville MPO based on the National Cooperative Highway Research Program (NCHRP) Report 616 on Multimodal Level of Service Analysis for Urban Streets. The evaluation of pedestrian levels of service involves the walking conditions within the shared roadway environment (e.g. sidewalk or path to the side of the roadway) since pedestrians typically do not utilize the roadway unless there is no other option.

As discussed in NCHRP Report 616, part of the development of the pedestrian level of service model involved pedestrians walking on a variety of roadway segments and rating their comfort level on each segment on a scale from A to F, with A being the best conditions and F the worst conditions. The pedestrians used in the research study consisted of all age groups and various levels of walking experience. Based on the response of the participants, the researchers developed an equation to determine the PLOS for the roadway segment. The PLOS equation uses some of the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. The model reflects the effect on walking suitability or "compatibility" due to factors such as roadway width, presence of sidewalks and intervening buffers, barriers within those buffers, traffic volume, motor vehicles speed, and on-street parking. The factors listed are shown in the following equation:

$$PLOS = -1.2276 \ln(W_{ol} + W_l + f_p \times W_b + f_{sw} \times W_s) + 0.0091 (Vol_{15}/L) + 0.0004\ SPD^{2\,+}\ 6.0468$$

Where
PLOS = Pedestrian Level of Service
W_{ol} = Width of outside lane
W_l = Width of shoulder or bicycle lane
f_p = On-street parking effect coefficient (=0.20)
%OSP = Percent of segment with on-street parking
f_b = Buffer area barrier coefficient (=5.37 for trees spaced 20 feet on center)

W_b = Buffer width (distance between edge of pavement and sidewalk, feet)
f_{sw} = Sidewalk presence coefficient (= 6 - 0.3W_s)
W_s = Width of sidewalk
Vol_{15} = Directional motorized vehicle count in the peak 15 minute time period
L = Total number of directional through lanes
SPD = Average running speed of motorized vehicle traffic

The PLOS score resulting from the application of the equation is then converted to a LOS ranging from A to F as shown in Table 1.

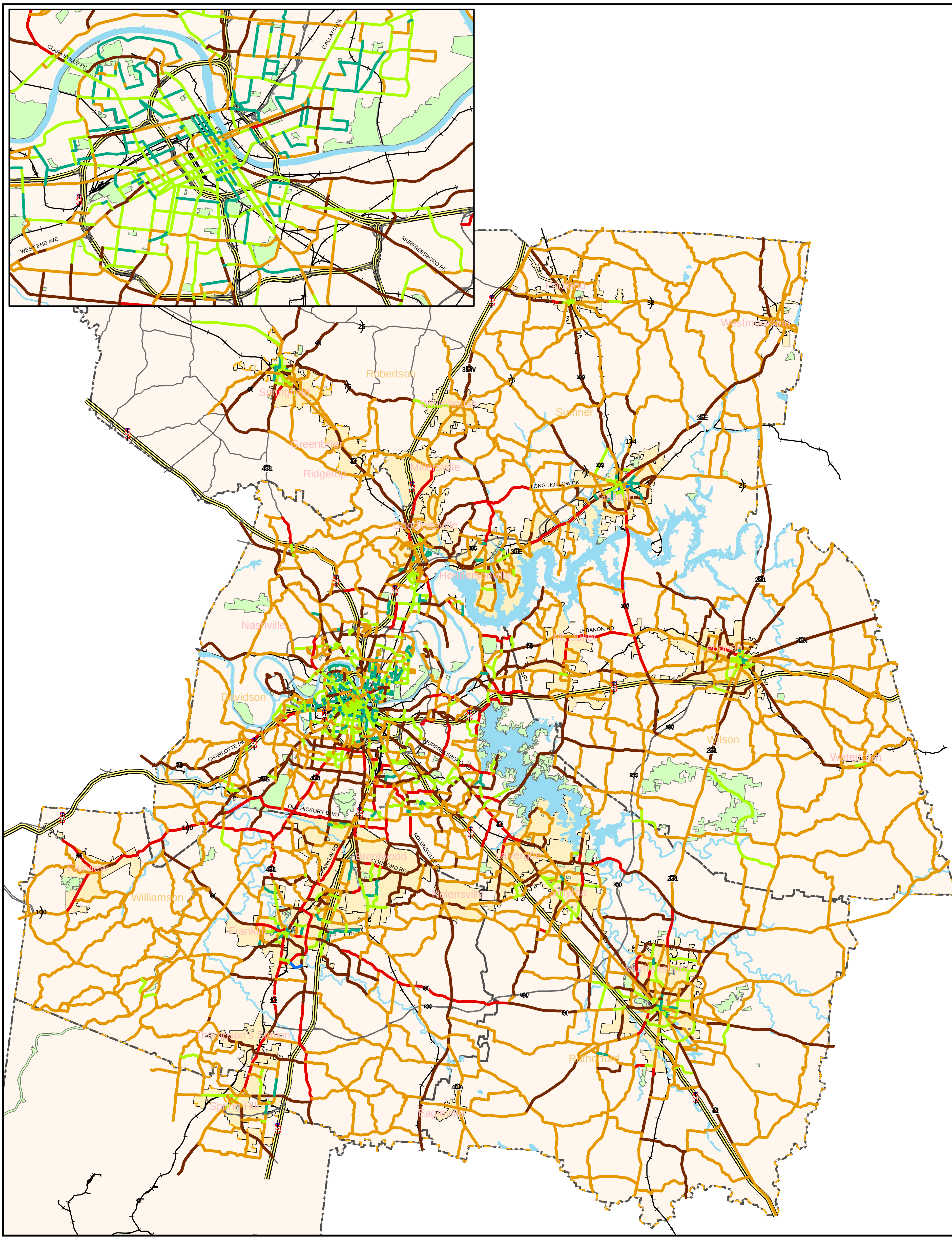
Table 1. Bicycle and Pedestrian Level of Service Rating

Grade	Score	Level of Service
A	$\leq$ 1.5	Extremely high
B	> 1.5 and $\leq$ 2.5	Very high
C	> 2.5 and $\leq$ 3.5	Moderately high
D	> 3.5 and $\leq$ 4.5	Moderately low
E	> 4.5 and $\leq$ 5.5	Very low
F	> 5.5	Extremely low

A PLOS model was developed for the Nashville region based on NCHRP Report 616 to evaluate the existing walking conditions in the Nashville MPO area. The PLOS model was run on the roadways which are included in the MPO's travel demand highway network and include arterial, collector, and some local roads in the Nashville MPO area.

Results of the Nashville area PLOS analysis are divided according to the roadway classification as well as the Level of Service. Chart 1 shows the results for the whole MPO area broken down for arterial, collector, and some local roads. As shown in the chart, a majority of the arterial, collector, and local roads that were inventoried are operating at a LOS D (2,048 miles). The mileage in this chart includes several roads that were inventoried outside the MPO boundary since they travel in that area. Map 2.1 illustrates the results of the PLOS analysis for the complete MPO area. Appendix A contains PLOS maps for each county.

Pedestrian Level of Service in the Nashville MPO Area



2

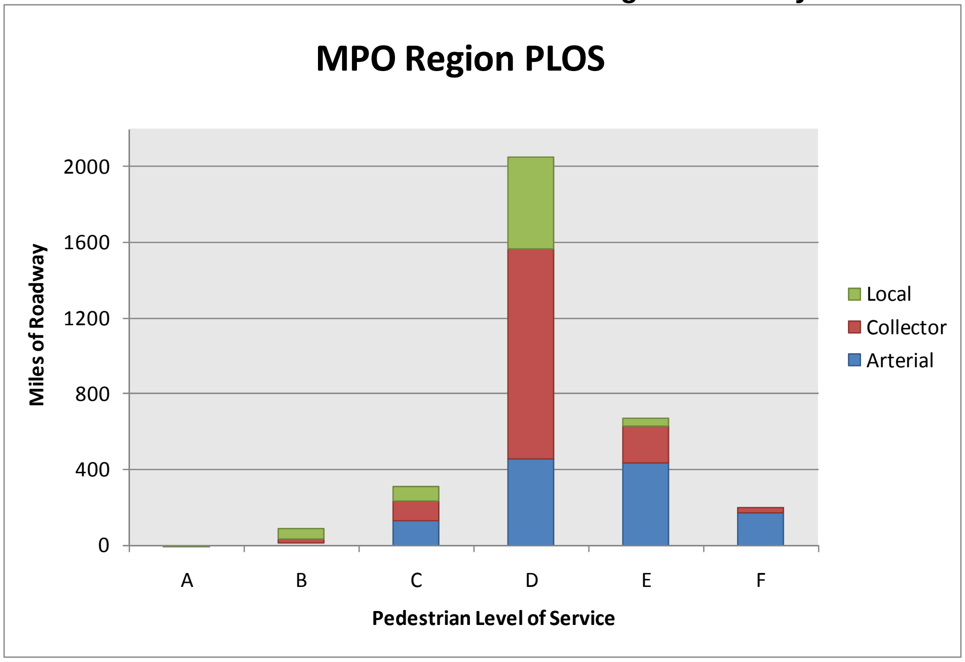
Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

0 0.5 1 2 3 4 Miles

This project is funded under an agreement with the Tennessee Department of Transportation.

Chart 1. PLOS for Nashville MPO Area According to Roadway Classification



The results of the PLOS are also broken down per county, as shown in Chart 2a and 2b. Chart 2a and Chart 2b shows the roads inventoried in all five counties combined to account for approximately 62% (or 1,913 miles) that operate at LOS D according to the PLOS model and 615 miles of roadway (or 20%) that operate a LOS E.

Chart 2a. Pedestrian Level of Service per County (Mileage)

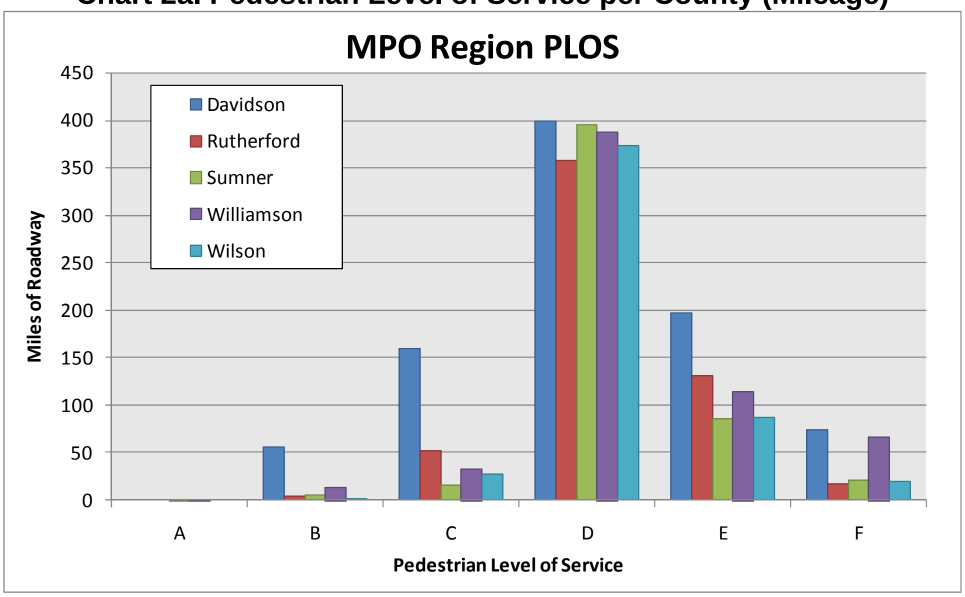
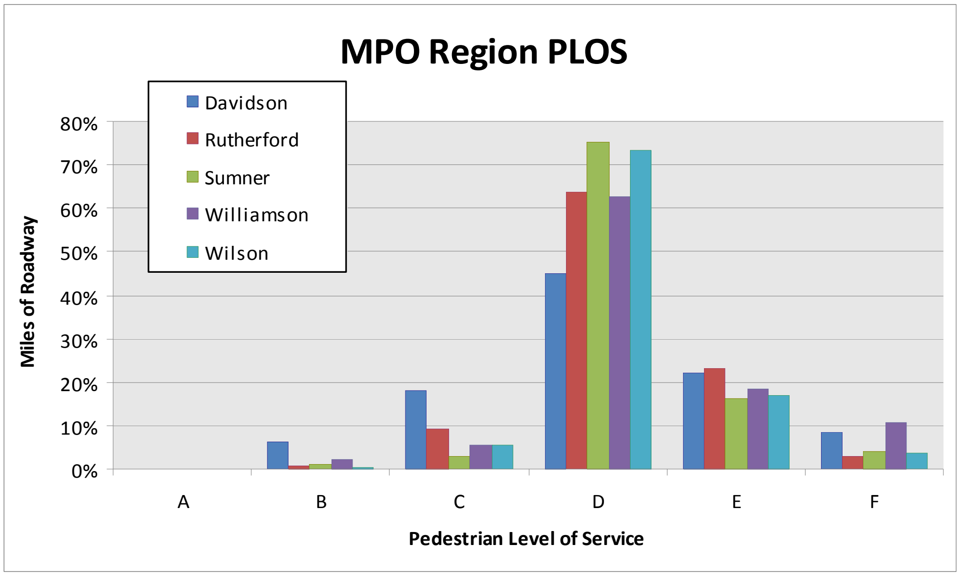


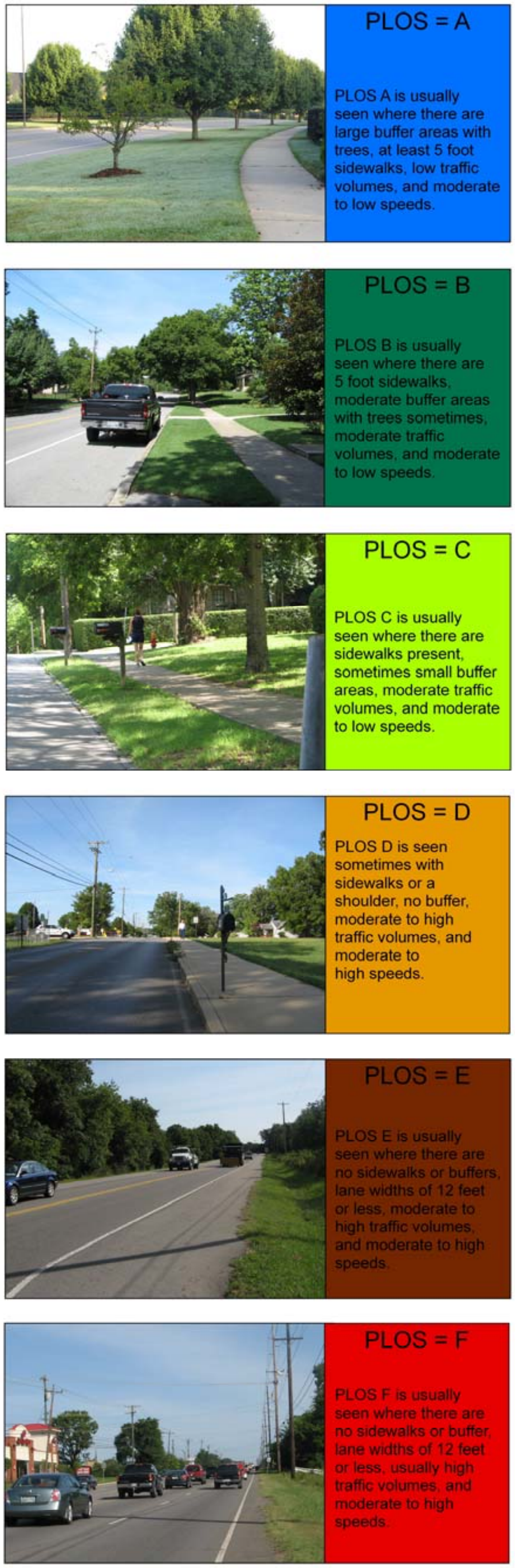
Chart 2b. Pedestrian Level of Service per County (Percentage)



Of the variables included in the PLOS model, the pedestrian levels of service are influenced mostly by the following four variables, which are listed in relative importance:

- Existence of a sidewalk
- Lateral separation of pedestrians from motorized vehicles
- Motorized vehicle volumes
- Motorized vehicle speeds

Examples of the influence of these factors are shown in the pictures below. The picture on top demonstrates a facility with a sidewalk, buffer area and barrier and results in a PLOS of A while the picture below has a sidewalk with no buffer area and no barrier and results in a PLOS of F.



The figure to the right contains examples of the different PLOS levels. Each of the examples provides a brief, general description of the characteristics associated with each PLOS rating A thru F.

BLOS

Similar to the PLOS analysis, a Bicycle Level of Service (BLOS) model for the Nashville region was developed based on NCHRP Report 616 for the analyses of the roadway segments inventoried in the Nashville MPO area.

As discussed in the NCHRP Report 616, bicyclists were asked to ride on a variety of roadway segments and then rate their comfort level on each segment on a scale from A to F with A being the best conditions and F the worst conditions. Like the pedestrians, the bicyclists used in the research study consisted of all age groups and riding capabilities. Based on the response of the participants, the researchers developed an equation to determine the BLOS for the roadway segment. The BLOS equation uses some of the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. The factors used in the calculation include the Average Daily Traffic (ADT) volume, number of through lanes on the roadway segment, speeds, percentage of trucks, the width of the outside travel lane, shoulder, and bike lane, the condition of the pavement, and the occupancy rate of on-street parking. The factors listed are shown in the following equation:

$$BLOS = 0.507 \ln(Vol_{15}/L) + 0.199\, SP_t(1+10.38HV)^2 + 7.066(1/ SP_p)^2 - 0.005(W_e)^2 + 0.760$$

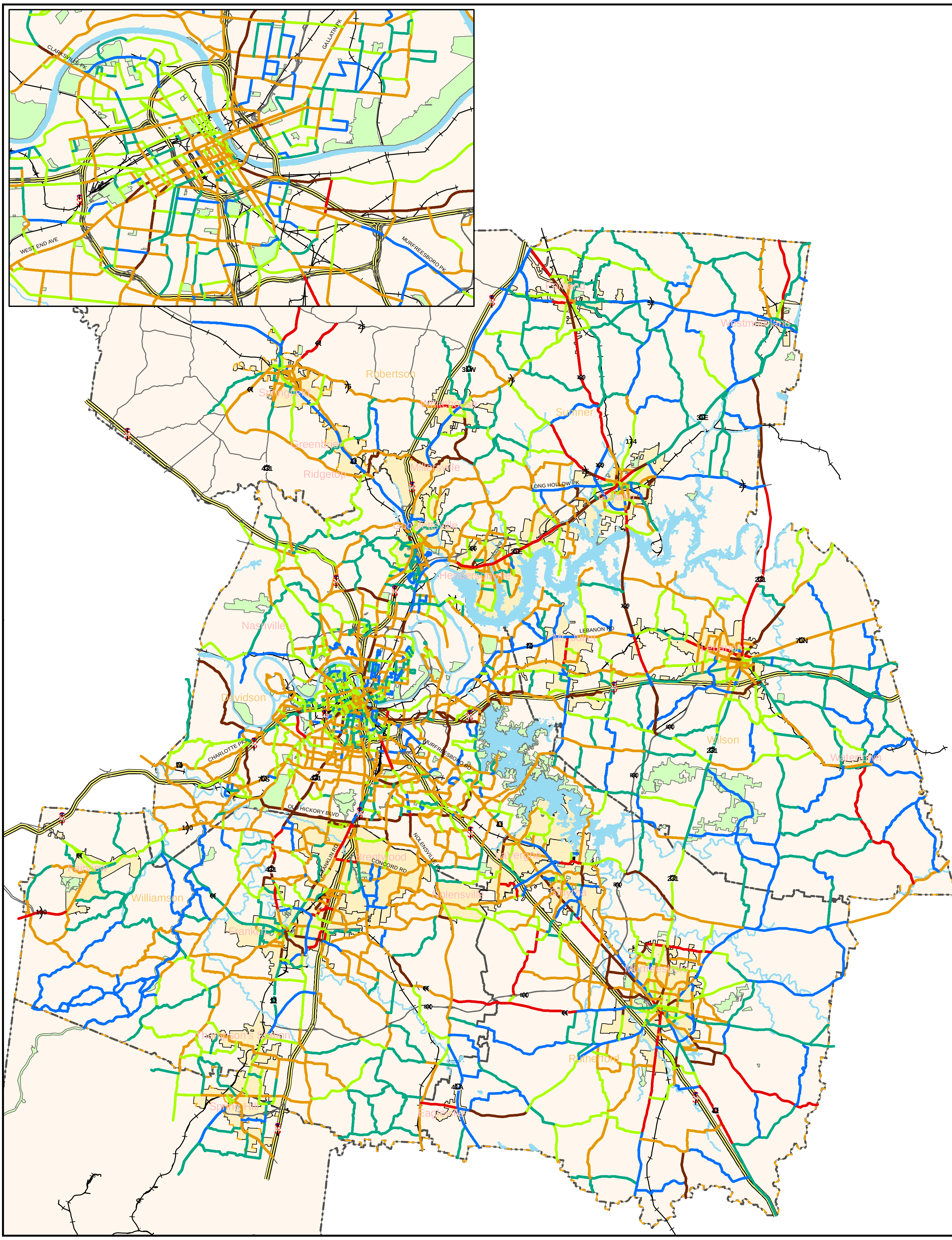
Where
BLOS = Bicycle Level of Service
Vol_{15} = Directional motorized vehicle count in the peak 15 minute time period
L = Total number of directional through lanes
SP_t = Effective speed factor = 1.1199 Ln (SP_p – 20) + 0.8103
SP_p = Posted speed limit (use for average running speed)
HV = Percentage of heavy vehicles
SP_p = FHWA's five point pavement surface condition rating
W_e = Average effective width of outside through lane

The BLOS score resulting from the application of the equation is then converted to a LOS ranging from A to F as shown in Table 1.

