alta
PLANNING + DESIGN

142 W. Monroe Ave
St. Louis, Missouri 63122
(314) 403-7460

MEMORANDUM

To: **John Hicks, Project Manager, St. Louis County Department of Transportation**

From: **Kevin Neill, Project Manager, Alta Planning + Design**
Paul Wojciechowski, Principal-In-Charge, Alta Planning + Design

Date: **Friday, August 30, 2019**
UPDATED Friday, September 20, 2019 with ArcGIS Online hyperlinks

Re: **Walk and Bike Comfort Analysis (Updated)**
St. Louis County Action Plan for Walking and Biking

Introduction

Measuring the level of comfort for walking and bicycling on St. Louis County Roadways provides an understanding of the quality, connectivity, and needs for improvement to better support active transportation and meet the value of creating an all ages and abilities network for walking and biking. The St. Louis County Action Plan for Walking and Biking uses two best practice analysis methods to determine level of comfort: Pedestrian Level of Service and Bicycle Level of Traffic Stress. This memorandum describes the methodology and results of each analysis for the St. Louis County Arterial and Collector Road System.

Pedestrian Level of Service

The Pedestrian Level of Service (PLOS) analysis examines the levels of comfort, safety, and ease of mobility that pedestrians experience traveling on the St. Louis County Arterial and Collector Road System. PLOS analysis incorporates important roadway characteristics including posted speed limit, number of travel lanes, presence of pedestrian facilities, and presence of a buffer between pedestrian and motor vehicle traffic to determine level of comfort for pedestrian travel. This in turn will highlight gaps within the pedestrian network and identify opportunities to enhance network connectivity through targeted infrastructure improvements. This PLOS analysis supplements other pedestrian facility data, such as ADA-related elements in developing a full understanding of pedestrian needs and prioritization of pedestrian recommendations later in the planning process. PLOS is a planning level analysis. Incorporating additional factors into the analysis in the future may change the results.

Methodology

PLOS analysis typically treats segments and intersections separately. However, due to the lack of available data regarding pedestrian crossing facilities at signalized and unsignalized intersections, PLOS will only be conducted for roadway segments. Even in the absence of intersection data, the PLOS is still a meaningful tool to analyze level of comfort for pedestrian travel along County-owned roads, and for identifying pedestrian system gaps by level of service.

Table 1: PLOS Data Inputs

Inputs	Data Availability
Sidewalks	Data available
Crosswalk Markings	Data not available
Curb Ramps	Data available
Traffic Signals	Data available for County-owned signals only
Stop Signs	Data not available
Speed Limit	Data available
Presence of On-Street Parking	Data not available
Bicycle Lanes	Data available

Segment Analysis

The selected segment-based PLOS is rooted in the concept that a doubling of travel speed results in a four-fold increase in vehicle stopping time and resulting crash severity. According to one study, speed has the following impact on pedestrian fatalities[1]:

- At 20 mph the odds of pedestrian fatality are 5 percent
- At 30 mph the odds of pedestrian fatality are 45 percent
- At 40 mph the odds of pedestrian fatality are 85 percent

While other studies have found some variation, these approximate numbers are reported consistently across the literature.

It is imperative that dedicated travel facilities are provided to create safe travel conditions for pedestrians. This PLOS analysis is based primarily on safety and does not consider factors of the built environment known to make walking an attractive and preferred form of transportation. While built environment factors are not explicitly considered, lower posted speeds and more dedicated pedestrian space will typically correlate with places people want to walk, based on the surrounding land uses and urban form (e.g., residential neighborhoods and commercial uses in lower speed urban areas).

The segment-based PLOS measures pedestrian safety using four factors: posted speed limit, roadway width (number of travel lanes), pedestrian buffer (on-street parking or bicycle lanes), and the presence of sidewalks. Table 7 outlines the scoring methodology of the PLOS analysis. The PLOS follows a five-point scale, with 1 representing the highest comfort level. Generally, more pedestrian space on a lower speed roadway segment correlates to a higher comfort level. An incomplete sidewalk network, higher speeds, and a greater number of lanes correlate to a lower comfort level. Bicycle lanes or on-street parking act as buffers between pedestrians and motor vehicle traffic, increasing comfort.

