MOBILITYPLAN 2050

Appendix H

Multimodal Assessment

Contents

MEMORANDUM

To: Tennessee Department of Transportation, Stantec

From: Alta Planning + Design

Date: November 18, 2024

Re: Task 6: Multimodal Assessment for Knoxville Regional TPO and Lakeway Area Metropolitan TPO – Updated after TDOT Review

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Introduction

Stantec has been retained by the Tennessee Department of Transportation (TDOT), in partnership with the Knoxville Regional TPO (KRTPO) and the Lakeway Area MTPO (LAMTPO) to provide professional services in the preparation of the 2050 Metropolitan Transportation Plan Update for each TPO. The Metropolitan Transportation Plan (MTP) examines all modes of travel with a 25-year outlook and recommends fiscally constrained projects (those that could be reasonably funded).

Alta is responsible for leading the multimodal assessment task using available roadway data. As part of the multimodal assessment, Alta completed a level of traffic stress (LTS) analysis for the bicycle (BLTS) and pedestrian (PLTS) network in KRTPO and LAMTPO, ranking streets from low stress (LTS 1, suitable for children) to high stress (LTS 4, suitable only to "strong and fearless" bicyclists/pedestrians). The LTS scores were assigned to the TDOT Roadway Centerline data and the LTS was informed by OpenStreetMap data, as well as sidewalk and bicycle facility feature data received by Alta from Stantec.

The memorandum has been organized in the following sections with breakdowns for KRTPO and LAMTPO:

- A discussion of Bicycle Infrastructure, including an overview of the existing bicycle facilities, an analysis of Bicycle Level of Traffic Stress (BLTS), and a connectivity analysis.
- A discussion of Pedestrian Infrastructure, including an overview of the existing pedestrian facilities, an analysis of Pedestrian Level of Traffic Stress (PLTS), and a connectivity analysis.
- The Appendices section includes detailed methodologies for each of the analyses.

Bicycle Infrastructure

Existing Infrastructure

Bicycle infrastructure includes facilities along roadways and corridors that support people traveling by bike. It also includes trails and shared use paths that are off the main street network. These facilities were integrated into the street network and given an LTS of 1 since they are, by their nature off-street, low-stress facilities.

Knoxville

There are approximately 581 miles of bicycle facilities within the KRTPO, including trails, greenways, bike lanes, buffered bike lanes, and state bike routes. **Figure 1** breaks down the length of each facility type within the region, and **Figure 2** illustrates where each of these facilities is located within the MPO boundary. A majority of the bike lanes are in downtown Knoxville, while trails, greenways, and state bike routes extend further into the spokes of the region, connecting to outdoor recreational activities.

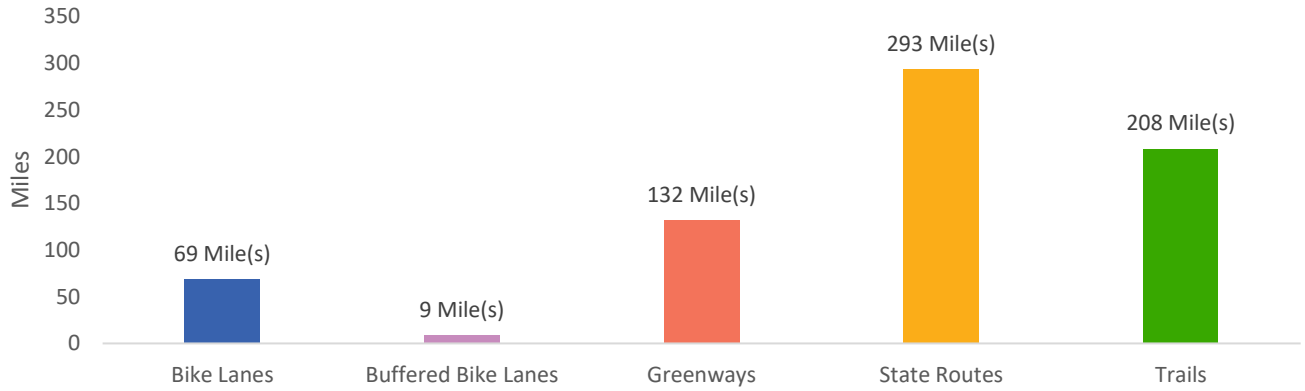


Figure 1. Miles of bike facilities in KRTPO

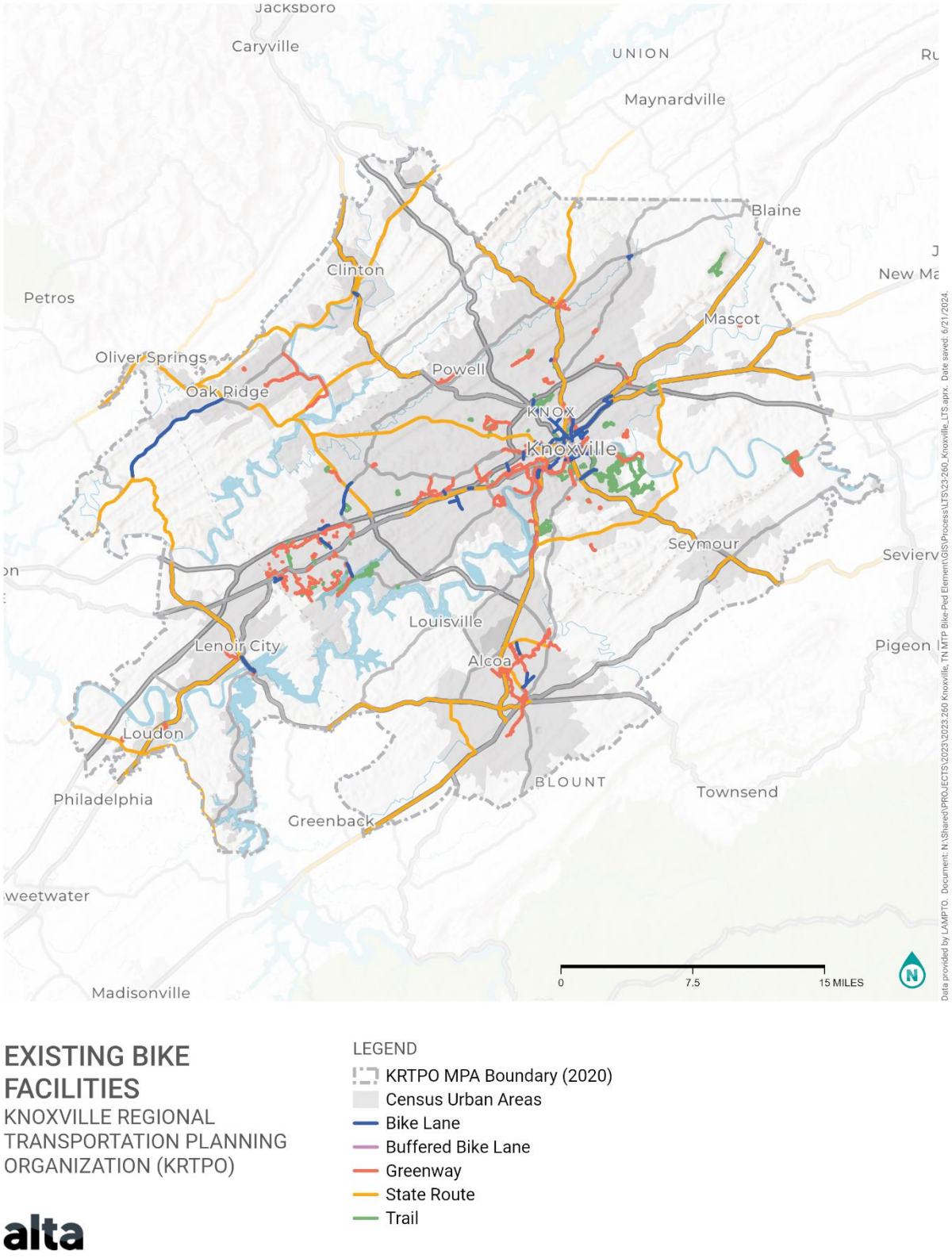


Figure 2. Existing Bike Facilities in KRTPO

Lakeway

There are approximately 96 miles of bicycle facilities within the Lakeway area, including trails, greenways, shared use paths, and state bike routes. **Figure 3** breaks down the length of each facility type within the region, and **Figure 4** illustrates where each of these facilities is located within the MPO boundary.