A BLOS model was developed for the Nashville region utilizing local roadway data to evaluate existing bicycling conditions in the Nashville MPO area. Like the PLOS analyses, the BLOS model was run on the roadways which are included in the MPO's travel demand highway network and includes arterial, collector, and some local roadways.

Results of the Nashville area BLOS analysis are broken into the roadway classification as well as the Level of Service. Chart 3 shows the results for the whole MPO area broken down for arterial, collector, and local roads. As shown in the chart the highest number of arterial and collector roadways were determined to operate at a LOS D. Map 2.2 illustrates the results of the BLOS analysis for the complete MPO area. Appendix A contains the county maps with the BLOS analysis.

Bicycle Level of Service in the Nashville MPO Area



2

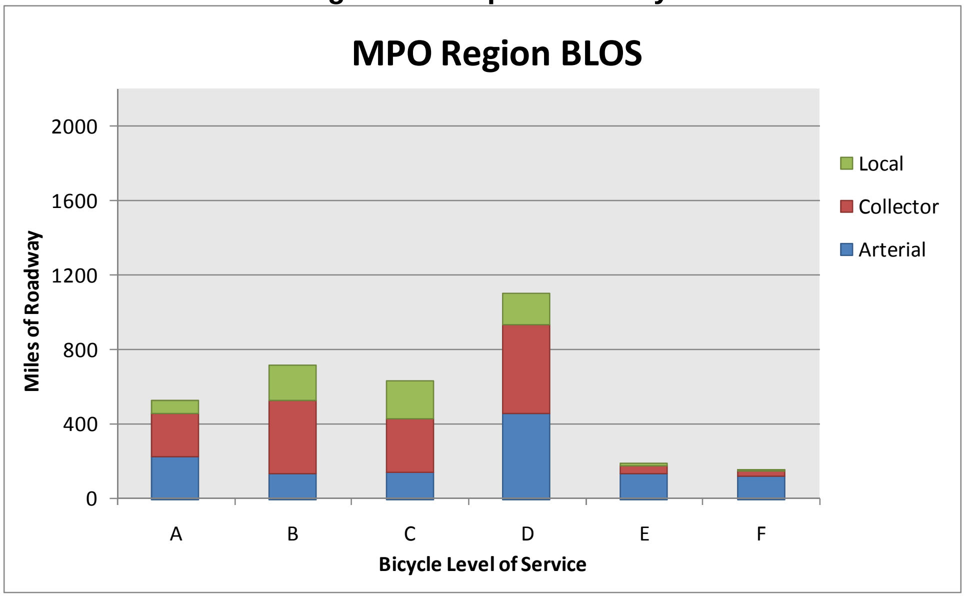
0 0.5 1 2 3 4 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Chart 3: MPO Region BLOS per Roadway Classification



The results of the BLOS analysis are also broken down per county, as shown in Charts 4a and 4b. As shown in the charts Rutherford County has the highest number of roadway segments that operate at LOS A (119 miles) as well as the highest number of LOS F roadway segments (48 miles). While Davidson County has a large amount of roadways that operate at LOS D (413 miles), it is also interesting to note that Davidson County has the lowest number of LOS F roadway miles (6 miles or 1%). Davidson, Williamson, and Rutherford Counties all have the most roadway segments operating at LOS D. Wilson and Sumner Counties have more roadway segments that operate at LOS B than any other level of service.

Chart 4a: MPO Region BLOS per County (Mileage)

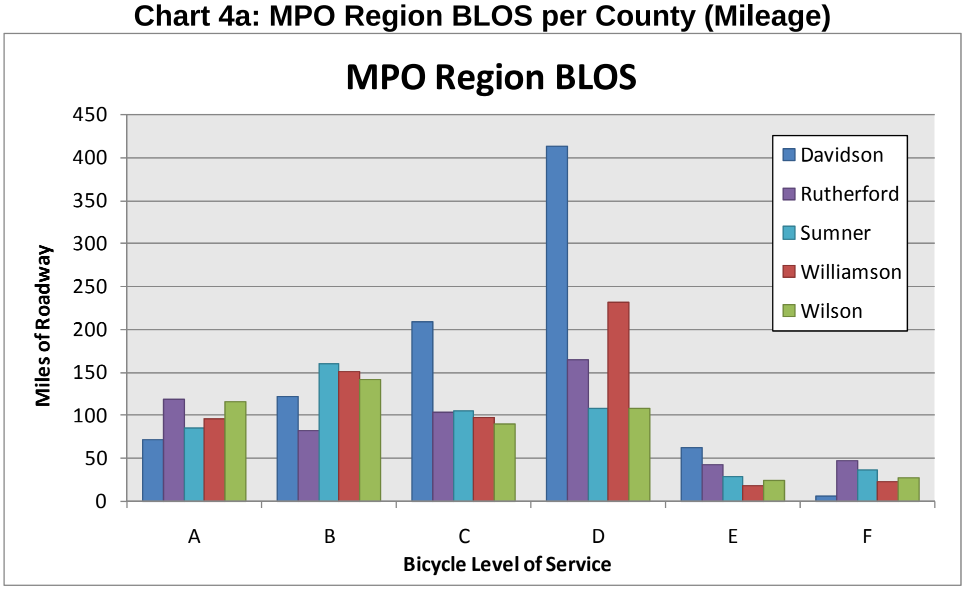
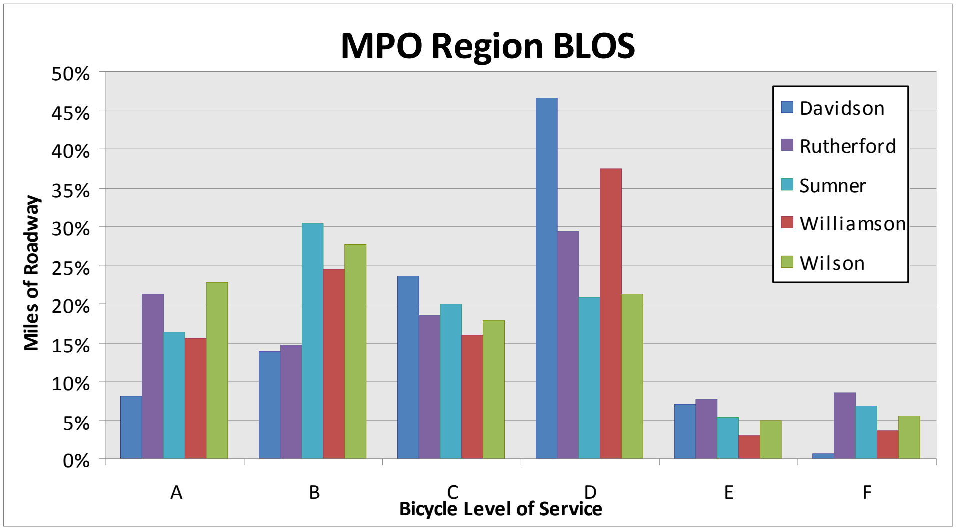


Chart 4b: MPO Region BLOS per County (Percentage)



In the BLOS model, there are several variables in the equation. However, bicycle levels of service are influenced mostly by the five variables listed in relative importance as follows:

- Average effective width of the outside through lane,
- Motorized vehicle volumes,
- Motorized vehicle speeds,
- Heavy vehicle (truck) volumes, and
- Pavement condition.

Examples of the influence of these factors are shown in the pictures below. The picture on top demonstrates a facility with a paved shoulder and 12-foot travel lane which operates at BLOS A while the picture below has no paved shoulder and a 10-foot travel lane and operates at a BLOS F.

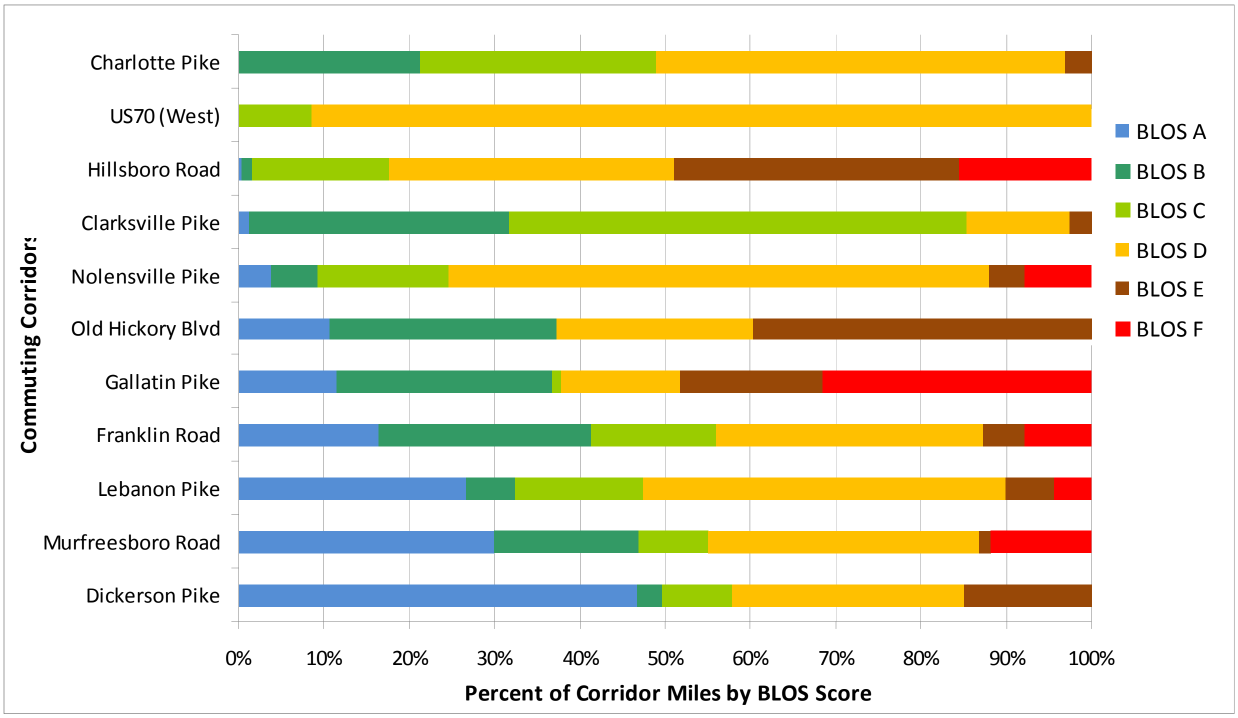
The figure to the right contains examples of the different BLOS levels. Each of the examples provides a brief, general description of the characteristics associated with each BLOS rating A thru F.

2.1.1 Commuter Corridors

A review of commuter corridors in the Nashville area was undertaken looking at the results of the BLOS analysis. In total, eleven corridors including ten arterial radial roadways and one circumferential route were selected to compare the findings of the BLOS analysis.

Chart 5 shows the results of the BLOS for the commuter corridors in the Nashville MPO area. As shown in Chart 5, five of the major corridors throughout the MPO area have roadway segments that operate at BLOS A-F. These corridors include Nolensville Pike, Gallatin Pike, Franklin Road, Lebanon Pike, and Murfreesboro Road. The BLOS varies along the corridors as the roadway characteristics change such as the speed, presence of a shoulder, lane width, and traffic volume.

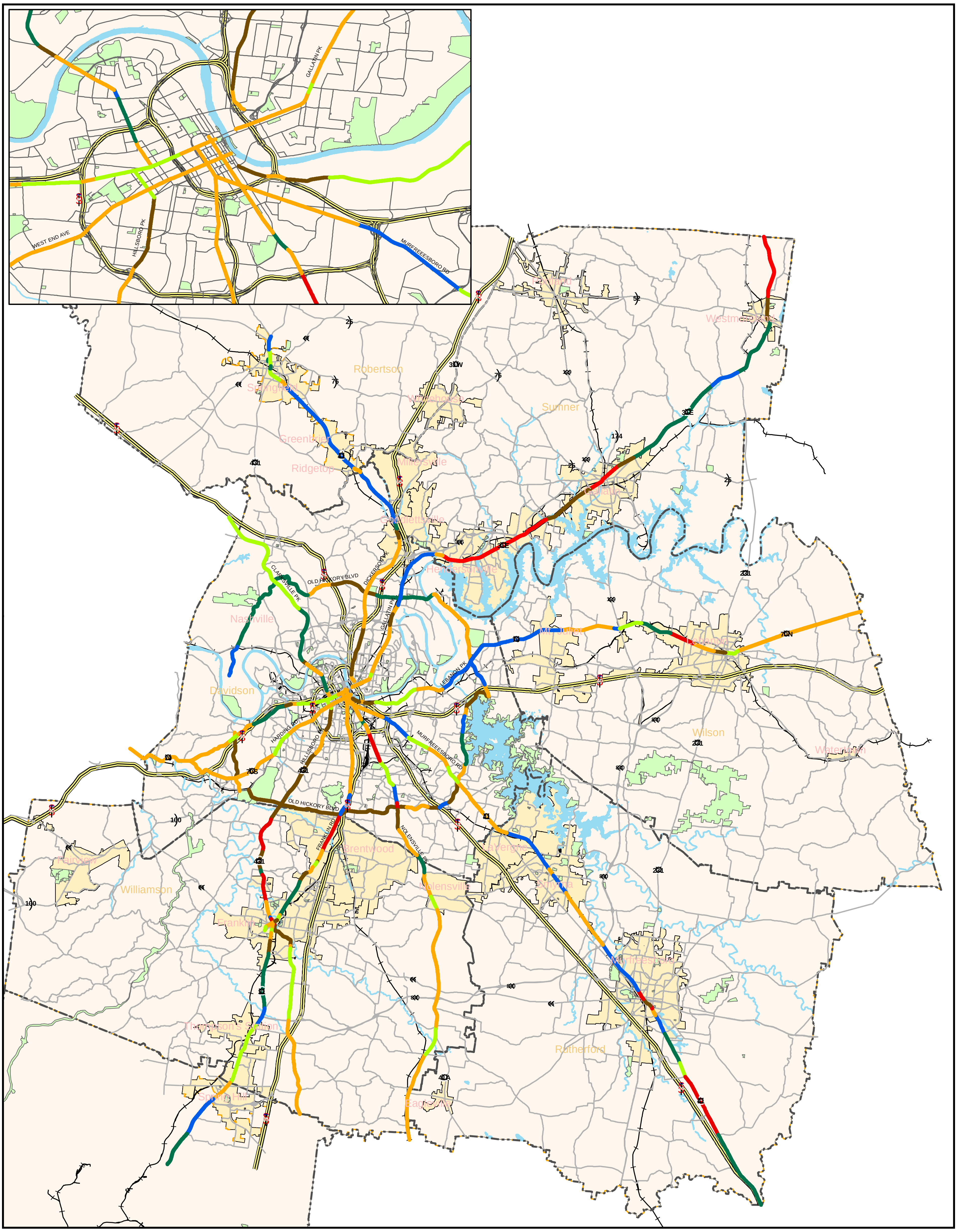
Chart 5: BLOS Analyses of Commuter Corridors



Map 2.3 depicts the results of the analyses and illustrates the various BLOS scores at the locations along the corridors.

As an example of the effects of the travel lane width, paved shoulder width, speed limit, and ADT on the BLOS, Map 2.4 shows the Nolensville Road corridor from downtown Nashville south through Williamson and Rutherford counties. The map shows the characteristics of various segments of Nolensville Road which operate at different levels of service.

Bicycle Level of Service on Major Corridors in the Nashville MPO Area



2

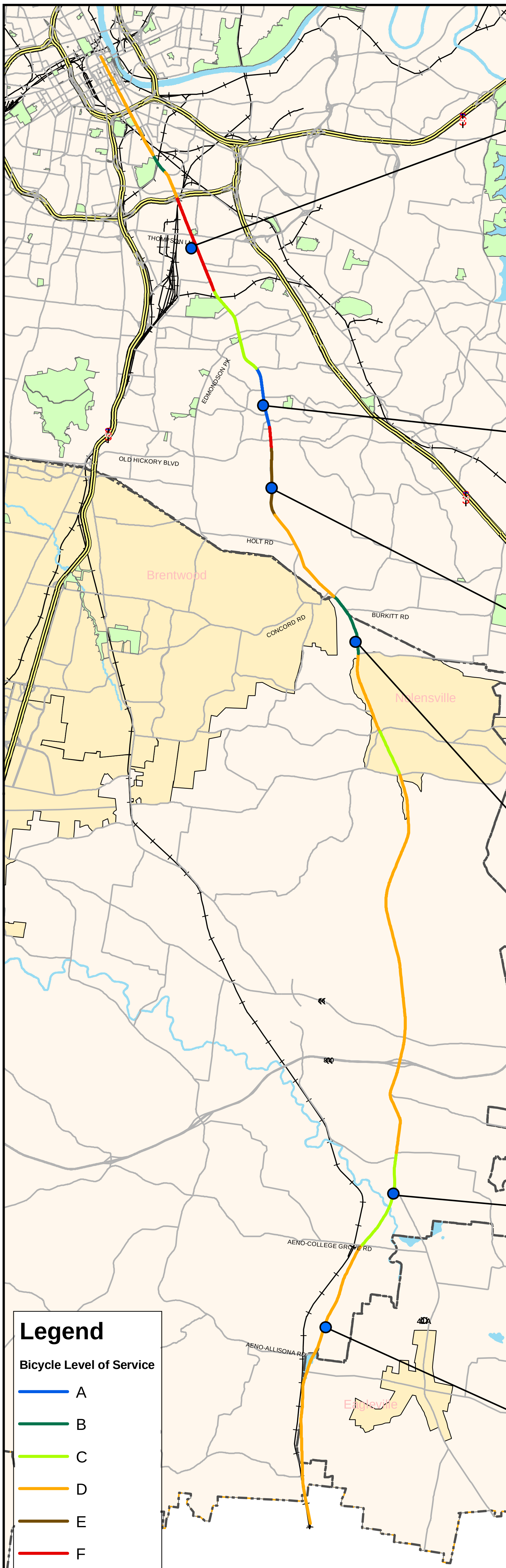
0 0.5 1 2 3 4 Miles

Legend

A	Arterials & Collectors
B	Interstate
C	County Boundaries
D	Bodies of Water
E	Railroad
F	MPO Planning Boundary
Parks	City Limits

This project is funded under an agreement with the Tennessee Department of Transportation.