[1] Killing Speed and Saving Lives, UK Dept. of Transportation, London, England. See also Limpert, Rudolph. Motor Vehicle Accident Reconstruction and Cause Analysis. Fourth Edition. Charlottesville, VA. The Michie Company, 1994, p. 663.

Table 2: Scoring Matrix for Pedestrian Level of Service: Roadway Segments (1 = Highest Comfort Level)

Pedestrian Space along Roadway	Speed Limit (mph)					
	<= 25 mph		30 - 35 mph		>= 40 mph	
	2 lanes	> 2 lanes	2 lanes	> 2 lanes	2 lanes	> 2 lanes
Complete sidewalk on both sides next to a buffer*	LOS 1	LOS 1	LOS 1	LOS 1	LOS 2	LOS 3
Complete sidewalk on both sides	LOS 1	LOS 1	LOS 2	LOS 3	LOS 3	LOS 4
Complete sidewalk on one side next to a buffer*	LOS 2	LOS 2	LOS 2	LOS 3	LOS 3	LOS 4
Complete sidewalk on one side	LOS 2	LOS 3	LOS 3	LOS 4	LOS 4	LOS 5
No sidewalk next to a buffer*	LOS 2	LOS 3	LOS 3	LOS 4	LOS 5	LOS 5
No dedicated space for walking	LOS 2	LOS 3	LOS 4	LOS 5	LOS 5	LOS 5

**A buffer typically consists of on-street parking, tree lawns, or bicycle lanes. Because on-street parking and tree lawn data is not available, bicycle lanes are the only type of buffer used for this analysis.*

Analysis Results

Pedestrian level of service on the County Arterial and Collector Road System varies considerably and is largely a reflection of the presence of sidewalks and the speed and width of the roadway. Nearly one quarter of all County arterials and collectors offer a PLOS 1 or PLOS 2. The majority of roads on the ARS/CRS received a score of PLOS 3 or PLOS 4. The remaining 17 percent of roads received a score of PLOS 5. No sidewalks are present on either side of the roadway for 96 percent of roads designated PLOS 5.

