NASHVILLE AREA
Metropolitan Planning Organization

2014 Regional Bicycle & Pedestrian:

Sidewalk and Bikeway Facilities Inventory

Bicycle and Pedestrian Level-of-Service Analysis

INVENTORY

In order to understand the walking and biking conditions in the Nashville MPO region, it is essential to understand the types of accommodations provided for non-motorized users. As such, this project began with an inventory of the existing bicycle and pedestrian infrastructure within the seven counties. In order to accomplish this task, a combination of data sources were utilized. Specifically, the Tennessee Department of Transportation's (TDOT's) Transportation Roadway Information Management System (TRIMS) database, Google Earth imagery, and in-field reviews were used to document the provision of facilities.

Throughout the inventory effort, a variety of roadway information was collected; the variables below were collected for roadways included in the MPO's travel demand model that are functionally-classified as arterials or collectors, not including interstates or controlled access facilities which prohibit pedestrian or bicycle use (e.g., Briley Parkway, Ellington Parkway, State Route 840, State Route 386, and State Route 396). The following variables were documented for these facilities:

- Number of Through Lanes
- Lane Width
- Shoulder Width
- Sidewalk Presence and Width
- Width of Sidewalk Buffers
- Presence and Type of Bicycle Facility
- Presence of Rumble Strips
- Percent of Roadway with Sidewalks
- Presence and Width of On-Street Parking
- Spacing of Trees or Other Pedestrian Barriers if Applicable (e.g., bollards)
- Traffic Volumes
- Percent Heavy Vehicles
- Speed Limit (Posted Speed Limit)
- Peak Hour Factor
- Directional Distribution of Traffic Volumes

In total, approximately 3,269 miles of roadways were inventoried. Of the inventoried roadways, 505 miles had sidewalk facilities and 423 miles had bicycle facilities. For purposes of the inventory, bicycle facilities included bike lanes, buffered bike lanes, designated bike routes, and shared roadways that were identified by pavement markings. Figure 1 below shows the distribution of inventoried roadways by county in the MPO area. Figure 2 and Figure 3 show the distribution of sidewalks and bicycle facilities in the seven-county area, respectively.

Figure 1: Inventoried Roadway Miles by County

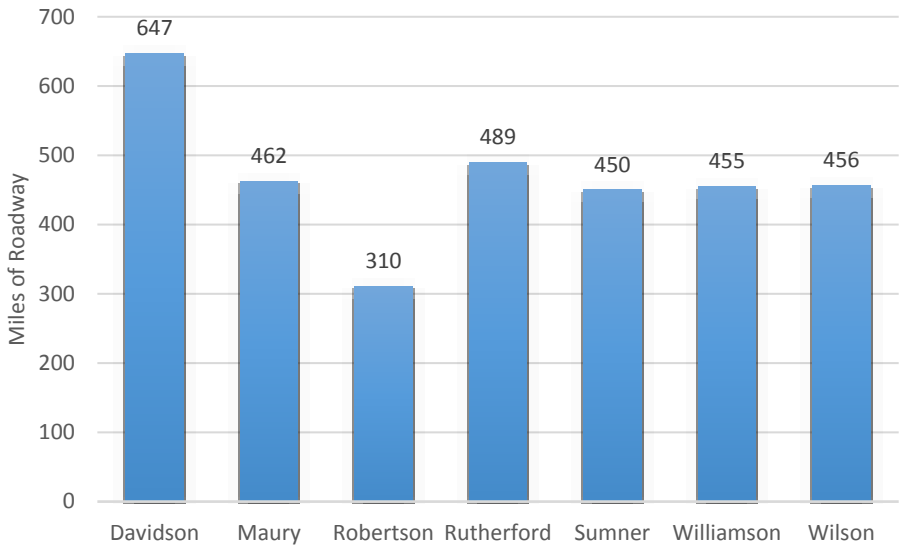


Figure 2: Miles of Inventoried Roadways with Sidewalks

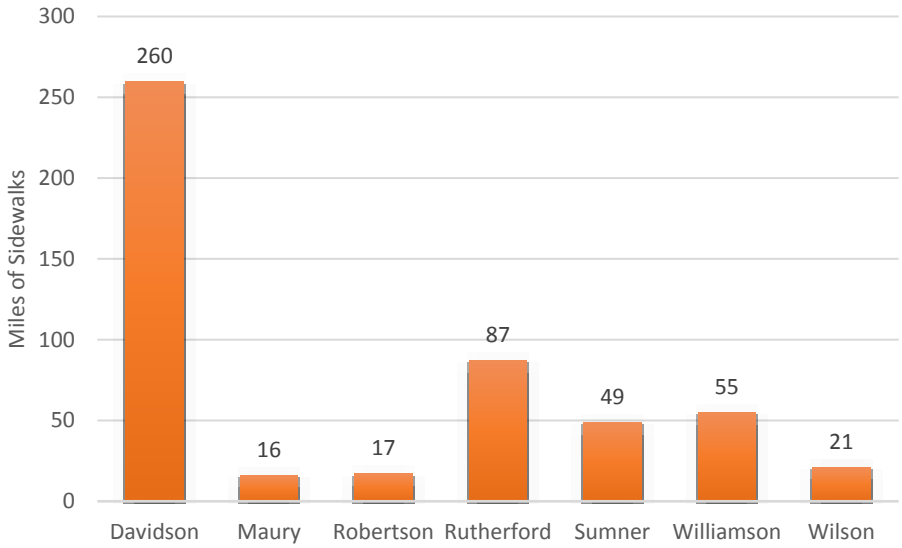
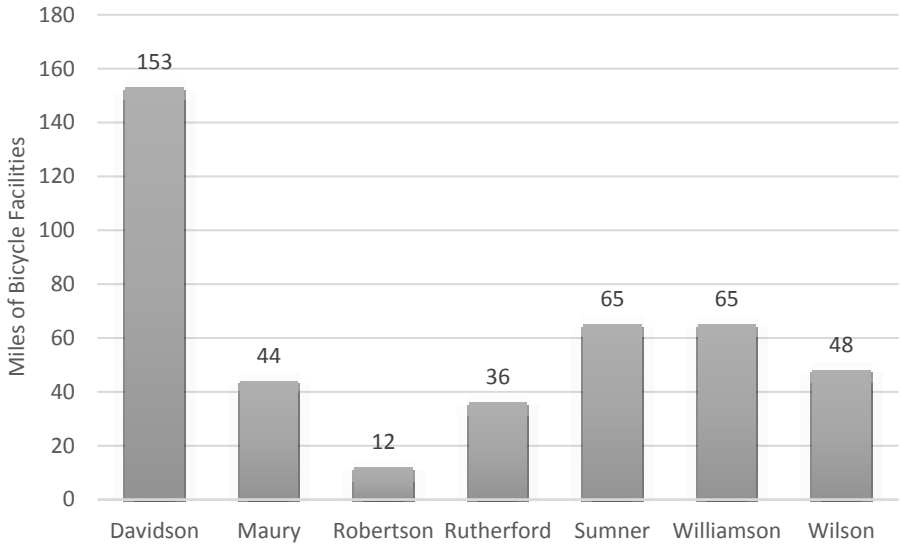
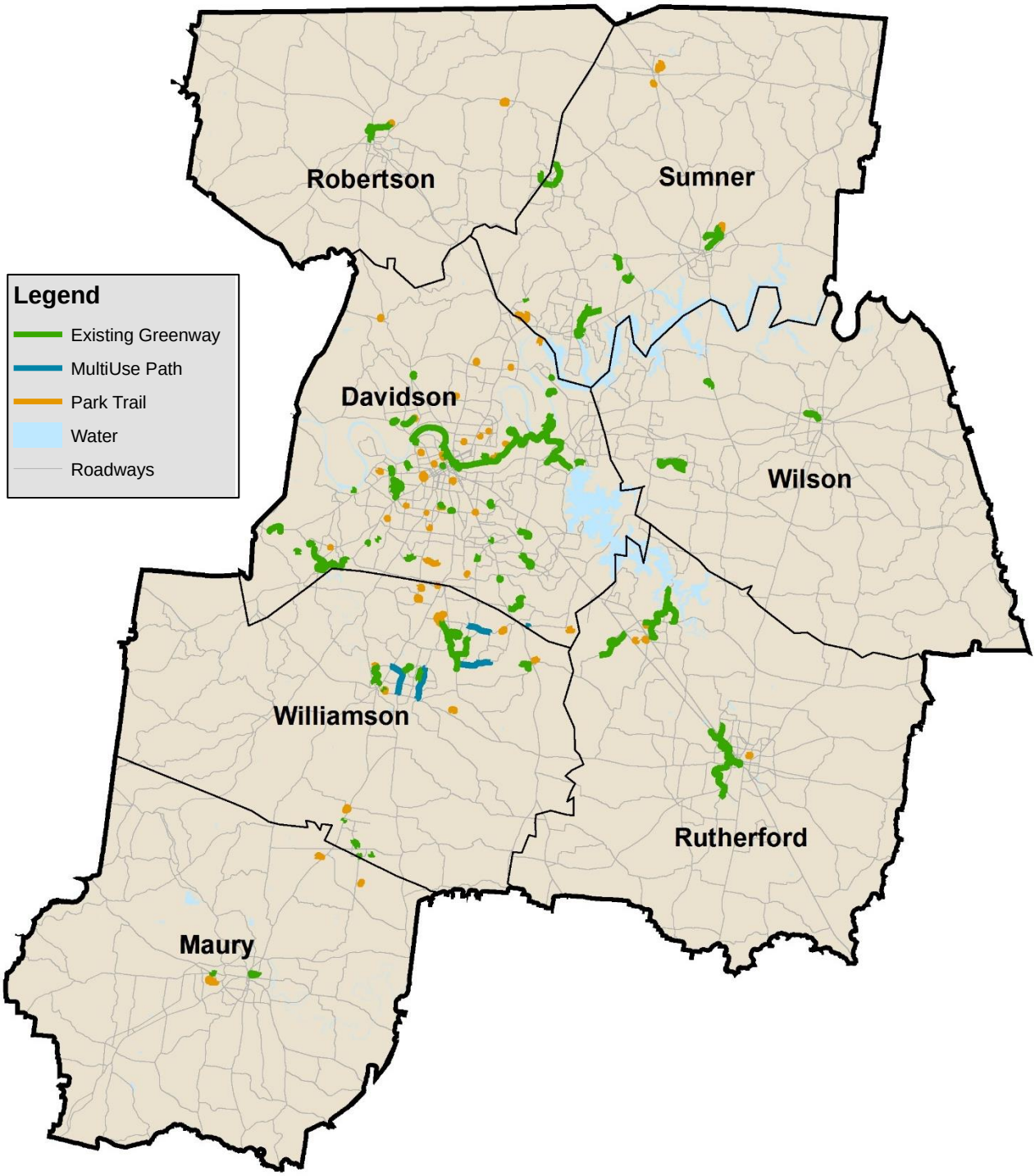


Figure 3: Miles of Inventoried Roadways with Bicycle Facilities



In addition to on-road facilities, an inventory of shared-use paths (greenway facilities) in the MPO region was undertaken to capture paved off-road facilities. Shared-use paths, or greenways, are non-motorized facilities most often built on exclusive rights-of-way with limited motor vehicle crossings. The inventory process began with a look at the greenways inventory effort undertaken in 2009 to determine where facilities existed then and where they have been constructed since that time. Overall, this inventory included the use of GIS and Google Earth as well as a review of municipality websites. Figure 4 below shows the various existing greenways, park trails, and multiuse paths. Currently, there are approximately 136 miles of greenways, 10 miles of multi-use paths, and 39 miles of trails located within the seven county MPO area.