Nolensville Road Corridor - BLOS



Location:
McCall St and Thompson Ln

BLOS = F
Travel Lane = 12 ft
Paved Shoulder = 2 ft
Speed = 40 mph
ADT = 33,090

Location:
Haywood Ln and Ashgrove Rd

BLOS = A
Travel Lane = 12 ft
Paved Shoulder = 12 ft
Speed = 45 mph
ADT = 33,090

Location:
Bradford Hills and Celebration Way

BLOS = E
Travel Lane = 12 ft
Paved Shoulder = 6 ft
Speed = 45 mph
ADT = 24,970

Location:
Battle Rd to Pettus Rd

BLOS = B
Travel Lane = 12 ft
Paved Shoulder = 6 ft
Speed = 45 mph
ADT = 11,555

Location:
Shelbyville Hwy to Taliaferro Rd

BLOS = C
Travel Lane = 12 ft
Paved Shoulder = 4 ft
Speed = 40 mph
ADT = 5,599

Location:
Flat Creek Rd to Bellefant Rd

BLOS = D
Travel Lane = 12 ft
Paved Shoulder = 0 ft
Speed = 55 mph
ADT = 3,786

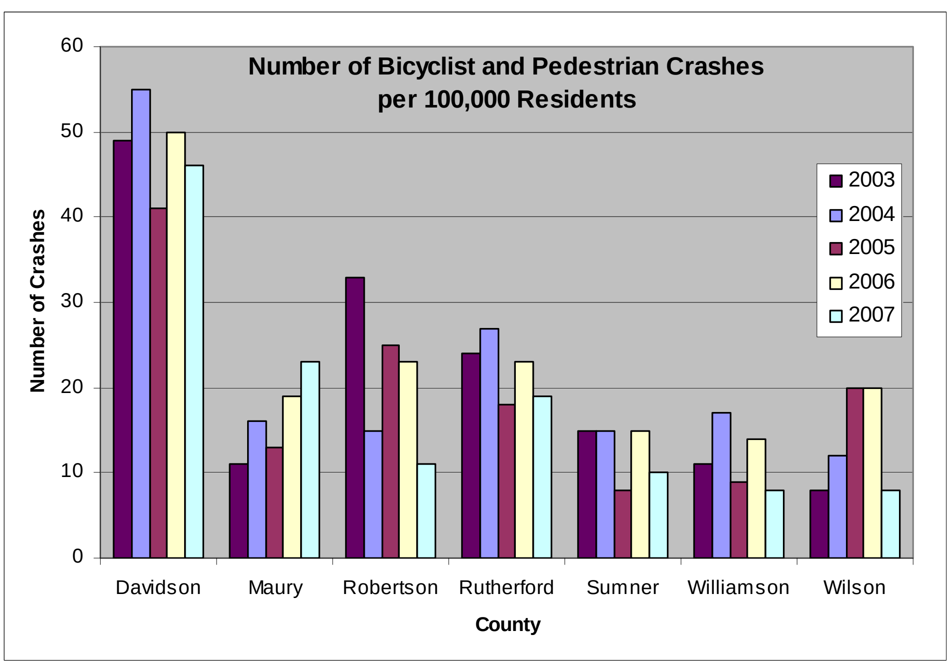
This project is funded under an agreement with the Tennessee Department of Transportation.

2.2 BICYCLE AND PEDESTRIAN CRASH ANAYLSIS

Increasing bicycle and pedestrian safety is one of the goals of this plan along with evaluating the existing levels of service and facility needs. In order to increase safety for bicyclists and pedestrians, the locations and characteristics of crashes need to be determined and analyzed so that specific facility improvements where necessary can be identified. Pedestrian and bicycle crashes are generally a function of exposure. Pedestrian and bicycle crashes occur more frequently in urban areas where traffic volumes and pedestrian facility use is higher than in rural areas. However, according to the Federal Highway Administration (FHWA), 65% of pedestrian crashes occur at non-intersections. Nationally, about half of bicyclist crashes with motor vehicles occur at or near intersections.

A bicycle and pedestrian crash analysis was undertaken to complement the level of service analysis previously discussed. This analysis evaluated crashes involving bicyclist and pedestrians in the MPO based on data provided by TDOT. The data were evaluated to determine areas and corridors in the MPO that need improvements to increase safety for bicyclist and pedestrians. This information can be utilized to help prioritize facility improvements. The data spanned the five-year time period between 2003-2007. According to the data, 2,076 reported crashes involving a pedestrian or bicyclist occurred within the MPO during this time period, 107 of which resulted in a fatality.

In the figure below, the number of bicycle and pedestrian crashes per 100,000 population for each year between 2003-2007 separated by each of the seven counties are shown. The figure shows that Davidson County consistently has the highest number of crashes per 100,000 population, which is expected based on exposure and greater use within Davidson County compared to the outlying counties. The figure also identifies a reduction in bicyclist and pedestrian crashes in six of the seven counties since 2003. Any number of factors could contribute to such a trend, but the most likely factor is increased education and awareness for both motorists and non-motorists coupled with improved bicycle and pedestrian facilities.



Furthermore, the crash data were evaluated geographically on a corridor level for a three-year period (2003-2005). This analysis is limited to state routes and interstates within the MPO. Crashes that occurred on local routes have been excluded. The following roadway segments in the MPO were identified as high-crash roadway segments, with ten or more pedestrian crashes and five or more bicyclist crashes. As shown, seven segments in Davidson County had ten or more pedestrian crashes within the three-year analysis period, and one segment in Rutherford County had five or more bicycle crashes.

High-Crash Bicycle and Pedestrian Roadway Segments (2003-2005 Crash Data)

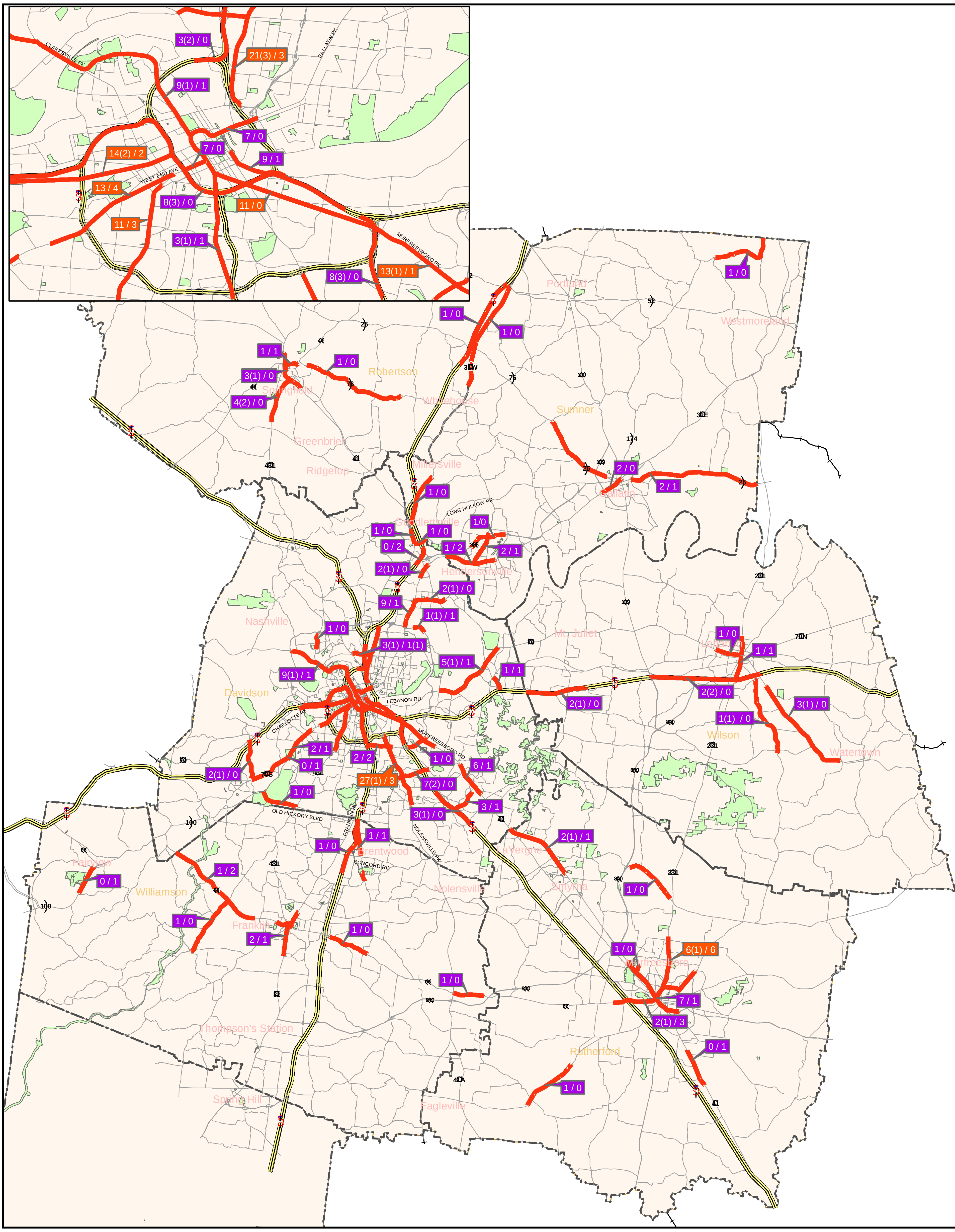
Route	Street Name	Segment	# Ped Crashes	# Ped Fatalities	# Bike Crashes	# Bike Fatalities
Davidson County						
SR 1	West End Ave	Between 15th Ave & Cherokee Rd	13	0	4	0
SR 1	Lafayette St	Between Broadway & Fairfield Ave	11	0	0	0
SR 1	Murfreesboro Pk	Between Fairfield Ave & McGavock Pk	13	1	1	0
SR 11	Nolensville Pk	Between I-440 & Old Hickory Blvd	27	1	3	0
SR 11	Dickerson Pk	Between Jefferson St & I-65	21	3	3	0
SR 24	Charlotte Pk	Between I-40/65 & White Bridge Pk	14	2	2	0
SR 106	Hillsboro Pk, 21st Ave, Broadway	Between 16th Ave & Abbott Martin Rd	11	0	3	0
Rutherford County						
SR 10	Memorial Blvd	Between W Thompson Ln & New Nashville Hwy	6	1	6	0

Source: Tennessee Department of Transportation. These data were for planning purposes only and are protected by USC 409.

Map 2.5 illustrates the location of bicycle and pedestrian crashes by corridor within the MPO region.

In order to determine some overarching causes of pedestrian and bicycle crashes and deficiencies in non-motorized facilities, an analysis of crash characteristics was conducted. This analysis, which included all the crashes in the MPO between 2003 and 2005, determined that approximately 86% of all crashes involving bicyclists or pedestrians occurred with no adverse weather conditions. Approximately 48% of the crashes occurred in the evening after 5pm and 35% occurred when it was dark outside. Approximately half of the crashes occurred at intersections and half occurred at non-intersections or on roadway segments. Further discussion of the MPO crash characteristic analysis as well as detailed analyses for each of the seven counties is located in the Appendix B.

Bicycle and Pedestrian Crashes by Corridor in the Nashville MPO Area *



* The crashes are shown for 2003-2005 on state routes and interstates.

2

0 0.5 1 2 3 4 Miles

Legend

- Crash Locations
- Arterials & Collectors
- Interstate
- 1(1)/1(1) Pedestrian Crash (Fatality[1])/ Bicycle Crash (Fatality[1])
- 1(1)/1(1) Pedestrian Crash > 10 or Bicycle Crash > 5
- Parks
- County Boundaries
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits

This project is funded under an agreement with the Tennessee Department of Transportation.

[1] The number of crashes that resulted in a fatality are listed in parantheses.

3.0 TRAVEL DEMANDS

The objective of the development of the Non-Motorized Demand Model (Trip Model) was to produce a decision tool that would allow planners and engineers to determine the real need for walking and biking facilities within the Nashville region. At the macro level, this is a regional bike and pedestrian model that incorporates the entirety of the transportation planning area of the Nashville region. The whole Nashville Area MPO (Davidson, Rutherford, Williamson, Wilson, Sumner, and portions of Robertson and Maury Counties) is included in the Trip Model. Aside from the scope of the model's planning area, however, the Trip Model is very much a microscopic model, producing a fine-grained, parcel-level analysis fit for walking and biking trips.

3.1 TRIP MODEL

The Trip Model uses land use, demographic, and proximity data for every parcel in the study area to predict the trip making characteristics of each individual parcel. It has been documented that cyclists are comfortable with trips less than 3 miles and pedestrians are comfortable with trips less than one quarter mile. Therefore, the use of parcels produces more accurate and more meaningful trip generation results for walking and biking trips due to the shorter nature of the trips. Analysis of areas larger than 0.25 square miles (160 acres), such as TAZ's, compromise the accuracy of the predicted walking and biking trips.

The Trip Model is based on data from national and local sources such as the 2001 National Household Transportation Survey, U.S. Census data, and Nashville MTA On-Board Survey done in 2006. As other land use, demographic, or pertinent data becomes available, the trip generation drivers can be modified to incorporate this data or to produce new trip types. The Trip Model uses eight specific trip types for walking and five trip types for cycling which include travel to school, travel to recreation, travel to shop, travel to work, travel to errand, walk to transit, walk from transit, and walk from parking.

Households are the most common trip origins, but trips also originate from workplaces and transit stops. Although trips are attributed only to the originating parcel, there must be a suitable destination in proximity for the trip to occur.

To estimate the walking or cycling trips for a parcel, several things must be known about that parcel; namely, its household count, employment, and the shortest distance to the nearest school, recreational facility, retail area, and transit stop. Also, some information relative to its proximity to employment in the study area and whether any substantial public parking exists is important.

Once the distance relationships to other land uses are known, the effect of distance on making the walk or bike trip is quantified. This is done using a series of distance impedance curve equations developed by RPM from data in the National Household Travel Survey. The closer the land use, the more likely that the trip will be made by walking or bicycling.

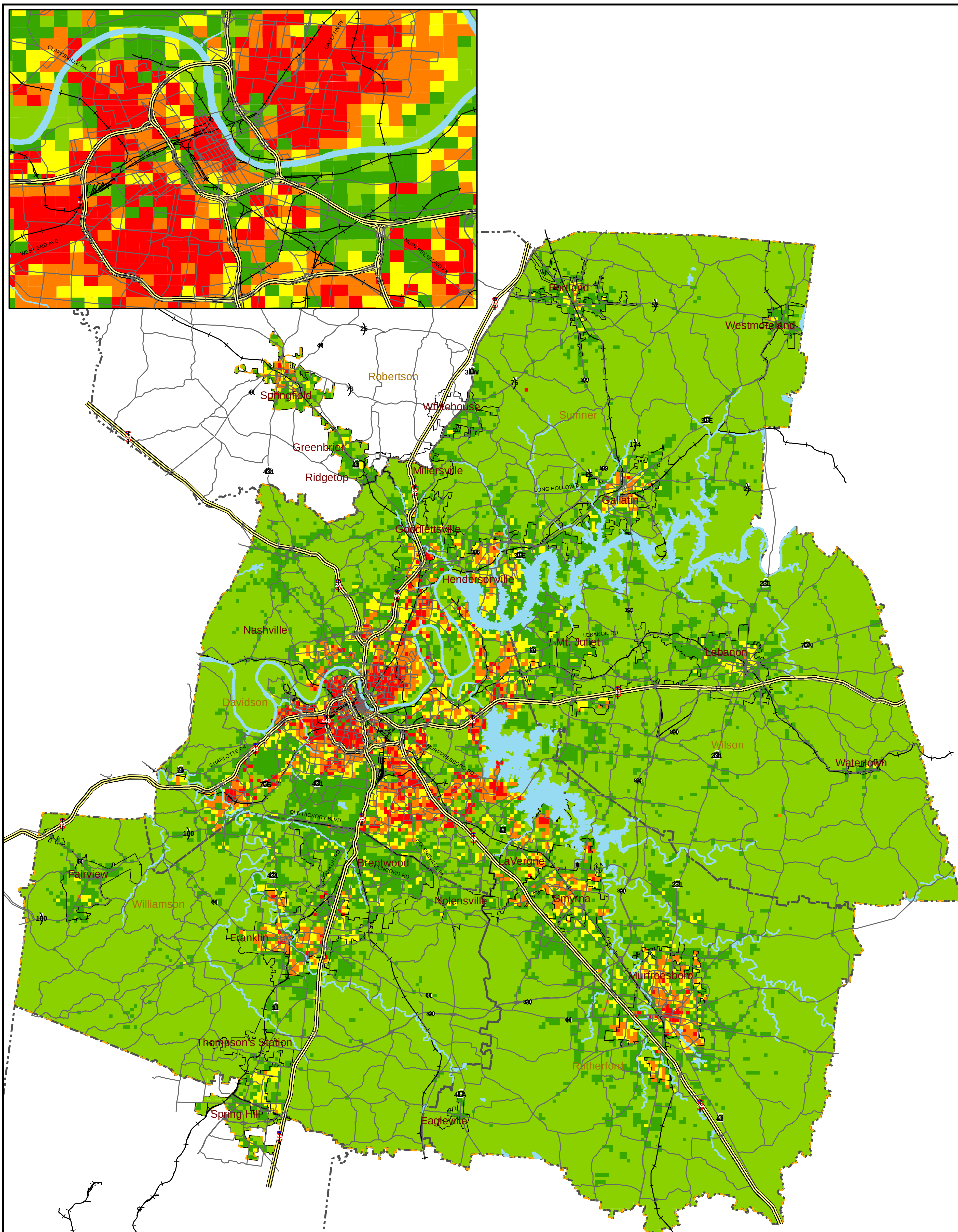
The result of the equation for each trip type is the expected number of walking and bicycling trips by type. These trips can be reported individually by trip type. However, these trips are also summed to obtain the total number of one-way walking and bicycling trips on a typical work/school day.

The results of the travel demand model can be reported on a parcel level as well as by blocks or neighborhoods. In addition, the trips can be aggregated to a street network to allow a roadway segment analysis of non-motorized trips. The demand for walking and biking trips per quarter mile grid for all eight of the trip types is shown on Map 2.6.