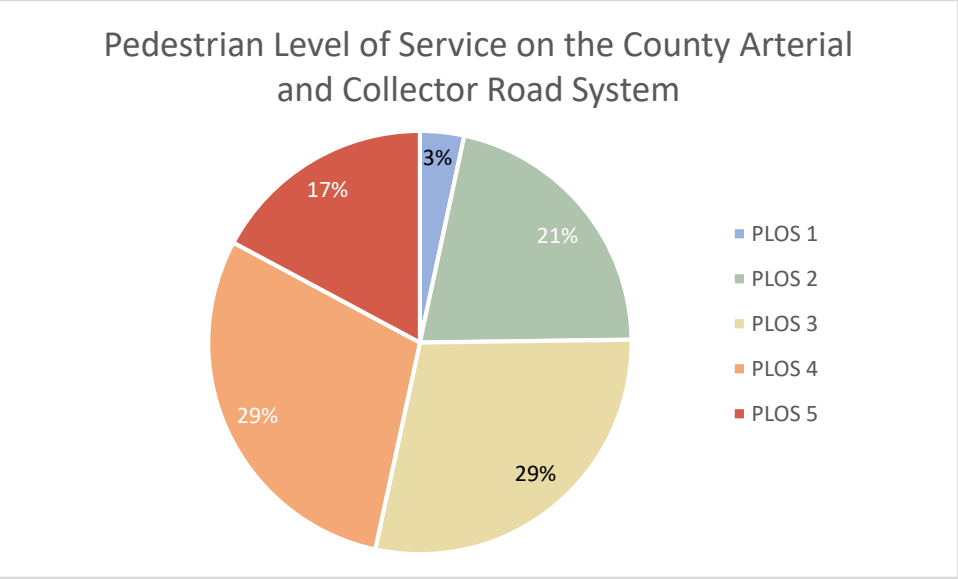


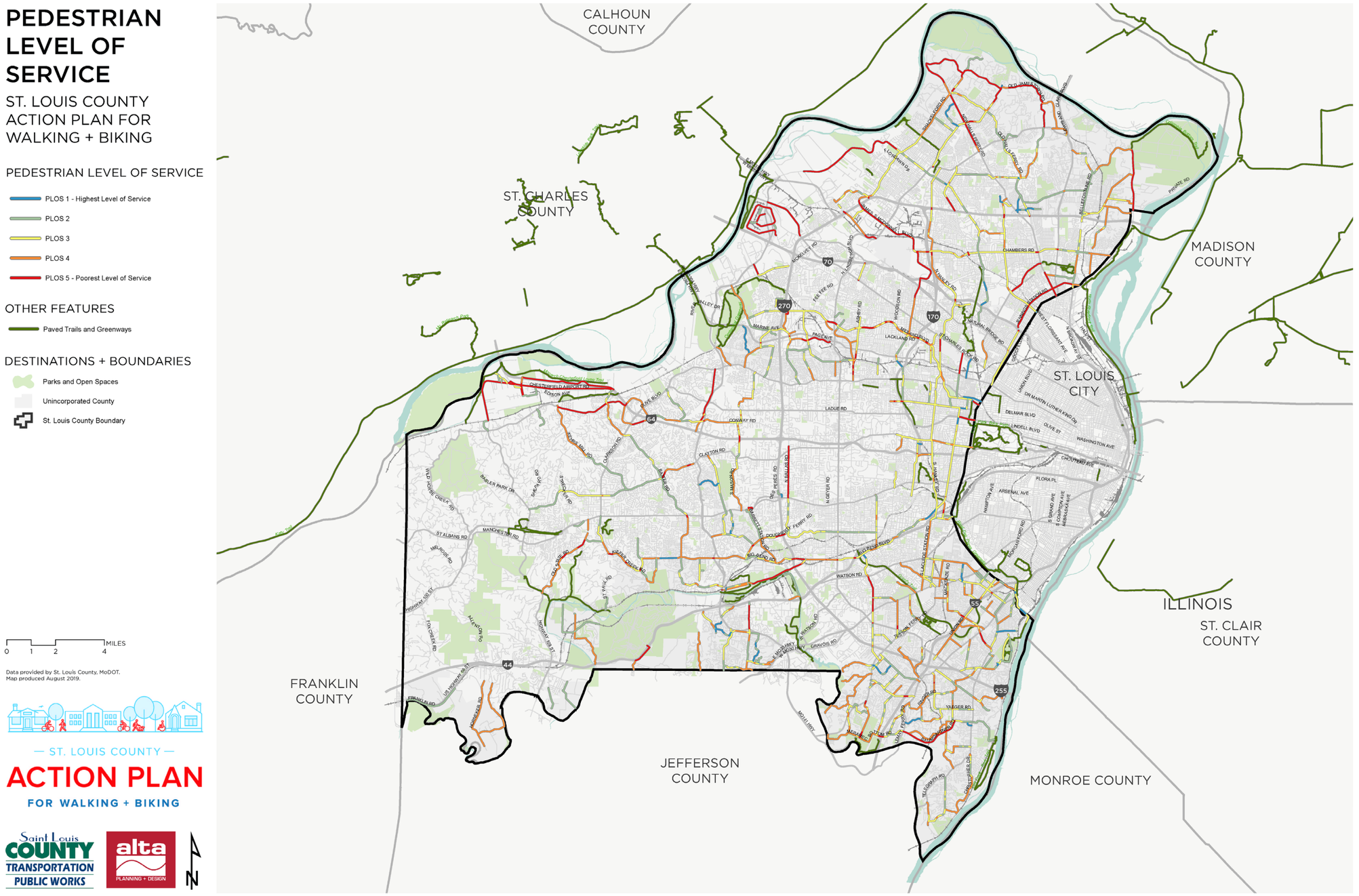
Figure 1: Pedestrian Level of Service on County Arterial and Collector Roadways

Map 1 displays the results of the pedestrian level of service analysis. Road segments in blue (PLOS 1) offer the highest level of service for pedestrian travel, while road segments in red (PLOS 5) offer the lowest level of service for pedestrian travel. These results are also displayed in an ArcGIS Online map located accessible via this link: http://arcg.is/0CHKKr. As the map depicts, pedestrian level of service is neither uniform across St. Louis County, nor is it regularly uniform along a given corridor. The lack of uniformity across St. Louis County reflects the diversity of roadway types and conditions on the County Arterial and Collector Road System, from two-lane rural routes with no pedestrian facilities, to five- and six-lane suburban arterial roads with sidewalks on both sides of the road. This diversity across the system is typical for a pedestrian level of service analysis across a large area. The lack of consistent PLOS scores along some County corridors reflects not only changes in road conditions like posted speed limit and number of travel lanes, but also the presence of sidewalks. The lack of sidewalk continuity along some corridors, like Big Bend Boulevard, Midland Boulevard in Overland, Mason Road in Creve Coeur, and Reavis Barracks Road in South St. Louis County, is a reflection of piecemeal sidewalk installation and spot infill over many decades, often conducted in coordination with other roadway improvements or private developments adjacent to the road.