Figure 4: Existing Greenways, Park Trails, and Multiuse Paths



LEVEL OF SERVICE ANALYSIS

In the 2009 MPO Bicycle and Pedestrian Plan, NCHRP Report 616 served as the methodology for determining bicycle and pedestrian levels-of-service (BLOS/PLOS). In the five years since, this methodology was adapted and incorporated into the 2010 Highway Capacity Manual (HCM). The Level of Service for walking and bicycling is based on the comfort level of the pedestrian and bicyclist on the roadway; 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

Using the 2010 HCM, a Pedestrian Level-of-Service (PLOS) analysis was conducted for all inventoried roadway segments in the 7-county MPO area; this included roadways in the MPO's travel demand model that are functionally-classified as arterials or collectors, not including interstates or controlled access facilities which prohibit pedestrian use (e.g., Briley Parkway, Ellington Parkway, State Route 840, State Route 386, and State Route 396). The PLOS analysis uses various traffic and roadway factors to measure the walking suitability of a roadway segment. The equation for this evaluation is shown below:

$$\mathrm{PLOS} = -1.2276 \ln\left(W_v + 0.5 * W_1 + 50 * p_{pk} + W_{buf} * f_b + W_{aA} * f_{sw}\right) + 0.0091 \left(\frac{v_m}{4 * N_{th}}\right) + 4 * \left(\frac{S_r}{100}\right)^2 + 6.0468$$

Where:

PLOS =Pedestrian Level-of-Service

W_v =Effective total width of outside through lane, bicycle lane, and shoulder as a function of traffic volume (ft) – dependent on hourly traffic volume

W_1 =Effective width of combined bicycle lane and shoulder (ft) – dependent on percent of occupied on-street parking

p_{pk} =Proportion of on-street parking occupied (assumed to be 100% if on-street parking was present)

W_{buf} =Buffer width between roadway and available sidewalk (ft)

f_b =Buffer area coefficient (assumed to be 1.00)

W_{aA} =Adjusted available sidewalk width = min (W_A, 10) (ft)

W_A =Available sidewalk width (= 0 if sidewalk does not exist or W_T –W_{buf} if sidewalk exists) (ft)

W_T =Total width of outside through lane, bicycle lane, and paved shoulder (ft) – dependent on presence and occupancy of on-street parking

f_{sw} =Sidewalk width coefficient (= 6 - 0.3W_{aA})

W_s =Width of sidewalk (ft)

v_m =Mid-segment demand flow rate (direction nearest to the subject sidewalk) (vph)

N_{th} =Number of through lanes on the segment in the subject direction of travel

S_r =Motorized vehicle running speed (assumed to be the posted speed limit) (mph)

Since its incorporation into the 2010 HCM, this procedure has a few notable changes from the procedure used in the 2009 study that may result in changes in the PLOS scores of many segments in the MPO area. Primarily, the variables W_T, W_v, and W_1 are calculated differently with regard to low-volume roadways and the inclusion of bicycle facilities and parking lanes in shoulder

widths. Additionally, the traffic volume included in the PLOS calculation has been changed from the peak 15-minute traffic volume to the peak hour volume. Once the above equation was calculated, the PLOS score was converted into a LOS ranging from A to F as shown in Figure 5.

Figure 5: Pedestrian Level-of-Service Rating

PLOS	Scoring Criteria	
A	≤ 2.00	Extremely High
B	> 2.00 and ≤ 2.75	Very High
C	> 2.75 and ≤ 3.50	Moderately High
D	> 3.50 and ≤ 4.25	Moderately Low
E	> 4.25 and ≤ 5.00	Very Low
F	> 5.00	Extremely Low

This conversion resulted in over 2,000 miles of roadways having a PLOS of C or better; this equates to approximately 67% of all roadways as shown below in Figure 6. Figure 7 shows the results for each of the seven counties in the MPO area. These results are also depicted geographically in Figure 8 through Figure 14 on the following pages.

Figure 6: Pedestrian Level-of-Service for MPO Roadways

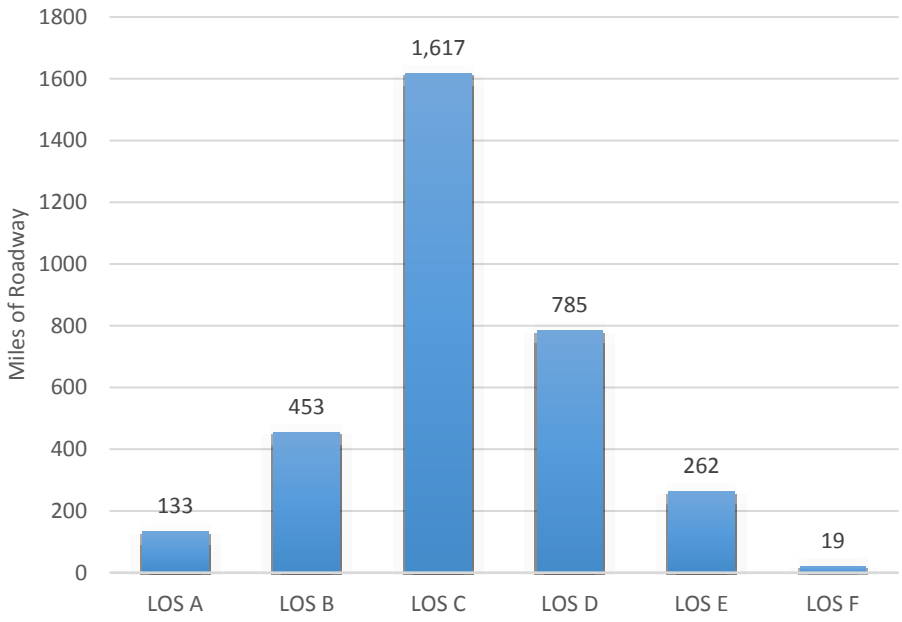


Figure 7: Pedestrian Level-of-Service Miles by County

	Davidson	Maury	Robertson	Rutherford	Sumner	Williamson	Wilson	Total
LOS A	61	14	7	11	20	11	9	133
LOS B	178	30	22	88	41	62	32	453
LOS C	179	293	187	211	259	191	297	1,617
LOS D	151	110	79	143	112	114	76	785
LOS E	74	14	13	35	18	66	42	262
LOS F	4	1	2	1	0	11	0	19

