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MEMORANDUM

August 28, 2025

To: Patrick Trouba, Bobby Evans
Organization: Mid-America Regional Council
From: Lucas Yu, Hugh Kelley, Scott Harris
Project: MARC Regional Bike Plan

Re: Level of Traffic Stress Methodology

Background

A Bicycle Level of Traffic Stress (LTS) analysis identifies the stress of street networks for people bicycling based on the built environment, traffic speed, and traffic volume characteristics of street segments. LTS is one of the key inputs to a Bicycle Network Analysis, which will be developed in the next phase of the project. The methodology used to identify LTS is adapted from criteria published by Dr. Peter Furth of Northeastern University and the Mineta Transportation Institute.[1] The LTS analysis scores street segments on a scale from 1 to 4, with LTS 1 and 2 indicating low stress and LTS 3 and 4 indicating higher levels of stress.

Purpose

The stress that individuals feel when bicycling is both a product of facility design and user perceptions of safety. Some people are comfortable riding with more and/or faster-moving motor vehicle traffic and with less separation. However, as shown in Figure 1, people generally fall into less stress-tolerant categories based on differing levels of bicycling confidence:

- Not Interested or Able
- Interested but Concerned (The majority of the adult population)
- Somewhat Confident (Risk averse but comfortable cyclists)
- Highly Confident (Most risk tolerant cyclists)

[1] Furth, P. G. (2014). Level of Traffic Stress Criteria. https://peterfurth.sites.northeastern.edu/level-of-traffic-stress/

Comfort Typology of Bicyclists

Design User Profile	Not Interested or Able	Interested but Concerned	Somewhat Confident	Highly Confident
Percent of General Public	31-37%	51-56%	5-9%	4-7%

Figure 1: Types of Bicyclists and Traffic Stress Tolerance

A small portion of the population is likely comfortable bicycling in heavy and fast-moving traffic, however members of the Interested but Concerned group typically make up the majority of the population who can or would like to bicycle.[2] This group prefers bicycle facilities separated from vehicles, bicycle routes on streets with low traffic speeds and volumes, or a combination of both to consider traveling by bike. Therefore, measuring the LTS of the existing transportation network can help determine the quality of the bike network from the perspective of most potential cyclists.

To serve “Interested but Concerned” members of the community, the quality of bike facilities are related to the rider’s level of confidence seen in Figure 2. Only LTS 1 facilities are generally acceptable to users like small children and other low-confidence users. Capable but cautious or concerned users are often comfortable on LTS 2 facilities like calm residential streets and buffered bike lanes along busier streets. Finally, somewhat and highly confident users will comfortably share major streets with car traffic of varying quantities and speeds and LTS scores of 3 or 4.

[2] Dill, J., & McNeil, N. (2013). Four Types of Cyclists?: Examination of Typology for Better Understanding of Bicycling Behavior and Potential. Transportation Research Record, 2387(1), 129–138. https://doi.org/10.3141/2387-15

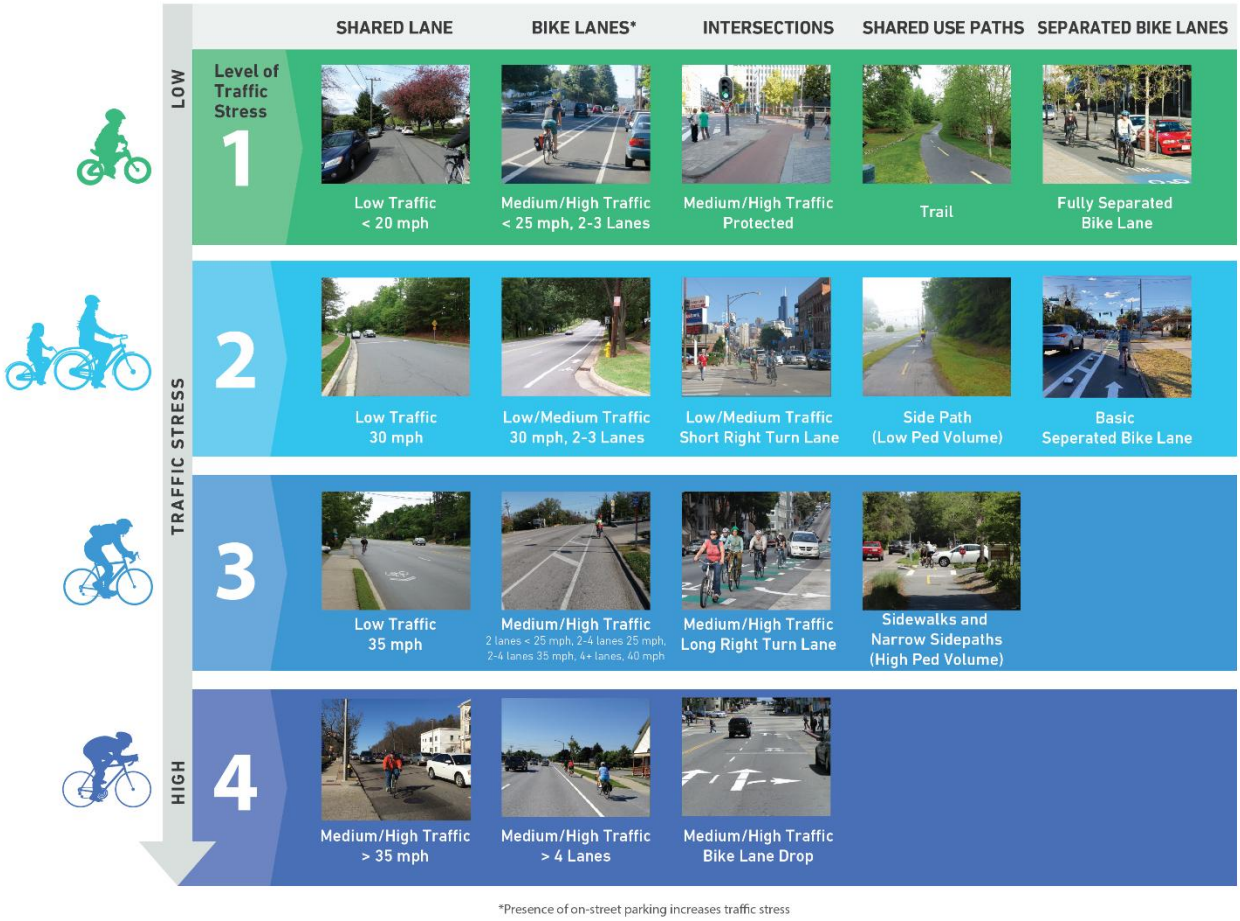

Figure 2: Level of Traffic Stress (LTS) and corresponding facility and street types[3]

Methodology

The LTS analysis yielded scores for the region's street network (except for limited access highways) using the inputs and methodology discussed in this section.

Bicycle Facilities

The LTS analysis determines comfort level on existing bicycle facilities based on facility type. Existing facility types, as well as assumptions guiding the stress scores for bicycle facilities in the region are listed below:

- **Trail**: assumed to be low stress (LTS 1).
- **Protected bike lane:** assumed to be low stress (LTS 1)
- **Bike lane**: whether these are low- or high-stress depends on other street characteristics such as lane and street geometry, traffic volume, traffic speeds, and parking.
- **Shared roadway facility, including sharrows and neighborhood bikeways:** similar criteria as bike lanes as the presence of sharrows or signage does not positively impact a street's stress level.

[3] For LTS scoring purposes, high, medium, and low traffic generally refer to greater than 6,000 AADT, greater than 3,000 and below 3,000 AADT respectively. Refer to Table 2 for further detail.

Street Network Characteristics

For streets without protected bike lanes, the following street segment characteristics are factors in the LTS scores:

- Posted speed
- Number of travel lanes per direction
- Average daily traffic (ADT) volume
- Presence of on-street parking lanes
- Presence of a centerline

Assumptions were applied for inputs where data was not available and are documented below. Overall, streets with speed limits at or above 25 miles per hour with traffic volumes above 3,000 vehicles per day are considered "high stress" if they do not have any sort of dedicated bicycle facility (e.g., bike lanes or protected bike lanes). Streets with two or more lanes per direction (or streets with only one lane per direction where speeds exceed 30 miles per hour) are typically only considered "low stress" if they have protected bike lanes.

Data Sources and Assumptions

Toole Design developed the base roadway network for the BLTS analysis by merging the MARC 911 and MoDOT centerlines, incorporating lane counts, functional class, and partial one-way data. While MoDOT includes traffic volumes and MARC 911 contains some one-way information, both values were incomplete in the whole MARC region. To ensure regional consistency and fill these gaps, 2024 traffic volumes from Replica were used as the sole source for traffic data, and one-way directionality from OpenStreetMap was selectively joined and conflated only to supplement missing data in the base network.

Two additional datasets were provided during review of the LTS draft results. The first was an internal MARC data set that included more complete speed limit values. This data set was used to review and confirm the assumptions for speeds across different functional classes. The primary observation made was that unlike the rest of the study area, where local road speeds are 25 mph, local streets in Wyandotte County were 30 mph. Wyandotte County speed limit data is reflected in the LTS dataset and does not require assumptions by functional class so all other local roads can be assumed 25 mph.