St. Louis County routinely addresses gaps in the sidewalk network through sidewalk infill projects identified in the sidewalk policy and through larger roadway projects that include pedestrian components. Additionally, the County partners with MoDOT and local agencies to address pedestrian needs on a regular basis. Moving forward, the pedestrian level of service can be used to inform the development and prioritization of recommendations for sidewalk infill and pedestrian enhancements in the Action Plan.

PEDESTRIAN LEVEL OF SERVICE

ST. LOUIS COUNTY ACTION PLAN FOR WALKING + BIKING



— ST. LOUIS COUNTY —

ACTION PLAN

FOR WALKING + BIKING

Saint Louis COUNTY TRANSPORTATION PUBLIC WORKS

alta PLANNING + DESIGN

Map 1: Pedestrian Level of Service for the St. Louis County Arterial and Collector Road System

Bicycle Level of Traffic Stress

A majority of the public would like to walk or ride bicycles more but are discouraged from doing so by perceived safety concerns, lack of facilities, or a lack of knowledge about where the appropriate facilities are located. Surveys nationally show that 50-60 percent of people say they would ride a bicycle more (or start riding) if they had access to facilities that provided more separation from traffic, lower traffic speeds, and/or lower traffic volumes.[2] Additionally, evidence has shown that increasing the number of bicyclists on the road improves safety for all transportation modes. Cities with high bicycling rates tend to have lower crash rates.[3]

The Bicycle Level of Traffic Stress (LTS) Analysis evaluates "a combination of perceived danger and other stressors (e.g., noise, exhaust fumes) associated with riding a bike close to vehicle traffic"[4]. The analysis incorporates roadway and traffic characteristics, including posted speed limit, street width, and the presence and character of bicycle lanes, to categorize each roadway segment and intersection into one of four levels of traffic stress:

- LTS 1 - tolerated by most children
- LTS 2 - tolerated by the mainstream adult population
- LTS 3 - tolerated by "cyclists who are 'enthused and confident' but still prefer having their own dedicated space for riding
- LTS 4 - tolerated only by those characterized as "strong and fearless"

The results of the LTS analysis help identify existing areas with a high level of service as well as focus areas for improvement. LTS provides an intuitive framework to describe the benefits of bicycle infrastructure, and demonstrates that some roadways need more intervention than others to provide a truly comfortable experience.

Methodology

The methods used for the LTS analysis were adapted from the 2012 Mineta Transportation Institute (MTI) Report 11-19: Low-Stress Bicycling and Network Connectivity. The approach outlined in the MTI report uses roadway network data, including posted speed limit, the number of travel lanes, and the presence and character of bicycle lanes, as a proxy for bicyclist stress/comfort level. The method used in this analysis utilizes additional data such as on-street parking, traffic signals, shared-use paths, and motor vehicle volumes (ADT) to provide a more nuanced, context-sensitive interpretation of on-the-ground conditions. A recent study by Furth et al provided additional methodological guidance for incorporating ADT.[5]

The typical Level of Traffic Stress analysis is completed through an assessment of street segments, intersection approaches, and intersections using spatial data and aerial imagery. Figure 2 below depicts these three elements. Broadly, every street link (a section of roadway) receives three scores based on its characteristics: one score for its segment, the space of roadway between intersecting streets; one score for the approach to an intersection, accounting for right turn lanes; and one score for its intersection, where one segment crosses another. However, due to the lack of

---

[2] Roger Geller, City of Portland Bureau of Transportation. Four Types of Cyclists. (2009). http://www.portlandonline.com/transportation/index.cfm?&a=237507.
[3] Marshall, Wesley E., and Norman W. Garrick. "Evidence on why bike-friendly cities are safer for all road users." Environmental Practice 13, no. 1 (2011): 16-27.
[4] Mekuria, Maaza C., Peter G. Furth, and Hilary Nixon. Low-Stress Bicycling and Network Connectivity (2012), 1.
[5] Furth, Peter G., Theja VVK Putta, and Paul Moser. "Measuring low-stress connectivity in terms of bike-accessible jobs and potential bike-to-work trips: A case study evaluating alternative bike route alignments in northern Delaware." Journal of Transport and Land Use 11, no. 1 (2018).

available data for intersection approaches, particularly number, presence, and type of turning lanes, this analysis does not include intersection approaches. See Table 1 below for more information about data limitations and assumptions.