Figure 8: Davidson County PLOS Results

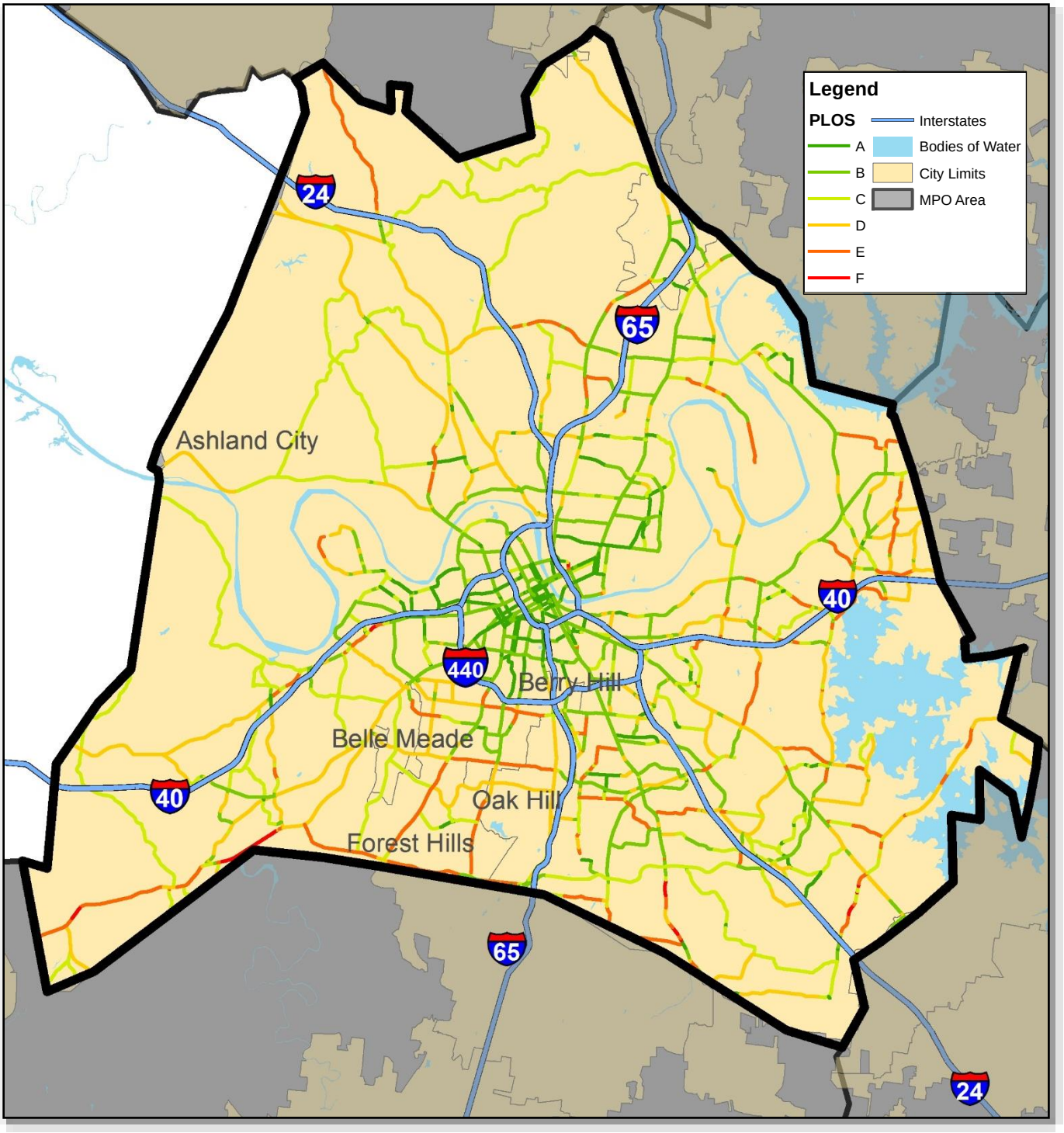


Figure 9: Maury County PLOS Results

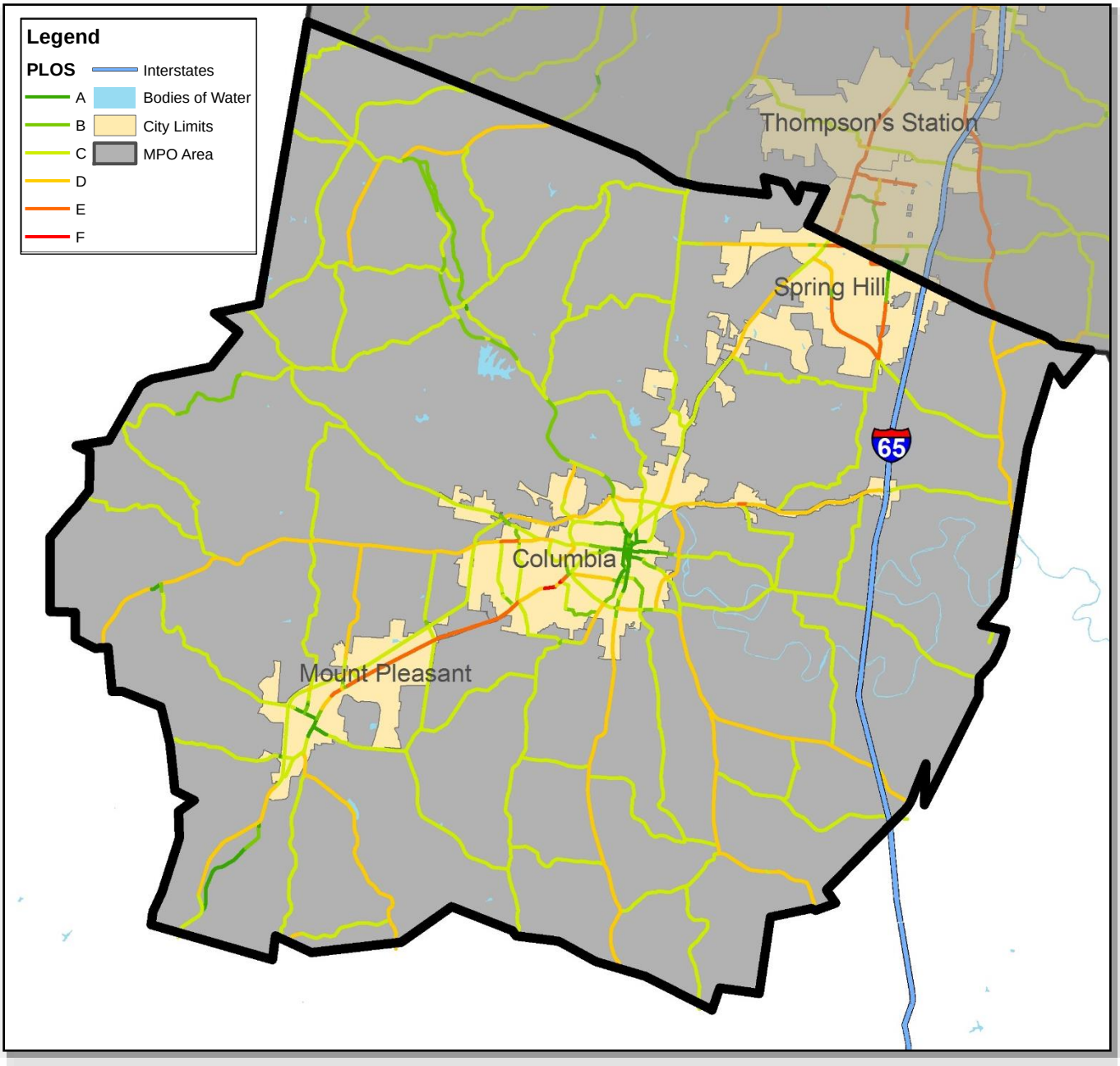


Figure 10: Robertson County PLOS Results

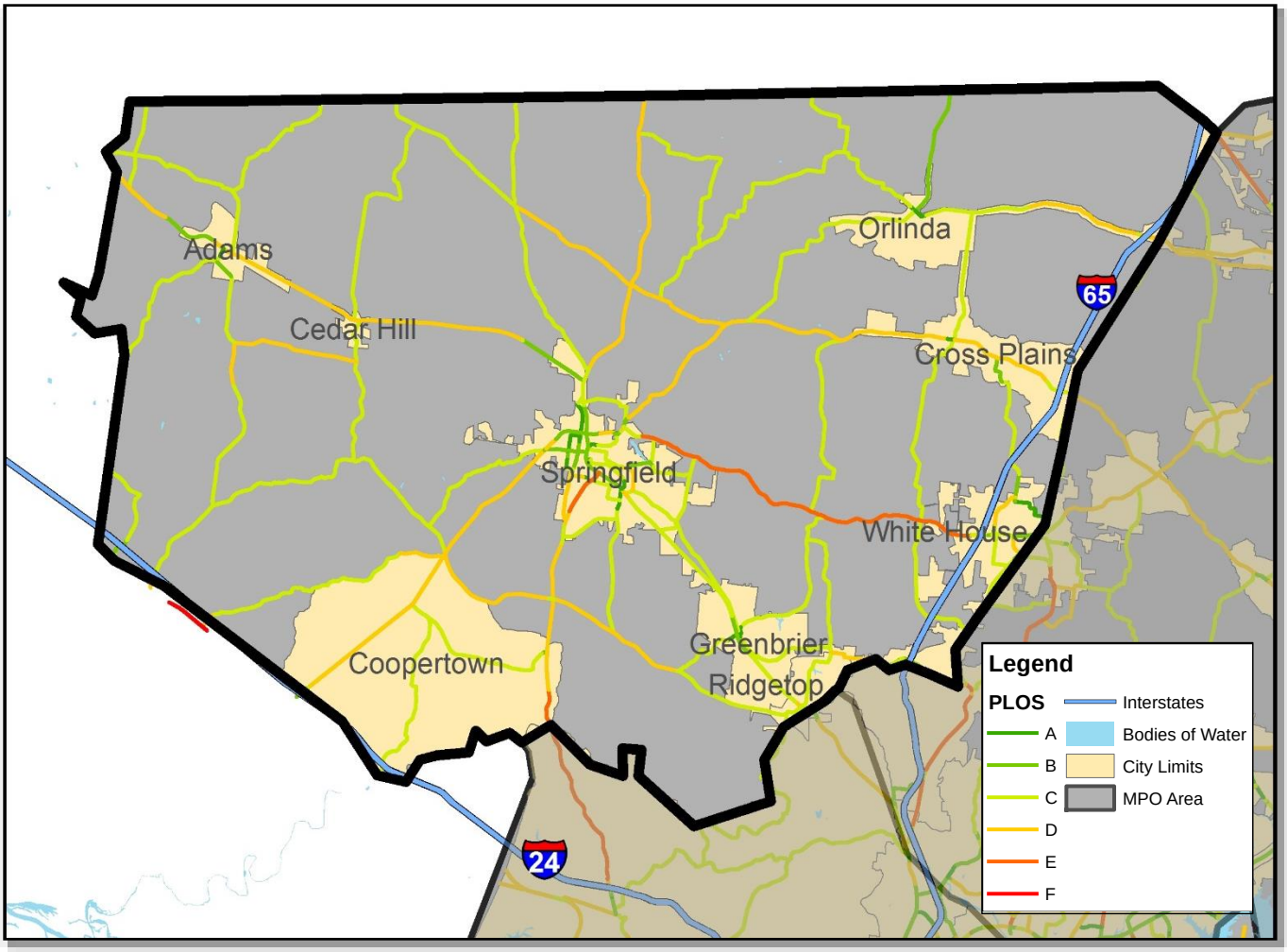


Figure 11: Rutherford County PLOS Results