Map 2.6 shows the most concentrated areas of walking and biking trips in Davidson County in the Vanderbilt, Mid-Town, Downtown, and East Nashville areas, as well as the core areas of the cities of Murfreesboro, Franklin, Hendersonville, Lebanon, and Springfield. These areas tend to have a mixture of commercial, office, and retail land uses within close proximity to residential neighborhoods and higher density housing such as apartments.

A more detailed description of the model assumptions and constraints is listed in Appendix B.

Demand for Biking and Walking Trips in the Nashville MPO Area



2

0 0.5 1 2 3 4
Miles

Legend

- < 5 Non-Motorized Trips
- 6 - 50 Non-Motorized Trips
- 51 - 100 Non-Motorized Trips
- 101 - 200 Non-Motorized Trips
- > 200 Non-Motorized Trips
- Arterials & Collectors
- Interstate
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

4.0 HEALTH ASSESSMENT

The link between lack of physical activity and chronic disease is undeniable. Sixty percent of the U.S. adult population is at risk for chronic disease because they do not meet the recommended 30 minutes of daily physical activity. The last three decades has also seen a significant rise in the number of obese adults and children. Tennessee, ranks among one of the more obese states in the U.S. and was recently found to have 31% of its adult population labeled as obese according to the 2007 Behavioral Risk Factor Surveillance System data. In addition, the study found that 17% of the youth in Tennessee are obese as well.

The built environment can have an effect on the levels and frequency of physical activity. Regular physical activity is beneficial to people of all ages, having positive effects on health, longevity, and quality of life. It has been found to improve self-image, self-esteem, physical and mental wellness, and overall health. Negative health effects associated with low physical activity include heart disease, certain types of cancers, high blood pressure, stroke, osteoporosis, obesity, diabetes, and higher mortality rates. It should be noted that some of these negative health effects can also be reversed with physical activity such as obesity, some types of diabetes, and some cases of high blood pressure.

Chronic diseases, such as cardiovascular disease, asthma, and diabetes, are more closely associated with lifestyle or environmental factors as opposed to infection. Chronic disease accounts for 7 of every 10 deaths and affects the quality of life of 90 million Americans. Although chronic diseases are among the most common and costly health problems today, they are also among the most preventable. Adopting healthy behaviors such as being physically active can prevent or control the effects of these diseases. The statistics illustrate the importance of this issue. For example, physical inactivity and poor diet are responsible for an estimated 840,000 deaths annually from coronary heart disease, stroke, and diabetes in the U. S. in 2006.

Much of the research that links neighborhood environments with health focuses on four issues: physical activity, access and affordability, environmental exposure, and social networks. Physical activity studies explore how issues of land use can encourage or discourage physical activity. Access and affordability looks at the health consequences associated with the lack of or limited access to schools, transit, food, goods and services, recreational facilities, and public spaces. Environmental exposure deals with the health consequences of poor quality air, water, and soil, as well as noise. Finally, social capital explores the ways in which healthy neighborhoods facilitate the communication of information, provide social support, and transmit accepted behaviors.

The built environment can have an effect on the levels and frequency of physical activity. Physical activity occurs not only through traditional means of exercise, such as walking, running, biking, and swimming, but also through daily activities such as taking the stairs instead of the elevator or walking and biking to run errands or to get to work or school. The design of the physical environment can either facilitate or reduce the opportunities for physical activity. Greater land use mixes, population and employment density, street connectivity and continuity of the bike and pedestrian network, are all believed to contribute to positive health outcomes, as are the presence of recreational facilities and parks.

While contributory links between chronic health conditions and the built environment are still evolving, there is evidence that a relationship exists. According to data collected for the

Behavioral Risk Factor Surveillance System (BRFSS) and Healthy People 2010 (CDC), certain populations experience a decrease in physical activity and an increase in health disparities relative to the general population.

While research studies have identified many personal characteristics that appear to be associated with a higher or lower propensity for physical activity, a higher level of disparity exists relative to income, race, and age. Population groups that suffer the worst health status also are those that have the highest poverty rates and the least education. In addition to income levels, research has shown that African Americans and Hispanics are generally less physically active than whites, and that by age 75, one in three men and one in two women engage in no regular physical activity.

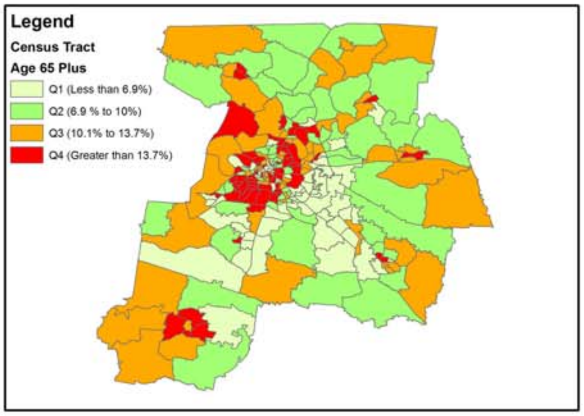
For purposes of this Plan, an assessment was undertaken to identify locations within the MPO which would constitute higher than average health risk areas. Using 2000 U.S. Census data (at the tract level), three population categories were identified:

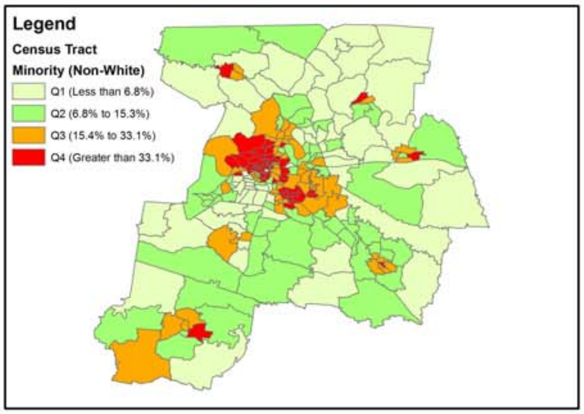
- Persons 65 years of age or over
- Minority (non-white)
- Persons with Income Levels of "Below Poverty"

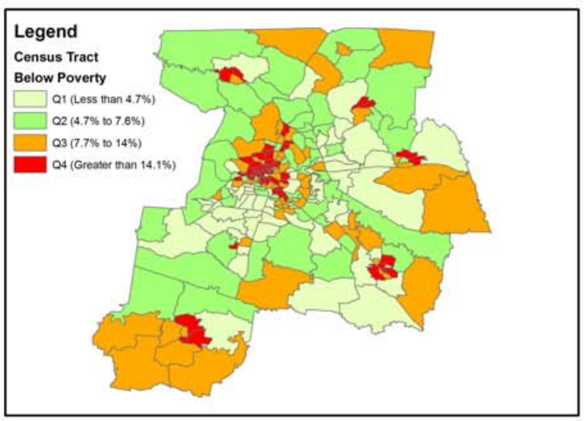
Each population category was divided into quartiles (4 equal ranges – 1 being the lowest quartile and 4 the highest quartile of the range) to identify higher than average areas within the MPO area by category.

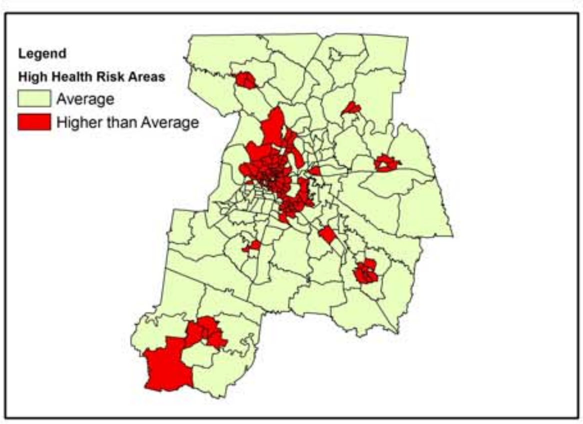
The following figure depicts the results of this assessment which includes the identification of high concentrations of each individual population category and a composite assessment of locations of higher than average health risk, based on the highest quartile for each category, within the MPO.

Assessment of High Health Risk Areas in the Nashville Region









5.0 OPPORTUNITIES & CHALLENGES

There are a number of opportunities, challenges, and obstacles to increasing walking and bicycling transportation in the greater Nashville region. These include both physical and non-physical constraints as well as political and policy aspects. This section describes the opportunities and challenges that currently exist in the MPO region relative to increased walking and biking travel and the provisions for such accommodations.

In the initial stage of this project three efforts were undertaken to establish an overall understanding of the level of activity, interest, and obstacles relative to the provision of non-motorized accommodations.

The first effort included a series of meetings, one in each of the MPO's member counties (Davidson, Rutherford, Sumner, Williamson, and Wilson) with local stakeholders. These stakeholder meetings were conducted in December 2008 and were held with representatives from each local school system, college and university, parks department/greenway commission, planning department, public works department, transit agency, local public health agency, and local law enforcement agency within each respective county.

In total, 50 representatives participated in the stakeholder meetings providing valuable insight into local efforts to improve walking and biking conditions within their respective areas. Stakeholders were asked what types of programs and initiatives are occurring locally with regards to walking and biking, what if any funding programs they have or use in advancing non-motorized modes, what opportunities and constraints they see with regards to promoting greater provisions for walking and biking, and what they are hearing from constituents and local residents relative to this topic.

The second effort included a series of public meetings, one in each of the MPO's member counties (for a total of five public meetings) in which the general public was invited. In total, 212 residents from the MPO region participated in the first round of public meetings, which were held in late February 2009. At each of these meetings participants were asked to share information on the types of walking and biking facilities they use today, for what purposes (e.g. transportation, exercise, etc.), what obstacles they encounter when using these facilities, and lastly, what improvements do they see for improving walking and biking conditions.

The third effort included the use of an online survey which was initiated in January 2009. Approximately nineteen questions were part of the survey which was intended to gain insight into individuals walking and biking habits as well as obstacles and opportunities for improving non-motorized accommodations within the greater Nashville region. At the end of April 2009, nearly 1,700 surveys were completed providing valuable insights into walking and biking activity and conditions in the greater Nashville region.

The culmination of these efforts resulted in the identification of numerous challenges and opportunities for improving and increasing walking and bicycling within the greater Nashville region. The following is a listing of the identified challenges and opportunities including a discussion on each.

5.1 ACCOMMODATION PROVISIONS

5.1.1 Facilities

Challenge
By far the most frequently stated challenges to walking and biking in the greater Nashville region were:

- the lack of facilities (e.g. no sidewalks, bike lanes, bike routes, etc.),
- the lack of a connected and complete system of facilities, and
- the lack of support facilities for biking (e.g. bike racks, lockers, etc.).

Residents feel that the current system of bicycle and pedestrian facilities, or the lack thereof, makes it difficult for individuals to choose to walk or bike. Equally, it was stated that for those that do choose to walk or bike they are confronted with a system that is not complete and has gaps in the sidewalk and bikeway system. Additionally, these facilities are not well connected with other facilities (e.g. bike lanes to or from a greenway) or to other modes (e.g. sidewalks to transit). In terms of support facilities it was stated that a lack of bike racks and other accommodations such as lockers, restrooms, and shower facilities make commuting by bike to work or other activities difficult.

Opportunity
Despite these constraints there were a fair number of people that spoke to the positive experiences with the facilities that do exist. Greenways and the number of users on these facilities were often referred to when walking and bicycling facilities were mentioned. This perception was affirmed through the stakeholder meetings in which professional staff spoke to the high level of interest and use of existing greenways in their respective communities.

5.1.2 Design

Challenge
An obstacle most communities face in the greater Nashville area as well as throughout the United States is the number of sidewalk facilities which were designed prior to the Americans with Disabilities Act (ADA). Many of these sidewalks are not designed to accommodate mobility impaired users as can be seen by the obstacles in the sidewalk such as utility poles, mailboxes, and benches. Often these sidewalks do not provide curb ramps and other provisions which would allow for greater access by those in wheelchairs and with disabilities as well as help families with strollers.

Many communities within the region have worked to address this issue and have since established newer standards which meet ADA requirements. However, the costs to reconstruct sidewalks to current ADA standards is high and there are still a large number of roadways and locations with topography and other constraints that make addressing ADA provisions difficult, if not impossible.

In addition to sidewalk provisions, there were a number of people that spoke to the challenges of bike riding in the region given certain design practices which impact bicycling. Several issues raised included the use of rumble strips along roadways with otherwise perfectly useable paved shoulders, storm grates which run parallel to the direction of travel and cause a hazard for bicyclist, and the lack of consistent signage and wayfinding signs for travel by bicycle.

Opportunity
As mentioned many communities in the region have adopted standards to address the ADA requirements for pedestrian facilities to ensure new facilities are constructed to meet the current standards. Additionally, many of the city and county bicycle and pedestrian plans include guidance on the placement of rumble strips, proper storm grates, and signage.

5.1.3 Maintenance

Challenge
A lack of maintenance and poor facility conditions were stated as issues and challenges that affect walking and biking in the region. Debris in bike lanes, on paved shoulders, and sidewalks was frequently stated as an issue and situation which makes walking and biking at times a challenge.

Opportunity
Bicycles and bicyclists tend to be particularly susceptible to maintenance problems. Since bicyclists often ride near the right edge of the road, they use areas that are generally maintained less often than the main travel lanes. Regular street sweeping is an effective means of removing various roadway debris (e.g. sand, gravel, glass, trash etc.). A number of communities in the region have begun to add the sweeping of bike lanes as part of their normal street sweeping programs.

5.2 EDUCATION, AWARENESS, AND ENFORCEMENT

5.2.1 Sharing the Road

Challenge
The second most stated challenge to pedestrian and bicycle travel in the region was identified as a lack of driver understanding of laws and awareness of rights and responsibilities of pedestrians and bicyclists. It was also equally stated that pedestrians and cyclists also often lack a clear understanding of their obligation to the rules of the road and their responsibilities for ensuring safe travel for themselves as well.

Opportunity
Increased education of drivers and awareness of pedestrians and bicyclists were common themes that emerged as an opportunity for improving walking and biking conditions in the region. When looking at the array of activities in the region on this topic there are several example practices that currently exist such as Walk/Bike Nashville's training and education programs geared towards bicyclists and students, bicycle rodeos which are occurring at the local level in communities such as the City of Franklin, and recent Safe Routes to School program initiatives like the ones in Metro Nashville and Williamson County.

5.2.2 Safer Streets

Challenge
Lack of enforcing laws, including speeding, wrong way riding, and other safety provisions, both for motorist as well as pedestrians and cyclists, was stated as a challenge for the safety of all

highway users. A motorist who understands that bicyclists have a right to be on the road and must sometimes venture into the middle of a lane to avoid an obstacle, is not likely to honk at or threaten a bicyclist. Likewise, a knowledgeable cyclist will obey traffic signals and will not ride against the flow of traffic.

Opportunity
Enforcement of laws concerning walking and biking as well as greater involvement with law enforcement on pedestrian and bicycle safety was viewed as essential to improving the environment of non-motorized user needs in the region.

5.3 CONNECTIVITY

5.3.1 Land Uses and Land Use Patterns

Challenge
A topic that drew great discussion was the placement of land use and the overall land use pattern in the greater Nashville region, and the implication of such, on walking and biking travel as well as transit. Land use issues discussed included a lack of mixed use development and a lack of concentrated development activity centers that make walking and bicycling a more realistic option for replacing many automobile trips.

With most walking trips less than two miles and most biking trips less than five miles one can quickly see the importance of land use decisions which foster greater opportunities for walking and biking. A sizable number of comments relative to land use and land use patterns include the concentration of land uses, the connectivity of land uses with walking and biking facilities, the place of schools and school siting practices, and development patterns associated with greater opportunities for transit use.

Opportunity
Over the last several years there have been a number of mixed-use developments approved in the region and many communities are exploring land use decisions with full consideration of walking and biking needs. Additionally, the topic of school siting policies are beginning to move to the forefront as school systems and planning departments work together on school placement within the community.

5.3.2 Crossing Major Features

Challenge
Much like land use patterns as an obstacle to walking and biking, crossing major features such as interstates, major intersections, bridges and underpasses, and railroads were all identified as features which make walking and biking difficult. The Nashville region is one of few places in the country with three major interstate systems converging on its central city. Additionally, there are a number of controlled access roadways in the region which pedestrians and cyclist must find their way around as well as major river crossings such as the Cumberland River.

Opportunity
The greenway system in the Nashville area provides bridges crossing the river and railroad tracks. The Cumberland River Bridge spanning the Cumberland River connects the Stones River greenway and Shelby Bottoms greenway. The rehabilitation of the Shelby Pedestrian

Bridge provides a connection across the Cumberland River and also the Old White Bridge Road Bridge provides a connection across railroad tracks.

5.4 VEHICULAR TRAFFIC & CULTURAL ENVIRONMENT

Challenge
One of the biggest challenges to riding a bike or walking in the region is busy, high speed roads. The high volume and speed of vehicular traffic and a cultural environment that is geared toward the automobile, both resonated with many as a leading factor or challenge to walking and bicycling in the region. Because bicyclists and pedestrians use roadways and sidewalks along these roadways, the amount of traffic, the speed of traffic, and driver behavior greatly influence the perception and comfort of individuals who use these roadways to walk or bike.

Opportunity
An emerging practice to combat this systemic issue is the policy of Complete Streets. Complete streets are designed and operated to enable safe access for all users. A complete streets policy ensures that transportation agencies routinely plan, design, and operate the entire right-of-way to enable safe access for drivers, transit users and vehicles, pedestrians, and bicyclists, as well as for older people, children, and people with disabilities. As revealed in the peer review, Charlotte, Chicago, Denver, and Louisville each have a Complete Streets policy.

5.5 FUNDING

Challenge
Funding, or the lack of, was mentioned as a key factor impacting the provision of sidewalks and bikeways in the region. Numerous times statements pertaining to the lack of funding for sidewalks and bikeway improvements and programs was mentioned. Political and community support associated with funding was also mentioned.