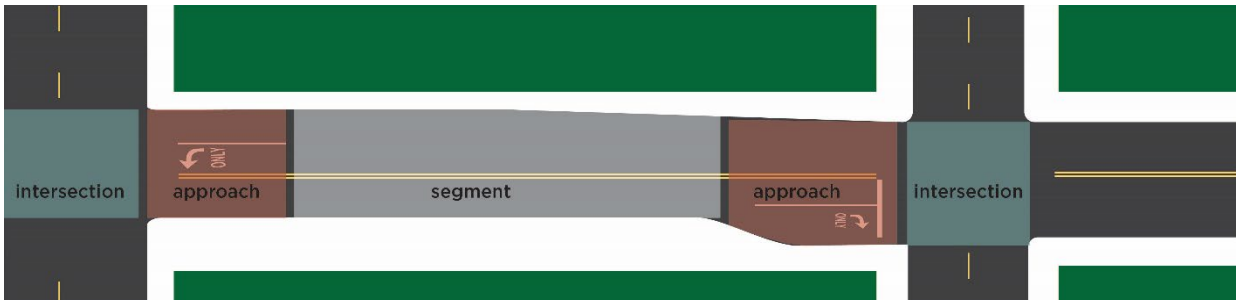


Figure 2: Street link showing the three possible scores it could receive. Because not all links have these three sections, some links may instead receive one or two scores.

The scores assigned are based on a link's characteristics that affect a bicyclist's perception of safety and comfort. The scores range from 1 to 4, where 1 represents the lowest stress, and 4 represents highest stress and discomfort. These three scores determine the overall LTS score. It is important to note that LTS scores are assigned based on a weakest link principle; this means that while a segment may provide a relatively low-stress path, a high-stress intersection will result in an overall high-stress score. The tables below summarize the scoring methodology used in this analysis.

Table 3: LTS Data Inputs and Assumptions

Inputs	*Notes*	*Assumptions*	*Data Source*
Bicycle Facilities	Bicycle lanes have a positive impact on bicycle level of travel stress and are a primary input for developing an LTS model. The width of facilities can have an impact on the associated comfort level. Wider facilities provide greater comfort, especially on higher-speed roadways.	For analysis purposes, a standard width of 5 feet was assumed for all bike lanes within the county. Buffered bike lanes, which provide an additional degree of separation from motor vehicles and great operating space for bicyclists, were considered to be greater than 6 feet, meeting the requirements for the LTS 1 widths outlined in the following tables.	Great Rivers Greenway's Gateway Bike Plan Network feature class, which includes MoDOT, GRG, St. Louis County, and municipal bicycle facilities.
Speed Limit	Higher 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 county and city limits.	St. Louis County street centerline feature class
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. Bicycle levels of travel stress are greater on bicycle lanes adjacent to parking than on bicycle lanes without parking due to the potential for 'dooring' incidences.	Without parking location data readily available, the LTS analysis assumes that no bike lanes are located adjacent to on-street parking.	Data not available.