The second additional dataset reviewed was MARC modelled AADT volumes. This included primarily arterials and some collectors. The project team used Replica AADT values dataset instead because it included all streets, the data was known to be recent values for 2025 and because it was based on OSM centerlines, which had already been conflated to the MARC and MoDOT centerlines in order to use the one-way data. For collectors and arterials, AADT is generally not a key consideration since the lane count and speed limits above 30 mph result in those roads being high stress regardless of traffic volumes. Indeed, on arterials and collectors, lower volumes can result in significantly higher speeds depending on the design of the road. In contrast, AADT above 3000 cars per day is the threshold at which an unlined road or road with a single lane in each direction becomes LTS 3 or 4 depending on the speed limit. Thus, the Replica estimates for local roads are very valuable to the analysis.

Together, this combined data set provided most of the necessary inputs required to perform LTS analysis on most streets in the region. For streets with missing information, assumptions were made based on the functional class of the street. These assumptions are shown in Table 1. Interstates and other limited-access roads were excluded from the analysis.

Table 1: Street Characteristic Assumptions by Functional Classification

Functional Classification	Posted Speed	Travel Lanes per Direction	ADT[4]
Principal Arterial	40 mph	3	20,000
Minor Arterial	35 mph	2	5,000
Major/Minor Collector	30 mph	1	3000
Local Street	25 mph	0[5]	500

[4] ADT has a greater impact on streets in shared condition; however, ADT above 3,000 does not further impact the stress level (everything above 3,000 ADT will be high stress—LTS 3 or 4) so it is not critical to be accurate above that threshold.

[5] Zero lane per direction is used to indicate local streets with no presence of centerline.

Score Calculation

LTS was computed based on the type of bicycle facility present on a street and the street's characteristics, provided or assumed, based on the thresholds in Table 2.

Table 2: Level of Traffic Stress Thresholds

Mixed traffic criteria

Number of lanes	Effective ADT[6]	Posted Speed (MPH)						
		≤ 20	25	30	35	40	45	50+
2-way street with no 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 4	LTS 4
	1501-3000	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	3000+	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
1 thru lane per direction (1-way, 1-lane street or 2-way 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 4	LTS 4
	1501-3000	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4
	3001-6000	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	6001-10000	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	10001+	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
2 thru lanes per direction	0-6000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	6001-12000	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
	12001+	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
3+ thru lanes per direction	any ADT	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4

Bike lanes and shoulders not adjacent to a parking lane[7]

Number of lanes	Bike lane width[8]	Prevailing Speed (MPH)					
		≤ 25	30	35	40	45	50+
1 thru lane per direction, or unlaned	6+ ft	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 4
	4 or 5 ft	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4
2 thru lanes per direction	6+ ft	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4	LTS 4
	4 or 5 ft	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4	LTS 4
3+ lanes per direction	any width	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4

Bike lanes alongside a parking lane

Number of lanes	Bike + Pkg lane width[9]	Prevailing Speed (MPH)				
		≤ 20	25	30	35	40+
1 lane per direction	15+ ft	LTS 1	LTS 1	LTS 2	LTS 2/3[11]	LTS 4
	14 ft	LTS 2	LTS 2	LTS 2/3[10]	LTS 3	LTS 4
	12-13 ft	LTS 2	LTS 2/3[11]	LTS 2/3[11]	LTS 3	LTS 4
2 lanes per direction (2-way) 2-3 lanes per direction (1-way)	15+ ft	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
	14 ft	LTS 2/3[11]	LTS 2/3[11]	LTS 3	LTS 4	LTS 4
	12-13 ft	LTS 2/3[11]	LTS 2/3[11]	LTS 3	LTS 4	LTS 4
other multilane		LTS 3	LTS 3	LTS 3	LTS 4	LTS 4

[6] Effective ADT = ADT for two-way roads; Effective ADT = 1.67*ADT for one-way roads

[7] If bike lane / shoulder is frequently blocked, use mixed traffic criteria. Qualifying bike lane / shoulder should extend at least 4 ft from a curb and at least 3.5 ft from a pavement edge or discontinuous gutter pan seam

[8] Bike lane width includes any marked buffer next to the bike lane.

[9] Qualifying bike lane must have reach (bike lane width + parking lane width) ≥ 12 ft. Bike Lane width includes any marked buffer next to the bike lane.

[10] Rating depends on parking turnover. Low turnover (i.e. residential) = LTS 2, high turnover (i.e. commercial or mixed use) = LTS 3. "Parking turnover" is interpreted as "parking usage" since turnover data is nonexistent and the bigger factor in a lot of places lower-density places is having mostly empty parking lanes that can create a low-stress environment. This analysis assumed all parking was high usage and turnover.

Results

LTS evaluates the level of traffic stress experienced by bicyclists, with lower scores indicating more favorable conditions for biking and higher scores indicating unfavorable conditions. The scores are defined as follows:

- LTS 1 – Very low traffic stress (Acceptable to children, older adults, etc.)
- LTS 2 – Low traffic stress (Interested but concerned, acceptable to most potential bicyclists)
- LTS 3 – Moderate traffic stress (Enthused/Confident)
- LTS 4 – High stress (Strong/Fearless)

The mileage of streets with different LTS is summarized in Table 3 by different functional class categories. As shown in the table, while most regional roadways are LTS 1 or LTS 2, nearly all low LTS streets are non-arterial streets (collectors, local streets, and separated or off-street bike facilities).

Table 3: Summary Statistics of LTS Mileage by Functional Class

LTS Category	Total Mileage	Mileage Percentage	Milage by Functional Class	Milage by Functional Class	Percentage By Functional Class
LTS 1	11,341.8	61.21 %	Arterial	28.9	0.15 %
			Non-Arterial	11199.5	58.47 %
LTS 2	3,137.7	16.94 %	Arterial	51.6	0.27 %
			Non-Arterial	3092.3	16.14 %
LTS 3	1,782.6	9.62 %	Arterial	296.8	1.55 %
			Non-Arterial	1489.2	7.77 %
LTS 4	2,267.0	12.24 %	Arterial	1488.5	7.77 %
			Non-Arterial	881.3	4.60 %

Figure 3 presents the LTS distribution by county, and the region-wide LTS results are plotted in Figure 4; to reduce visual clutter in the dense roadway network, only arterial roads and separate bike facilities are displayed. The LTS results for local streets and minor collectors regionwide are shown in Figure 5.

The Appendix to this memo includes an LTS map for each county in the MARC region and citywide maps for each of the six largest cities in the region.