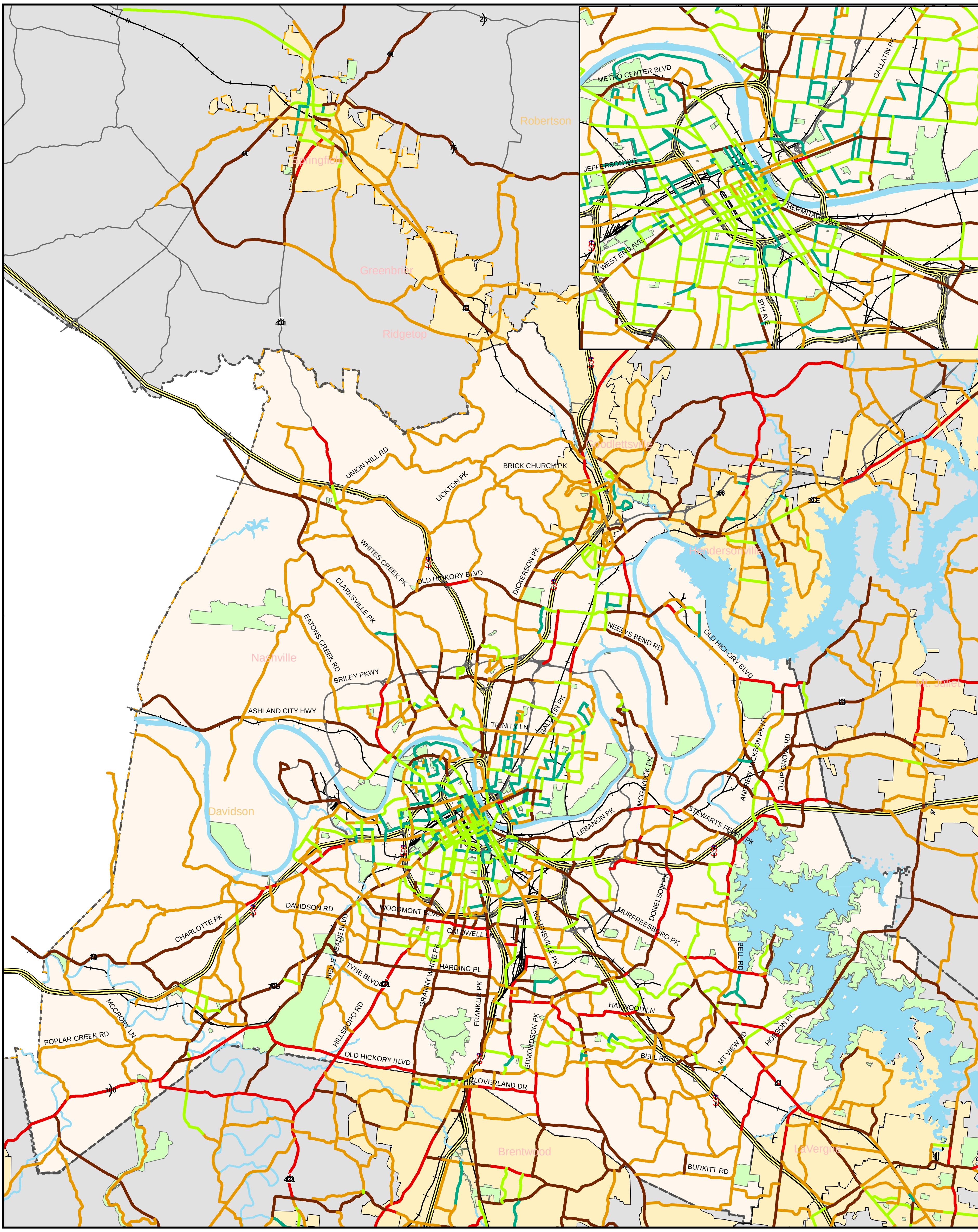
Both the citizen and stakeholder involvement processes revealed that many feel without adequate funding for sidewalk and bikeway improvements, the region is not likely going to be able to increase walking and biking travel given a lack of funding for facilities.

Opportunity
The primary funding source for most bicycle and pedestrian projects in the region is federal transportation funds. There are also a wide range of grant sources including federal, state, and local programs that have been used. A number of communities in the region have allocated local funds for sidewalk and bikeway improvements and one community is using a portion of their hotel/motel tax to fund greenway improvements.

Appendix A

Pedestrian & Bicycle Level of Service (PLOS/BLOS) Maps by County

Pedestrian Level of Service in Davidson County



2

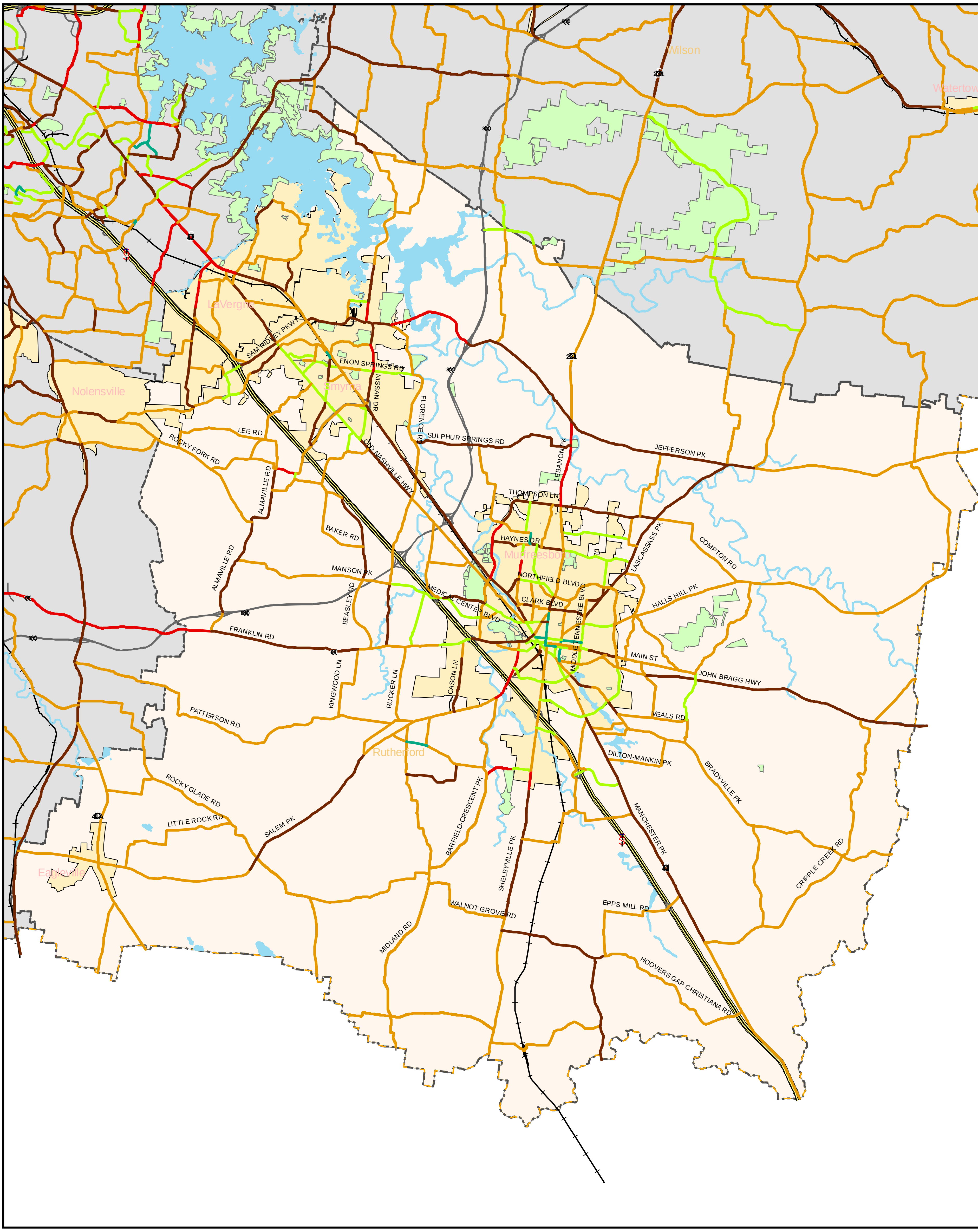
Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

0 1 2 4 6 8 Miles

This project is funded under an agreement with the Tennessee Department of Transportation.

Pedestrian Level of Service in Rutherford County



2

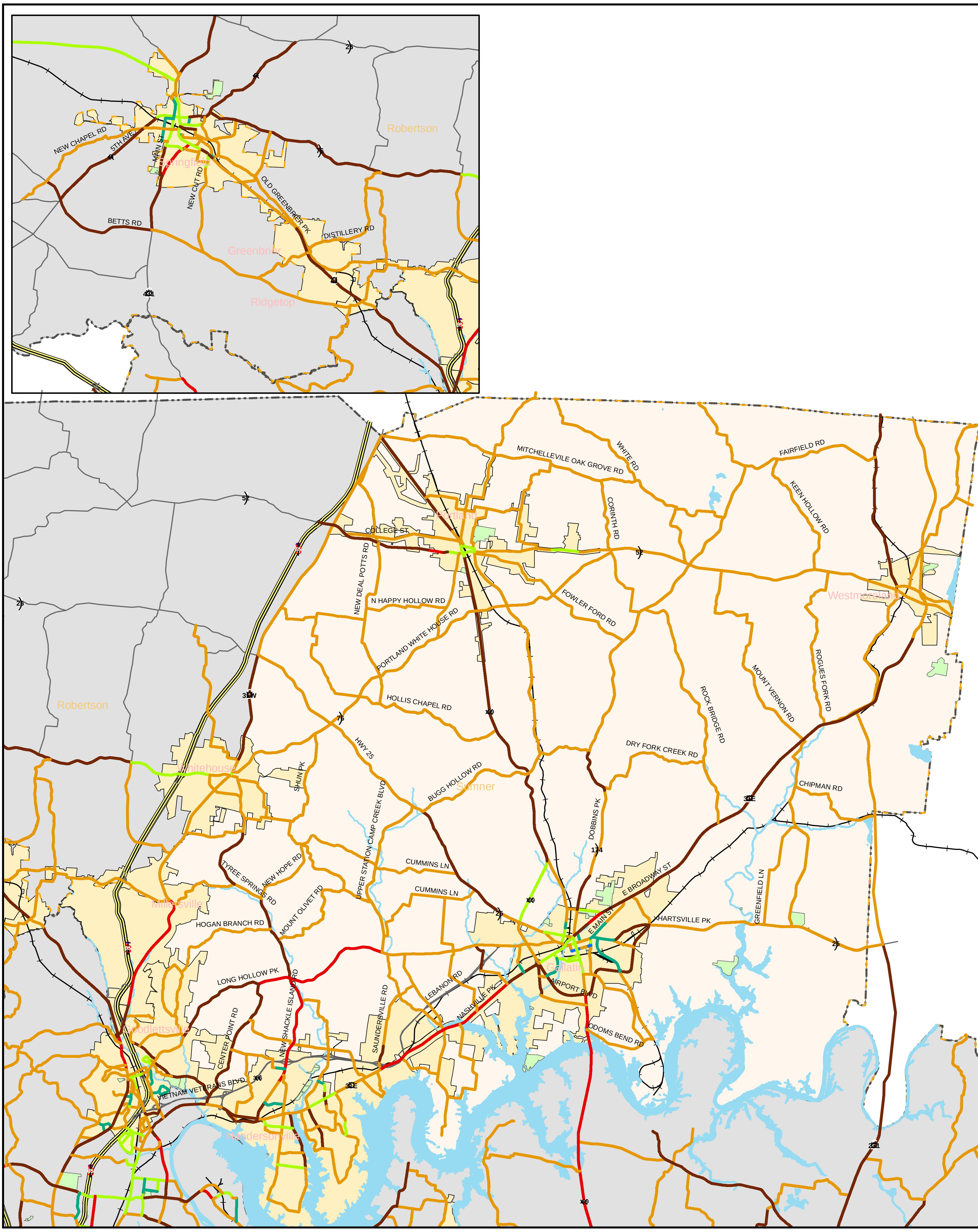
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Pedestrian Level of Service in Sumner County



2

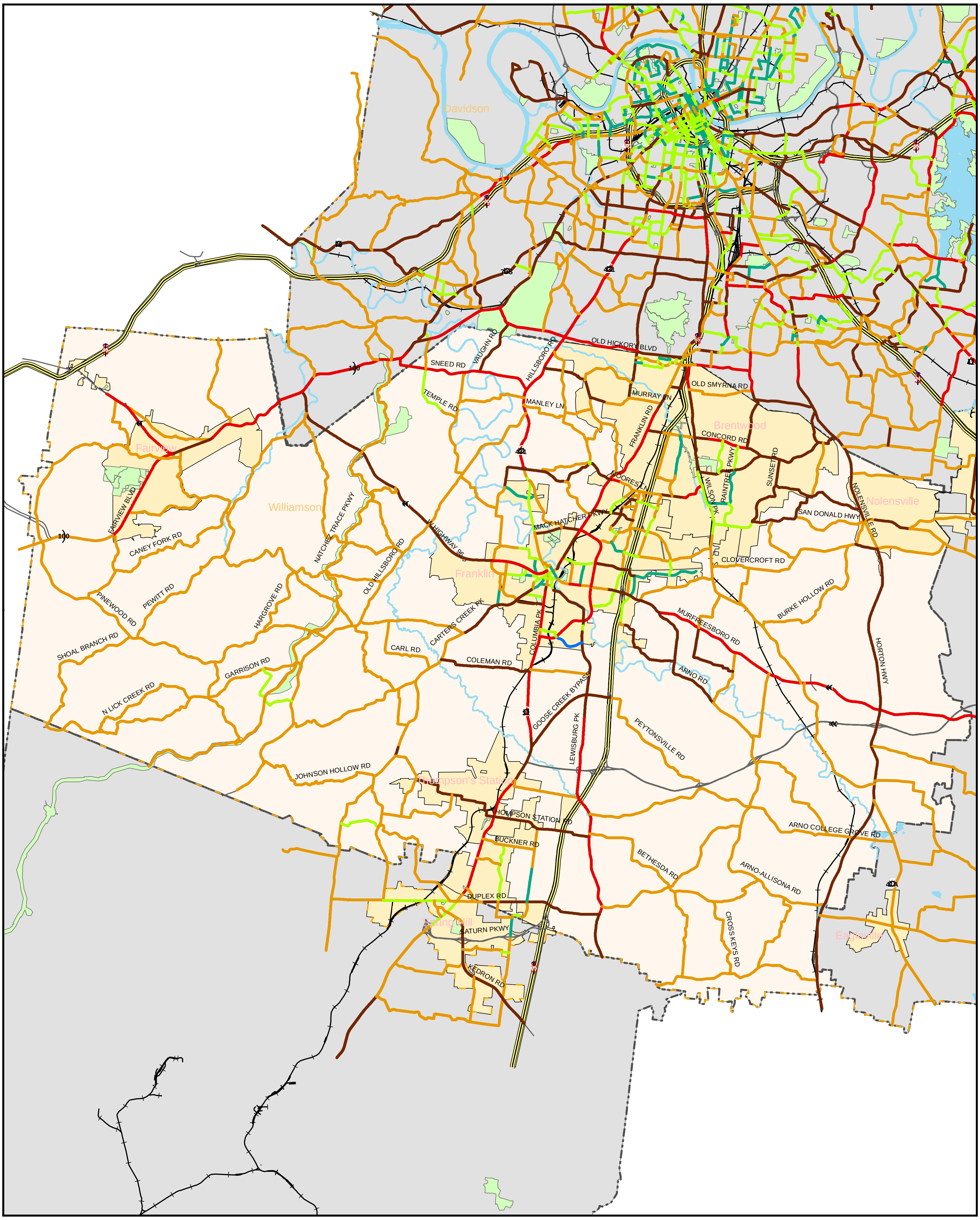
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Pedestrian Level of Service in Williamson County



2

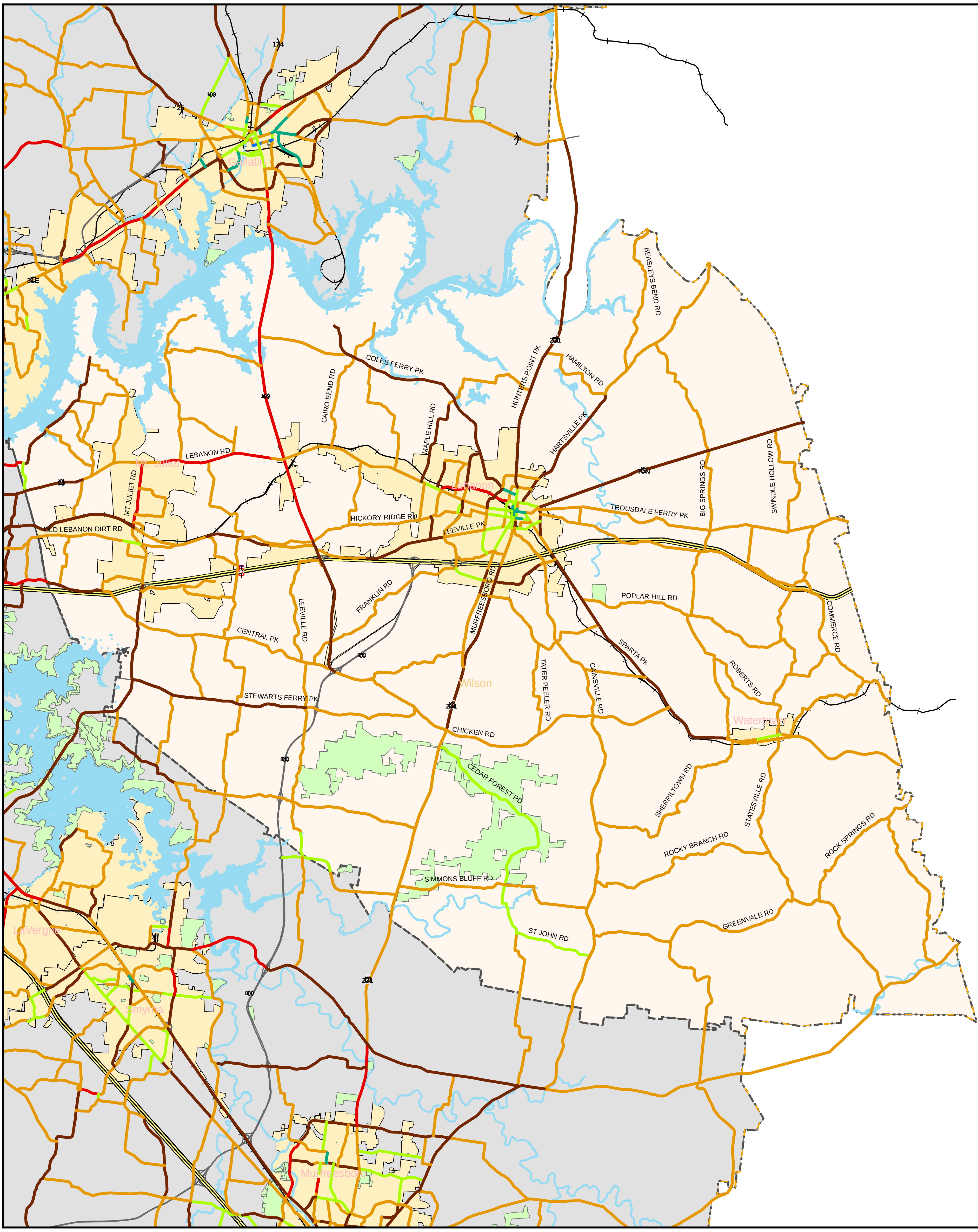
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Pedestrian Level of Service in Wilson County