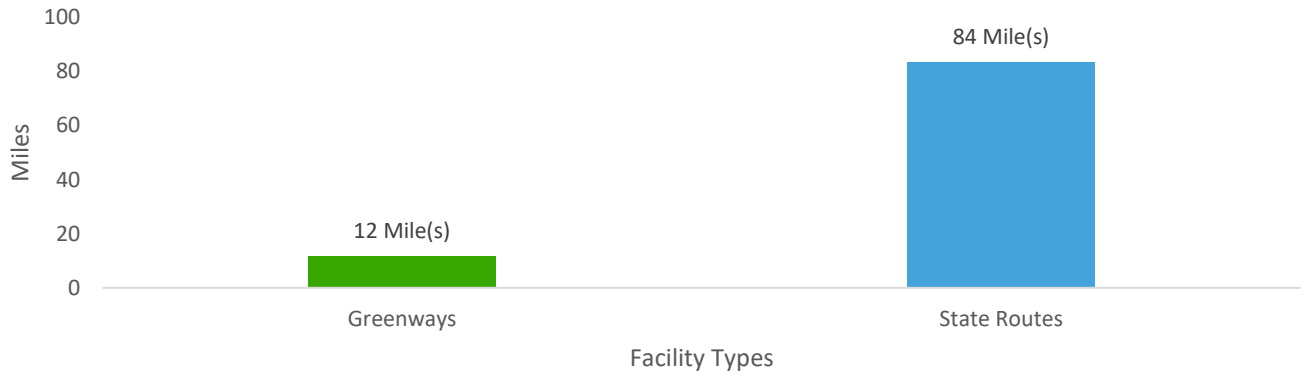


Figure 3. Miles of bike facilities in LAMTPO

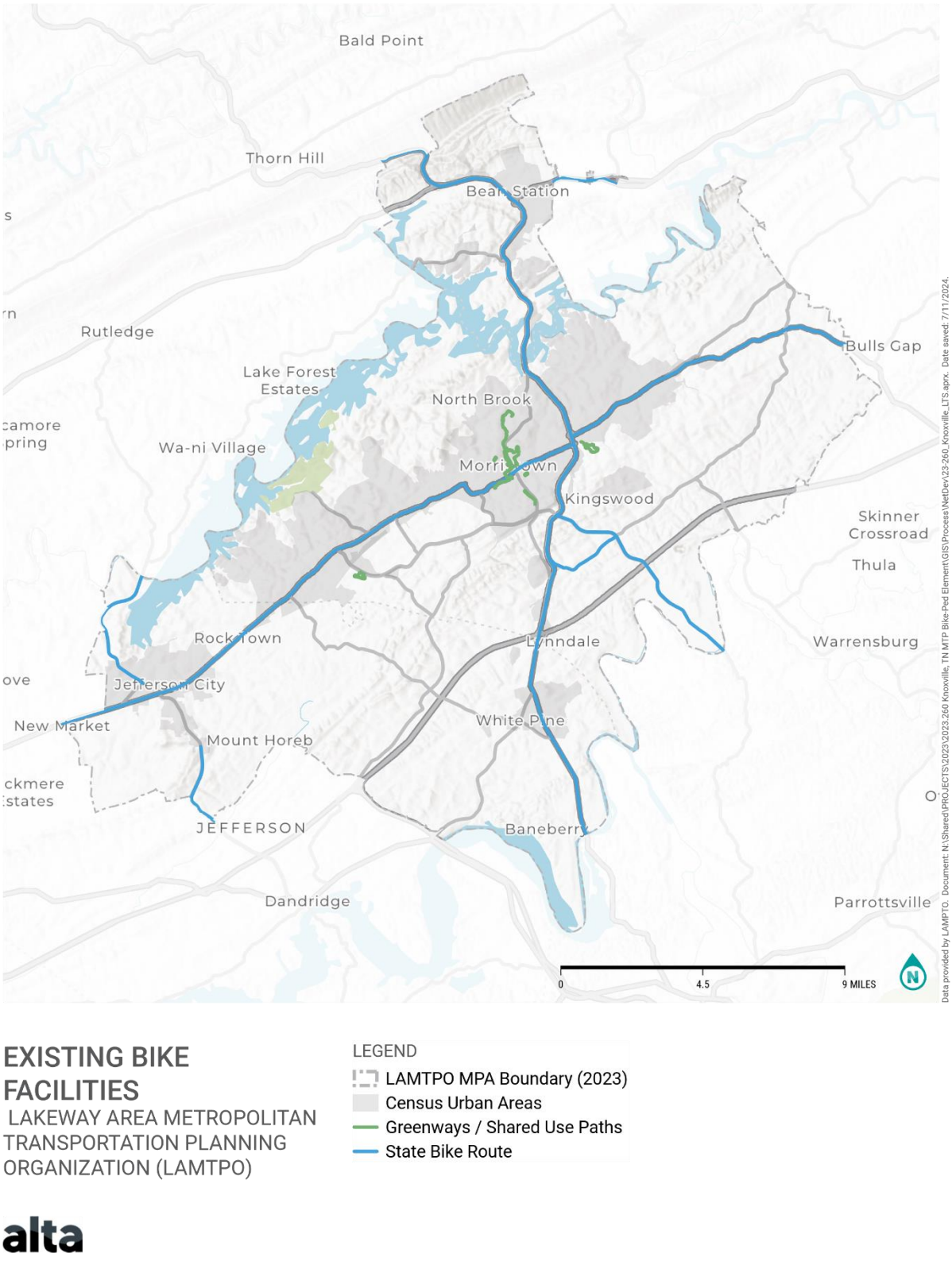


Figure 4. Existing Bike Facilities for LAMTPO

Bicycle Level of Traffic Stress (BLTS)

Alta assessed the bicycle level of comfort using the Level of Traffic Stress (LTS) methodology. The LTS analysis estimates the level of comfort for people biking on a given roadway segment. LTS scores are determined by characteristics of a given roadway segment that affect a user's perception of safety and comfort. Roadway characteristics like posted speed limit, number of lanes, and the presence of sidewalks or bike facilities affect BLTS outcomes. Our baseline assumptions deriving key attributes from OpenStreetMap (OSM) are documented in **Appendix A.** The combination of this criteria classifies a road segment into one of four levels of traffic stress:

- **BLTS 1** represents roadways where bicyclists of all ages and abilities would feel comfortable riding. These roadways are generally characterized by low volumes, low speeds, no more than two travel lanes, and traffic control measures at intersections. These roadways may have bicycle facilities; separated shared use paths for bicycles also fall into this category.
- **BLTS 2** represents slightly less comfortable roadways where most adults would feel comfortable riding.
- **BLTS 3** represents moderately uncomfortable roadways where most experienced bicyclists would feel comfortable.
- **BLTS 4** represents high-stress roadways where only strong and fearless bicyclists would feel comfortable riding. These roadways are generally characterized by high volumes, high speeds, several travel lanes, and complex transitions approaching and crossing intersections.

Figure 5 illustrates the level of comfort scores and how they relate to both the type of rider and the characteristics of a roadway. More detail on the BLTS analysis is also included in **Appendix B.**

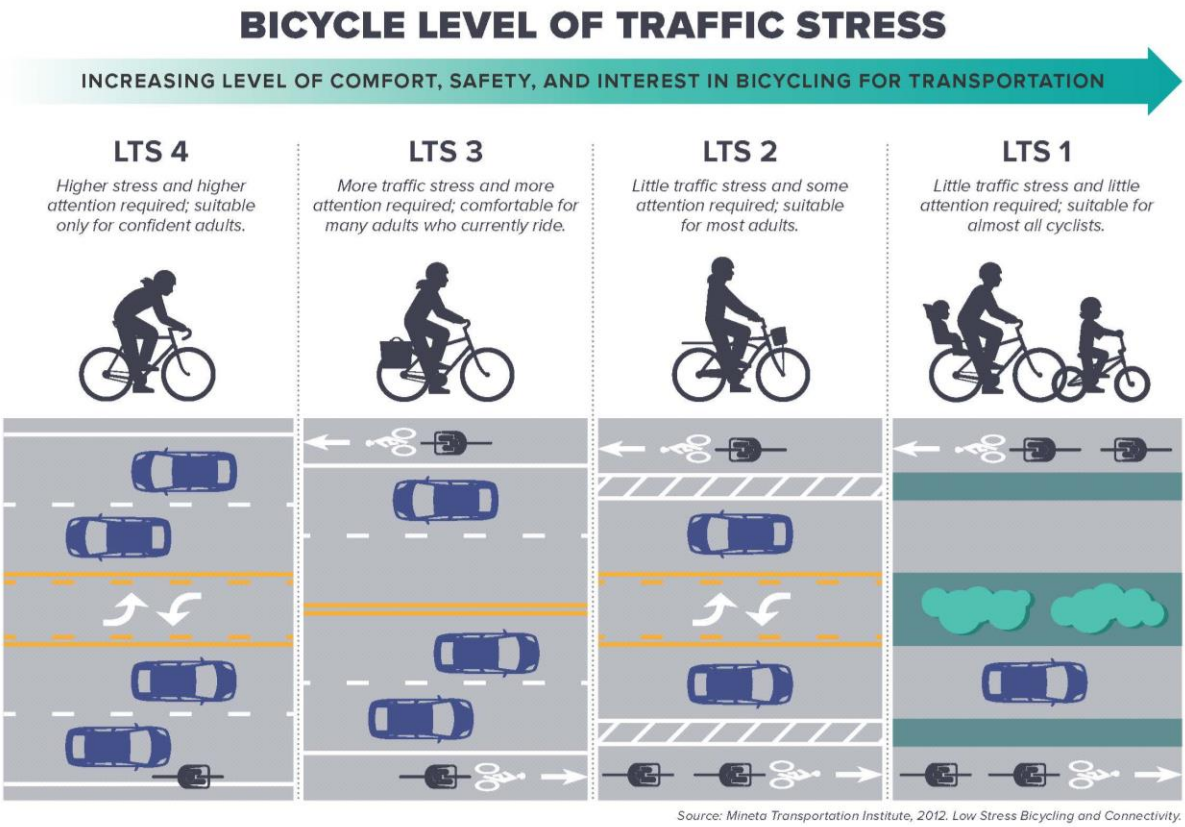


Figure 5. Bicycle Level of Traffic Stress Infographic

Knoxville

The majority of streets in the KRTPO are LTS 1 since they are residential streets with low traffic volumes and a low number of lanes. After LTS 1, the greatest length of street network is scored LTS 4 with over 1,200 miles of high-stress roads in the KRPTO region. These streets have a high number of lanes and see a greater volume of auto traffic without any protected facilities, making a trip on these streets highly stressful. **Figure 6** breaks down the miles of network for each LTS group and **Figure 7** visualizes the LTS on the KRTPO road network. Trails and other off-street facilities have been integrated with the street centerline network.

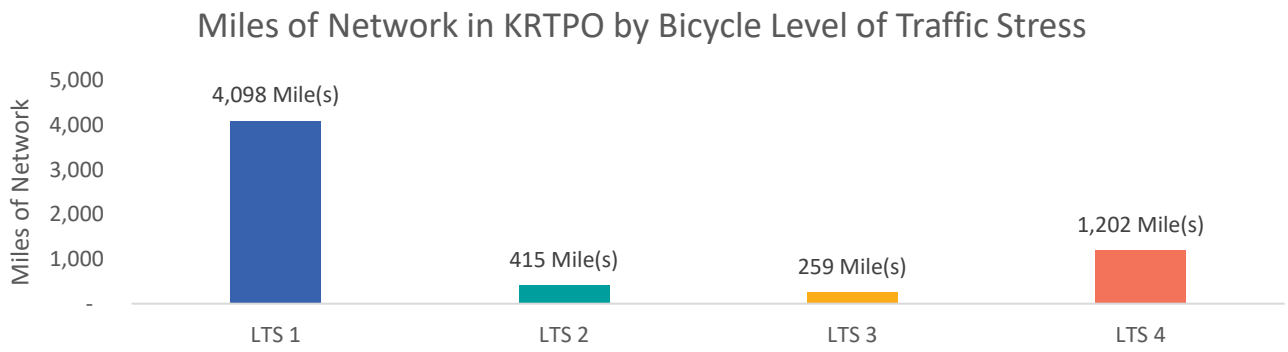
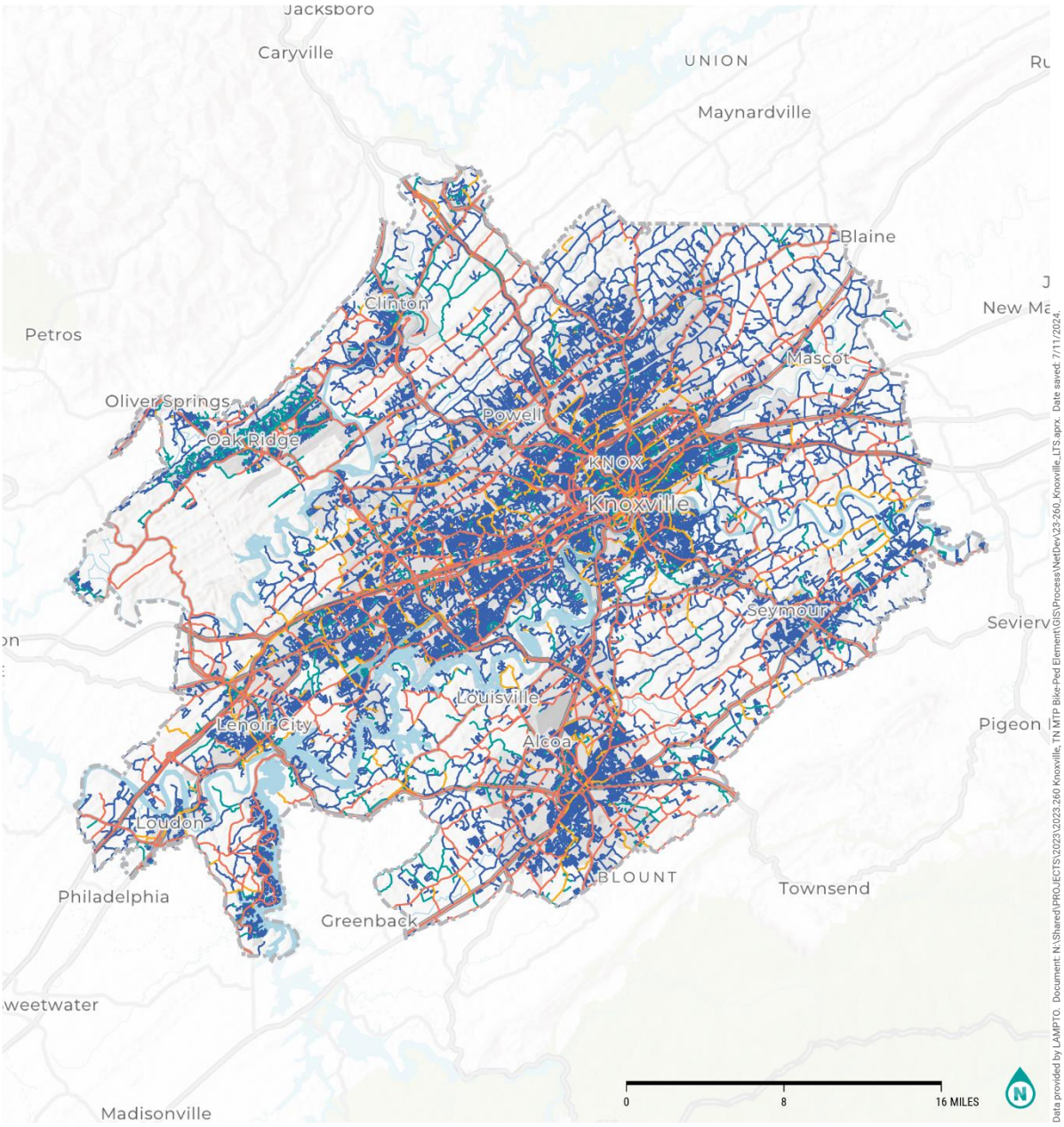