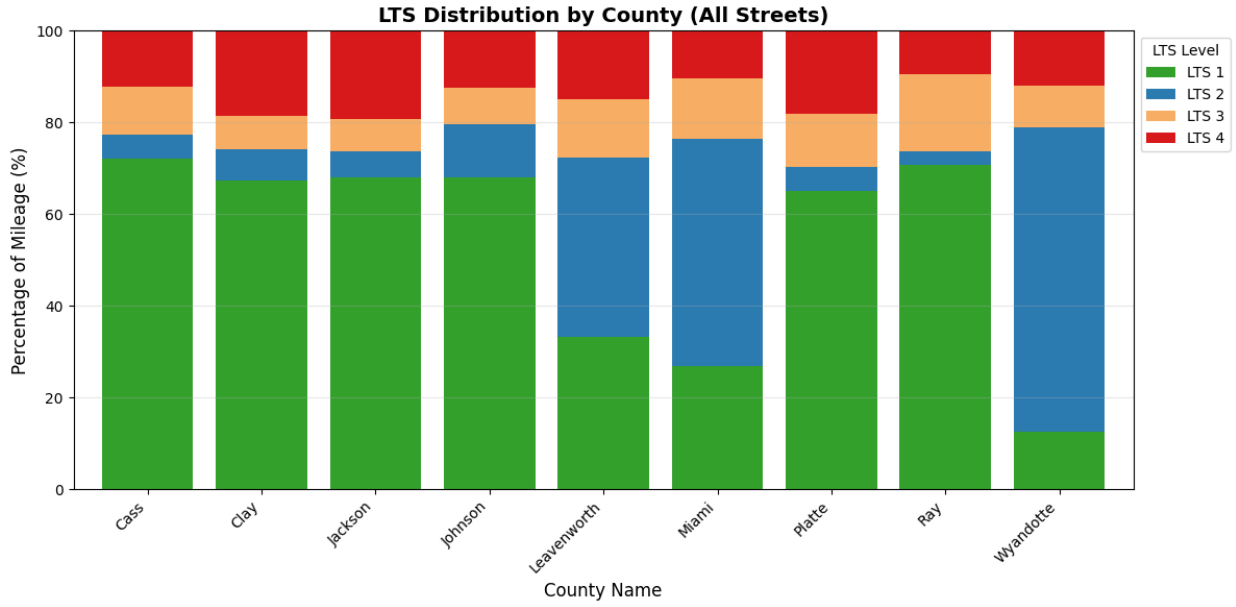

Figure 3: LTS Distribution by County

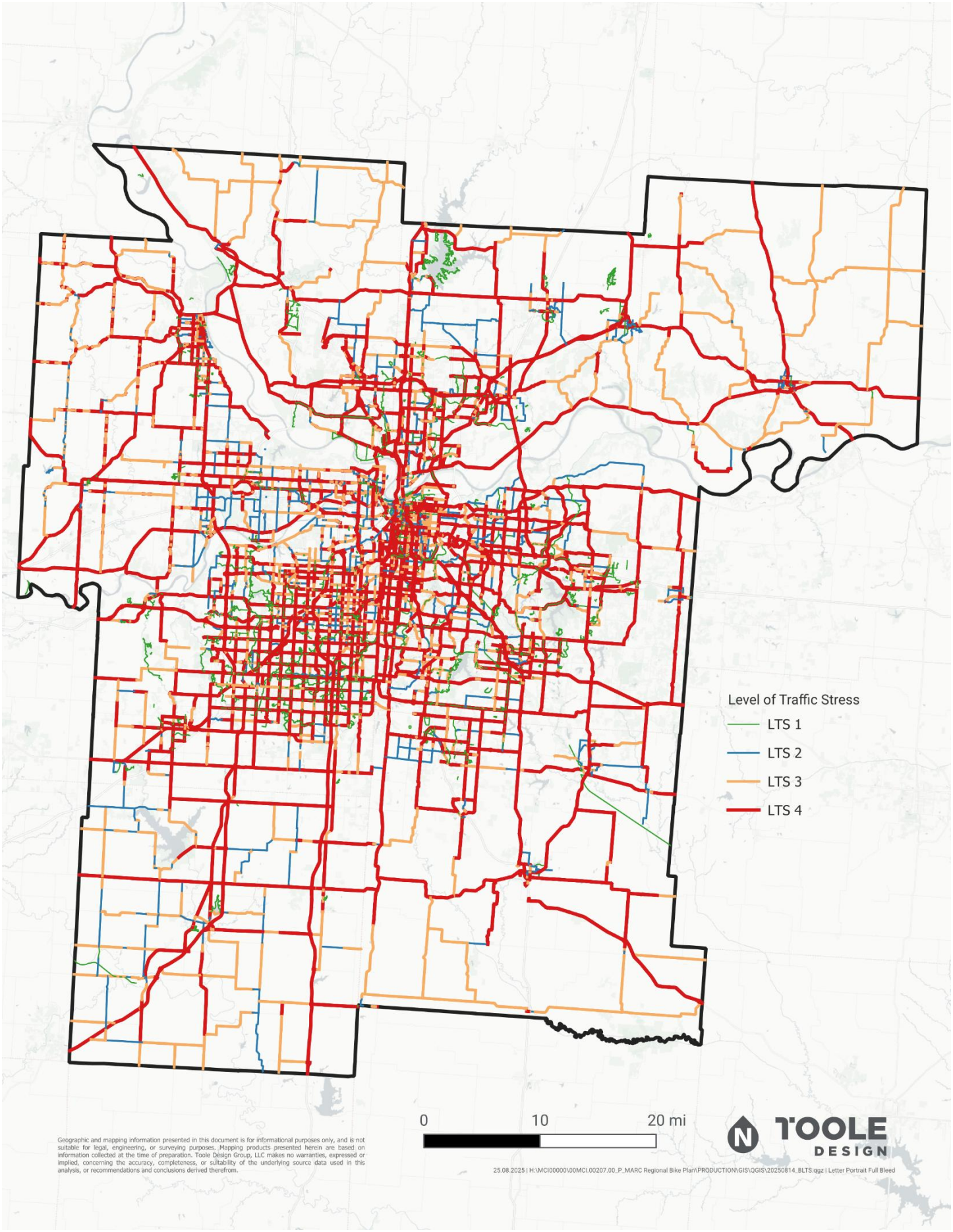

Figure 4: Level of Traffic Stress – Arterial Roads and Separated Bike Facilities

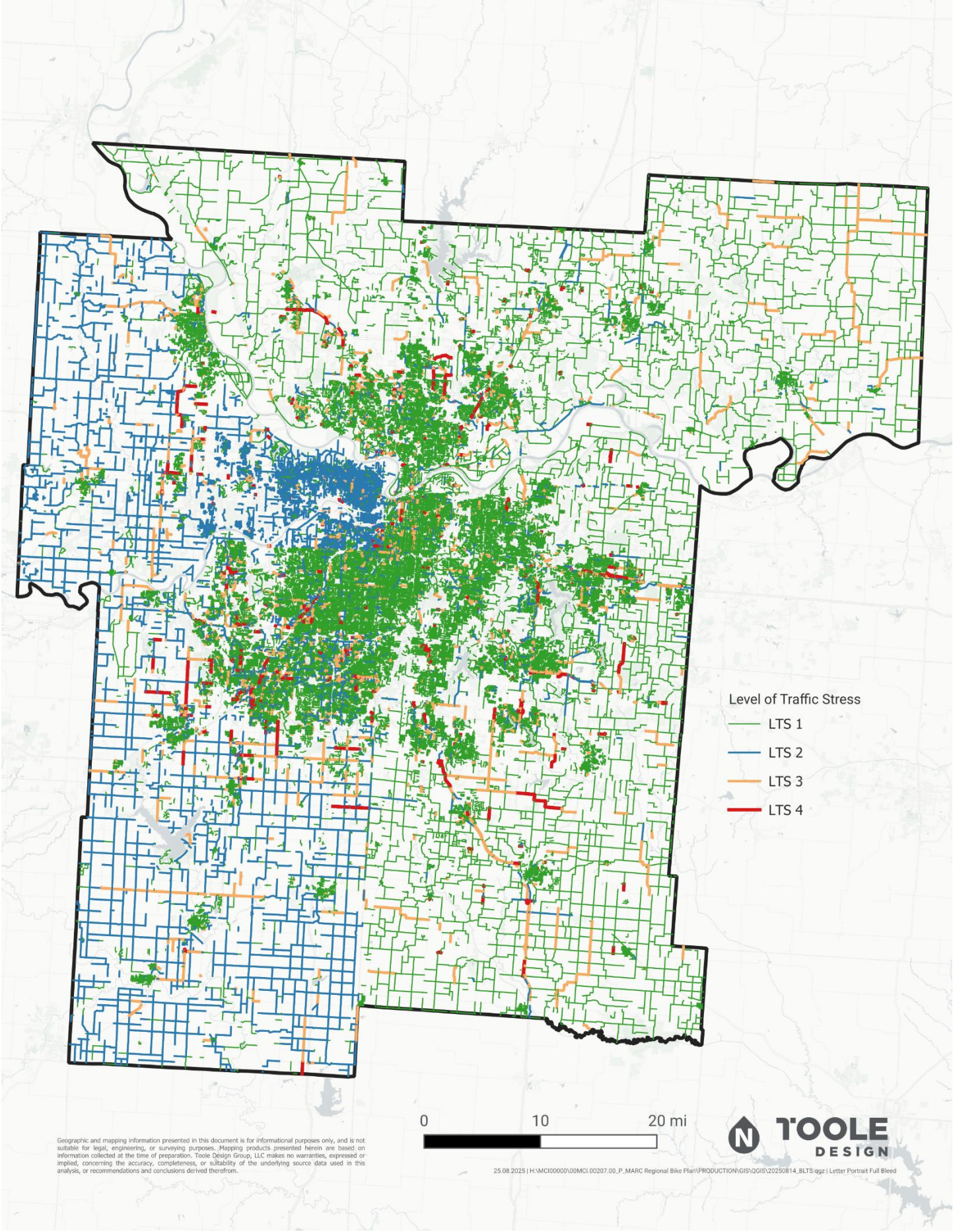