2

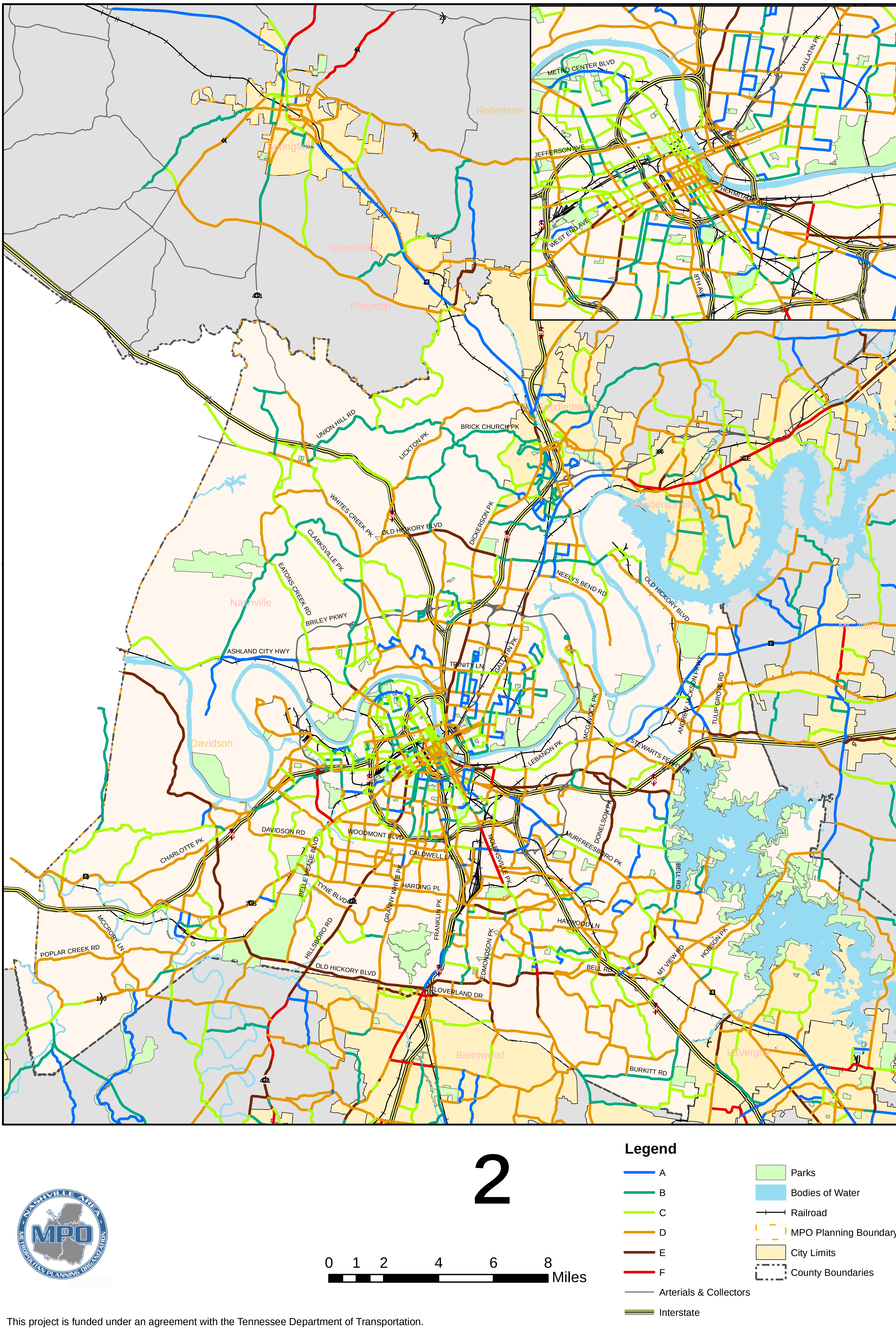
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

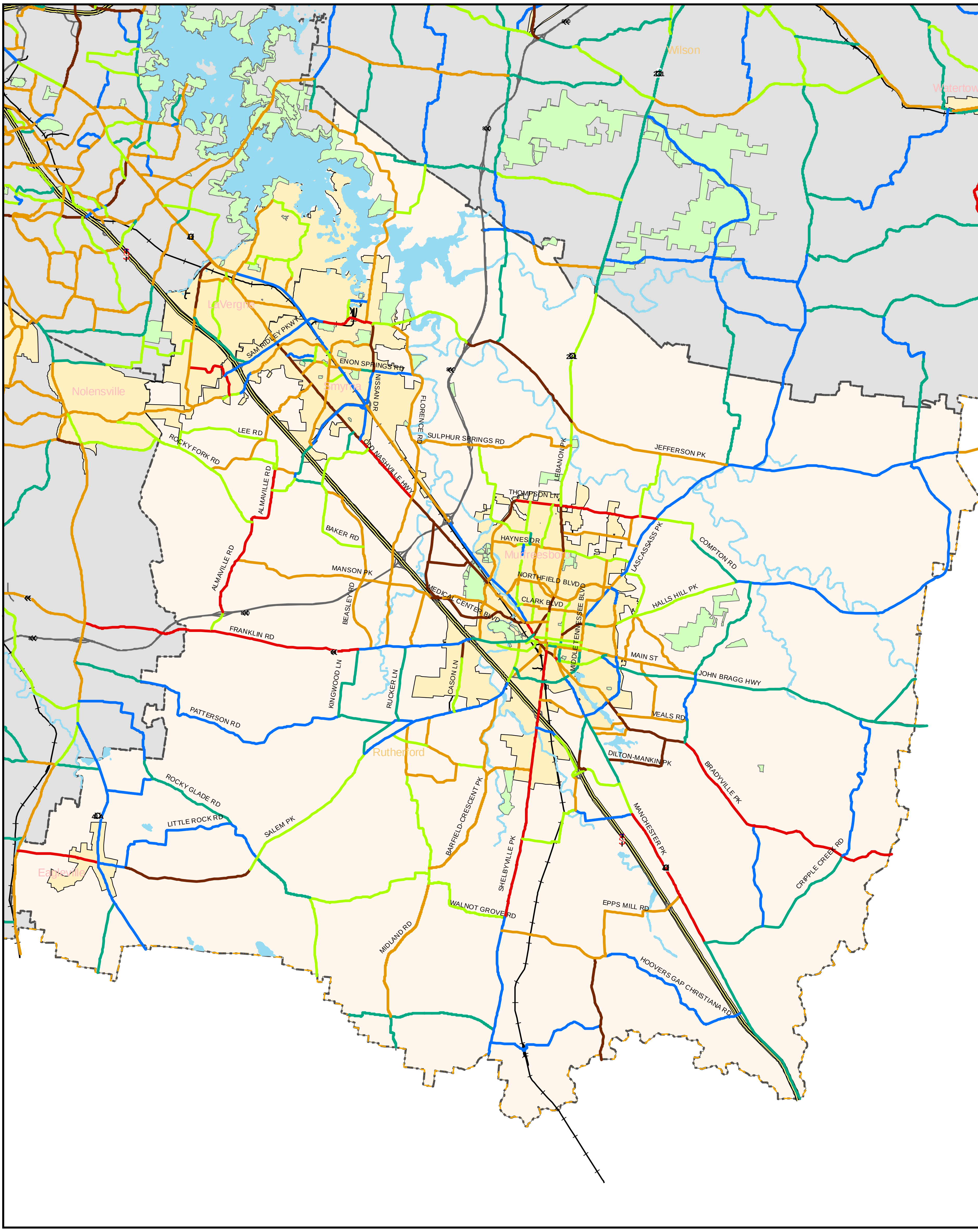
This project is funded under an agreement with the Tennessee Department of Transportation.

Bicycle Level of Service in Davidson County



This project is funded under an agreement with the Tennessee Department of Transportation.

Bicycle Level of Service in Rutherford County



2

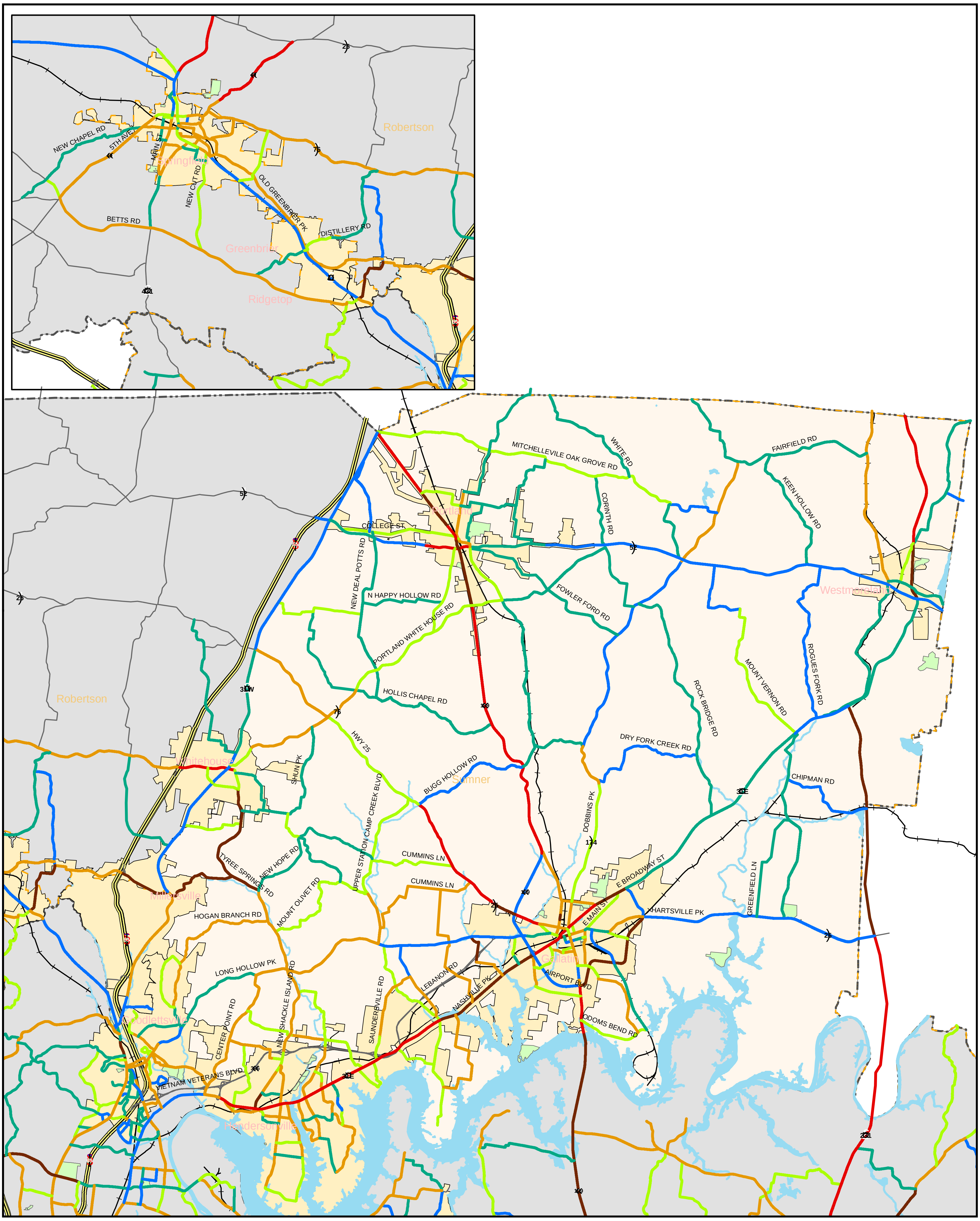
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Bicycle Level of Service in Sumner County



2

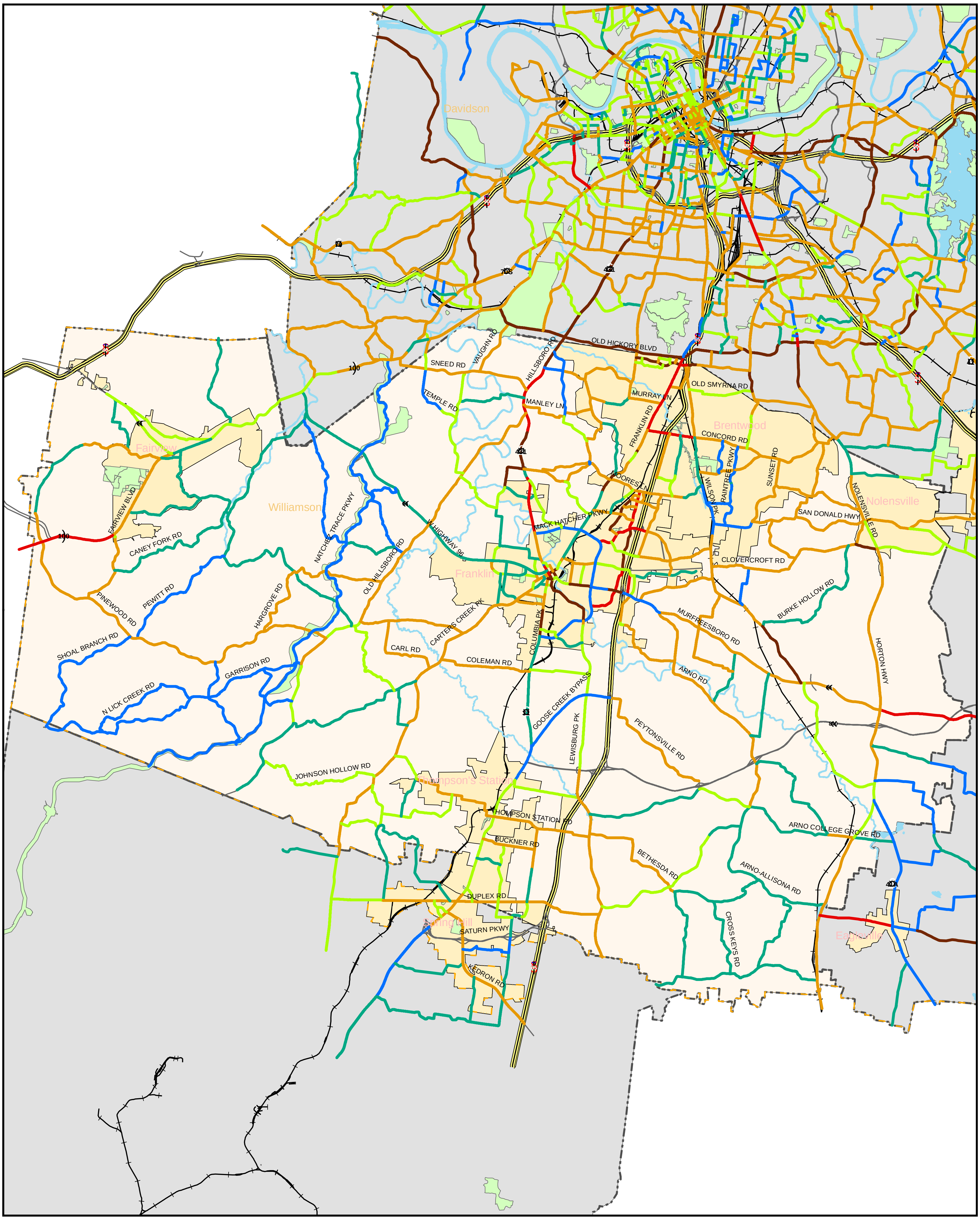
0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Bicycle Level of Service in Williamson County



Legend

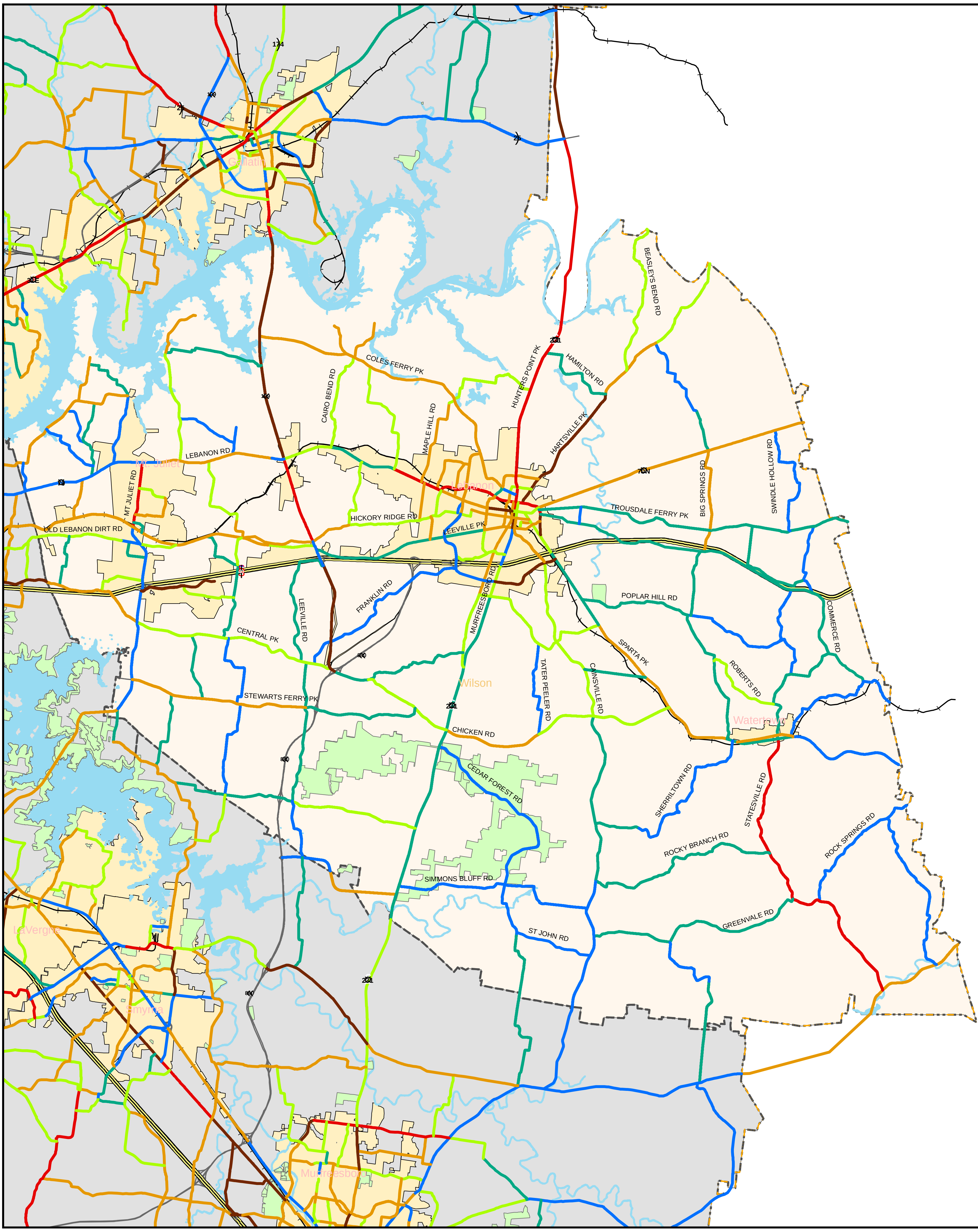
A	Parks
B	Bodies of Water
C	Railroad
D	MPO Planning Boundary
E	City Limits
F	County Boundaries
Arterials & Collectors	
Interstate	

2

0 1 2 4 6 8 Miles

This project is funded under an agreement with the Tennessee Department of Transportation.

Bicycle Level of Service in Wilson County



2

0 1 2 4 6 8 Miles

Legend

- A
- B
- C
- D
- E
- F
- Arterials & Collectors
- Interstate
- Parks
- Bodies of Water
- Railroad
- MPO Planning Boundary
- City Limits
- County Boundaries

This project is funded under an agreement with the Tennessee Department of Transportation.

Appendix B

Nashville Area MPO Bicycle and Pedestrian Crash Assessment

Pedestrian/Bicyclist Crash Analysis

Pedestrian and bicyclist crash data occurring between 2003 and 2007 were obtained from the state and analyzed to determine how many crashes have occurred in each of the five counties in the MPO as well as in Maury and Robertson counties. The data was evaluated to determine areas and corridors in the MPO that need improvements to increase safety for bicyclist and pedestrians.

Table 1 identifies the number of crashes that occurred in each county. According to the data, 2,076 reported crashes involving a pedestrian or bicyclist occurred during this time period, 107 of which resulted in a fatality as shown in Table 2.