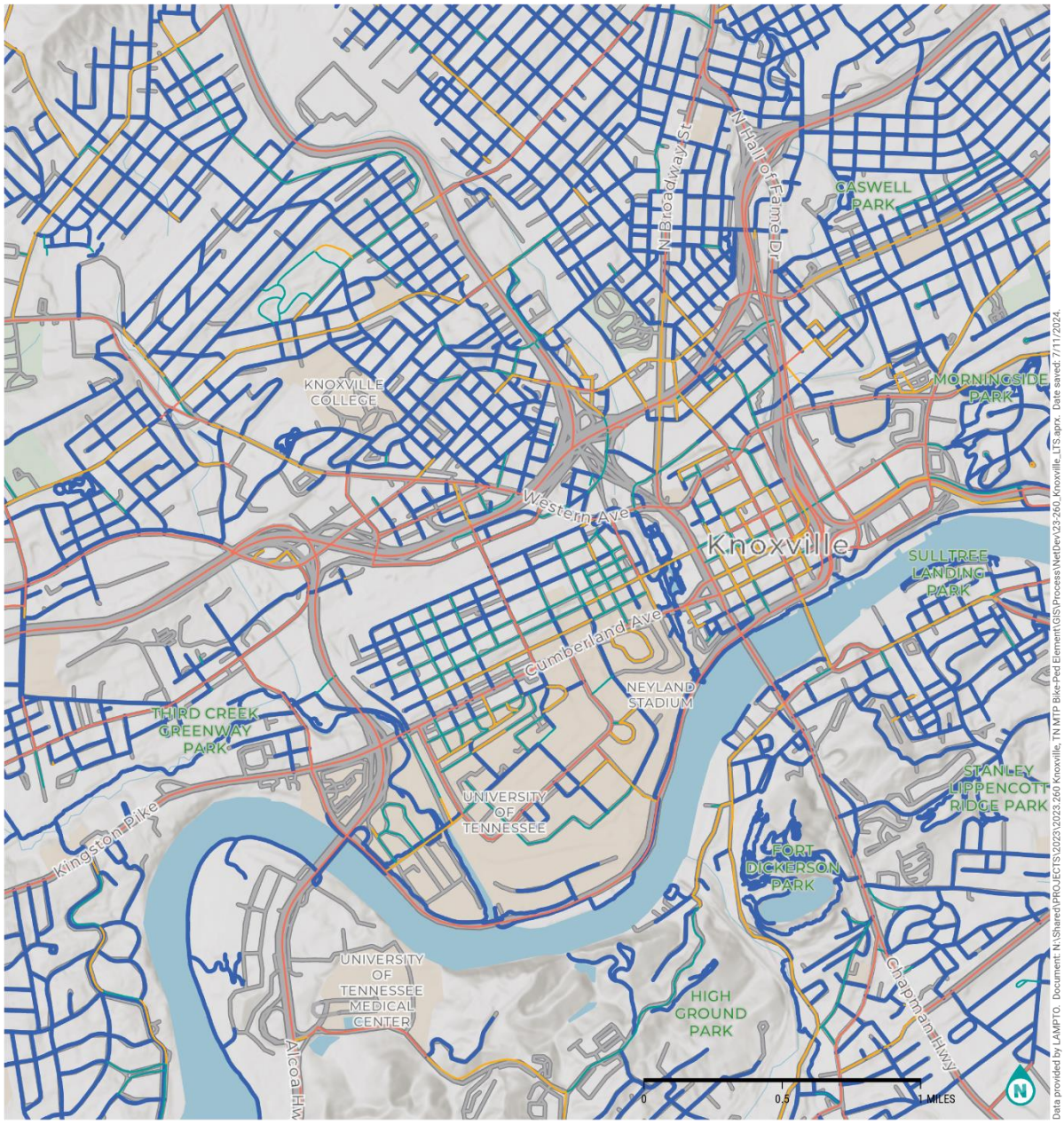
Figure 6. Miles of Network in KRTPO by BLTS



BIKE LEVEL OF TRAFFIC STRESS (LTS)
KNOXVILLE REGIONAL TRANSPORTATION PLANNING ORGANIZATION (KRTPO)

LEGEND
KRTPO MPA Boundary (2020)
Bike LTS
1 - Low Stress
2
3
4 - High Stress

Figure 7. Bicycle Level of Traffic Stress for the Knoxville Regional Transportation Planning Organization



BIKE LEVEL OF TRAFFIC STRESS (LTS)
KNOXVILLE REGIONAL TRANSPORTATION PLANNING ORGANIZATION (KRTPO)

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LEGEND
KRTPO MPA Boundary (2020)
Bike LTS
1 - Low Stress
2
3
4 - High Stress

Figure 8. Bicycle Level of Traffic Stress in Downtown Knoxville

Lakeway

Similar to Knoxville, Lakeway mostly has streets with a bicycle LTS of 1. Lakeway is characterized by low-density residential streets with low traffic volumes and a low number of lanes. Furthermore, like Knoxville, the next highest LTS is 4 with over 300 miles of high-stress roads in the LAMTPO area. These streets have a high number of lanes and see a greater volume of auto traffic without any protected facilities, making a trip on these streets highly stressful. **Figure 9** breaks down the miles of network for each LTS group and **Figure 10** visualizes the LTS on the LAMTPO road network. Trails and other off-street facilities have been integrated with the street centerline network.

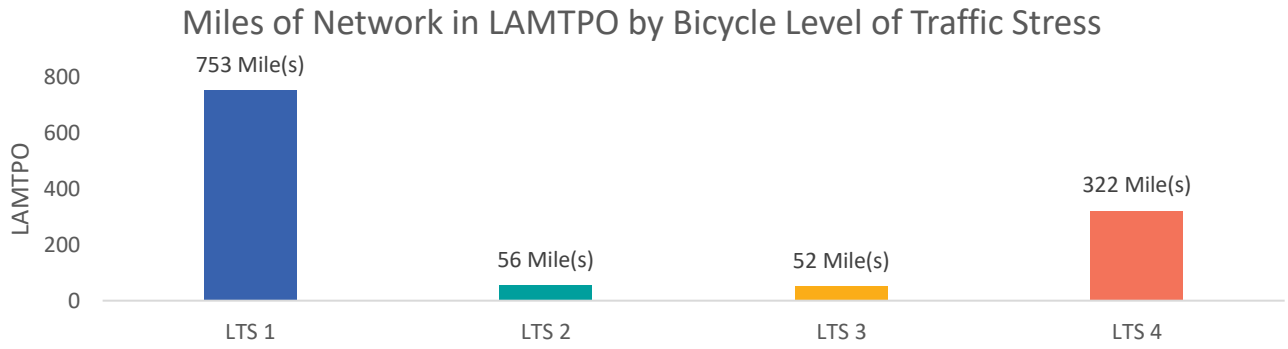


Figure 9. Miles of Network in LAMTPO by BLTS

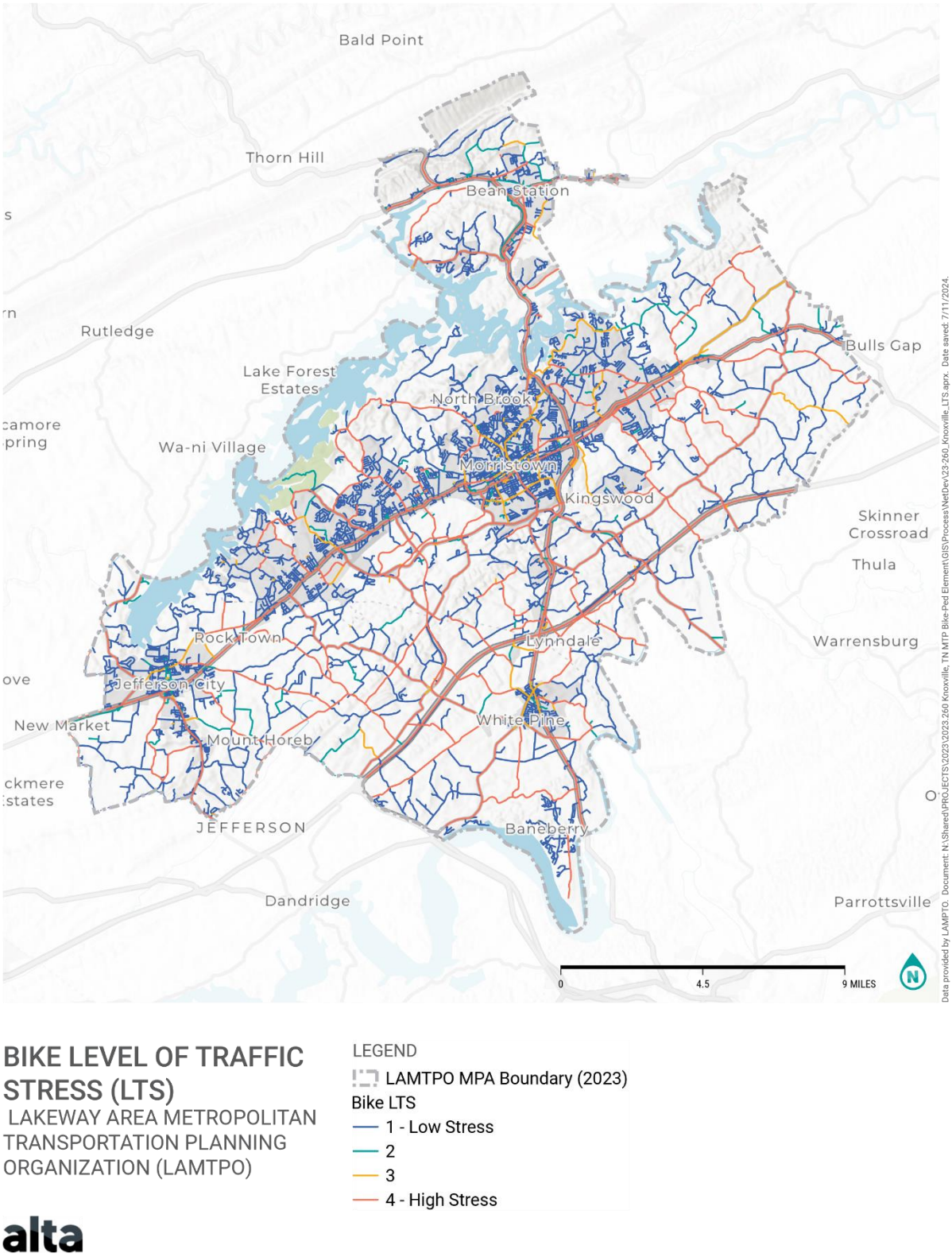


Figure 10. Bicycle Level of Traffic Stress for LAMTPO

Pedestrian Infrastructure

Existing Infrastructure

Pedestrian infrastructure includes sidewalks along roadways and includes trails and shared use paths that are off the main street network. Sidewalks and off-street facilities were integrated into the street network. Off-street facilities were given an LTS of 1 since they are low-stress facilities.