Figure 5: Level of Traffic Stress – Local Streets and Minor Collectors

Appendix

LTS Results - Jackson County, MO

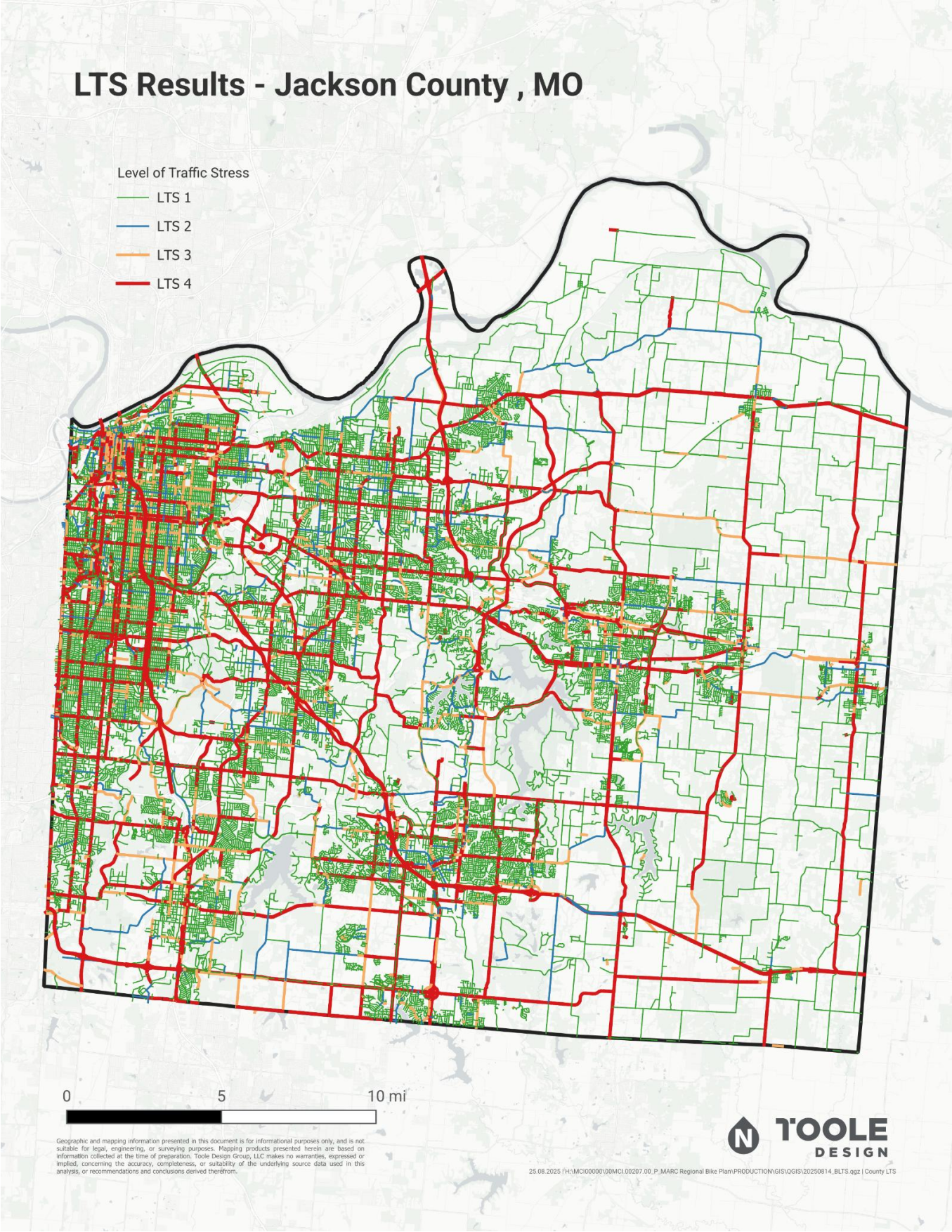

Figure 6: Level of Traffic Stress – Jackson County, MO

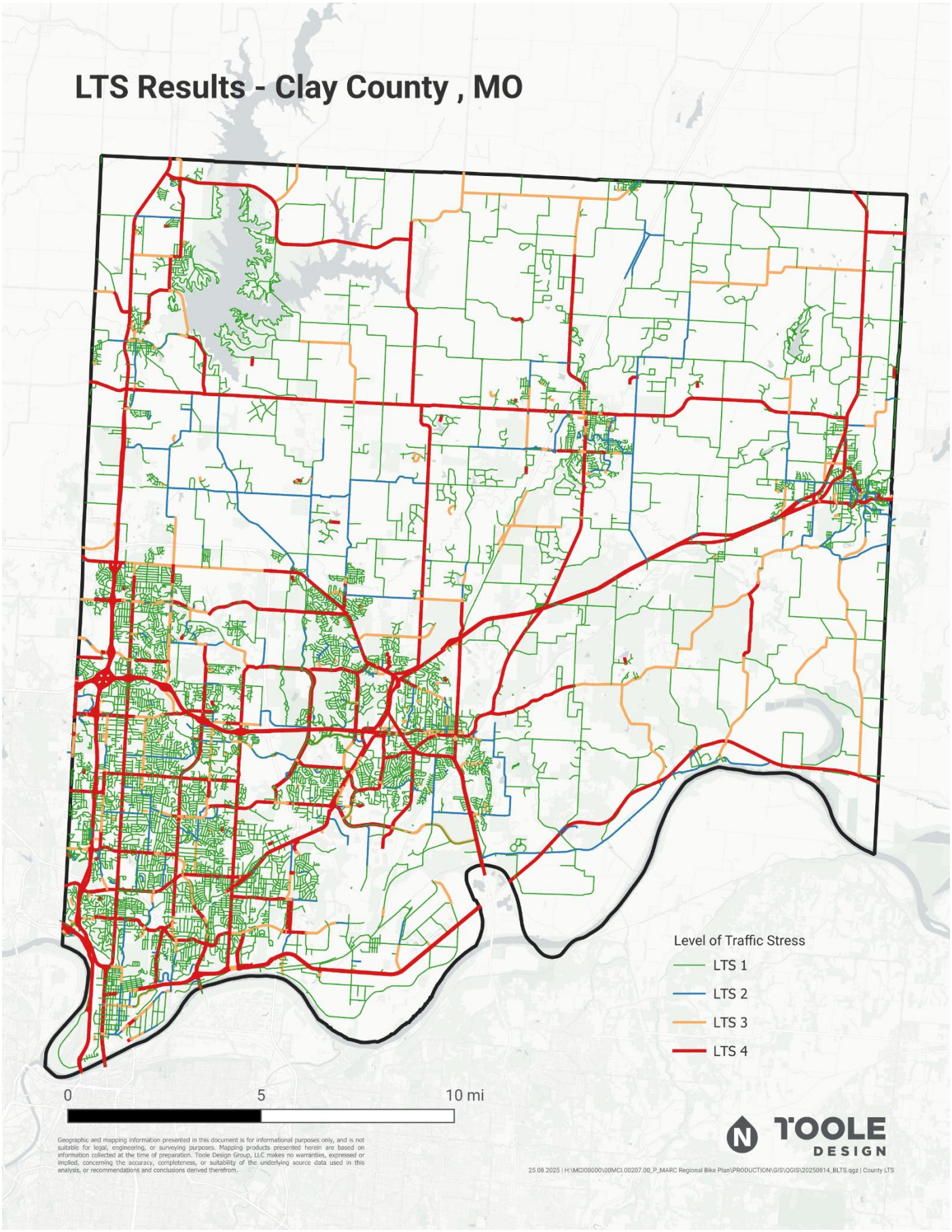