Table 1: Total Pedestrian & Bicycle Crashes (2003-2007)

County	2003		2004		2005		2006		2007		Total	
	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike
Davidson	234	55	256	71	217	35	252	54	234	49	1193	264
Maury	6	2	11	1	9	1	9	6	14	4	49	14
Robertson	15	4	8	1	13	2	12	2	5	2	53	11
Rutherford	33	15	30	26	29	11	34	20	28	17	154	89
Sumner	13	7	13	8	11	0	11	11	13	2	61	28
Williamson	8	7	15	10	5	9	14	8	12	2	54	36
Wilson	6	2	8	4	14	6	15	6	4	5	47	23
Total	315	92	341	121	298	64	347	107	310	81	1611	465
Total Pedestrian & Bicycle	407		462		362		454		391		2076	

Source: Tennessee Department of Transportation

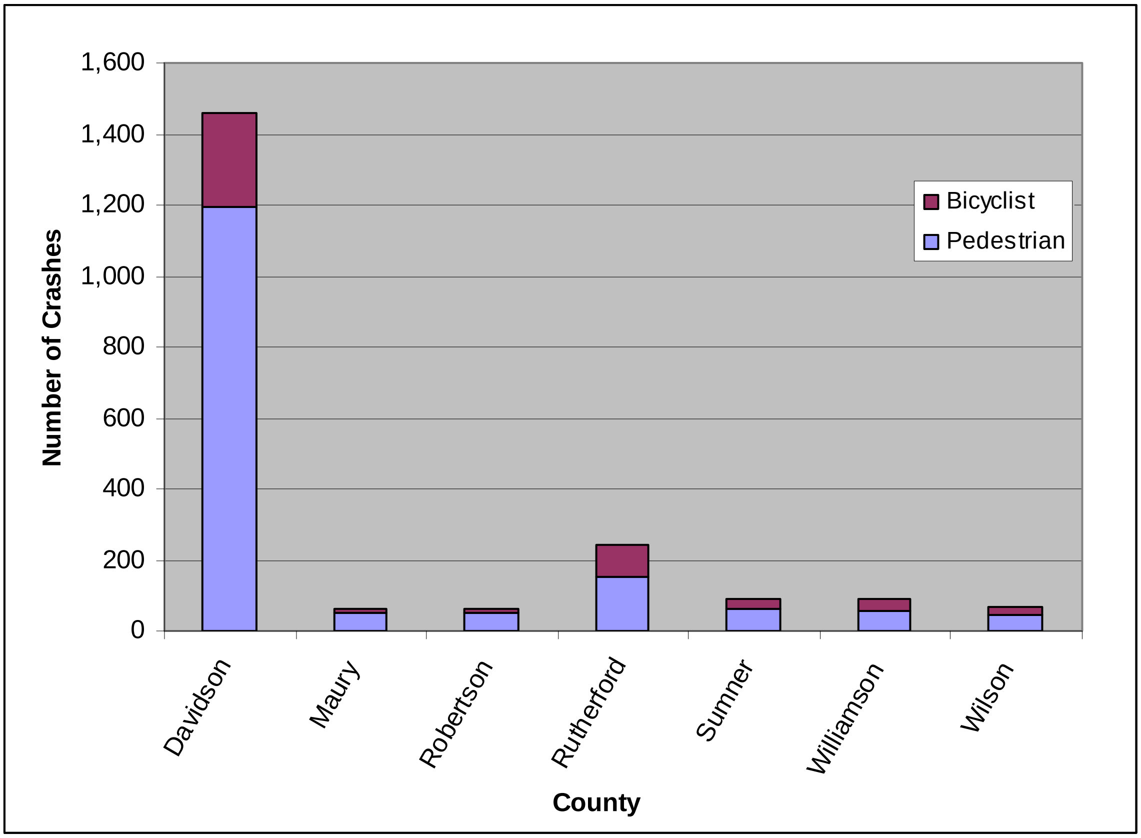
Table 2: Total Pedestrian & Bicycle Fatalities (2003-2007)

County	2003		2004		2005		2006		2007		Total	
	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike	Ped.	Bike
Davidson	15	0	12	0	10	5	17	1	12	1	66	7
Maury	2	0	1	0	0	0	1	0	2	0	6	0
Robertson	0	0	1	0	3	0	0	0	0	0	4	0
Rutherford	3	0	1	0	2	0	5	0	1	0	12	0
Sumner	0	0	0	0	0	0	1	0	0	0	1	0
Williamson	0	1	1	0	0	0	0	0	0	0	1	1
Wilson	3	0	1	0	2	0	2	0	1	0	9	0
Total	23	1	17	0	17	5	26	1	16	1	99	8
Total Pedestrian & Bicycle	24		17		22		27		17		107	

Source: Tennessee Department of Transportation

Figure 1 provides a depiction of which counties experienced the highest number of bicyclist and pedestrian crashes during the five-year period from 2003 to 2007. As expected, Davidson County had the most crashes involving a pedestrian and bicyclist, well beyond the number that occurred in outlying counties.

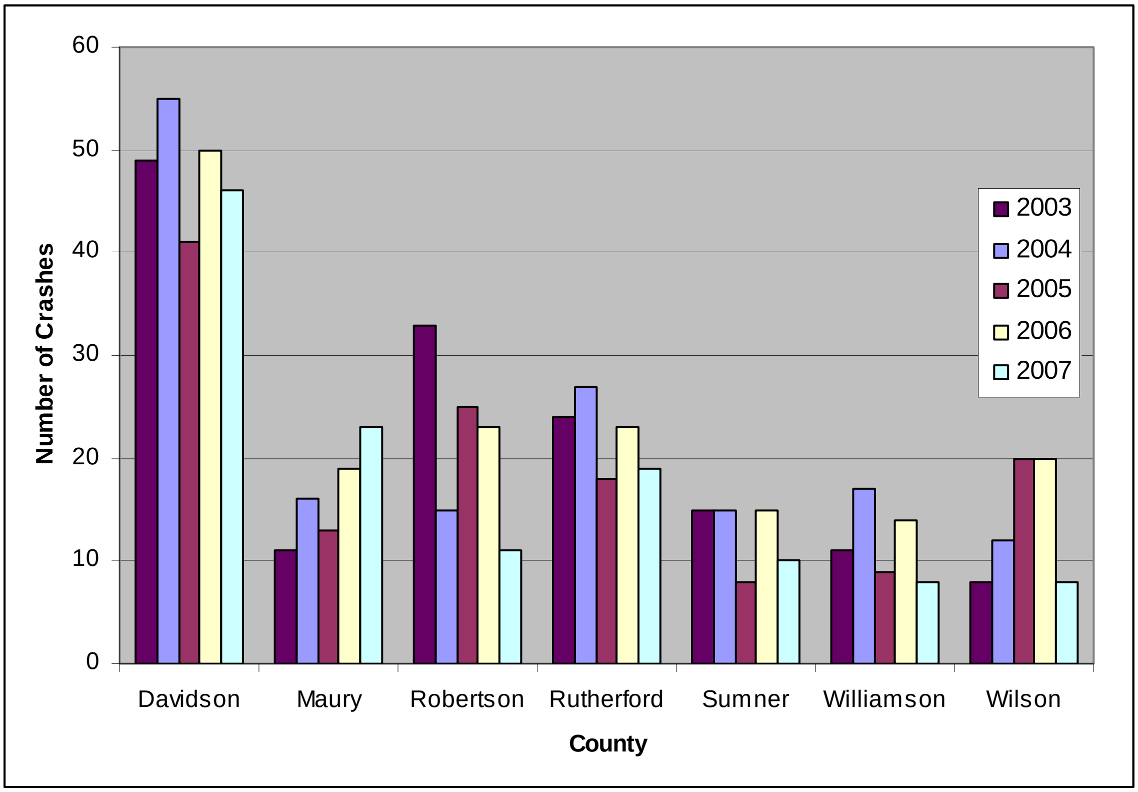
Figure 1: Number of Bicyclist and Pedestrian Crashes 2003-2007



Source: Tennessee Department of Transportation

In Figure 2, the number of crashes per 100,000 population for each year between 2003-2007 separated by each of the seven counties are shown. The figure shows that Davidson County consistently has the highest number of crashes per 100,000 population. Figure 2 also identifies a reduction in bicyclist and pedestrian crashes in each of the counties since 2003. Any number of factors could contribute to such a trend, but the most likely factor is increased education and awareness for both motorists and non-motorists coupled with improved bicycle and pedestrian facilities.

Figure 2: Number of Bicyclist and Pedestrian Crashes Per 100,000 Residents



Source: Tennessee Department of Transportation

According to the National Highway Traffic Safety Administration's (NHTSA) *National Pedestrian Crash Report*, June 2008, nearly two pedestrians die in vehicle crashes per 100,000 population. In the seven counties of the MPO, there were 1.05 pedestrian fatalities and only 0.70 bicyclist fatalities per 100,000 population in 2007. In Davidson County, the pedestrian fatality rate is nearly two per 100,000 population, similar to the national rate.

Furthermore, crash data were evaluated geographically on a corridor level for a three-year period (2003-2005). Figure 3 identifies the number of bicyclist and pedestrian crashes that occurred on each corridor segment. This analysis is limited to state routes and interstates within the MPO. Crashes that occurred on local routes have been excluded do to a lack of information on geographic location of the crash. Table 3 identifies each of the corridor segments by county where crashes involving a bicyclist or pedestrian has occurred. Table 3 additionally identifies the number of those crashes resulting in fatalities.

Table 3: Bicyclist and Pedestrian Crashes by Corridor (2003-2005)

Route	Street Name	Segment	# Ped Crashes	# Ped Fatalities	# Bike Crashes	# Bike Fatalities
Davidson County (249 Total Crashes, 27 Total Fatalities)						
SR 1	Harding Pk	Between Woodmont Blvd & Old Hickory Blvd	2	0	1	0
SR 1	West End Ave	Between 15th Ave & Cherokee Rd	13	0	4	0
SR 1	Broadway	Between I-40 & 8th Ave	7	0	0	0
SR 1	Lafayette St	Between Broadway & Fairfield Ave	11	0	0	0
SR 1	Murfreesboro Pk	Between Fairfield Ave & McGavock Pk	13	1	1	0
SR 1	Murfreesboro Pk	Between Briley Pkwy & Hobson Pk	6	0	1	0
SR 6	Gallatin Pk	Between Conference Dr & W Monticello Ave	2	1	0	0
SR 6	Main St, James Robertson Pkwy	Between S 5th St & Broadway	7	0	0	0
SR 6	8th Ave, Franklin Pk	Between Lafayette St & Woodmont Blvd/ Thompson Ln	3	1	1	0
SR 6	Gallatin Pk	Between W Old Hickory Blvd & Briley Pkwy	9	0	1	0
SR 11	Nolensville Pk	Between I-440 & Old Hickory Blvd	27	1	3	0
SR 11	N Dickerson Pk	Between Long Hollow Pk & I-65	1	0	0	0
SR 11	Dickerson Pk	Between Jefferson St & I-65	21	3	3	0
SR 12	Metrocenter Blvd, 8th Ave N	Between James Robertson Pkwy & Briley Pkwy	9	1	1	0
SR 24	Lebanon Pk	Between Shute Ln & McGavock Pk	5	1	1	0
SR 24	Charlotte Pk	Between I-40/65 & White Bridge Pk	14	2	2	0
SR 24	Hermitage Ave	Between Broadway & Fairfield Ave	9	0	1	0
SR 45	W Old Hickory Blvd	Between Bridge Way Ave & Gallatin Pk	2	1	0	0
SR 45	Old Hickory Blvd	Between Andrew Jackson Pkwy & I-40	1	0	1	0
SR 65	Trinity Ln	Between Whites Creek Pk & Dickerson Pk	3	1	1	1
SR 100	Harding Pk	Between Hwy 70 & Harding Pl	0	0	1	0

Table 3: Bicyclist and Pedestrian Crashes by Corridor (2003-2005) cont.

Route	Street Name	Segment	# Ped Crashes	# Ped Fatalities	# Bike Crashes	# Bike Fatalities
Continue Davidson County (249 Total Crashes, 27 Total Fatalities)						
SR 106	Hillsboro Pk, 21st Ave, Broadway	Between 16th Ave & Abbott Martin Rd	11	0	3	0
SR 112	Clarksville Pk	Between Briley Pkwy & W Hamilton Ave	1	0	0	0
SR 155	Briley Pkwy	Between Gallatin Pk & McGavock Pk	1	1	1	0
SR 155	Thompson Ln	Between I-65 & Nolensville Pk	2	0	2	0
SR 155	Briley Pkwy	Between I-24 & Murfreesboro Pk	1	0	0	0
SR 174	Long Hollow Pk	Between Conference Dr & Main St	1	0	0	0
SR 251	Old Hickory Blvd	Between Hwy 70 & Charlotte Pk	2	1	0	0
SR 254	Bell Rd	Between I-24 & Murfreesboro Pk	3	0	1	0
SR 254	Old Hickory Blvd	Between Hillsboro Pk & Hwy 100	1	0	0	0
SR 255	Harding Pk; Donelson Pk	Between Nolensville Pk & Antioch Pk	7	2	0	0
I-24	Interstate 24	Between I-40 & Briley Pkwy/Thompson Ln	8	3	0	0
I-24	Interstate 24	Between Old Hickory Blvd & Haywood Ln	3	1	0	0
I-40	Interstate 40	Between White Bridge Rd & Fesslers Ln	8	3	0	0
I-65	Interstate 65	Between Long Hollow Pk & Alta Loma Rd	0	0	2	0
I-65	Interstate 65	Between I-24 & Jefferson St	3	2	0	0
Maury County (0 Total Crashes, 0 Total Fatalities)						
Robertson County (11 Total Crashes, 3 Total Fatalities)						
SR 11	Memorial Blvd	Between Blackwood Rd & 17th Ave/Black Patch Dr	3	1	0	0
SR 49	5th Ave	Between Bill Jones Industrial Dr & N Main St	1	0	1	0
SR 65	Tom Austin Hwy	Between Memorial Blvd & Mt Zion Rd	4	2	0	0
SR 76	Hwy 76	Between 5th Ave & New Hall Rd	1	0	0	0
I-65	Interstate 65	Between Maple St & Calstia Rd	1	0	0	0

Table 3: Bicyclist and Pedestrian Crashes by Corridor (2003-2005) cont.

Route	Street Name	Segment	# Ped Crashes	# Ped Fatalities	# Bike Crashes	# Bike Fatalities
Rutherford County (32 Total Crashes, 4 Total Fatalities)						
SR 1	New Nashville Hwy	Between N Thompson Ln & Baird Ln	7	0	1	0
SR 1	Murfreesboro Rd; Lowery St	Between Stones River Rd & Enon Springs Rd	2	1	1	0
SR 2	SE Broad St, Manchester Pk	Between Dilton Mankin Rd & Mt Tabor Rd	0	0	1	0
SR 10	Memorial Blvd	Between W Thompson Ln & New Nashville Hwy	6	1	6	0
SR 96	Old Fort Pkwy, Memorial Blvd, Lascassas Pk, Clark Blvd	Between Gresham Ln & Dejarnette Ln	2	1	3	1
SR 99	New Salem Rd	Between Rockvale Rd & Clearidge Dr	1	0	0	0
SR 266	W Jefferson Pk	Between SR-840 & Murfreesboro Rd	1	0	0	0
SR 268	N Thompson Ln, Compton Rd	Between New Nashville Hwy & Haynes Dr	1	0	0	0
Sumner County (15 Total Crashes, 0 Total Fatalities)						
SR 6	Main St	Between Vietnam Veterans Blvd Exit & Cherokee Rd	1	0	2	0
SR 6	Nashville Pk, Main St, Broadway	Between Belvedere Dr & Water Ave	2	0	0	0
SR 25	Red River Rd; Hartsville Pk	Between Bugg Hollow Rd & State Hwy 10A	2	0	1	0
SR 41	Louisville Pk	Between Dickerson Pk & Denson Ln	1	0	0	0
SR 41	Highway 31	Between Portland Rd & Maple St	1	0	0	0
SR 174	Fairfield Rd	Between Keen Hollow Rd & Sumner County Line	1	0	0	0
SR 258	New Shackle Island Rd	Between Gallatin Pk & Vietnam Veterans Blvd	2	0	1	0
SR 386	Vietnam Veterans Blvd	Between Forest Retreat Rd & Callender Ln	1	0	0	0
Williamson County (13 Total Crashes, 0 Total Fatalities)						
SR 6	Franklin Rd, Columbia Pk	Between Mack Hatcher Memorial Pkwy & Mack Hatcher Memorial Pkwy	2	0	1	0
SR 46	Old Hillsboro Rd	Between Hwy 96 & Southall Rd	1	0	0	0
SR 96	Murfreesboro Rd	Between Horton Hwy & SR-840	1	0	0	0

Table 3: Bicyclist and Pedestrian Crashes by Corridor (2003-2005) cont.

Route	Street Name	Segment	# Ped Crashes	# Ped Fatalities	# Bike Crashes	# Bike Fatalities
Continue Williamson County (13 Total Crashes, 0 Total Fatalities)						
SR 96	Murfreesboro Rd	Between Carothers Pkwy & N Chapel Rd	1	0	0	0
SR 100	Hwy 100, Fairview Blvd	Between Cumberland Rd & Old Nashville Rd	0	0	1	0
SR 252	Wilson Pk	Between Moores Lane & Old Hickory Blvd	1	0	1	0
I-65	Interstate 65	Between Vaden Dr & Old Hickory Blvd	1	0	0	0
Wilson County (11 Total Crashes, 5 Total Fatalities)						
SR 10	Cumberland St	Between I-40 & Oakdale Dr	1	0	1	0
SR 24	Main St	Between Cumberland St & Hartman Dr	1	0	0	0
SR 26	Sparta Pk	Between Maddox-Simpson Pkwy & Linwood Rd	3	1	0	0
SR 266	Cainsville Rd	Between Maddox-Simpson Pkwy & SR 265	1	1	0	0
I-40	Interstate 40	Between Mt Juliet Rd & Wilson County Line	2	1	0	0
I-40	Interstate 40	Between Baddour Pkway & Hwy 109	2	2	0	0

Source: Tennessee Department of Transportation.
Note: This figure and corresponding data are covered by USC 409 and are intended for planning purposes only.

In order to identify potential countermeasures that could be implemented to increase safety and reduce crashes involving bicyclists and pedestrians, further analysis was conducted to determine possible causes for the crashes in the MPO. This analysis was conducted utilizing crash data from the years 2003-2005. All crashes, including those occurring on local roads, were included in the characteristics crash analysis. Table 4 summarizes the crash characteristics for the entire five-county MPO plus all of Maury and Robertson counties.

Table 4: MPO Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions				
	No Adverse Conditions	Rain	Snow, Sleet, or Hail	Unknown
Pedestrian	461	74	4	7
Bicyclist	138	11	0	2
Total	599	85	4	9
Percentage – Total	86%	12%	1%	1%
Percentage – Pedestrian	84%	14%	1%	1%
Percentage – Bicyclist	92%	7%	0%	1%

Time of Day				
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)	Unknown
Pedestrian	110	154	272	10
Bicyclist	30	59	60	2
Total	140	213	332	12
Percentage – Total	20%	30%	48%	2%
Percentage – Pedestrian	20%	28%	50%	2%
Percentage – Bicyclist	20%	39%	40%	1%

Lighting Conditions					
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)	Unknown
Pedestrian	319	217	161	56	10
Bicyclist	118	31	22	9	2
Total	437	248	183	65	12
Percentage – Total	63%	35%	74%	26%	2%
Percentage – Pedestrian	58%	40%	74%	26%	2%
Percentage – Bicyclist	78%	21%	71%	29%	1%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	261	285	546	48%	52%
Bicyclist	76	75	151	50%	50%
Total	337	360	697	48%	52%

As shown in Table 4, 86% of all crashes involving bicyclists or pedestrians occurred with no adverse weather conditions. Approximately 48% of the crashes occurred in the evening after 5pm and 35% occurred when it was dark outside. Approximately half of the crashes occurred at intersections and half occurred at non-intersections or on roadway segments. The following tables (Tables 5-11) provide the same crash characteristic data on a county level.