Inputs	Notes	Assumptions	Data Source
ADT	Average annual daily traffic (ADT) estimates the volume of motor vehicle traffic on a given roadway, which can impact a bicyclists' experience and comfort.	While these traffic volumes in the HPMS may differ from those provided by St. Louis County, they are already tied to existing street centerlines and therefore ready for inclusion in the analysis. The St. Louis County traffic count points feature class will be used elsewhere in the planning process to verify traffic volumes and inform plan recommendations.	Federal Highway Administration's 2017 Highway Performance Monitoring System (HPMS) shapefile
Number of Travel Lanes	Roadways with multiple travel lanes in each direction are generally considered to be less comfortable for bicyclists, particularly in mixed traffic, whereas two-lane roadways are considered more comfortable.		Federal Highway Administration's 2017 HPMS shapefile
Shared Use Path Location	Shared use paths and sidepaths can be a vital component of a municipality's active transportation network. Increased separation from motor vehicles can improve comfort and safety; however, trails are still impacted by the quality of roadway crossings.	For roadways with adjacent shared use paths (sidepaths), an LTS score was still generated for on-street bicycling. Roadway crossings were evaluated; however, most crossings occurred at a signalized intersection.	Great Rivers Greenway's Gateway Bike Plan Network feature class, which includes MoDOT, GRG, St. Louis County, and municipal bicycle facilities.
Signalized Intersection Locations	The LTS analysis processes signalized and unsignalized intersections differently. Signalized intersections offer safer, more comfortable crossing opportunities by controlling motor vehicle traffic and reducing conflicting movements.	Data only available for St. Louis County-owned intersections. To identify traffic signals not owned by St. Louis County, it will be assumed that traffic signals are present at the intersection of any two or more roads that are part of the Federal-Aid system (functionally classified roads).	St. Louis County signalized intersections feature class, Federal Highway Administration's 2017 HPMS shapefile
Turn Lanes	Right turn lanes at intersection approaches create merging areas where bicyclists and motor vehicles share space or cross paths. These shared spaces and conflict zones create less comfortable conditions for people bicycling.	Because this data is not readily available, intersection approaches will not be analyzed as part of this LTS analysis.	Data not available

The following tables specify the scoring criteria based on roadway configuration, bike lane and parking presence, crossing condition, and presence of right turn lane. The criteria are adapted from the original 2012 Mineta Institute report. These tables are used in combination to create the segment, approach, and intersection scores described above.

Table 4: Criteria for Level of Traffic Stress in Mixed Traffic

Number of Lanes	Effective ADT*	Prevailing Speed (mph)						
		< 20	25	30	35	40	45	50+
2-way street without a centerline	0 - 750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751 - 1500	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4
	1501 - 3000	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4	LTS 4
	3000+	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
1 thru lane per direction (1-way, 1-lane street or 2-lane street with centerline)	0 - 750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751 - 1500	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4
	1501 - 3000	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	3000+	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
2 thru lanes per direction	0 - 8000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	8001+	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
3+ thru lanes per direction	Any ADT	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4

**Lower value is used for streets without marked centerlines or classified as residential with fewer than 3 lanes.*

Table 5: Criteria for Bike Lanes Not Alongside a Parking Lane

Number of Lanes	Bike Lane Width (ft)	Prevailing Speed (mph)					
		< 25	30	35	40	45	50+
1 thru lane per direction, or street without a centerline	6+	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 - 5	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
2 thru lanes per direction	6+	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 - 5	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
3+ thru lanes per direction	Any width	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4

Table 6: Criteria for Bike Lanes Alongside a Parking Lane*

Number of Lanes	Bike Lane Reach (Bike Lane + Parking Lane Width) (ft)	Prevailing Speed (mph)		
		< 25	30	35
1 lane per direction	15+	LTS 1	LTS 2	LTS 2
	12-14	LTS 2	LTS 2	LTS 2
2 lanes per direction (2-way)	15+	LTS 2	LTS 2	LTS 2
2-3 lanes per direction (1-way)		LTS 2	LTS 2	LTS 2
Other multilane		LTS 3	LTS 3	LTS 3

**This table will not be used for this LTS analysis due to lack of available data.*

Table 7: Criteria for Unsignalized Crossings

Width of Street Being Crossed	Speed Limit of Street Being Crossed			
	Up to 25 mph	30 mph	35 mph	40 mph or more
Up to 3 lanes	LTS 1	LTS 1	LTS 2	LTS 3
4-5 lanes	LTS 2	LTS 2	LTS 3	LTS 4
6+ lanes	LTS 4	LTS 4	LTS 4	LTS 4

Table 8: Approach Criteria

Configuration	LTS
Single right-turn lane with length less than or equal to 75 feet	No effect on LTS
Single right-turn lane with length between 75 and 150 feet	LTS 3
Otherwise*	LTS 4

** This table will not be used for this LTS analysis due to lack of available data regarding intersection approaches.*

Analysis Results

The analysis of level of traffic stress for the County Arterial and Collector Road System and for roadways with existing and planned Gateway Bike Plan routes indicates generally unfavorable conditions for bicycling along these roads. The network's reliance on higher-speed, higher-volume, multi-lane roadways is a key determinant in the overall low scores for level of traffic stress. As shown in Figure 3, just ten percent of the roadways analyzed received a score of LTS 1 (generally comfortable for most adults and children) or LTS 2 (generally comfortable for most adults). In contrast, nearly half the network received a score of LTS 4 and is characterized by levels of traffic stress only tolerable to those described as "strong and fearless".