Figure 7: Level of Traffic Stress – Clay County, MO

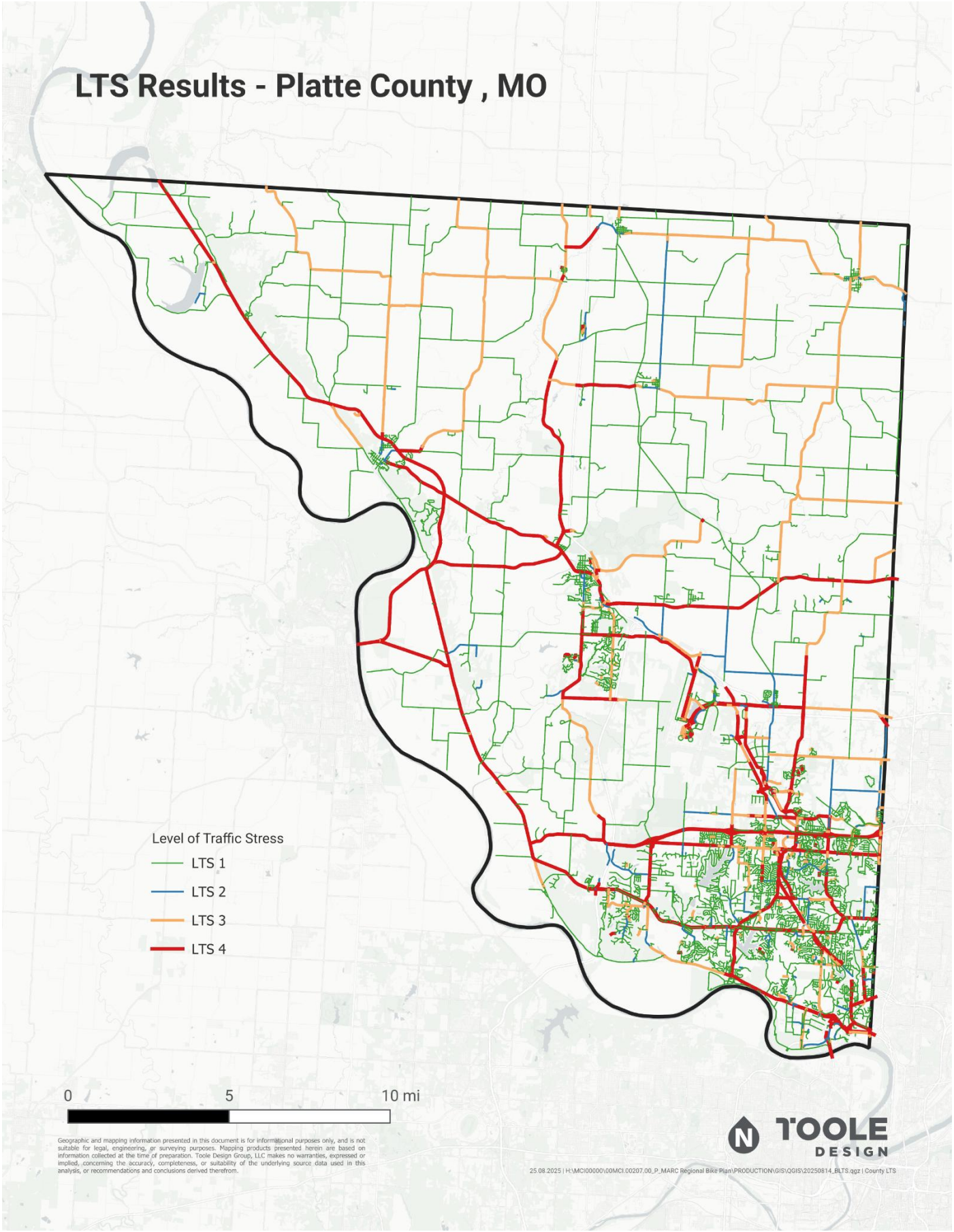

Figure 8: Level of Traffic Stress – Platte County, MO

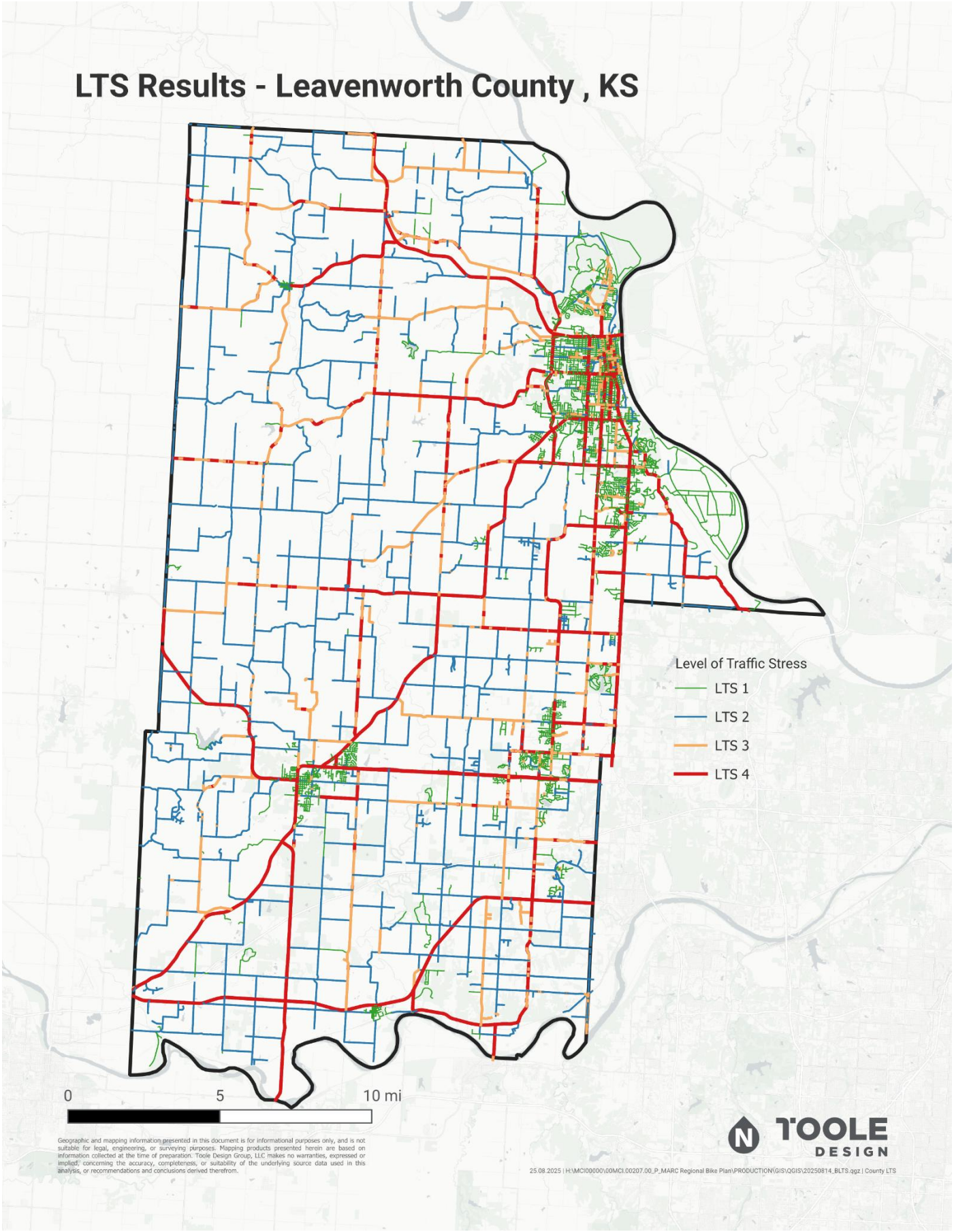

Figure 9: Level of Traffic Stress – Leavenworth County, MO