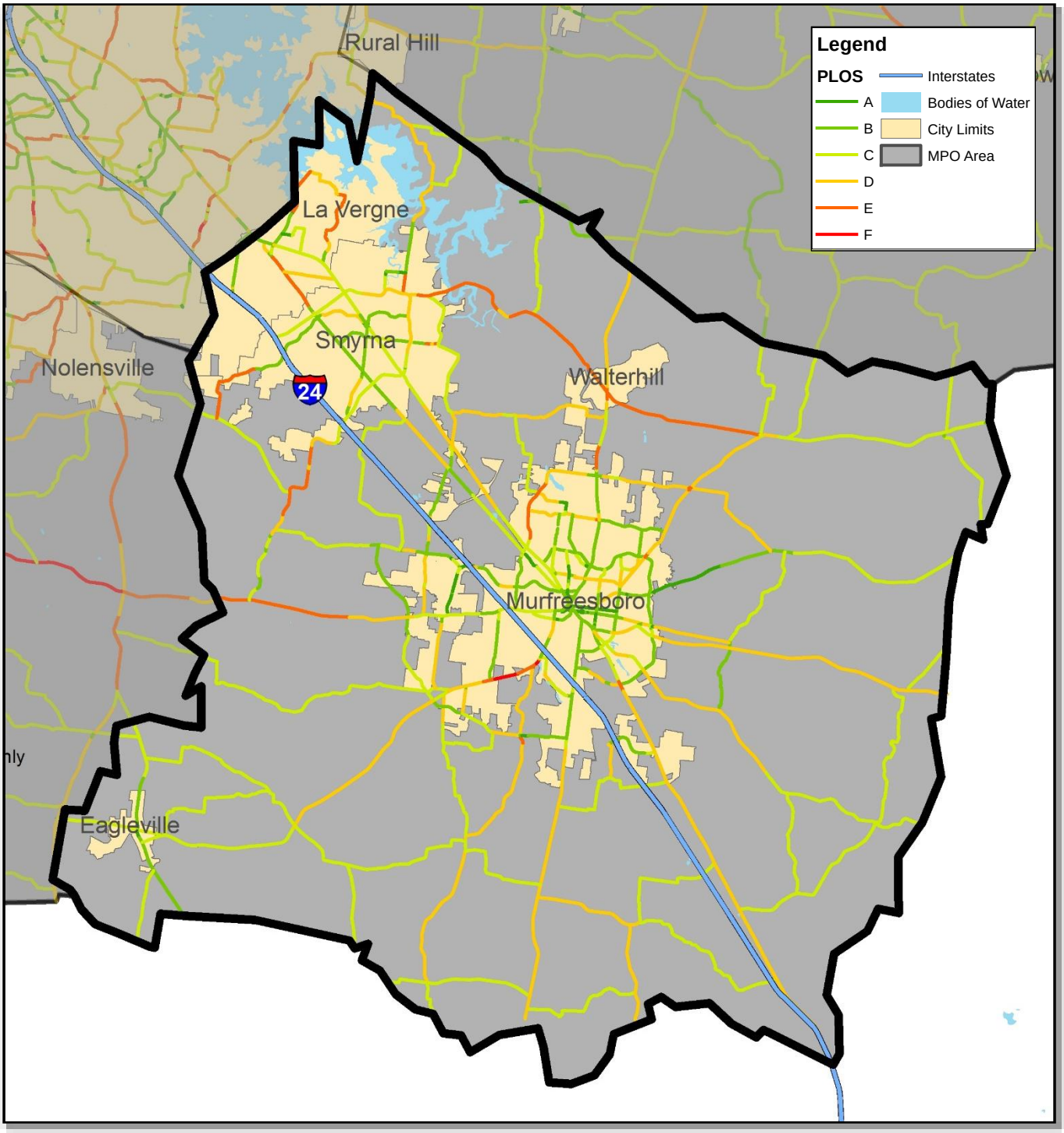


Figure 12: Sumner County PLOS Results

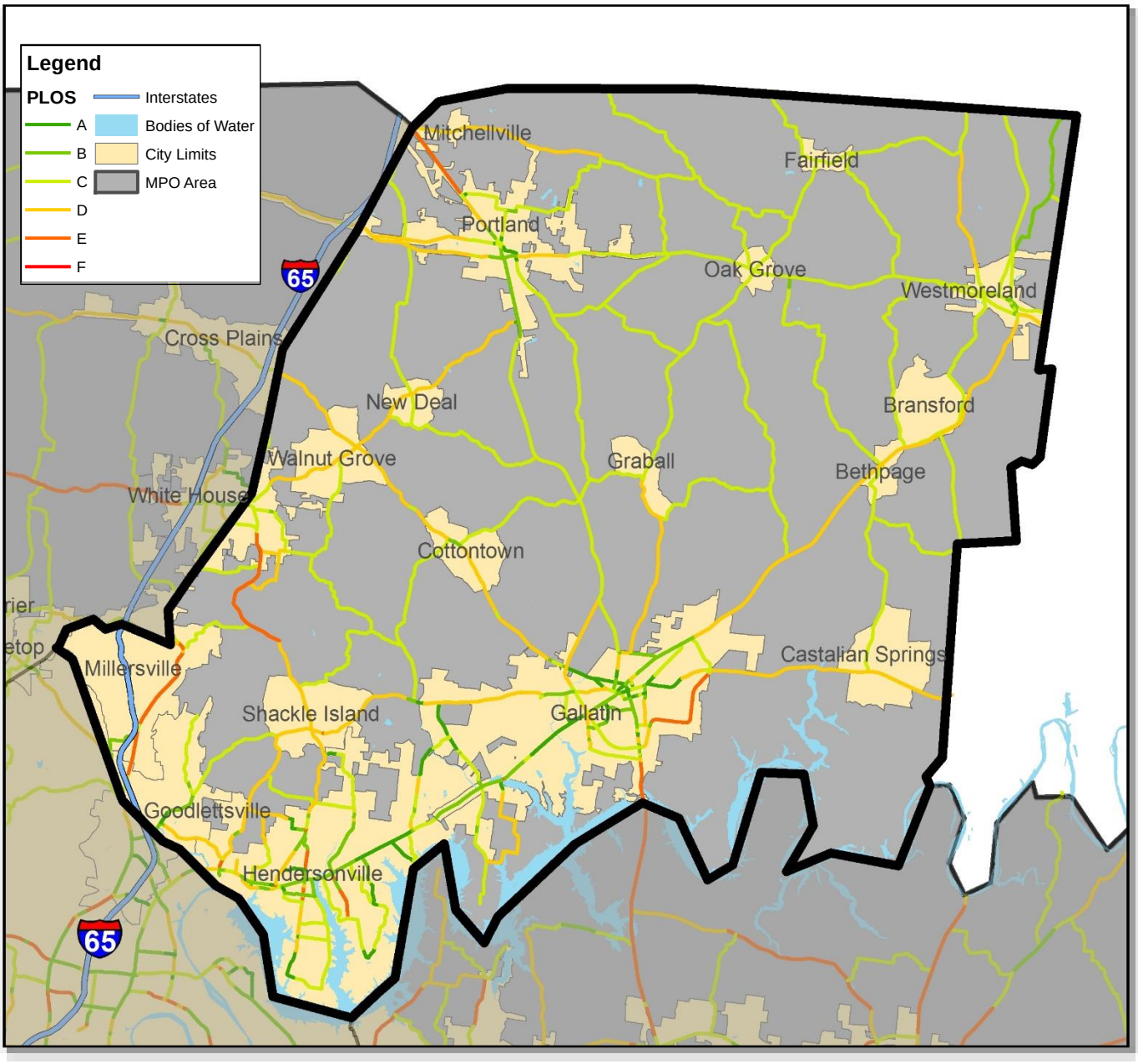


Figure 13: Williamson County PLOS Results

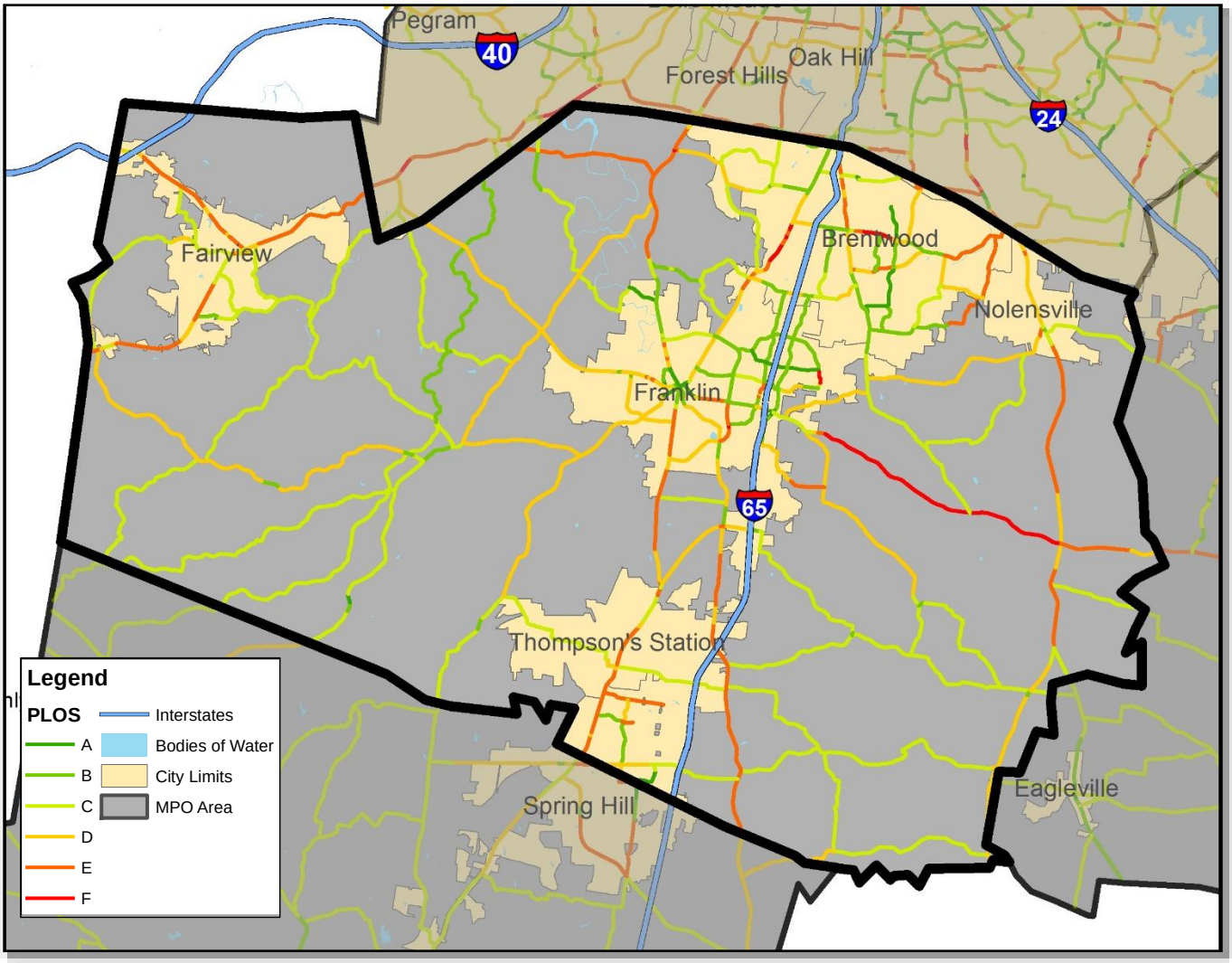
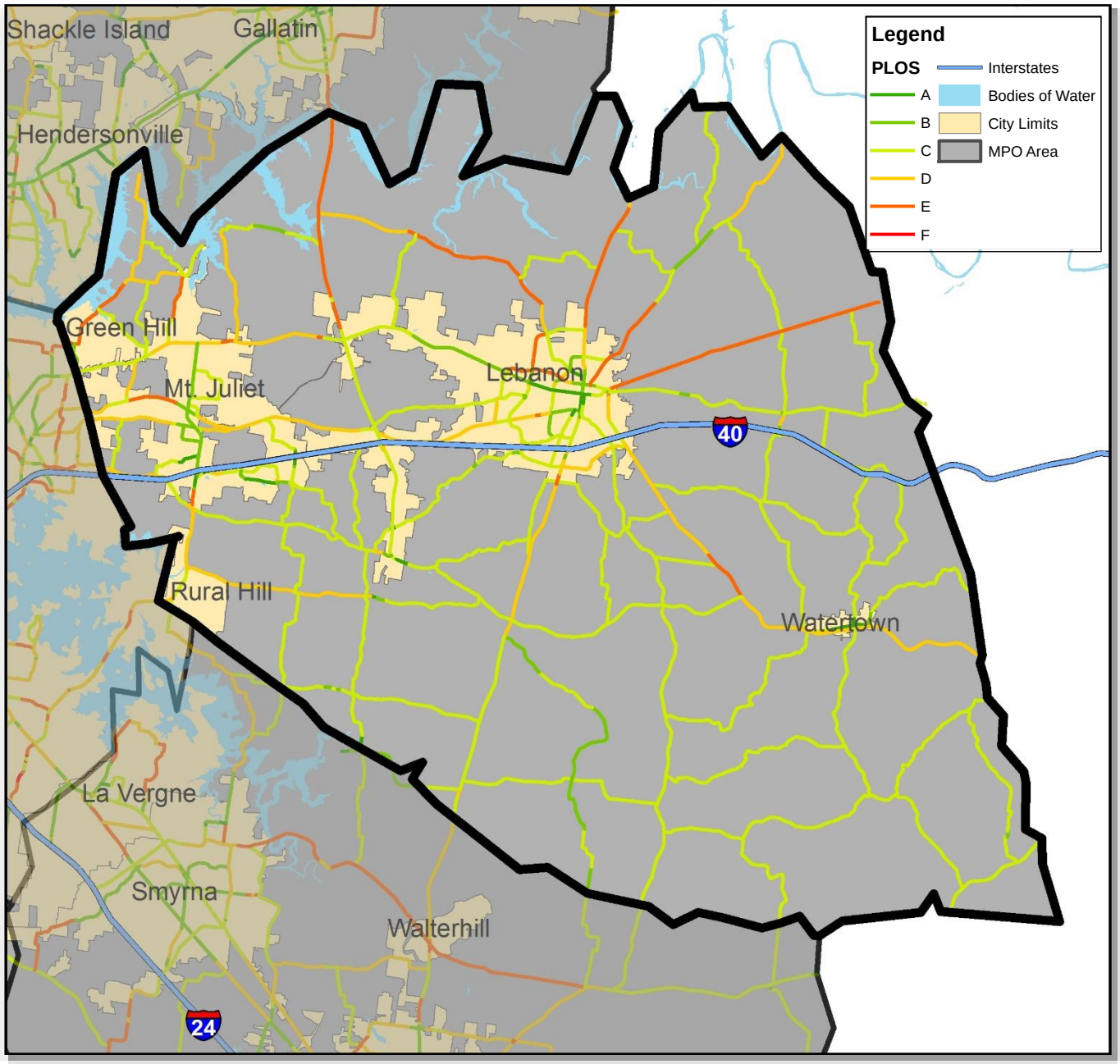