Knoxville

Over 88% of the street network in Knoxville does not have sidewalks. **Figure 11** breaks down the mileage for sidewalks in the KRPTO region. **Figure 12** illustrates where in the region these sidewalks are located—primarily in the downtown region, but also near Oak Ridge, Maryville, Loudon, and along the I-40 corridor west of Knoxville.

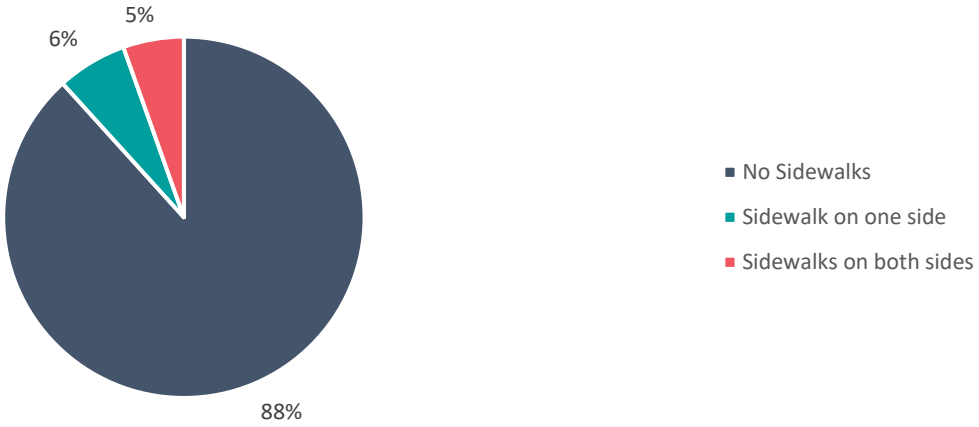


Figure 11. Sidewalk coverage in KRTPO

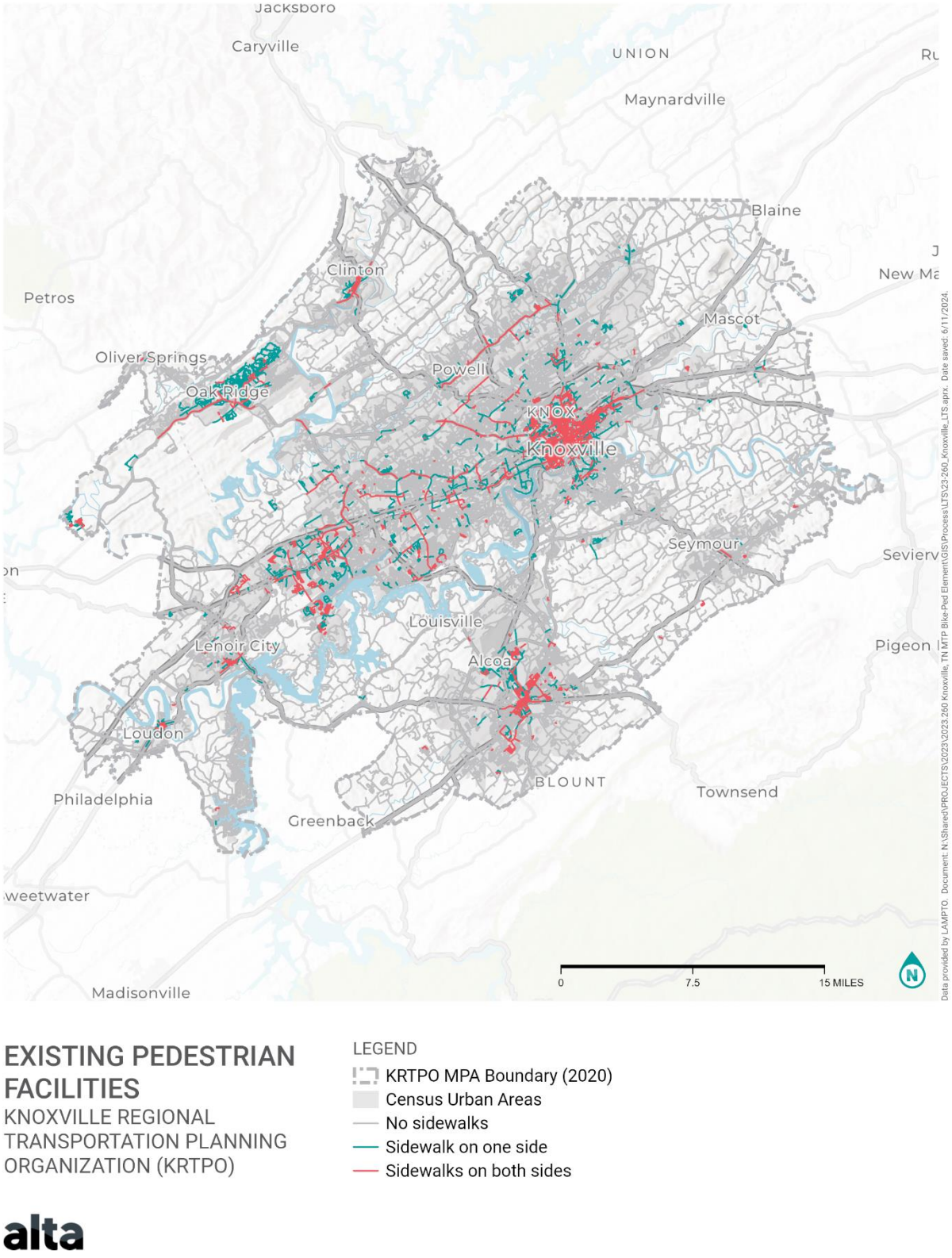


Figure 12. Existing Pedestrian Facilities for KRTPO

Lakeway

Over 95% of the street network in the Lakeway area does not have sidewalks. **Figure 11**breaks down the mileage for sidewalks in the LAMTPO region. **Figure 14** illustrates where in the region these sidewalks are located—primarily in the downtown region of Morristown and Jefferson City.

Figure 13. Sidewalk coverage in LAMTPO

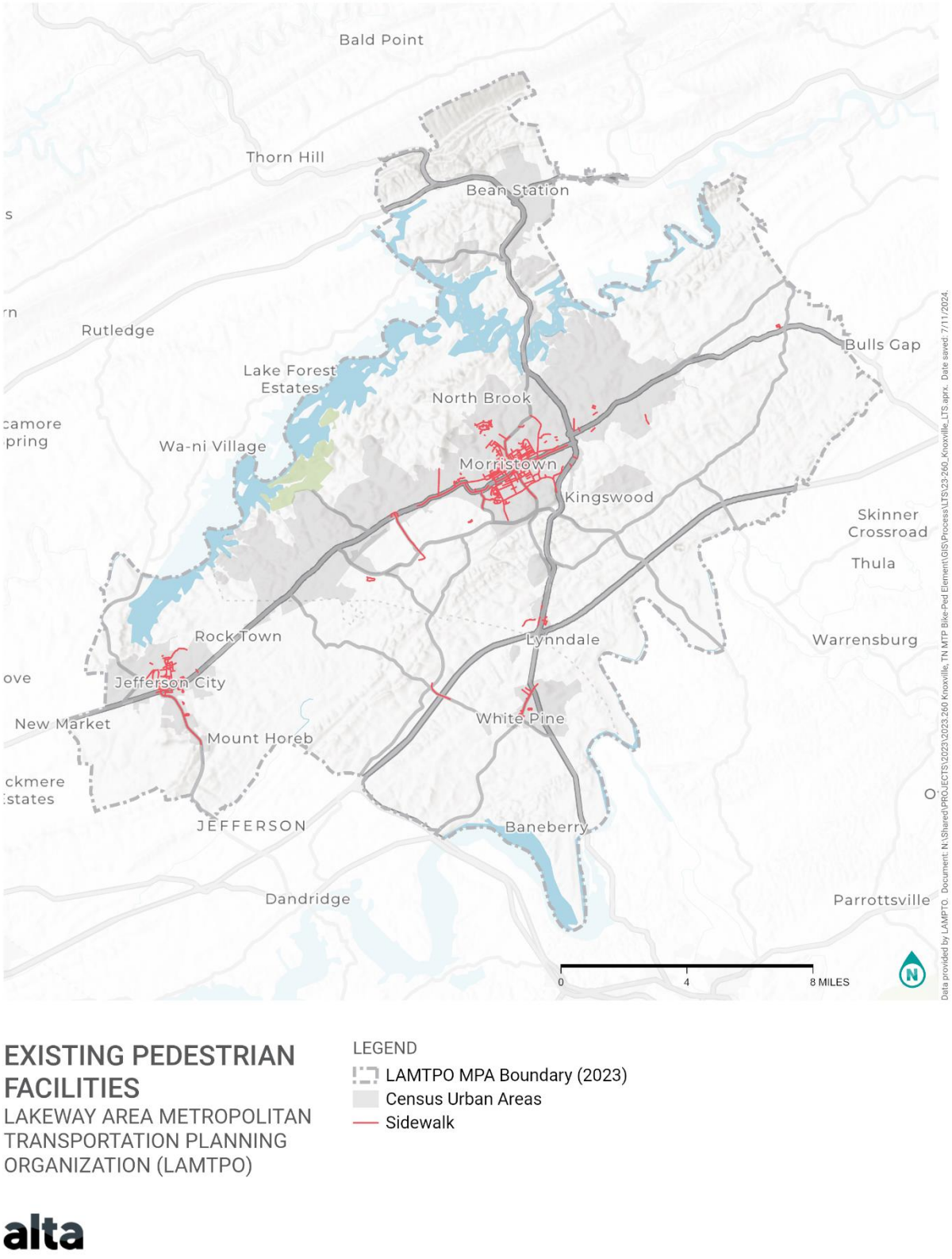


Figure 14. Existing Pedestrian Facilities for LAMTPO

Pedestrian Level of Traffic Stress (PLTS)

The Pedestrian Level of Traffic Stress (PLTS) methodology used in this analysis has been adapted from the Oregon Department of Transportation (ODOT) Analysis Procedures Manual[1] and is intended as a companion for BLTS. PLTS is determined by factors including sidewalk presence and width, sidewalk buffer width and type, posted speed limit, and number of travel lanes. Alta used available sidewalk data and conflated it with the baseline network for the purposes of imputing a pedestrian LTS. While there is a baseline sidewalk inventory for the region, it does not have attributes on buffer presence, vegetation, or tree canopy that is used to identify on-the-ground pedestrian comfort. These attributes were imputed, where available, from OpenStreetMap. PLTS scores classify road segments into one of four levels of traffic stress and, while similar to BLTS scoring, PLTS considers the level of attention required to safely walk in a specific environment in addition to the user experience:

- **PLTS 1** describes roadways where pedestrians of all ages and abilities would feel comfortable walking and require little attention to traffic.
- **PLTS 2** represents slightly less comfortable roadways that require more attention to traffic and are suitable for children over 10, teens and adults.
- **PLTS 3** represents moderately uncomfortable roadways, where most able-bodied adults would feel uncomfortable but safe.
- **PLTS 4** represents high traffic stress and would be used only by able-bodied adults with limited route choices.

Appendix C includes a more detailed description of the PLTS methodology.