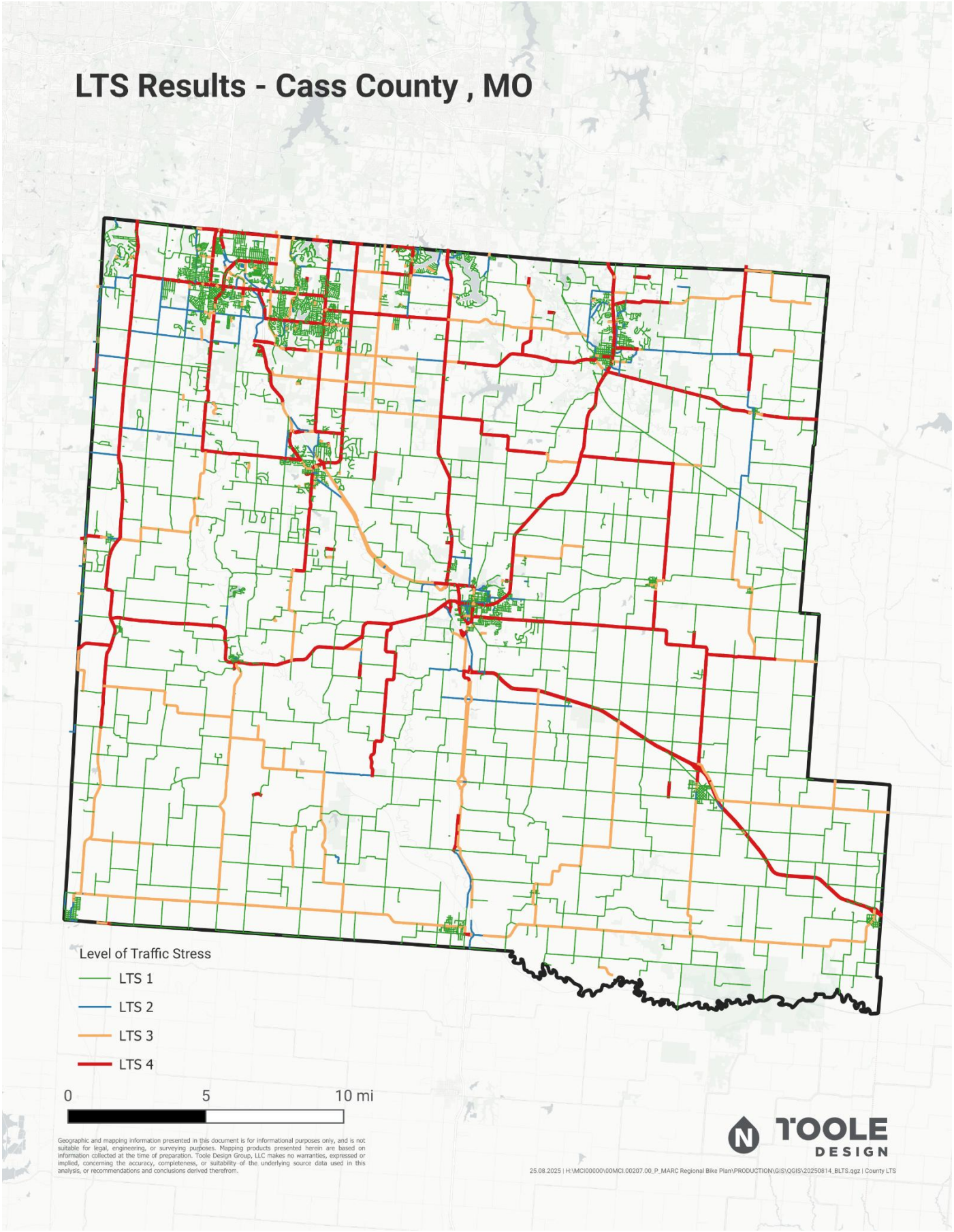

Figure 10: Level of Traffic Stress – Cass County, MO

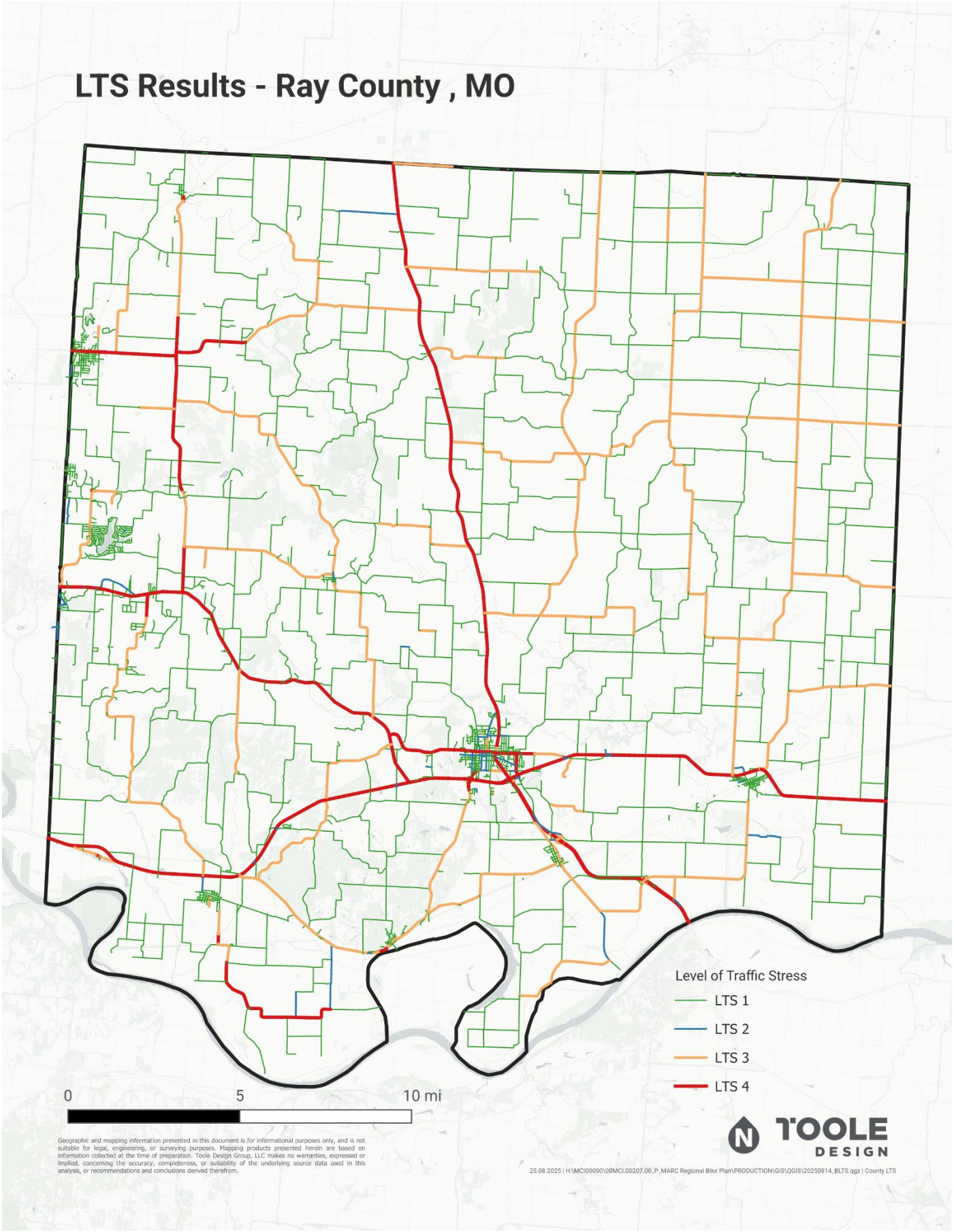

Figure 11: Level of Traffic Stress – Ray County, MO

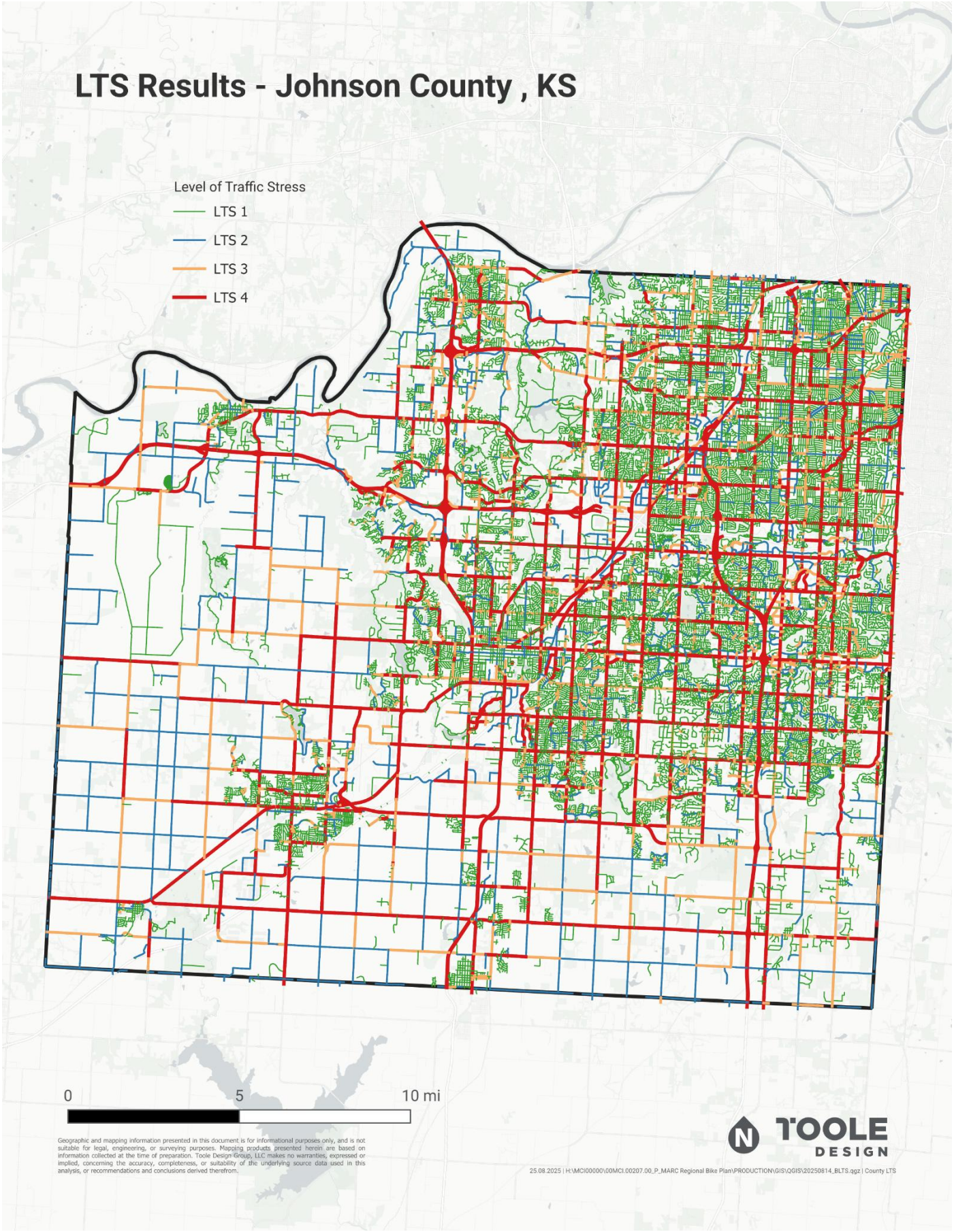

Figure 12: Level of Traffic Stress – Johnson County, KS