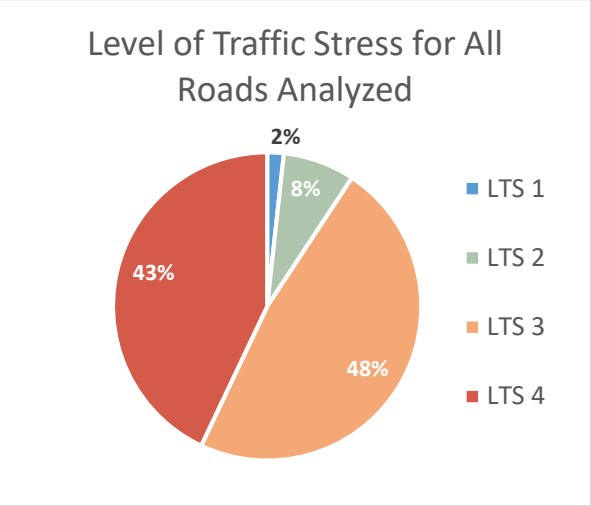


Figure 3: Level of Traffic Stress for All Roads Analyzed

The results of the bicycle level of traffic stress analysis are displayed in Map 2 on the following page. These results are also displayed in an ArcGIS Online map located accessible via this link: http://arcg.is/1eqe4K. Many major arterials that support longer trips and provide access to major destinations for both motor vehicle users and for people bicycling are characterized by levels of traffic stress that discourage bicycling for all but the strong and fearless group

of bicyclists, which typically includes recreational road cyclists and some commuter cyclists. These roads include both MoDOT and County-owned roads like Manchester Road, Olive Boulevard, Clarkson Road, St. Charles Rock Road, Gravois Road, Lemay Ferry Road, Hanley Road, Chambers Road, and Lindbergh Boulevard. Lower stress roadways generally fall into one of three categories:

- Low-speed, low-volume local and collector roadways in more urban and suburban settings, such as Holmes Avenue in Kirkwood, Amiot Road in Maryland Heights, Pacific Avenue in Webster Groves, Mathilda Ave in Affton, and Dale Avenue in Richmond Heights;
- Rural collectors in southwest St. Louis County with very low volumes of traffic, like Allenton and Alt Roads in Wildwood, Forby and Eureka Roads in Eureka, and Horneker and Allen Roads in unincorporated St. Louis County; and
- Arterial and collector roads with dedicated bicycle facilities, such as Manchester Road in Wildwood, Wydown Boulevard in Clayton, West Lockwood Avenue in Glendale, Big Bend Road in unincorporated St. Louis County (east of Dougherty Ferry Road), Natural Bridge Road in Normandy, and Woodson Road in Overland.

As the results indicate, investments in dedicated bicycle facilities have a noticeable impact on level of traffic stress. In general, collectors and arterials with higher travel speeds and vehicular volumes will require greater separation to improve the level of comfort for a wide range of ages and abilities. Where facility development on arterial and collector roadways is impractical or infeasible, alternate routing along local roadways can provide low-stress access to nearby destinations and support low-stress regional connectivity. Greenways and trails, particularly linear regional trails like Grant's Trail, St. Vincent Greenway, and the Ted Jones Trail can also extend low-stress networks, cross major barriers, and bridge gaps in the low-stress network. While these off-street facilities are not included in the level of traffic stress analysis because there is no motor vehicle traffic permitted on these facilities, they are displayed in Map 2 to highlight their potential to contribute to the low-stress bikeway network in St. Louis County, and the connections to these assets in the overall network should be facilitated by providing low stress connections to these facilities.