Figure 14: Wilson County PLOS Results



BLOS

Using the 2010 HCM, a Bicycle Level-of-Service (BLOS) analysis was conducted for all inventoried roadway segments in the 7-county MPO area; this included roadways in the MPO's travel demand model that are functionally-classified as arterials or collectors, not including interstates or controlled access facilities which prohibit bicycle use (e.g., Briley Parkway, Ellington Parkway, State Route 840, State Route 386, and State Route 396). The BLOS analysis uses various traffic and roadway factors to measure the biking suitability of a roadway segment. The equation for this evaluation is shown below:

$$\mathrm{BLOS} = 0.507 \ln\left(\frac{\mathrm{V}}{\mathrm{PHF} * \mathrm{N}}\right) + 0.1999\left(1.1199 \ln\left(\mathrm{S_p} - 20\right) + 0.8103\right) * (1 + 10.38\mathrm{HV})^2 + 7.066 \left(\frac{1}{\mathrm{P}}\right)^2 - 0.005(\mathrm{W_e})^2 + 0.057$$

Where:

BLOS =Bicycle Level-of-Service
V =Hourly directional volume (vph)
PHF =Peak hour factor
N =Number of directional lanes
S_p =Posted speed limit (mph)
HV =Percentage of heavy vehicles (decimal)
P =FHWA's 5-point pavement surface condition rating – assumed to be 3
W_e =Average effective width of the outside through lane (ft) – dependent on width of shoulder, width of outside thru lane, and percent of occupied on-street parking.

Since its incorporation into the 2010 HCM, this procedure has a few notable changes from the procedure used in the 2009 study that may result in changes in the BLOS scores of many segments in the MPO area. Primarily, the W_e variable is calculated differently with regard to shoulder widths. Previously, this variable was calculated based on a series of conditional statements which included the variables representing the width of the outside thru lane, the shoulder width, the width of the bike facility, and the traffic volume. While the variables included in these calculations remain the same, the conditional statements for calculating W_e have changed slightly. Ultimately, these changes indicate that there is a reasonable difference in the comfort of cyclists on roadways with shoulders greater than eight feet in width compared to those with shoulder widths between four and eight feet in width. Additionally, the traffic volume included in the BLOS calculation has been changed from the peak 15-minute traffic volume to the peak hour volume. Once the above equation was calculated, the BLOS score was converted into a LOS ranging from A to F as shown in Figure 15.

Figure 15: Bicycle Level-Of-Service Rating

BLOS	Scoring Criteria	
A	≤ 1.50	Extremely High
B	> 1.50 and ≤ 2.50	Very High
C	> 2.50 and ≤ 3.50	Moderately High
D	> 3.50 and ≤ 4.50	Moderately Low
E	> 4.50 and ≤ 5.50	Very Low
F	> 5.50	Extremely Low

This conversion resulted in nearly 2,200 miles of roadways having a BLOS of C or better; this equates to approximately 66% of all roadways as shown below in Figure 16. Figure 17 shows these results for each of the seven counties in the MPO area. These results are also depicted geographically in Figure 18 through Figure *24* on the following pages.

Figure 16: Bicycle Level-of-Service for MPO Roadways

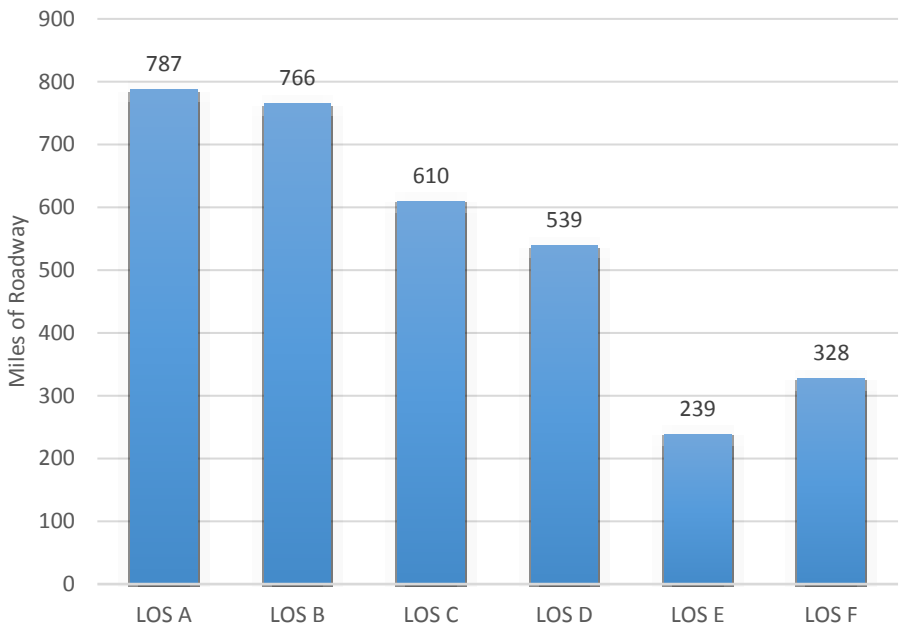


Figure 17: Bicycle Level-of-Service Miles by County

	Davidson	Maury	Robertson	Rutherford	Sumner	Williamson	Wilson	Total
LOS A	41	174	76	84	124	89	199	787
LOS B	77	127	97	109	131	70	155	766
LOS C	119	75	65	95	82	115	59	610
LOS D	194	31	33	114	43	94	30	539
LOS E	64	41	18	33	40	38	5	239
LOS F	152	14	21	54	30	49	8	328