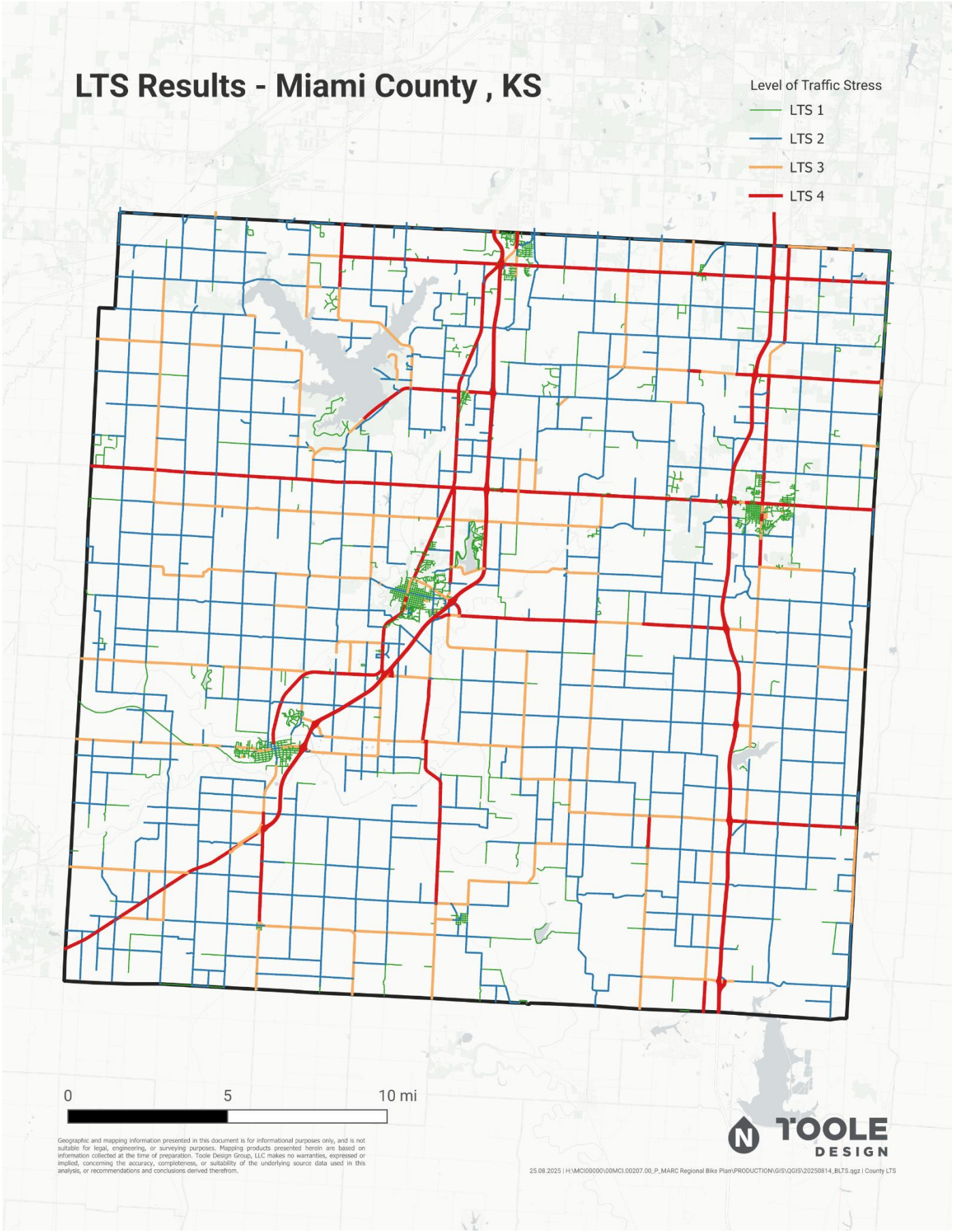

Figure 13: Level of Traffic Stress – Miami County, KS

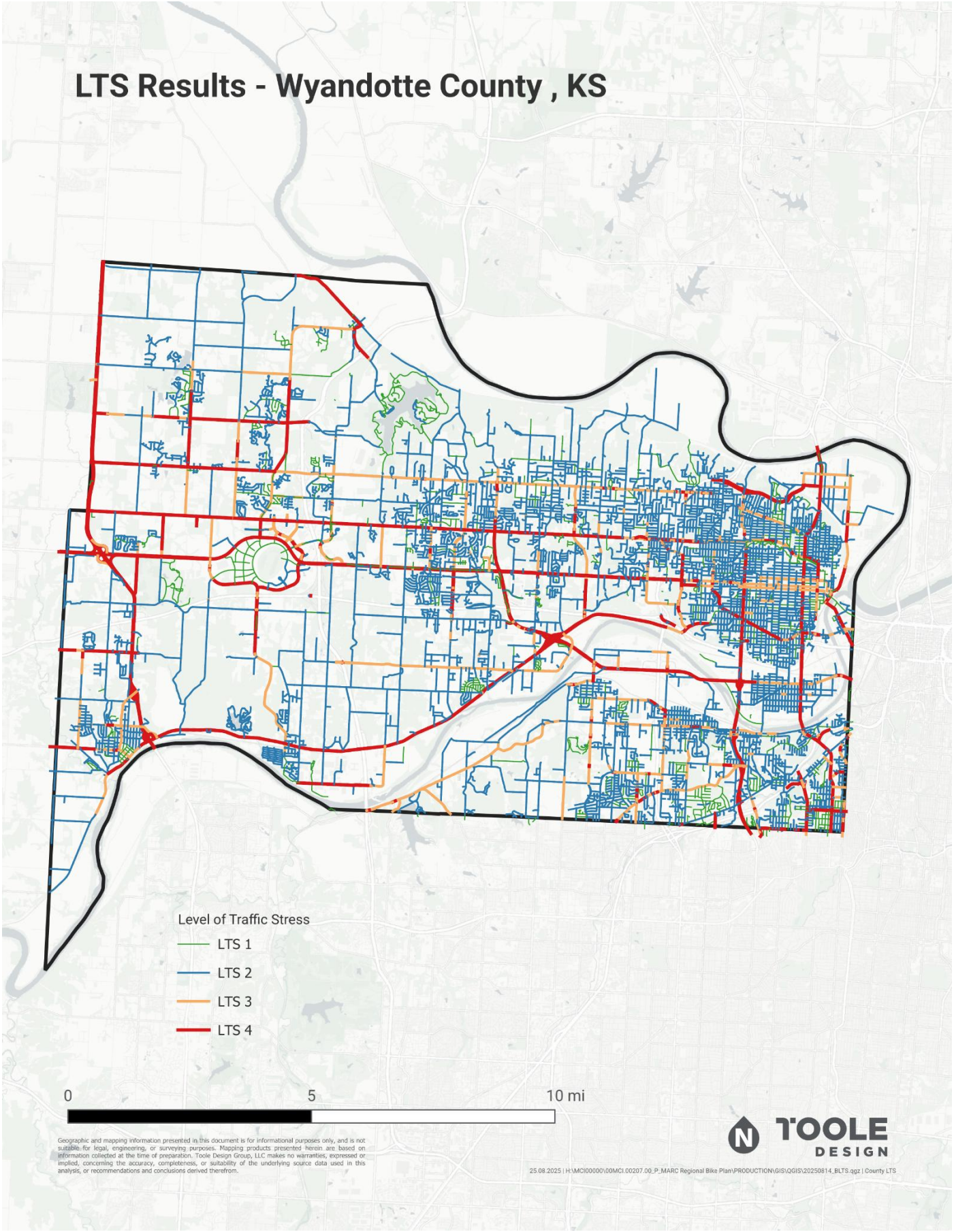

Figure 14: Level of Traffic Stress – Wyandotte County, KS

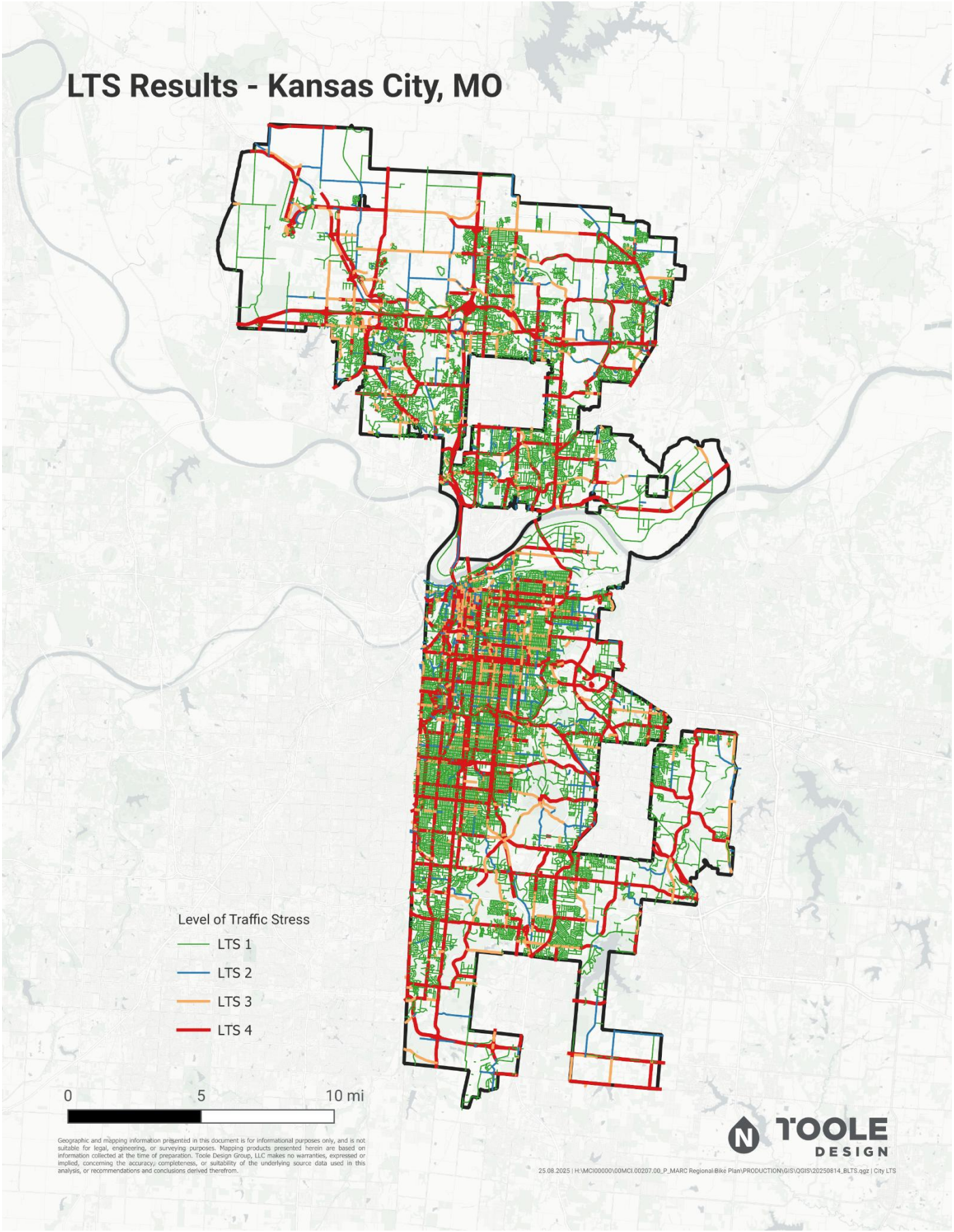