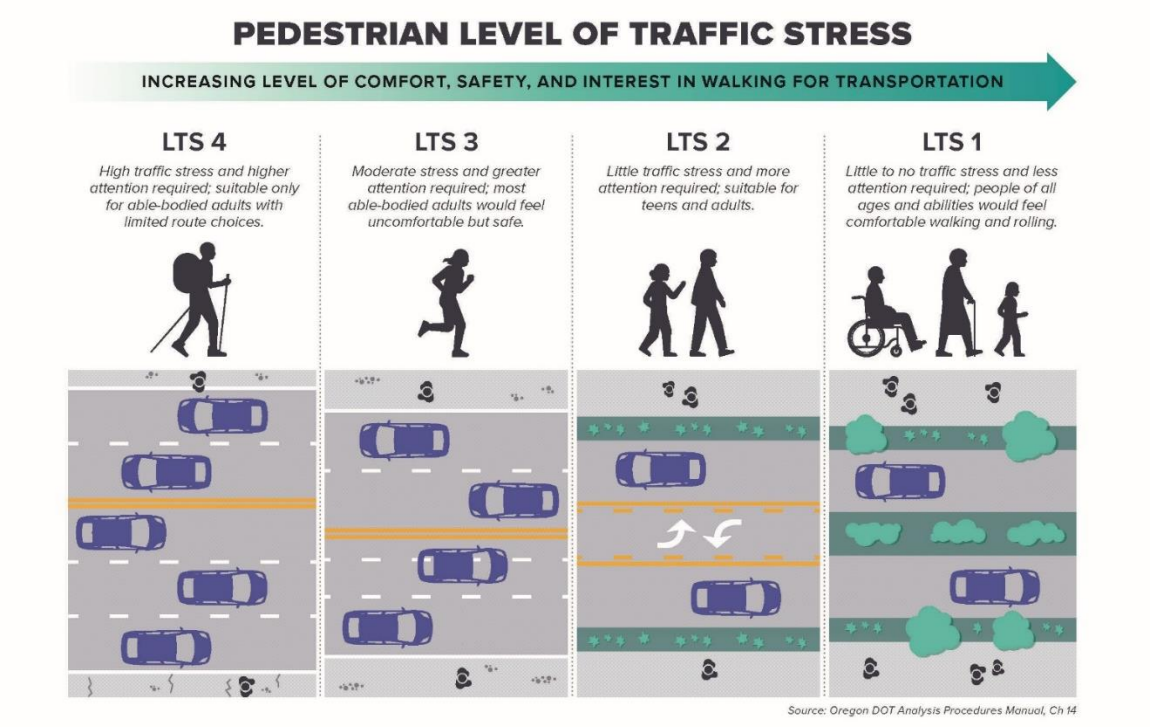


Figure 15. Pedestrian Level of Traffic Stress Infographic

[1] Oregon Department of Transportation (ODOT) Analysis Procedures Manual available online at https://www.oregon.gov/odot/planning/pages/apm.aspx

Knoxville

Figure 16 shows that majority of Knoxville's streets are a PLTS of 2, followed by PLTS 4. Many local, residential streets have low speed limits, few lanes, and low traffic volumes, but a lack of sidewalks, so they are considered LTS 2. Arterials and high-volume streets are typically LTS 4. **Figure 18** illustrates that despite sidewalks being concentrated in the downtown, the PLTS for downtown Knoxville is still high in certain areas due to traffic volumes, speed, and the number of lanes.

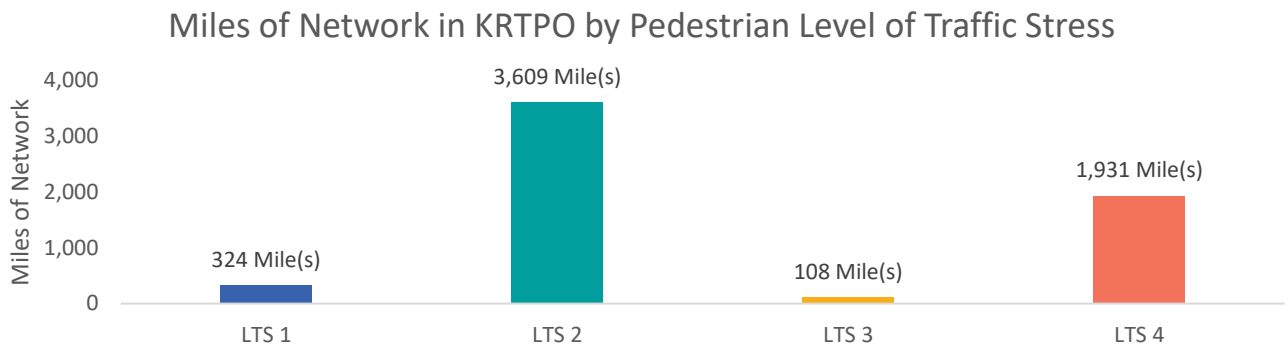


Figure 16. Miles of Network in KRTPO by PLTS

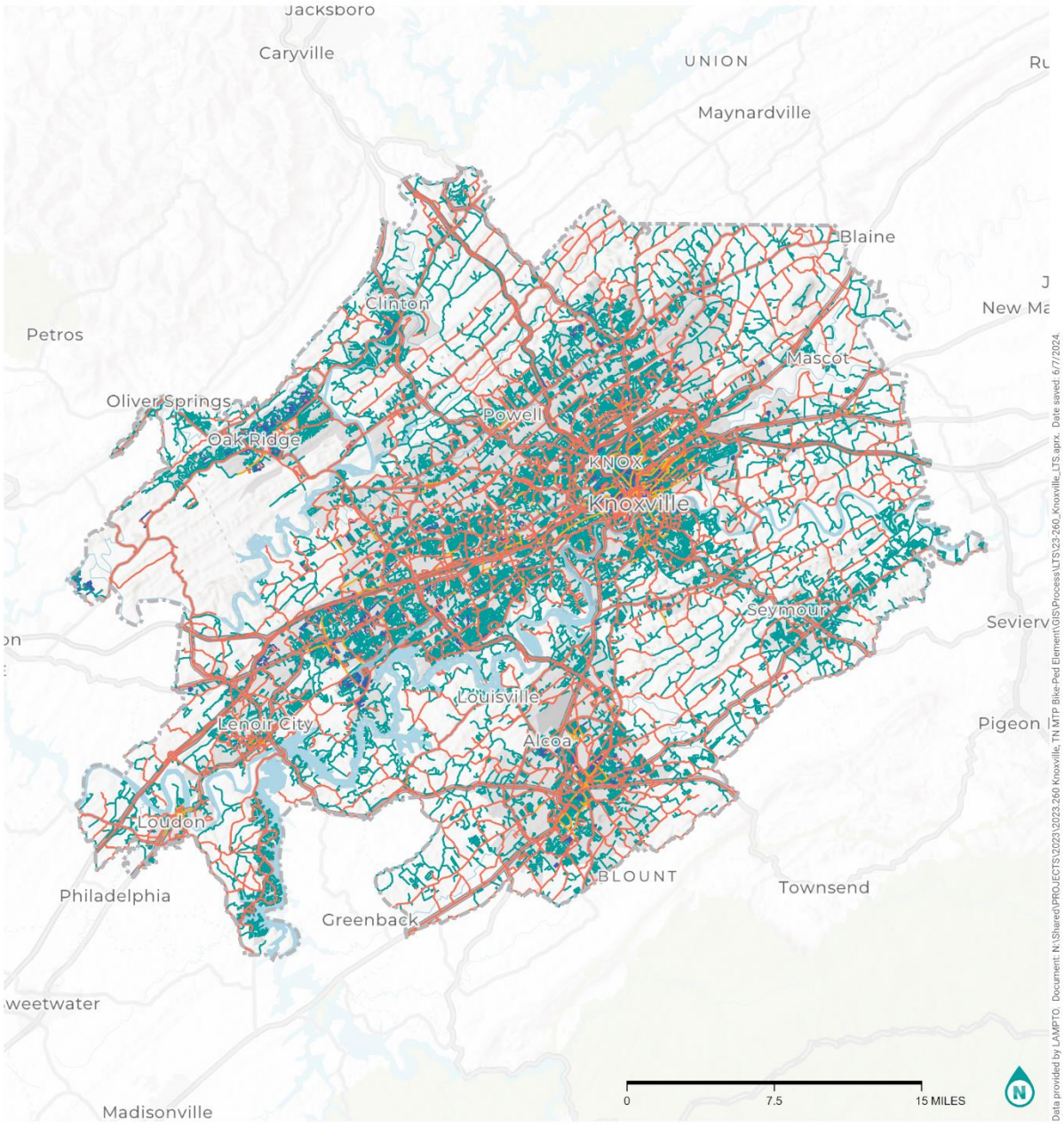
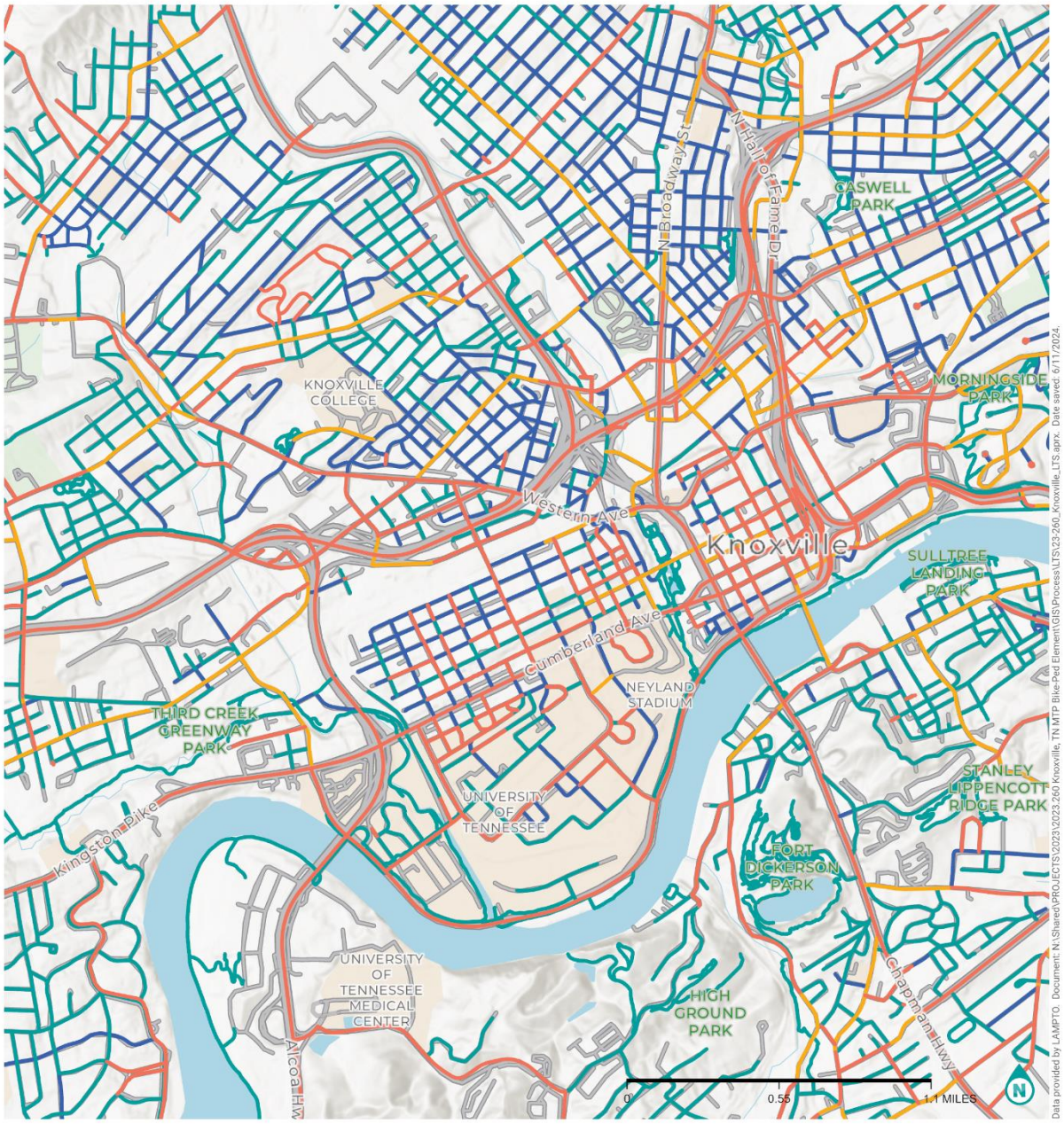


Figure 17. Pedestrian Level of Traffic Stress for the Knoxville Regional Transportation Planning Organization



PEDESTRIAN LEVEL OF TRAFFIC STRESS (LTS)
KNOXVILLE REGIONAL TRANSPORTATION PLANNING ORGANIZATION (KRTPO)

LEGEND
Pedestrian LTS
1
2
3
4

alta

Figure 18. Pedestrian Level of Traffic Stress for Downtown Knoxville

Lakeway

Similar to Knoxville**, Figure 19** shows that the majority of roads are PLTS of 2, followed by 4. This reflects the residential nature of many streets in the LAMTPO area. **Figure 20** shows the location of PLTS scored on the network, with a diversity of scores in the downtown of Morristown reflecting the fact that there are both sidewalks and higher traffic volumes in this area.