BICYCLE LEVEL OF TRAFFIC STRESS

ST. LOUIS COUNTY ACTION PLAN FOR WALKING + BIKING

LEVEL OF TRAFFIC STRESS

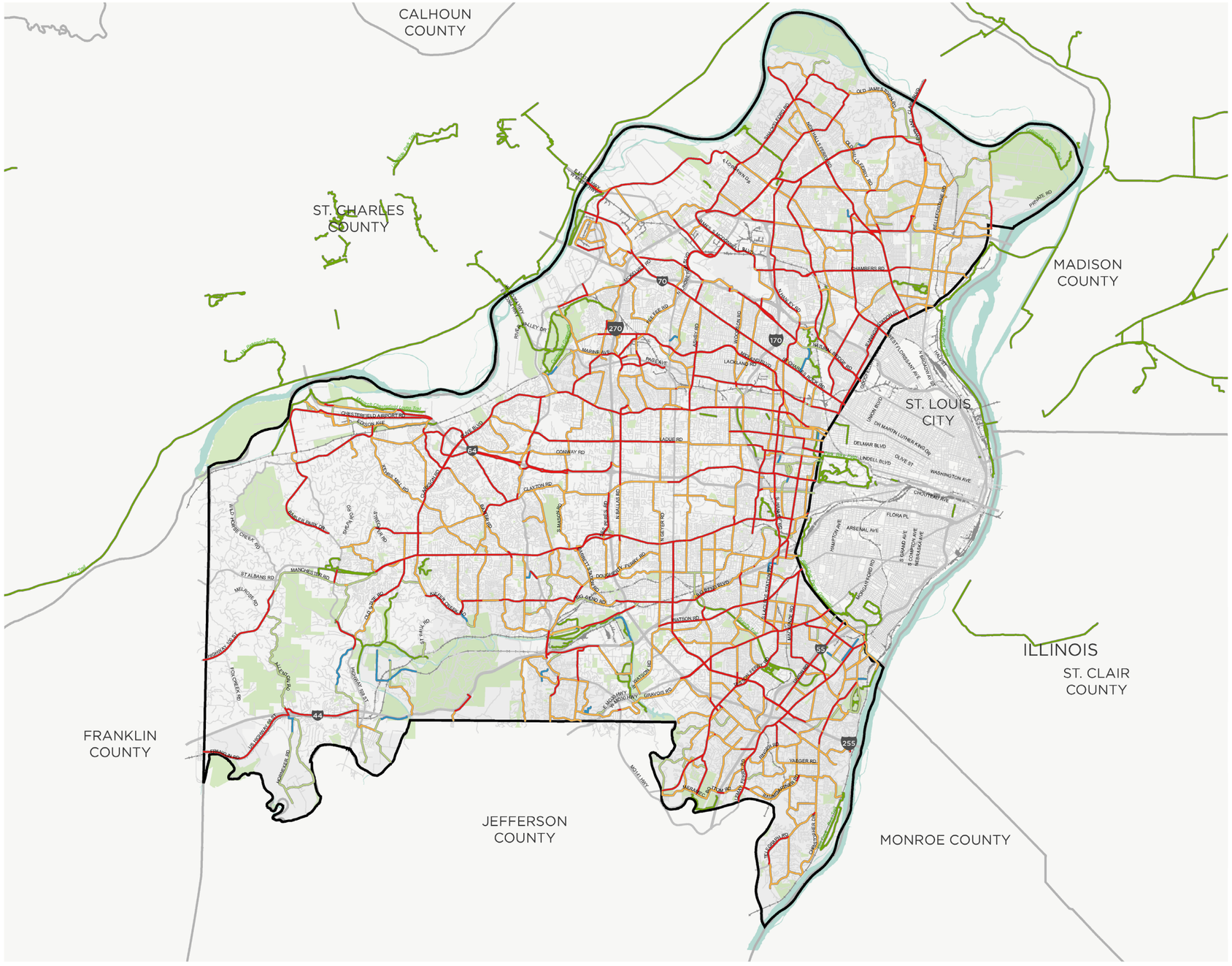
- LTS 1 (Most Comfortable)
- LTS 2
- LTS 3
- LTS 4 (Least Comfortable)

OTHER FEATURES

- Paved Trails and Greenways

DESTINATIONS + BOUNDARIES

- Parks and Open Spaces
- Unincorporated County
- St. Louis County Boundary



Data provided by St. Louis County, MoDOT.
Map produced August 2019.

— ST. LOUIS COUNTY —
ACTION PLAN
FOR WALKING + BIKING

Saint Louis COUNTY TRANSPORTATION PUBLIC WORKS

alta PLANNING + DESIGN

N

Map 2: Bicycle Level of Traffic Stress Results