Figure 18: Davidson County BLOS Results

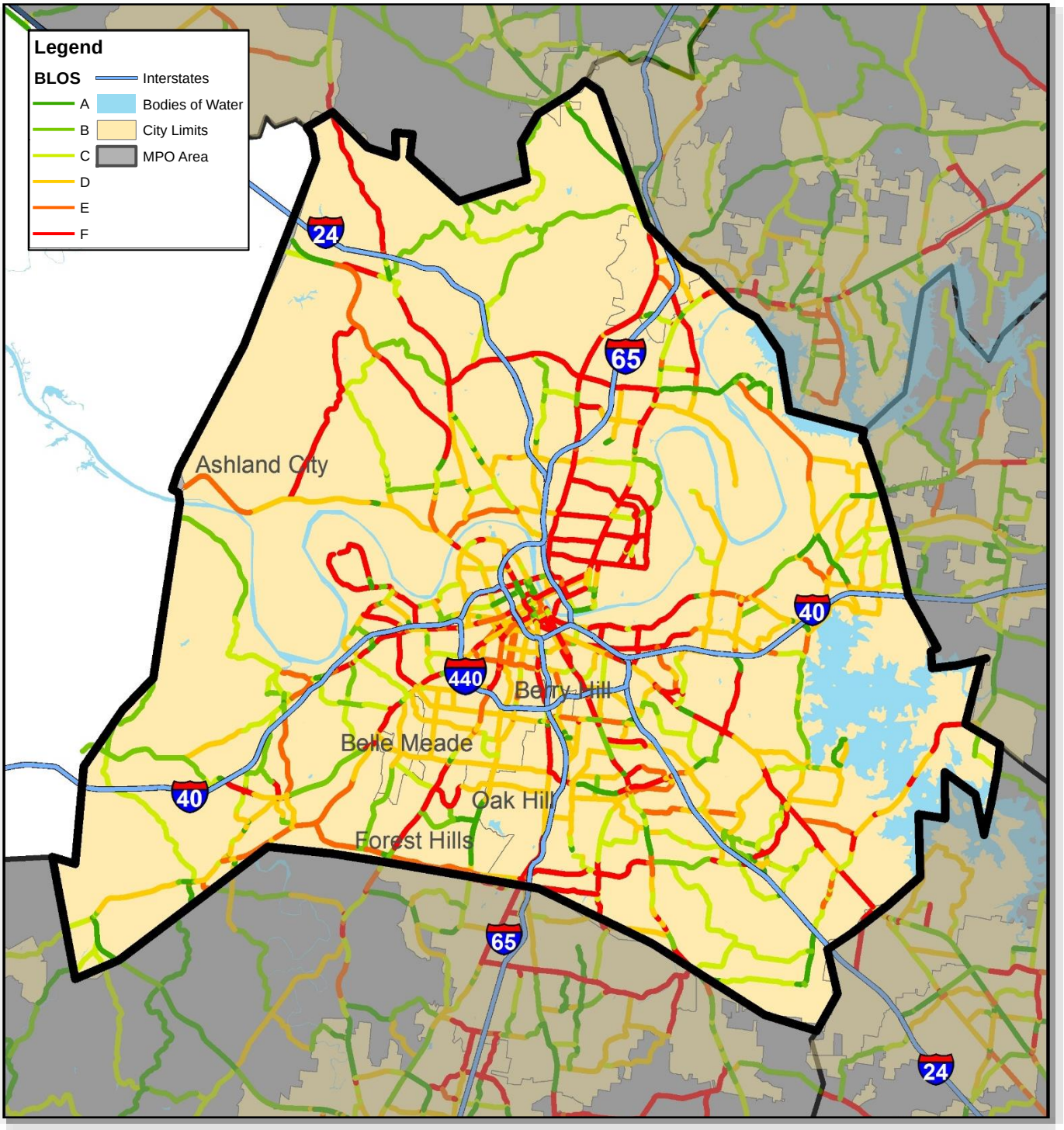


Figure 19: Maury County BLOS Results

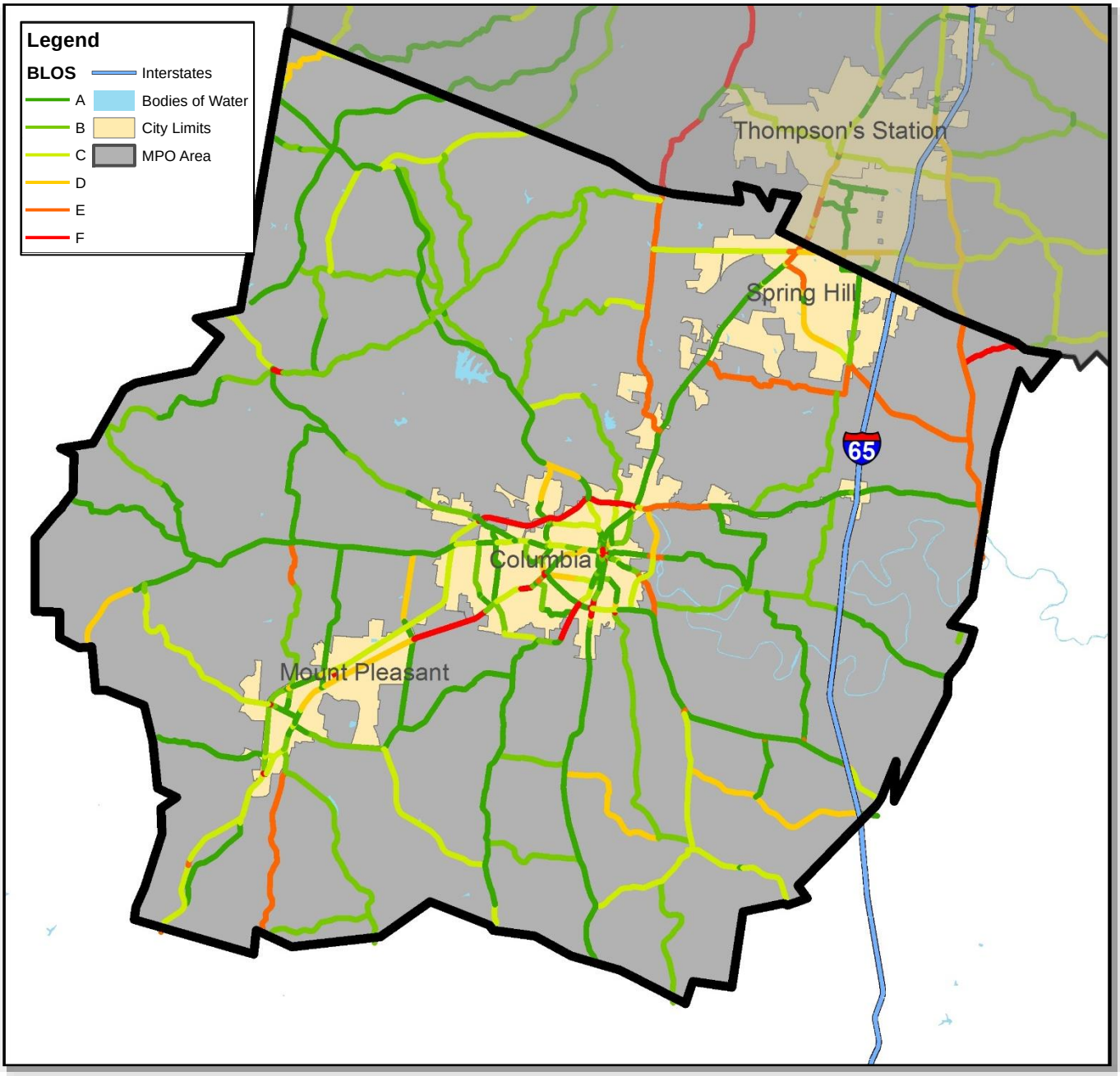


Figure 20: Robertson County BLOS Results

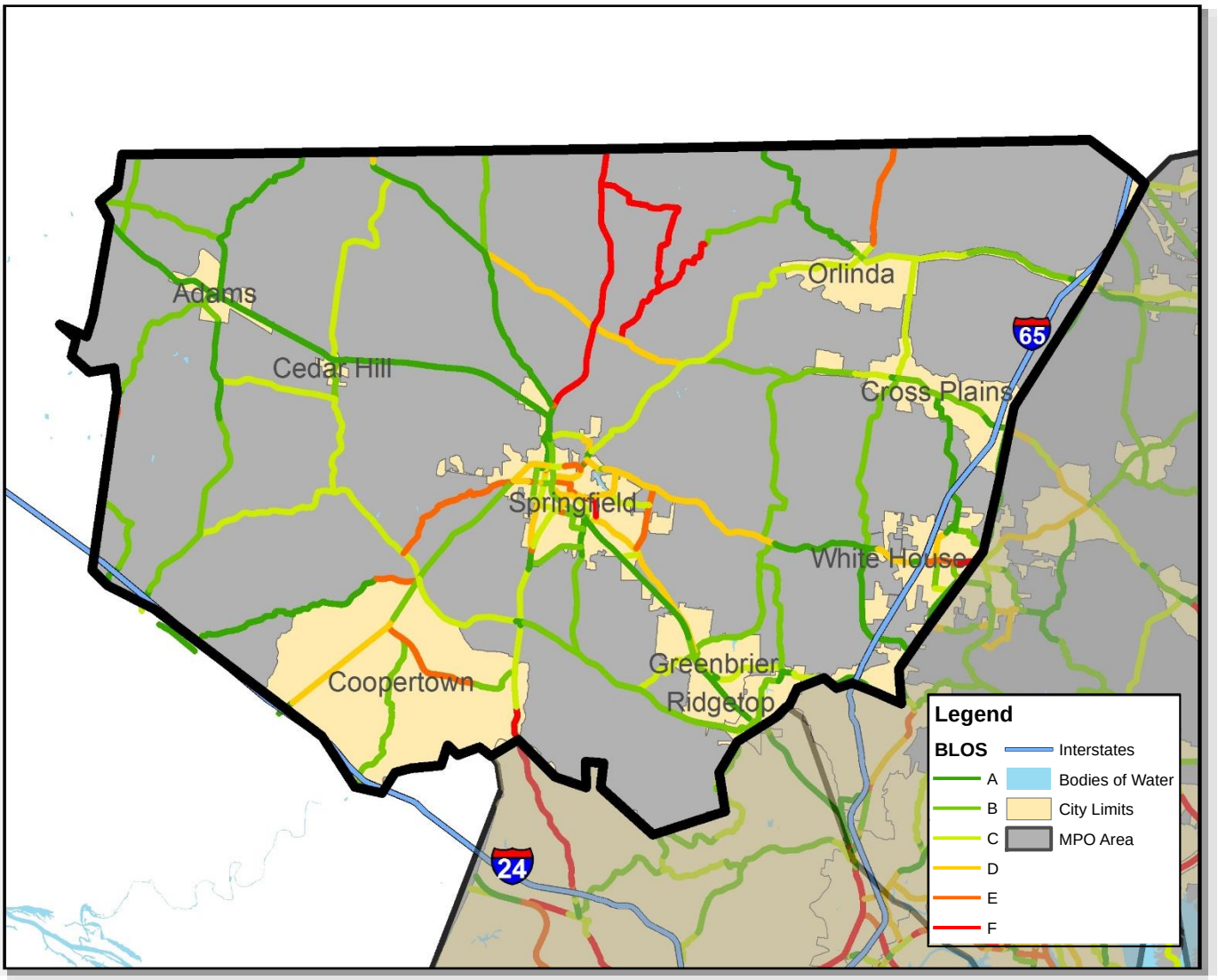


Figure 21: Rutherford County BLOS Results