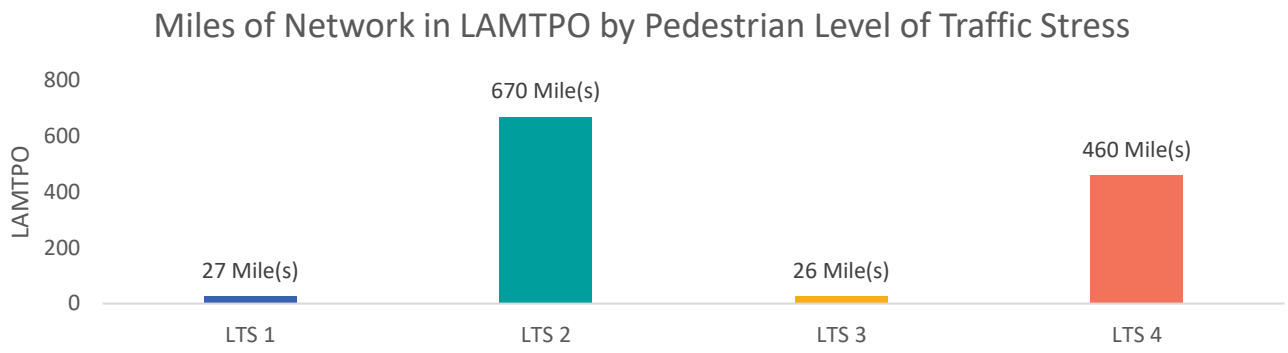


Figure 19. Miles of Network in LAMTPO by PLTS

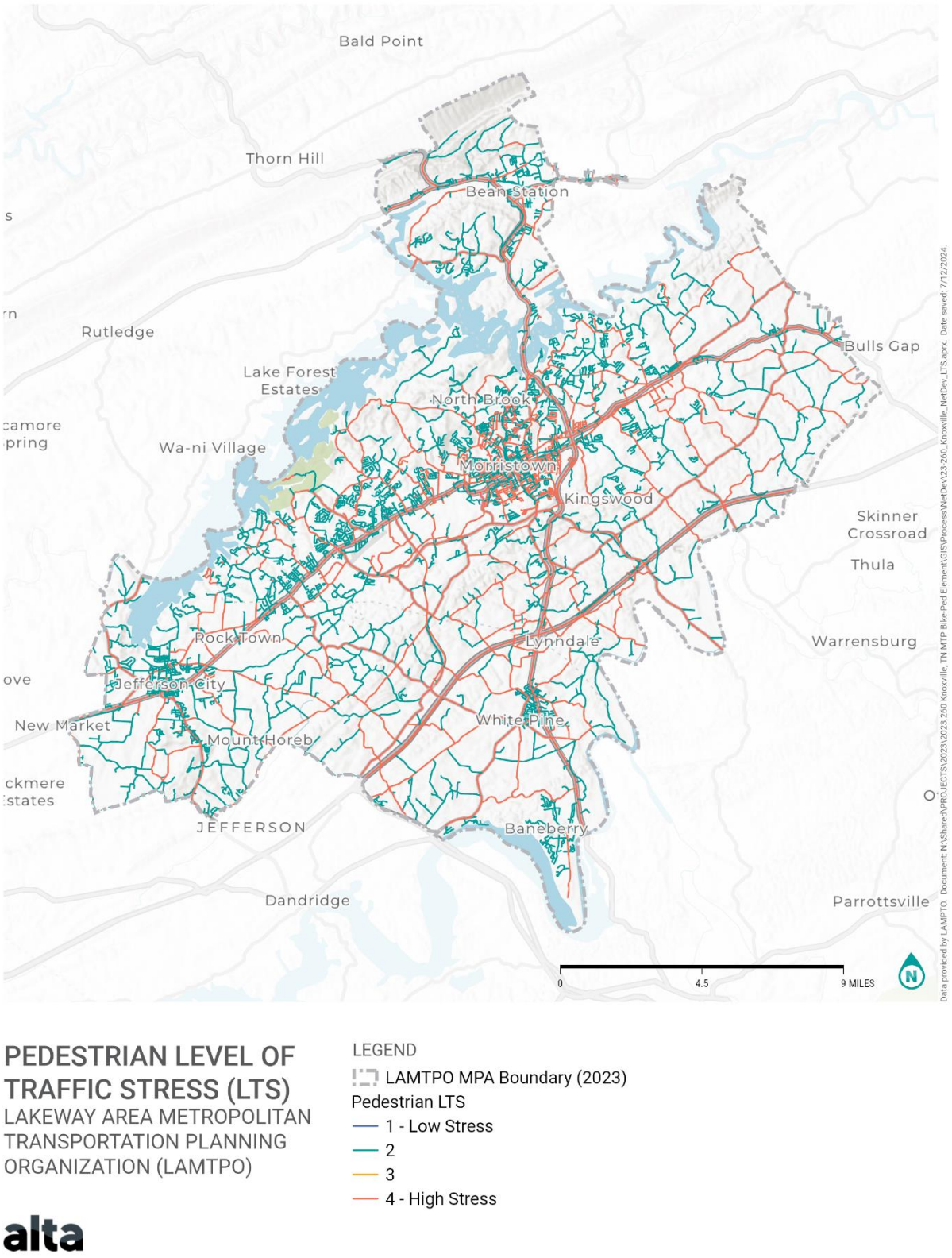


Figure 20. Pedestrian Level of Traffic Stress for the Lakeway Area Metropolitan Public Transportation Organization

Limitations

1. No crosswalks data.
2. Some roadway attributes the team had to make assumptions on when developing the LTS for both regions.
    a. Some assumptions needed to be made on roadway speed limits:
        i. Non-residential roads outside of urban areas were assumed to be 45 mph
        ii. Non-residential roads inside urban areas were assumed to be 35 mph
        iii. All other roads where the speeds were listed as 0 mph in the data, were assumed to be 25 mph
        iv. For all roads conflated using a line and whisker method with Open Street Map centerlines, speeds listed from Open Street Map were used.
    b. Some assumptions needed to be made on bike lane widths:
        i. If a bike lane existed, it was assumed to be 4 ft wide
    c. Some assumptions needed to be made on sidewalk widths:
        i. If a sidewalk existed, it was assumed to be 5 ft wide
    d. Some assumptions needed to be made on number of lanes:
        i. If number of lanes was missing, and the roads conflated using a line and whisker method with Open Street Map centerlines, number of lanes listed from Open Street Map were used.
        ii. If number of lanes was missing, and the roads did not conflate well using a line and whisker method with Open Street Map centerlines, the number of lanes for the roadway was assumed to be 2.
        iii. Otherwise, provided number of lanes was used.
    e. Some assumptions needed to be made on traffic volumes:
        i. Residential and Unclassified type roadways were assumed to have 1,500 vpd
        ii. Living, Track and Undefined type roadways were assumed to have 2,000 vpd
        iii. Tertiary type roadways were assumed to have 5,000 vpd
        iv. Secondary type roadways were assumed to have 10,000 vpd
        v. Primary type roadways were assumed to have 20,000 vpd
        vi. Trunk type roadways were assumed to have 30,000 vpd
        vii. Motorway type roadways were assumed to have 45,000 vpd
    f. Some assumptions needed to be made for one way, residential streets:
        i. For BLTS, one-way, residential streets were assumed to be maximum LTS 2

Appendix A: Level of Traffic Stress and OpenStreetMap Derivation Assumptions

Overview

Alta uses a tiered data collection framework for level of traffic stress (LTS) analysis that derives initial analysis inputs from readily accessible data, in order to determine where additional data collection will be of the most value to meet project goals. In the case of LTS analysis, Alta derives initial base analysis inputs from OpenStreetMap (OSM) data.[2] This appendix documents how Alta develops the input variables for this analysis.

Where OSM data includes values for lanes, posted speeds, bike lanes, sidewalks, parking lanes, and one-way tags, these tags are used to populate a database for LTS inputs. Once that database is populated, Alta uses the Mekuria et al., 2012 LTS methodology to score roadway segments. This initial LTS is intended to be augmented by automated or manual review of aerial imagery, local GIS data, and/or street view data. Once the base input values have been validated, the LTS scores can be refreshed using Alta's LTS calculation scripts. This enables evaluation of new scenarios as needed in addition to standardized network analysis.

OpenStreetMap Processing

When using OSM networks for LTS analysis, there are several considerations for creating a useful network for visualization and analysis. The following sections outline how Alta processes OSM data for LTS and related network analyses.

[2] OSM is a crowdsourced database of geographic features including administrative boundaries, street centerlines, points of interest, building footprints, physical and natural features, and other types of geographic information. OSM is one of the most prominent examples of volunteered geographic information, where community processes drive the contributions of geographic information to a shared database (2). These geographic features are tagged based on their attributes, and while community wiki pages provide guidance on which tags apply to which features, there is no centralized authority that authenticates these contributions. For example, street networks in OSM may include tags where contributors denote functional classification, number of lanes, one-way classification, speed limits, presence of sidewalks, and the type of bicycle facility that might be present on the network. While OSM is not always accurate, it has been benchmarked against comparable map data sources such as Google and found to have comparable or better accuracy for bike paths depending on the type of error (3). Multiple non-profits, academics, and practitioners have found OSM to be an acceptable base for initial derivation of LTS analysis (4,5,6,7).

Network Connectivity

OSM networks contain segments that are not ready for network analysis in most instances. There are various software processing packages such as the Open-Source Routing Machine and OpenTripPlanner that come with routines to prepare OSM networks for network analysis. Alta uses scripts built on the OSMnx[3] Python package to derive its geospatial networks. This package is used to ensure that extracted networks are valid and have appropriate end-to-end connectivity provided by network segments. This process compiles all OSM networks wherein the highway tag[4] is available and the corresponding geometry is a line. For cartographic presentations, it is often preferable to filter out features such as service roads (roads within parking lots) and footways (sidewalks drawn separately from the centerline). This is typically done to focus attention to facilities that jurisdictions and regions can reasonably improve.

Tag Processing

In many cases, OSM data includes tags for attributes such as lanes, posted speed, bicycle infrastructure, and other facility information recorded in the database. This data is more likely to be completed in urbanized areas globally, and on major facilities such as arterials and highways. There can be substantial variance in tag availability from location to location, but the presence of bike paths and a consistent indicator of functional classification is generally well recorded in OSM. In the case of bike lane blockage rates, Alta assumes these instances are rare unless manual review of commercial districts indicates otherwise. When tags are missing from OSM for the purposes of LTS analysis, the assumptions outlined in Table 1 are used as proxy values.