Table 6: Davidson County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions				
	No Adverse Conditions	Rain	Snow, Sleet, or Hail	Unknown
Pedestrian	344	53	3	5
Bicyclist	75	3	0	1
Total	419	56	3	6
Percentage – Total	86%	12%	1%	1%
Percentage – Pedestrian	85%	13%	1%	1%
Percentage – Bicyclist	95%	4%	0%	1%
Time of Day				
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)	Unknown
Pedestrian	83	117	199	6
Bicyclist	17	28	33	1
Total	100	145	232	7
Percentage – Total	21%	30%	48%	1%
Percentage – Pedestrian	20%	29%	49%	2%
Percentage – Bicyclist	22%	35%	42%	1%

Lighting Conditions					
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)	Unknown
Pedestrian	233	164	132	32	8
Bicyclist	62	16	12	4	1
Total	295	180	144	36	9
Percentage – Total	61%	37%	80%	20%	2%
Percentage – Pedestrian	58%	40%	80%	20%	2%
Percentage – Bicyclist	79%	20%	80%	20%	1%
Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	215	190	405	53%	47%
Bicyclist	44	35	79	56%	44%
Total	259	225	484	54%	46%

In Davidson County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Nearly 50% of pedestrian and bicyclist crashes occurred after 5pm and 37% occur after dark.
- Adverse weather conditions do not appear to be a major contributor to bicyclist and pedestrian crashes.
- Slightly more than half of both bicyclist and pedestrian crashes occurred at intersections.
- Less than 10% of crashes occurred under dark (not lighted) conditions.

Table 6: Maury County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions			
	No Adverse Conditions	Rain	Snow, Sleet, or Hail
Pedestrian	9	4	0
Bicyclist	3	0	0
Total	12	4	0
Percentage – Total	75%	25%	0%
Percentage – Pedestrian	69%	31%	0%
Percentage – Bicyclist	100%	0%	0%

Time of Day			
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)
Pedestrian	2	6	5
Bicyclist	0	2	1
Total	2	8	6
Percentage – Total	12%	50%	38%
Percentage – Pedestrian	15%	46%	39%
Percentage – Bicyclist	0%	67%	33%

Lighting Conditions				
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)
Pedestrian	8	5	2	3
Bicyclist	3	0	0	0
Total	11	5	2	3
Percentage – Total	69%	31%	40%	60%
Percentage – Pedestrian	62%	38%	40%	60%
Percentage – Bicyclist	100%	0%	0%	0%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	5	8	13	38%	62%
Bicyclist	2	1	3	67%	33%
Total	7	9	16	44%	56%

In Maury County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Approximately 50% of pedestrian and bicyclist crashes occurred between noon and 5pm.
- Approximately 31% of crashes occurred after dark and 60% of those crashes occurred under non-lighted conditions.
- More than 60% of pedestrian crashes occurred at non-intersections.

With only 16 crashes occurring over a 5-year period in Maury County, however, these trends should be taken lightly as most crashes could be considered a random occurrence.

Table 7: Robertson County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions			
	No Adverse Conditions	Rain	Snow, Sleet, or Hail
Pedestrian	17	2	0
Bicyclist	4	0	0
Total	21	2	0
Percentage – Total	91%	9%	0%
Percentage – Pedestrian	89%	11%	0%
Percentage – Bicyclist	100%	0%	0%

Time of Day				
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)	Unknown
Pedestrian	0	5	12	2
Bicyclist	1	1	2	0
Total	1	6	14	2
Percentage – Total	4%	26%	61%	9%
Percentage – Pedestrian	0%	26%	63%	11%
Percentage – Bicyclist	25%	25%	50%	0%

Lighting Conditions				
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)
Pedestrian	11	8	2	6
Bicyclist	2	2	1	1
Total	13	10	3	7
Percentage – Total	57%	43%	25%	75%
Percentage – Pedestrian	58%	42%	50%	50%
Percentage – Bicyclist	50%	50%	30%	70%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	6	13	19	32%	68%
Bicyclist	3	1	4	75%	25%
Total	9	14	23	39%	61%

In Robertson County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- More than 60% of pedestrian and bicyclist crashes occurred after 5pm.
- Adverse weather conditions do not appear to be a major contributor to bicyclist and pedestrian crashes.
- Approximately 43% of crashes occurred after dark and 75% of those crashes occurred under non-lighted conditions.
- Nearly 70% of pedestrian crashes occurred at non-intersections, while 75% of bicyclist crashes occurred at intersections.

Table 8: Rutherford County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions				
	No Adverse Conditions	Rain	Snow, Sleet, or Hail	Unknown
Pedestrian	46	5	0	1
Bicyclist	31	6	0	0
Total	77	11	0	1
Percentage – Total	87%	12%	0%	1%
Percentage – Pedestrian	88%	10%	0%	2%
Percentage – Bicyclist	84%	16%	0%	0%

Time of Day			
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)
Pedestrian	10	13	29
Bicyclist	5	15	17
Total	15	28	46
Percentage – Total	17%	31%	52%
Percentage – Pedestrian	19%	25%	56%
Percentage – Bicyclist	13%	41%	46%

Lighting Conditions					
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)	Unknown
Pedestrian	26	25	18	7	1
Bicyclist	25	11	8	3	1
Total	51	36	26	10	2
Percentage – Total	57%	41%	72%	28%	2%
Percentage – Pedestrian	50%	48%	72%	28%	2%
Percentage – Bicyclist	67%	30%	73%	27%	3%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	17	35	52	33%	67%
Bicyclist	14	23	37	38%	62%
Total	31	58	89	35%	65%

In Rutherford County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Just over half of pedestrian crashes occurred after 5pm.
- Adverse weather conditions do not appear to be a major contributor to bicyclist and pedestrian crashes.
- Approximately 48% of pedestrian crashes occurred after dark while 67% of bicyclist crashes occurred during daylight.
- Approximately 65% of pedestrian and bicyclist crashes occurred at non-intersections.

Table 9: Sumner County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions				
	No Adverse Conditions	Rain	Snow, Sleet, or Hail	Unknown
Pedestrian	17	4	1	0
Bicyclist	7	1	0	1
Total	24	5	1	1
Percentage – Total	77%	16%	3%	3%
Percentage – Pedestrian	77%	18%	5%	0%
Percentage – Bicyclist	78%	11%	0%	11%
Time of Day				
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)	Unknown
Pedestrian	5	6	11	0
Bicyclist	1	6	1	1
Total	6	12	12	1
Percentage – Total	19%	39%	39%	3%
Percentage – Pedestrian	23%	27%	50%	0%
Percentage – Bicyclist	11%	67%	11%	11%
Lighting Conditions				
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)
Pedestrian	14	8	6	2
Bicyclist	8	1	1	0
Total	22	9	7	2
Percentage – Total	71%	29%	78%	22%
Percentage – Pedestrian	64%	36%	75%	25%
Percentage – Bicyclist	89%	11%	100%	0%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	8	14	22	36%	64%
Bicyclist	8	1	9	89%	11%
Total	16	15	31	52%	48%

In Sumner County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Approximately half of pedestrian crashes occurred after 5pm and 36% occurred after dark.
- Approximately 75% of the pedestrian crashes that occurred after dark occurred under lighted conditions.
- Approximately 64% of pedestrian crashes occurred at non-intersections, while approximately 89% of bicyclist crashes occurred at intersections.

Table 10: Williamson County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions				
	No Adverse Conditions	Rain	Snow, Sleet, or Hail	Unknown
Pedestrian	15	4	0	1
Bicyclist	12	1	0	0
Total	27	5	0	1
Percentage – Total	82%	15%	0%	3%
Percentage – Pedestrian	75%	20%	0%	5%
Percentage – Bicyclist	92%	8%	0%	0%

Time of Day				
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)	Unknown
Pedestrian	6	5	7	2
Bicyclist	5	5	3	0
Total	11	10	10	2
Percentage – Total	34%	30%	30%	6%
Percentage – Pedestrian	30%	25%	35%	10%
Percentage – Bicyclist	38%	39%	23%	0%

Lighting Conditions					
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)	Unknown
Pedestrian	16	3	1	2	1
Bicyclist	13	0	0	0	0
Total	29	3	1	2	1
Percentage – Total	88%	9%	33%	67%	3%
Percentage – Pedestrian	80%	15%	33%	67%	5%
Percentage – Bicyclist	100%	0%	0%	0%	0%

Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	9	11	20	45%	55%
Bicyclist	2	11	13	15%	85%
Total	11	22	33	33%	67%

In Williamson County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Approximately 88% of the pedestrian and bicyclist crashes occurred during daylight conditions.
- Approximately 55% of pedestrian crashes occurred at non-intersections, and approximately 85% of bicyclist crashes occurred at non-intersections.

Table 11: Wilson County Bicyclist and Pedestrian Crash Characteristics (2003-2005)

Weather Conditions					
	No Adverse Conditions	Rain	Snow, Sleet, or Hail		
Pedestrian	13	2	0		
Bicyclist	6	0	0		
Total	19	2	0		
Percentage – Total	90%	10%	0%		
Percentage – Pedestrian	87%	13%	0%		
Percentage – Bicyclist	100%	0%	0%		
Time of Day					
	Morning (5am-noon)	Afternoon (noon-5pm)	Evening (after 5pm)		
Pedestrian	4	2	9		
Bicyclist	1	2	3		
Total	5	4	12		
Percentage – Total	24%	19%	57%		
Percentage – Pedestrian	27%	13%	60%		
Percentage – Bicyclist	17%	33%	50%		
Lighting Conditions					
	Daylight	Dark	Dark (Lighted)	Dark (Not Lighted)	
Pedestrian	11	4	0	4	
Bicyclist	5	1	0	1	
Total	16	5	0	5	
Percentage – Total	76%	24%	0%	100%	
Percentage – Pedestrian	73%	27%	0%	100%	
Percentage – Bicyclist	83%	17%	0%	100%	
Intersection and Non-Intersection Related					
	Intersection	Non-Intersection	Total	Percent Intersection	Percent Non-Intersection
Pedestrian	1	14	15	7%	93%
Bicyclist	3	3	6	50%	50%
Total	4	17	21	19%	81%

In Wilson County, the crash data between 2003-2005 lends the following trends for crashes that occurred on state routes and interstates:

- Approximately 60% of pedestrian crashes and 50% of bicyclist crashes occurred after 5pm.
- Adverse weather conditions do not appear to be a major contributor to bicyclist and pedestrian crashes.
- Approximately 76% of bicyclist and pedestrian crashes occurred during daylight hours.
- Approximately 93% of pedestrian crashes occurred at non-intersection while 50% of bicyclist crashes occurred at non-intersections and 50% occurred at intersections.

Appendix C

Nashville Regional Non-Motorized Trip Generator (Trip Model)

Nashville Regional Non-Motorized Trip Generator (Trip Model)

INTRODUCTION

The objective of the development of the Non-Motorized Demand Model (Trip Model) was to produce a decision tool that would allow planners and engineers to determine the real need for walking and biking facilities within the Nashville region. At the macro level, this is a regional bike and pedestrian model that incorporates the entirety of the transportation planning area of the Nashville region. The whole Nashville Area MPO area (Davidson, Rutherford, Williamson, Wilson, Sumner, and portions of Robertson and Maury Counties) is included in the Trip Model. Aside from the scope of the model's planning area, however, the Trip Model is very much a microscopic model, producing a parcel-level analysis fit for walking and biking trips.

The Trip Model tool uses a parcel's demographic information and proximity to other land uses to predict how many walking and/or cycling trips a parcel will likely generate under ideal conditions. This information can be used to help understand the propensity for non-motorized transportation activity in an area and to help predict where transportation investments will have the greatest impact.

The Trip Model developed for this project differs from other currently available modeling procedures in several ways. Substantial differences are described as follows:

Parcel-Level Analysis
The Trip Model uses land use, demographic, and proximity data for every parcel in the study area to predict the trip making characteristics of each individual parcel. While this increases the data requirements and processing time, it also produces more accurate and more meaningful trip generation results. Most procedures, when used, make trip predictions on the TAZ-level (the same scale used for vehicle and freight trip models). Since most bicyclists are comfortable riding less than 3 miles and most pedestrians are comfortable walking less than 0.25 miles, it is more beneficial to perform the analysis on a smaller scale. Where TAZs are any larger than approximately 0.25 square miles (160 acres), the accuracy of these walking and biking trips becomes severely compromised.

Availability for Data Add-On
The Trip Model is based on data from national and local sources, such as the 2001 National Household Transportation Survey, US Census Data, and the Nashville MTA On-Board Survey done in 2006. As other land use, demographic, or other pertinent data becomes available, the trip generation drivers can be modified to incorporate this data or to produce new trip types.

An example of this would be if a national study found that socioeconomic considerations have a measureable impact on the number of walking trips generated by a household. Given the qualitative data from the study and the corresponding local socioeconomic data, the Trip Model could be modified to calculate its trip predictions on this new information.

Varied Trip Types
Some procedures use generalized trip types that mimic those used in traditional vehicle travel demand models (home-based work, home-based other, non-home based). The Trip Model instead uses eight specific trip types for walking and five trip types for cycling. The trip types are discussed in further detail in the following text.

Variable Reporting
Aside from an increased level of detail, estimating generated trips at a parcel level allows flexibility in reporting walking and cycling trips. Trips can be reported on the parcel level, but may be more useful reported by larger areas such as blocks or neighborhoods. Trips can also be aggregated to a street network to allow a roadway segment analysis of non-motorized trips.

Some major aspects of the Trip Model developed for this project include:

- The model predicts one-way, daily walking or biking trips from every parcel in the study area. It can be logically assumed that every generated trip has a return trip, so that these numbers could be multiplied times two to obtain total daily trips. However, the effects of trip chaining are not accounted for.
- Eight different types of walking trips are estimated and five different types of bike trips are estimated. These are: walk to school, walk to recreate, walk to shop, walk to work, walk to errand, walk to transit, walk from transit, walk from parking, bike to school, bike to recreate, bike to shop, bike to work, and bike to errand.
- The origin of the trip takes preeminence over the destination in the model. Households are the most common trip origins, but trips also originate from workplaces and transit stops. Although trips are attributed only to the originating parcel, there must be a suitable destination in proximity for the trip to occur. In other words, the model requires both an origin and a destination to generate a trip, but the trip is attributed to its origin.
- The trip model assumes ideal bike and pedestrian conditions. This includes uninterrupted connectivity of facilities at regular intervals that are in good condition. This assumption may be close to actual conditions in urban downtown settings, but is far from the reality in suburban and rural areas. This aspect contrasts the trip model with the LOS analysis, which considers the actual condition of the facility, but does not account for its usage.

HOW THE TRIP MODEL WORKS

To estimate the walking or cycling trips for a parcel, several things must be known about that parcel; namely, its household count, employment, and the shortest distance to the nearest school, recreational facility, retail area, and transit stop. Also, some information relative to its proximity to employment in the study area and whether any substantial public parking exists is important.

Once the distance relationships to other land uses are known, the effect of distance on making the walk or bike trip is quantified. This is done using a series of distance impedance curve equations developed by RPM from data in the National Household Travel Survey. The closer the land use, the more likely that the trip will be made by walking or cycling. Each parcel in the study area, then, has an impedance probability for every walking and biking trip type. The impedance probability is one factor in the total trip generation process.

Next, employment and population attributes are used in series of trip type equations. These equations follow the general formula shown below:

(No. households in the parcel)[1] x (type-specific factor series) x (impedance probability)

The first two terms in the equation quantify the number of non-motorized trips that are likely to occur based on national averages and assumptions regarding each parcel's trip making characteristics, without respect to how far the walking or cycling trip would be. The last term, the impedance probability as described above, accounts for the inverse relationship that distance has on these trips.

The result of the equation for each trip type is the expected number of walking and cycling trips by type. These trips can be reported individually by trip type. However, these trips are also summed to obtain the total number of one-way walking and cycling trips on a typical work/school day.

SPECIFIC CONSIDERATIONS BY TRIP TYPE

Travel to School: Only applied to residential parcels. Uses U.S. Census data to determine numbers of school-age children by parcel. Uses a proximity factor to scale down trips because not all children attend the school they live closest to.

Travel to Recreation: Only applied to residential parcels. Uses national data to factor the number of recreational trips made as a proportion of all trips made. Recreation trips are only made in the model if the household is in proximity to a park. In reality, many recreational trips have destinations other than a park, or have no destination at all, making these difficult to predict.

Travel to Shop: Only applied to residential parcels. Uses national data to factor the number of shopping (including personal service such as a haircut) trips made as a proportion of all trips made. Uses a proximity factor to scale down trips because not all shopping trips are made to the retail area closest to home.

Travel to Work: Only applied to residential parcels. Uses national data to factor the number of work trips made as a proportion of all trips made. Proximity to employment density used to estimate likelihood of trips. Uses a proximity factor to scale up trips to account for desirability to live close to work. Number of travel to work trips found to be very low because of employment density method.

Travel to Errand: Estimation of errand-type trips from work to other commercial uses. Only applied to workplace parcels where retail exists within ½ mile. Uses national data to factor the number of errand trips made as a proportion of all trips made. Proximity of employment to retail sales and services used to estimate likelihood of trips.

Walk to Transit: The first of two transit walking trips, this one estimates trips from home to the transit stop. Only applied to households within 1 mile of a transit stop. Uses national data to factor the number of all trips made using transit as a proportion of all trips made using other modes. Proximity of households to transit stops used to estimate likelihood of trips. The impedance curve for this trip was developed using the Nashville MTA On-Board Survey.

[1] This is the common equation form for trip types with households as the origin. Several trips types do not use the number of households as a determinant and would therefore have a different equation form.

Walk from Transit: The second of two transit walking trips, this one estimates trips from the transit stop to a final destination (based on employment). This is the only destination-based trip type and is only applied to employment sites within 1 mile of a transit stop. Uses the number of boarding trips from the Walk to Transit trip type listed above. Proximity of employment to transit stops and the relative amount of employment at each site used to estimate likelihood of these trips.

Walk from Parking: Only applied to major public surface parking lots and parking garages in urban areas (Nashville, Murfreesboro, and Franklin). Assumes that walk trips will originate from all parked vehicles. Uses parking space turnover and garage occupancy factors to scale up and down trips, respectively.

Note that the last three trip types are only applicable for walking trips and were not determined for cycle trips. The Nashville MTA On-Board Survey, which was conducted in 2006, found that over 87% of all transit trips were made after walking to the bus stop as opposed to only 0.5% being made after cycling to the bus stop. Therefore, Bike to Transit was not derived in model. Likewise, there is not expected to be a significant number of weekday bike trips made after driving to a parking lot, other than perhaps at a greenway trailhead, park, or similar area.