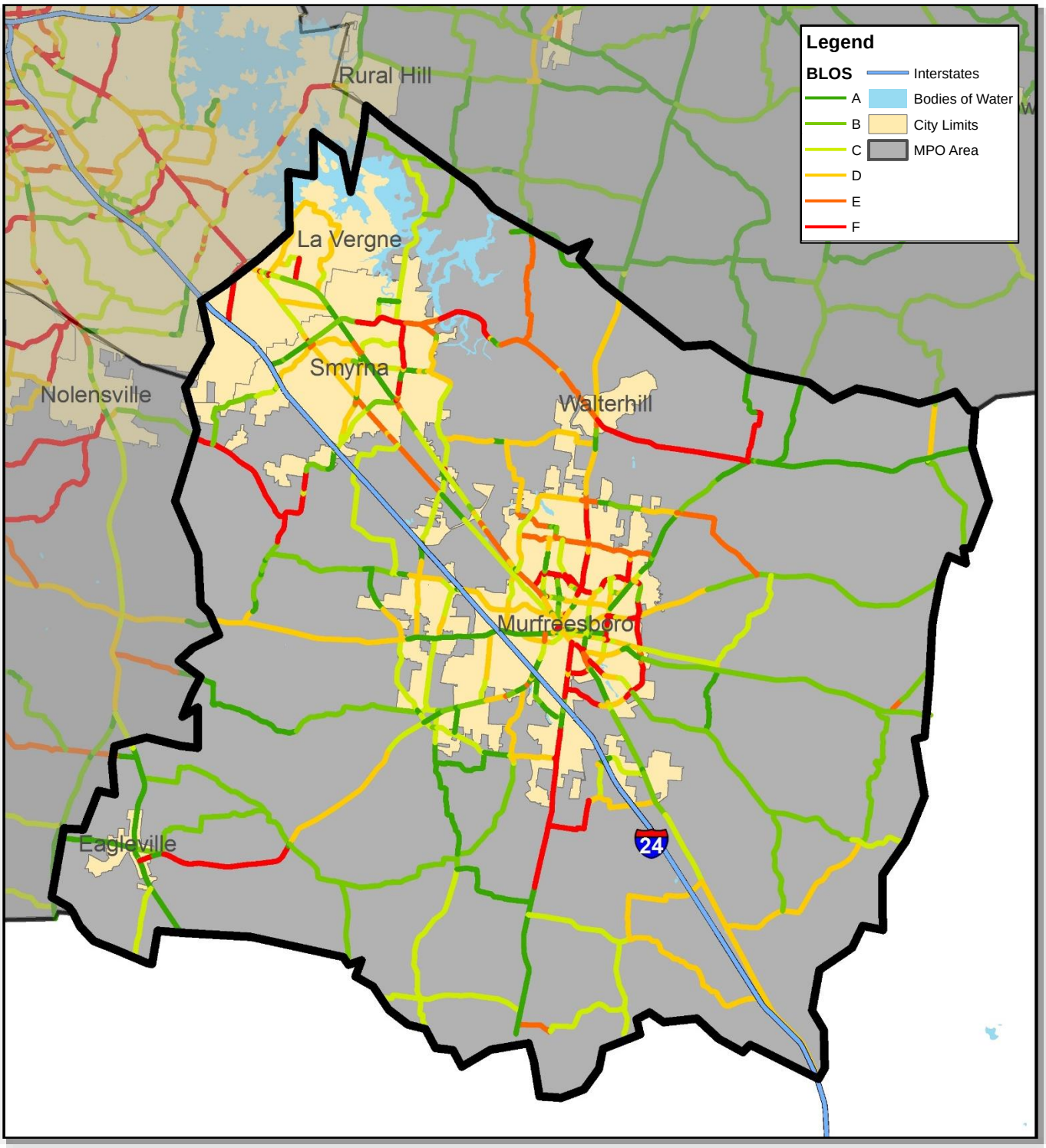


Figure 22: Sumner County BLOS Results

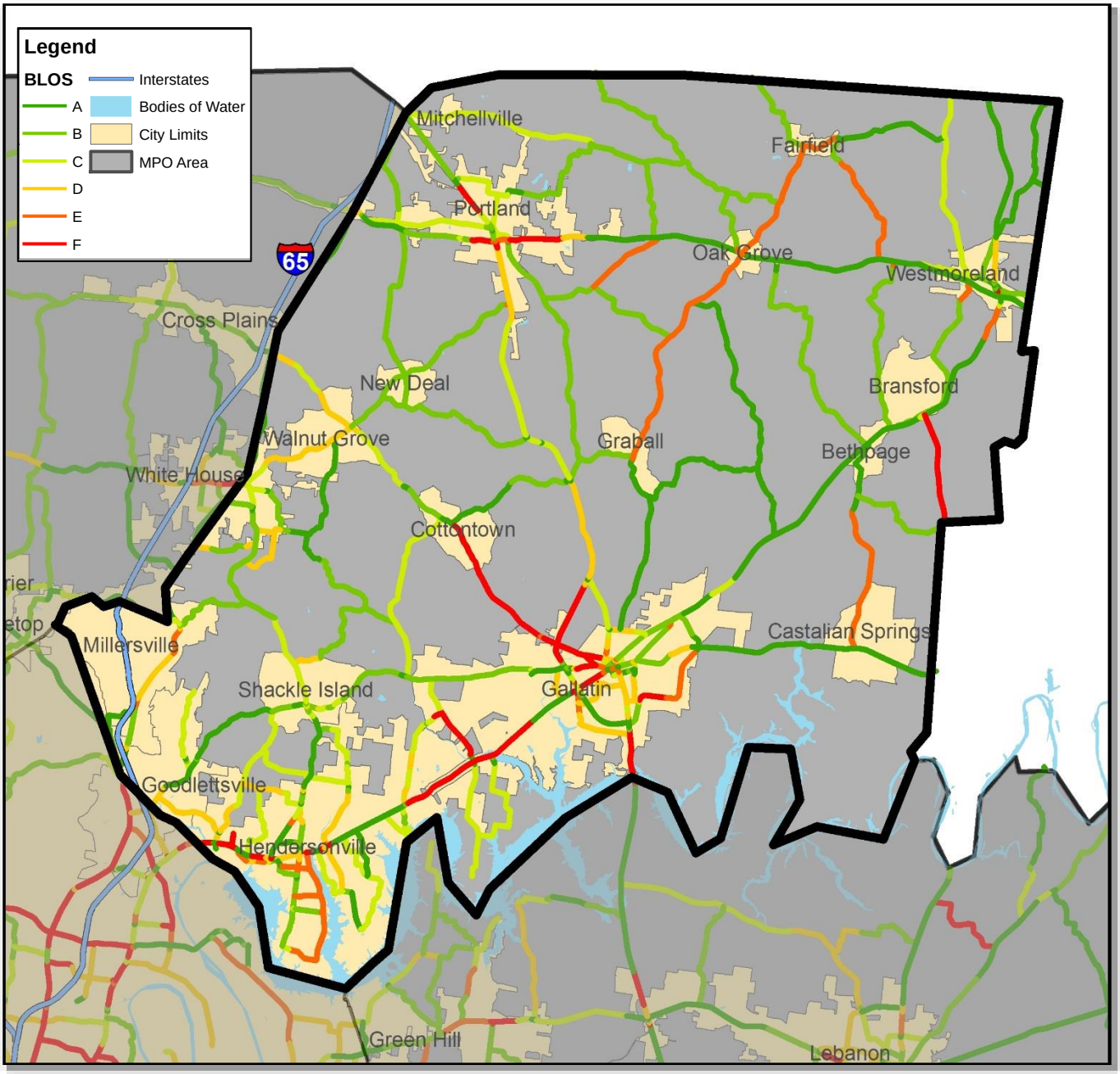


Figure 23: Williamson County BLOS Results

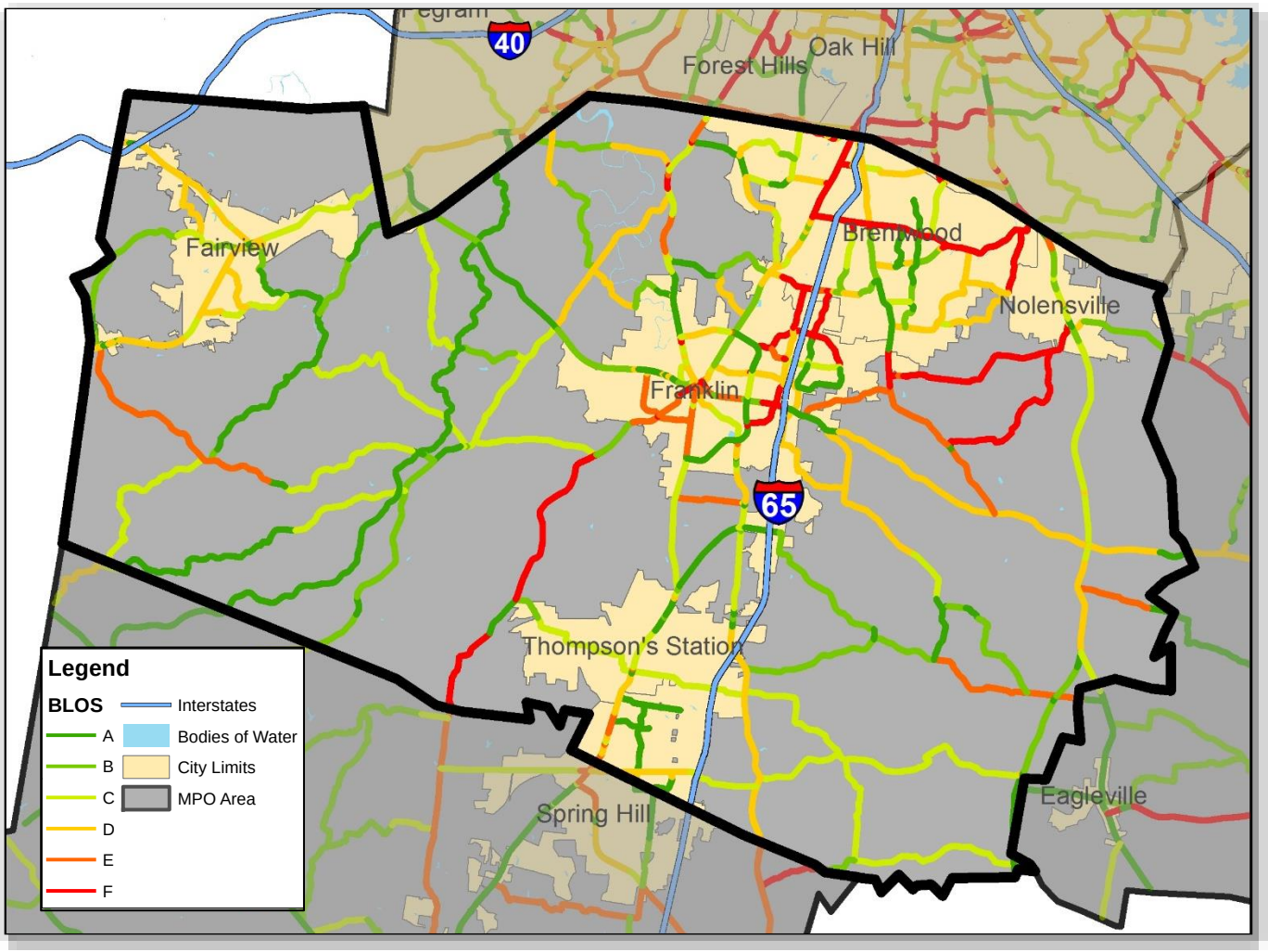
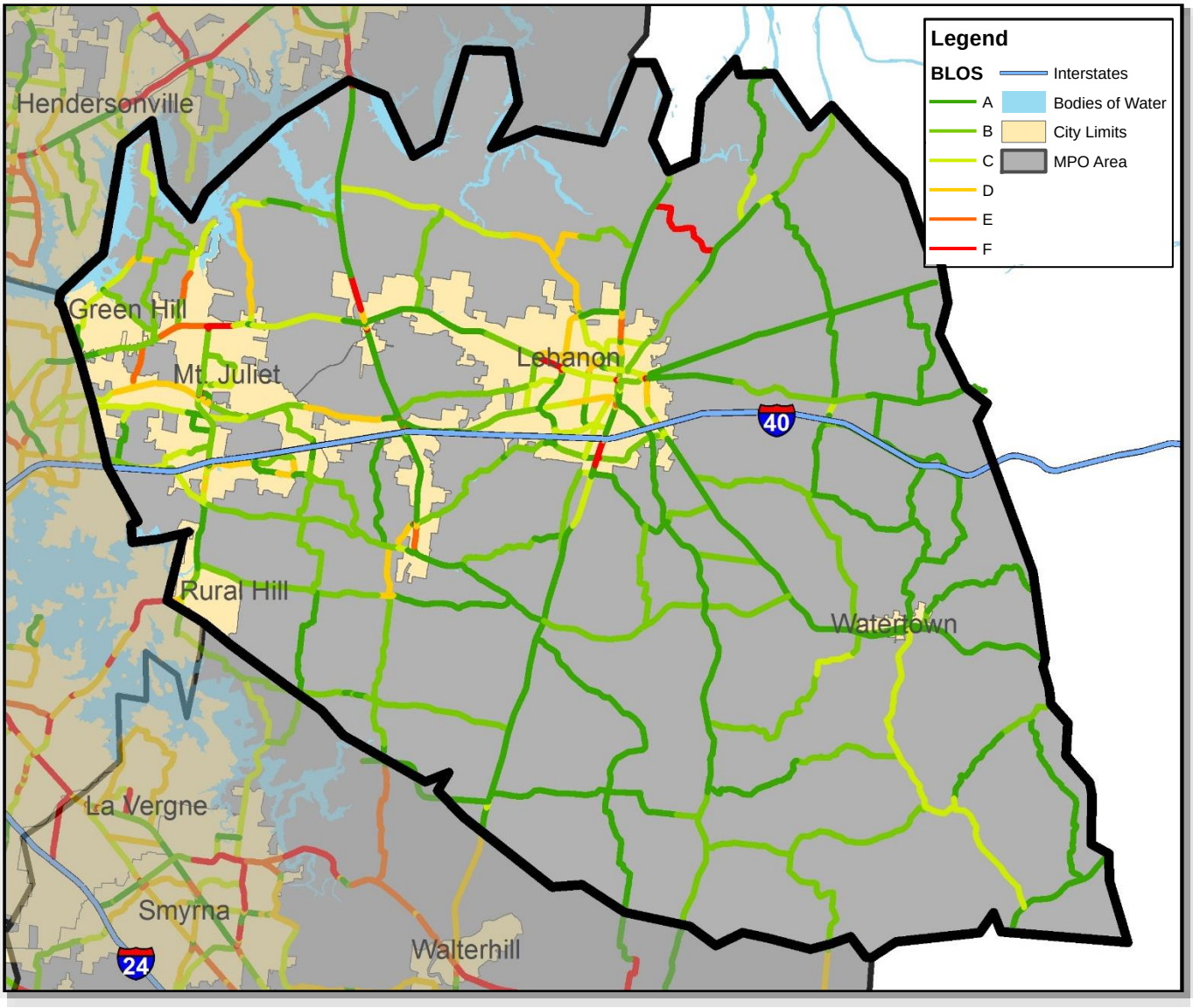