Table 1: Alta's OpenStreetMap Assumptions for Missing Inputs

Functional Class	Lanes[1,2,3]	Speed Limit[1,2,3]	Centerline Present[3]	AADT[3,4]
Residential	2	25	No	1,500
Living Street	2	25	No	2,000
Unclassified	2	25	Yes	1,500
Track	2	30	Yes	2,000
Tertiary	3	30	Yes	5,000
Secondary	4	35	Yes	10,000
Primary	4	45	Yes	20,000
Trunk	6	65	Yes	30,000
Motorway	6	65	Yes	45,000
OTHER	2	25	Yes	2,000

1. Lane assumptions for one-way streets are halved to reflect an accurate per-segment assumption. In addition, all one-way streets are assumed to have medians for the purposes of LTS computations.
2. These assumptions only apply if there is no tag provided for speed limit or number of lanes.
3. These assumptions were developed based on Wasserman et al. 2019 and Harvey et al. 2019.
4. Supplemental detail on road character assumptions and not utilized in LTS computation.

[3] Boeing (2017).
[4] Highway Tag. Key:highway - OpenStreetMap Wiki. (n.d.). https://wiki.openstreetmap.org/wiki/Key:highway.

LTS analysis also requires an understanding of other geometric considerations, such as bicycle facility width and parking lane width (if present). Alta begins with a "benefit of the doubt" approach for these attributes, meaning that if they are present, they are assumed to be of sufficient width. Validation is recommended for detailed LTS assessments, but this is typically less important for less rigorous, or large-scale (e.g., county-, region-, or state-wide) LTS-based analysis. Bicycle infrastructure-related tags are processed using assumptions outlined in Table 2.

Table 2: Alta's OpenStreetMap Assumptions for Bicycle Facilities

Cycleway Tag[1]	Bicycle Facility Type	Assumed Bicycle Facility Width (Feet)	Is Protected
Shared	Bike Route/Class III	0	No
Shared_lane	Bike Route/Class III	0	No
Lane	Bike Lane/Class II	4	No
Shared_busway	Bike Lane/Class II	4	No
Opposite_lane	Bike Lane/Class II	4	No
Cycleway[2]	Bike Path/Class I	10	Yes
Path	Bike Path/Class I	10	Yes
Track	Separated Bikeway/Class IV	8	Yes
Opposite_track	Separated Bikeway/Class IV	8	Yes
Buffered_lane	Separated Bikeway/Class IV	4	Yes
OTHER	NA	0	No

1. Alta processes nondirectional cycleway tags and directional cycleway tags as part of its conversion. The final LTS score is the worst-case score based on the direction of facilities.
2. Highway tags including the tag "cycleway" are also considered to be Class I facilities.

When parking lane-related tags are processed, assumptions related to their width and rates of bike lane blockage are outlined in Table 3.

Table 3: Alta's OpenStreetMap Assumptions for Parking Facilities

Parking Lane Tag	Assumed Parking Lane Width (Feet)
Parallel	8
Marked	8
Diagonal	16
Perpendicular	20
OTHER	NA

Citations

1. Mineta Institute. Mekuria M., Furth P., Nixon H. *Low-Stress Bicycling and Network Connectivity*. 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity
2. Mocnik, F.-B., A. Mobasheri, and A. Zipf. Open-Source Data Mining Infrastructure for Exploring and Analysing OpenStreetMap. Open Geospatial Data, Software and Standards, Vol. 3, No. 1, 2018, p. 7. https://doi.org/10.1186/s40965-018-0047-6.
3. Hochmair, H. H., D. Zielstra, and P. Neis. Assessing the Completeness of Bicycle Bike Path and Lane Features in OpenStreetMap for the United States. Transactions in GIS, Vol. 19, No. 1, 2014, pp. 63–81. https://doi.org/10.1111/tgis.12081.
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7. Mineta Institute. Chester Harvey, Kevin Fang, Daniel A. Rodriguez. Evaluating Alternative Measures of Bicycling Level of Traffic Stress Using Crowdsourced Route Satisfaction Data. 2019. https://scholarworks.sjsu.edu/mti_publications/276/
8. Boeing, G. 2017. OSMnx: New Methods for Acquiring, Constructing, Analyzing, and Visualizing Complex Street Networks. Computers, Environment and Urban Systems 65, 126-139. doi:10.1016/j.compenvurbsys.2017.05.004.

Appendix B: Bicycle Level of Traffic Stress Analysis

Overview

The bicycle level of traffic stress (BLTS) analysis estimates the level of comfort for people biking on a given roadway segment. The BLTS analysis identifies where "gaps" or deficiencies in a bike network exist, and provides a measure of how likely different types of riders, based on ability and comfort level, are to use the facility.

Alta's BLTS analysis methodology is adapted from the 2012 Mineta Transportation Institute Report 11-19: *Low-Stress Bicycling and Network Connectivity*.[5] BLTS is determined by characteristics of a given roadway segment that affect a bicyclist's perception of safety and comfort, including posted speed limit, number of travel lanes, and the presence and character of bicycle lanes. The combination of this criteria classifies a road segment into one of four levels of traffic stress:

- **BLTS 1** represents roadways where bicyclists of all ages and abilities would feel comfortable riding. These roadways are generally characterized by low volumes, low speeds, no more than two travel lanes, and traffic control measures at intersections. These roadways may have bicycle facilities; separated shared-use paths for bicycles also fall into this category.
- **BLTS 2** represents slightly less comfortable roadways, where most adults would feel comfortable riding.
- **BLTS 3** represents moderately uncomfortable roadways, where most experienced bicyclists would feel comfortable riding.
- **BLTS 4** represents high-stress roadways where only strong and fearless bicyclists would feel comfortable riding. These roadways are generally characterized by high volumes, high speeds, several travel lanes, and complex transitions approaching and crossing intersections.

The results of the BLTS analysis identify existing areas that are low stress for many bicyclists, as well as the degree to which roadways must be improved in order to provide a comfortable experience for riders of all ages and abilities. Additionally, scenario testing can be used to determine how a roadway or route's level of stress may change with improvements.

Methodology

BLTS analysis is completed through an assessment of street segments using spatial data and aerial imagery. Each segment of the roadway is evaluated based on its characteristics; if multiple scores are present within a segment, the highest (most stressful) score is used as the overall segment score.

Figure 21 illustrates the overall BLTS scoring process. Notes on data inputs and assumptions are found in Table 4. Segment scores are assigned as shown in Table 2 through Table 5.

[5] Mineta Institute. Mekuria M., Furth P., Nixon H. *Low-Stress Bicycling and Network Connectivity*. 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity.

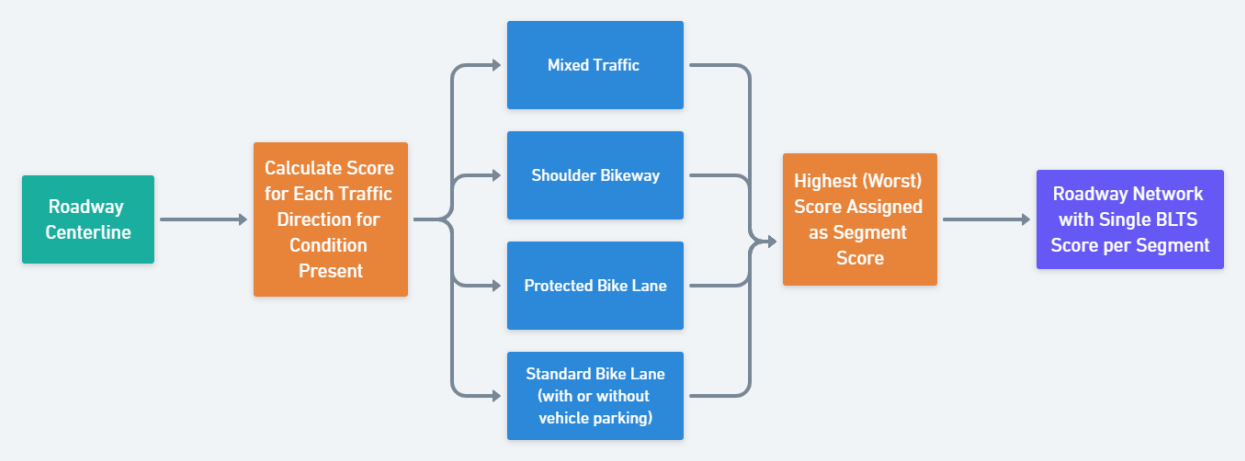

Figure 21: Bicycle Level of Traffic Stress Generalized Segment Scoring Process

Table 4: Data Inputs and Assumptions

Inputs	Notes	Assumptions
Bicycle Facilities	Bicycle lanes have a positive impact on BLTS and are a primary input for developing a BLTS model. The width of facilities can have an impact on the associated comfort level. Wider facilities provide greater comfort, especially on high-speed roadways.	For analysis purposes, a standard width of 4 feet was assumed for all bike lanes. Buffered bike lanes, which provide an additional degree of separation from motor vehicles and greater operating space for bicyclists, were considered to be greater than 6 feet, meeting the requirements for a BLTS 1 score as outlined in Table 2 and Table 3.
Speed Limit	High-speed roadways are considered to be less comfortable for bicyclists, particularly in mixed traffic or with minimal separation from motor vehicles. Low-speed roadways are considered more comfortable.	Speed limit data was available for a subset of roadways within the city limits. The BLTS evaluation was completed only for those roadways in which speed limit data was available.
Presence and Width of On-Street Parking Adjacent to Bicycle Lanes	On-street parking is particularly important for corridors on which bicycle lanes are present. BLTS is greater on bicycle lanes adjacent to parking than on bicycle lanes not adjacent to parking, due to the potential for "dooring" incidents.	A standard width of 7.5 feet was assumed for all parking lanes.
Number of Lanes	The number of travel lanes corresponds with an increase in the roadway width, which has an effect on bicyclists' level of stress. Roadways with fewer lanes are generally less stressful for bicyclists.	When data was not available or was inadequate, assumptions about number of lanes were made based on the roadway's functional classification according to OpenStreetMap or other available data.
Presence of Trails	Class I facilities can be a vital component of a municipality's active transportation network. Increased separation from motor vehicles can improve comfort and safety.	Class I facilities are scored as a BLTS 1.

Table 5 through Table 7 specify the scoring criteria based on roadway configuration, speed, and bike lane/parking lane presence and width. The criteria are adapted from the original 2012 Mineta Institute report. These tables are used in combination to assign an overall BLTS score; if multiple scores are present within a segment, the highest (most stressful) score is used as the overall segment score. These tables are used in combination to create the segment, approach, and intersection scores described previously.

Table 5: Criteria for Bicycle Level of Traffic Stress in Mixed Traffic

Prevailing Speed or Speed Limit (mph)	Street Width		
	2–3 Lanes	4–5 Lanes	6+ Lanes
≤ 25	BLTS 1 or 2	BLTS 3	BLTS 4
30	BLTS 2 or 3[1]	BLTS 4	BLTS 4
≥ 35	BLTS 4	BLTS 4	BLTS 4

1. Lower value is assigned to streets without marked centerlines or classified as residential with fewer than three lanes. Residential roadways are identified based on the Open Street Map "highway" tag.