Figure 24: Wilson County BLOS Results



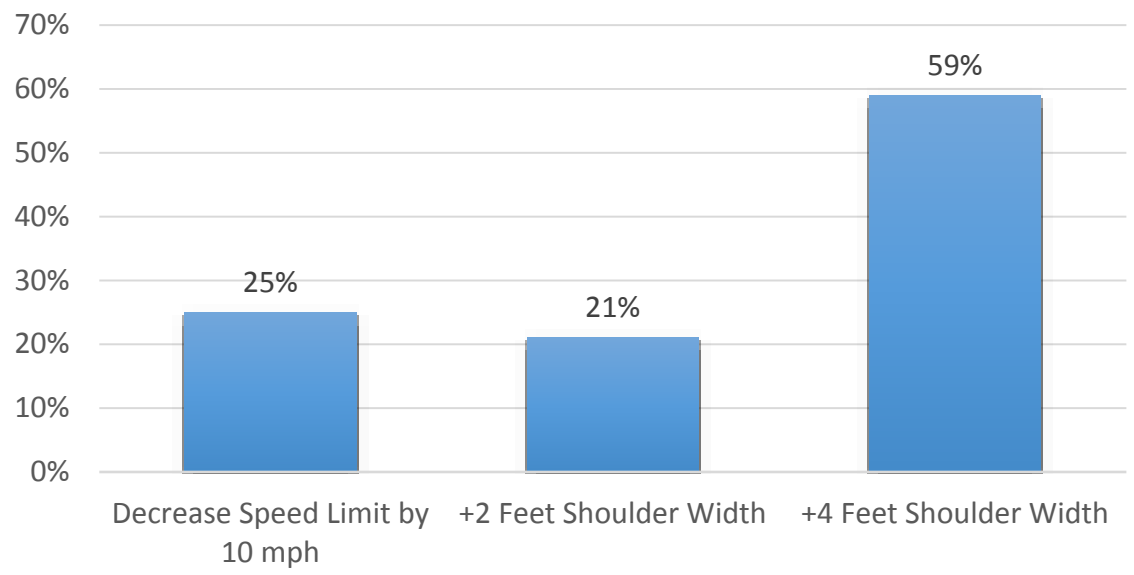
BLOS Sensitivity Analysis

Upon examination of the BLOS analysis results, there were approximately 70 miles of roadways that had bicycle facilities but also had a BLOS letter score of E or F. As such, a cursory sensitivity analysis was conducted to examine the BLOS effects of adding additional shoulder width to these roadways as well as decreasing the posted speed limits. To do this, roadway segments that had a BLOS of E or F and also contained a bicycle facility were isolated for this analysis. The aforementioned calculation was performed separately for the following three circumstances:

- Adding 2 feet of shoulder width
- Adding 4 feet of shoulder width
- Reducing the posted speed limit by 10 mph

Figure 25 below shows the results of this analysis. Of the scenarios tested, adding 4 feet of shoulder width appears to have the most significant effect on the mileage of roadways with BLOS E and F. Adding 2 feet of shoulder width and decreasing the posted speed limit by 10 mph had a similar degree of effectiveness on these facilities with poor BLOS results.

Figure 25: Decrease in Mileage of BLOS E/F



In the process of conducting this analysis, a literature review was conducted in regards to other sensitivities within the BLOS model. The following relationships, which were in concurrence with the results from this sensitivity analysis, were suggested:

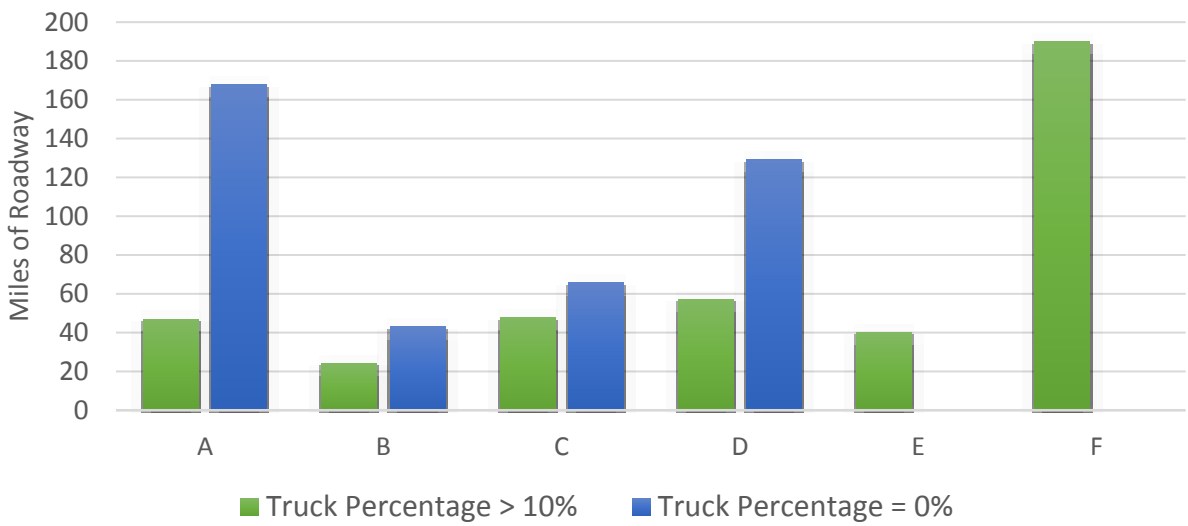
- The BLOS is more sensitive to traffic volumes at lower volumes.
- The BLOS improves more when additional operating space is given to a bicycle lane versus a wider outside travel lane.
- Heavy vehicles alone can cause BLOS to produce a failing grade, unless significant width is given to cyclists.
- The BLOS is more sensitive to changes in speed when speeds are lower.
- The BLOS is indifferent to physical separation between bicyclists and vehicles as the calculation currently does not have a way to capture the additional comfort a cyclist might

feel in a cycle track or buffered bike lane, for example; however, the methodology for determining a BLOS score on these types of facilities is beginning to emerge.

One of the observations from the sensitivity analysis was that many of the segments showing poor BLOS scores also had significant percentages of heavy vehicles. Combined with the conclusions from the literature review outlined above, it was concluded that an additional sensitivity analysis would be beneficial to examine how BLOS results are impacted by heavy vehicles on the roadway.

To conduct this analysis, segments with truck percentages greater than or equal to 10% were identified. The trucks were essentially removed from these segments in theory and the BLOS calculations were redone to compare the results, shown in Figure 26 below. It can be seen that when trucks are removed from the roadway, there is a near elimination of mileage with BLOS E and F.

Figure 26: BLOS Results for Sensitivity Analysis for Truck Percentages



As mentioned previously, the BLOS equation can produce failing results on roadway segments with high percentages of heavy vehicles unless significant width is given to cyclists. This analysis also examined the shoulder and bicycle facility widths on those facilities with moderately high truck percentages. Within the selection of roadways that have truck percentages greater than 10% and also have a BLOS better than E, it was found that 65% of those miles had greater than 4 feet of accommodation width for cyclists. These results seem to support the conclusion that truck movements should be considered when determining the provision and width of accommodations for bicyclist.