Table 6: Criteria for Bike Lanes Not Alongside a Parking Lane

	BLTS 1	BLTS 2	BLTS 3	BLTS 4
Street Width (through lanes per direction)	1	2	More than 2	(no effect)
Bike Lane Width	6 feet or more	5.5 feet or less	(no effect)	(no effect)
Speed Limit (mph)	30 mph or less	(no effect)	35 mph	40 mph or more
Bike lane blockage[1]	Rare	(no effect)	Frequent	(no effect)

1. Bike lane blockage is part of Alta's analysis methodology, but assumed to be rare by default.

Table 7: Criteria for Bike Lanes Alongside a Parking Lane

	BLTS 1	BLTS 2	BLTS 3	BLTS 4
Street Width (through lanes per direction)	1	(no effect)	2 or more	(no effect)
Sum of Bike Lane Width + Parking Lane Width	15 feet or more	14 or 14.5 feet	13.5 feet or less	(no effect)
Speed Limit (mph)	25 mph or less	30 mph	35 mph	40 mph or more
Bike lane blockage[1]	Rare	(no effect)	Frequent	(no effect)

1. Bike lane blockage is part of Alta's analysis methodology, but assumed to be rare by default.

The tables above account for on-street bike lanes not separated from traffic. Protected bike lanes are automatically scored as an LTS 1.

Appendix C: Pedestrian Level of Traffic Stress Methodology

Overview

The pedestrian level of traffic stress (PLTS) analysis estimates the level of comfort for people walking on a given roadway segment. The PLTS analysis identifies where "gaps" or deficiencies in a pedestrian network exist, and provides a measure of how likely pedestrians are to use the facility, based on ability and comfort level.

Alta's PLTS analysis methodology is adapted from the Oregon Department of Transportation's *Analysis Procedures Manual*[6] and is intended as a companion for bicycle level of traffic stress (BLTS). PLTS is determined by characteristics of a given roadway segment that affect a pedestrian's perception of safety and comfort including sidewalk presence and width, sidewalk buffer width and type, posted speed limit, and number of travel lanes. PLTS scores classify road segments into one of four levels of traffic stress and, while similar to BLTS scores, PLTS considers the level of attention required in addition to the user experience:

- PLTS 1 represents roadways where pedestrians of all ages and abilities would feel comfortable walking and require little attention to traffic.
- PLTS 2 represents slightly less comfortable roadways that require more attention to traffic and are suitable for children over 10, teens, and adults.
- PLTS 3 represents moderately uncomfortable roadways, where most able-bodied adults would feel uncomfortable but safe.
- PLTS 4 represents high traffic stress and would be used only by able-bodied adults with limited route choices.

The results of the PLTS analysis identifies existing areas that are low-stress for pedestrians, as well as the degree to which roadways must be improved in order to provide a comfortable experience for pedestrians of all ages and abilities. Additionally, scenario testing can be used to determine how a roadway or route's level of stress may change with improvements. The analysis is intended for use in urban areas specifically; while it can be used in rural conditions where pedestrian facilities exist, the methodology will yield a high PLTS score (greatest discomfort) where high-speed traffic is present.

Methodology

PLTS analysis is completed through an assessment of street segments using spatial data and aerial imagery. Each segment of the roadway is evaluated based on its characteristics; if multiple scores are present within a segment, the highest (most stressful) score is used as the overall segment score.

PLTS considers elements of the pedestrian environment both individually (e.g., buffer type), and in combinations that are known to influence each other (e.g., sidewalk width and pavement quality). The analysis uses the following overall guiding principles:

- The presence of a complete sidewalk serves as the foundation of the pedestrian network.
- As the sidewalk width increases and sidewalk condition improves, the level of stress of the pedestrian environment decreases.
- Buffering width is the total distance between the sidewalk and motor vehicle travel lanes. As width increases, the amount of separation between pedestrians and motor vehicles increases, and the pedestrian environment becomes less stressful.

[6] Oregon Department of Transportation, Transportation Development Division Planning Section: Transportation Planning Analysis Unit. 2020. *Analysis Procedures Manual* Version 2. https://www.oregon.gov/odot/Planning/Pages/APM.aspx.

- Buffer type describes the quality of the buffer that separates the sidewalk from the travel lanes. The presence of a buffer itself provides both actual and perceived safety benefits for the pedestrian, thus decreasing the stress of the pedestrian environment. A buffer with vertical elements is especially effective at increasing the safety of the pedestrian. Landscaping serves to enhance the pedestrian's travel experience.

Scores for each element of the pedestrian environment are assigned to each segment of the roadway centerline, and the worst (highest scoring) of the elements is used. If two sidewalks are present on a street, the worst (highest scoring) result is mapped to the centerline.

Figure 22 illustrates the overall PLTS scoring process. Notes on data inputs and assumptions are found in Table 8. Segment scores are assigned as shown in Table 9 through Table 12 specify the scoring criteria based on sidewalk presence, sidewalk width and condition, buffer type, and buffer width, in relation to the existing roadway condition (factors such as speed and number of lanes). The criteria are adapted from the Oregon Department of Transportation *Analysis Procedures Manual*. These tables are used in combination to assign an overall PLTS score; if multiple scores are present within a segment, the highest (most stressful) score is used as the overall segment score.

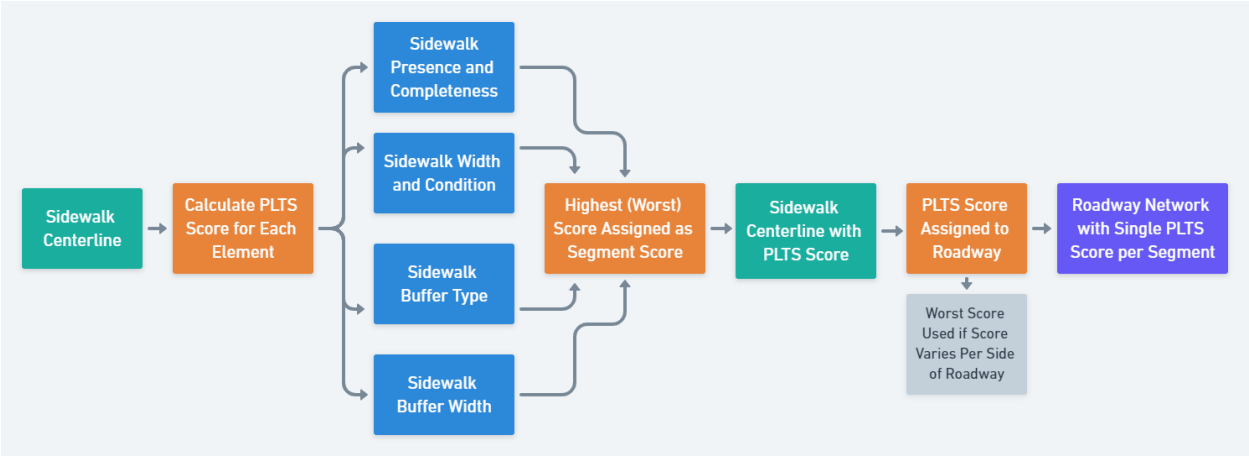

Figure 22: The Pedestrian LTS Scoring Process

Table 8. Data Inputs and Assumptions

Pedestrian Element	Rationale	Data Inputs
Sidewalk Presence and Completeness (Table 9)	The presence and completeness of sidewalk facilities is the baseline for measurement. At a minimum, sidewalks should be present and complete on most roadways to facilitate pedestrian travel.	Based on OpenStreetMap (OSM) data and supplemented by manual review within study area.
Sidewalk Width and Condition (Table 10)	The width of the sidewalk can have an impact on the associated comfort level. Wider sidewalks provide greater comfort, especially on high-speed roadways. The condition of the sidewalk is primarily based on concrete quality.	Based on OSM data and supplemented by manual review within the study area.
Sidewalk Buffer Type (Table 11)	The buffer type changes the pedestrian experience as it can offer a range of perceived and actual levels of protection. High-speed roadways are considered to be less comfortable, and a more substantial buffer increases pedestrian comfort.	Based on OSM data and supplemented by manual review within the study area.
Sidewalk Buffer Width (Table 12)	Total buffering width is the summation of the width of buffer, width of parking, width of shoulder, width of curb and gutter, and width of the bike lane on the same side of the roadway as the pedestrian facility being evaluated.	Based on OSM data and supplemented by manual review within the study area.

Table 9: Pedestrian Level of Traffic Stress Based on Sidewalk Presence and Completeness

Number of Travel Lanes	Posted or Prevailing Speed				
	≤ 25 mph		*30–35 mph*		*≥ 40 mph*
	2 Lanes	*> 2 Lanes*	*2 Lanes*	*> 2 Lanes*	*2 Lanes*
Complete Sidewalk on Both Sides[1]	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3
Complete Sidewalk on One Side	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
No Sidewalk[2]	LTS 2	LTS 4	LTS 4	LTS 4	LTS 4

1. Partial sidewalk coverage on a block is not considered complete.
2. Residential (OSM Highway class local) roadways without sidewalk default to LTS 2; roadways without sidewalk default to LTS 4.

Table 10: Pedestrian Level of Traffic Stress Based on Sidewalk Width and Condition

		Sidewalk Condition[3]			
		Good	*Fair*	*Poor*	*Very Poor*
Actual/Effective Width (feet)[1,2]	< 4	LTS 4	LTS 4	LTS 4	LTS 4
	≥ 4 to < 5	LTS 3	LTS 3	LTS 3	LTS 4
	≥ 5	LTS 2	LTS 2	LTS 3	LTS 4
	≥ 6	LTS 1	LTS 1	LTS 2	LTS 3

1. Effective width is the available/usable area for the pedestrian clear of obstructions. Effective width does not include areas occupied by storefronts or curbside features.
2. For analysis purposes, a standard width of five feet was assumed for all sidewalks.
3. Sidewalk condition is assumed to be good unless other information is available.

Table 11: Pedestrian Level of Traffic Stress Based on Physical Buffer Type

Buffer Type[1]	Prevailing or Posted Speed			
	≤ 25 mph	*30 mph*	*35 mph*	*≥ 40 mph*
No Buffer (curb tight)	LTS 2[2]	LTS 3	LTS 3	LTS 4
Solid Surface	LTS 2[2]	LTS 2	LTS 2	LTS 2
Landscaped	LTS 1	LTS 2	LTS 2	LTS 2
Landscaped with Trees	LTS 1	LTS 1	LTS 1	LTS 2
Vertical	LTS 1	LTS 1	LTS 1	LTS 2

1. Combined buffer: If two or more of the buffer conditions apply, use the most appropriate (typically the lower-stress type).
2. If no centerline is present (residential street) or the street is traffic calmed (including sporadic vertical separation such as street furniture, street trees, lighting, planters, surface change, and so on), then the PLTS can be lowered by one PLTS level.

Table 12: Pedestrian Level of Traffic Stress Based on Physical Buffer Width[1]

Total Number of Travel Lanes (both directions)[3]	Total Buffering Width (feet)[2]				
	< 5	*≥ 5 to < 10*	*≥ 10 to < 15*	*≥ 15 to < 25*	*≥ 25*
≤ 2	LTS 2[4]	LTS 2	LTS 1	LTS 1	LTS 1
3	LTS 3[4]	LTS 2	LTS 2	LTS 1	LTS 1
4–5	LTS 4[5]	LTS 3	LTS 2	LTS 1	LTS 1
6 ≥	LTS 4[5]	LTS 4[5]	LTS 3	LTS 2	LTS 2

1. Source: Based on Oregon Department of Transportation *Analysis Procedures Manual*, Table 14-23.
2. Total buffering width is the summation of the width of buffer, width of parking, width of shoulder, width of curb and gutter, and width of the bike lane on the same side of the roadway as the pedestrian facility being evaluated.
3. One-way facilities are assumed to have their lanes multiplied by 2 to represent exposure to lane crossing.
4. If no centerline is present (residential street) or the street is traffic calmed (including sporadic vertical separation such as street furniture, street trees, lighting, planters, surface change, and so on), then the PLTS can be lowered by one PLTS level.
5. Sections with a substantial physical barrier/tall railing between the travel lanes and the walkway (such as might be found on a bridge) can be lowered to PLTS 3.