Figure 15: Level of Traffic Stress – Kansas City, MO

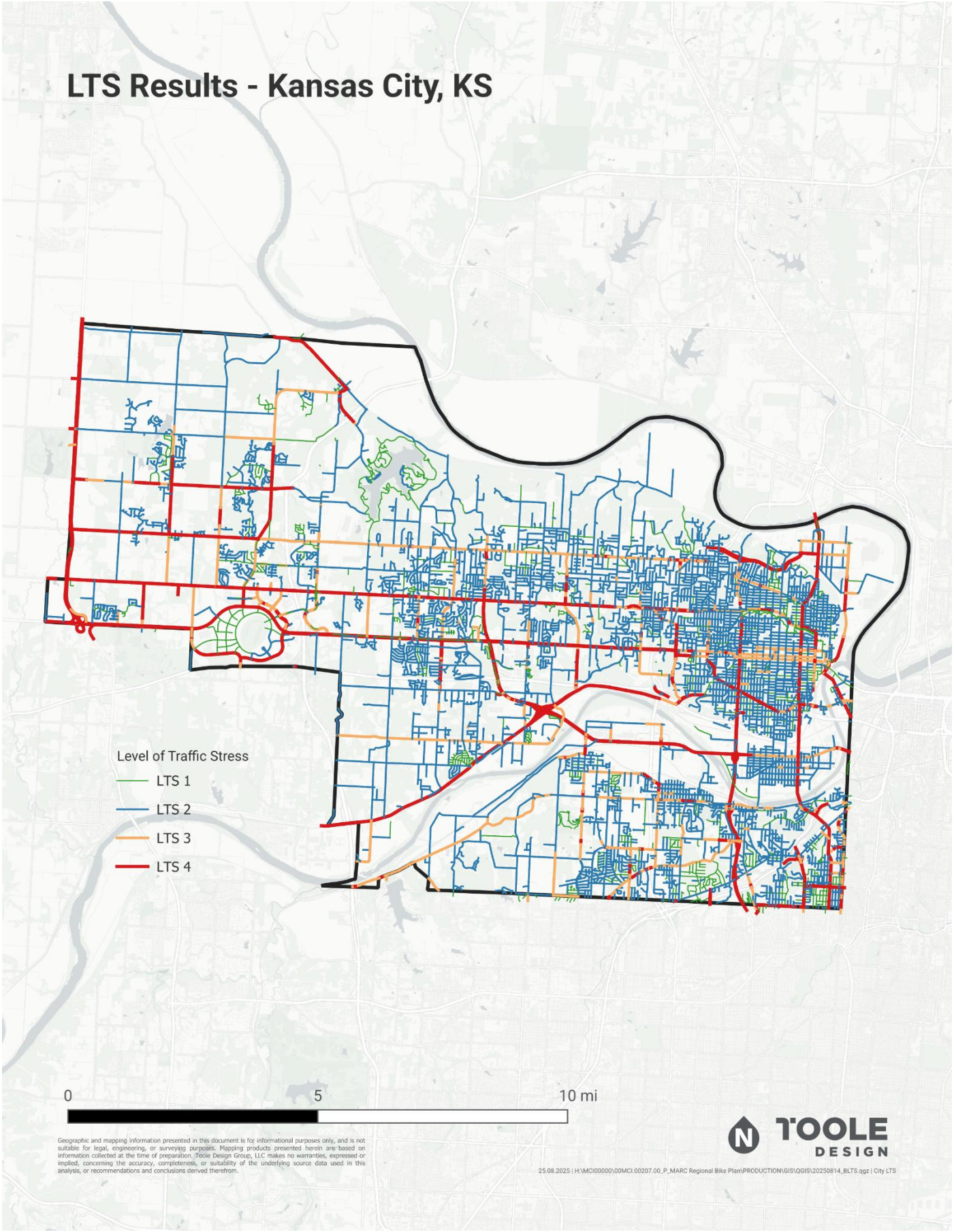

Figure 16: Level of Traffic Stress – Kansas City, KS

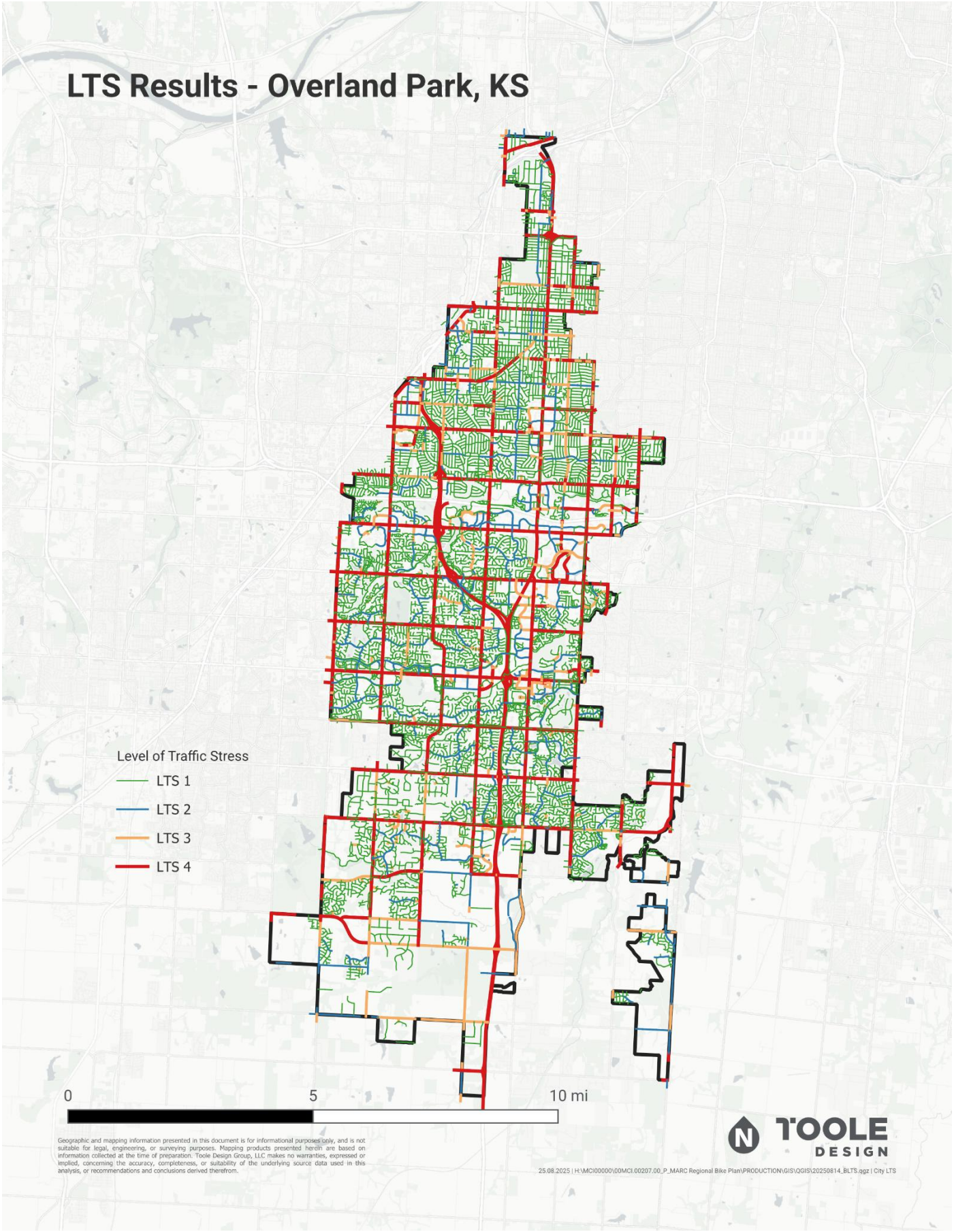

Figure 17: Level of Traffic Stress – Overland Park, KS

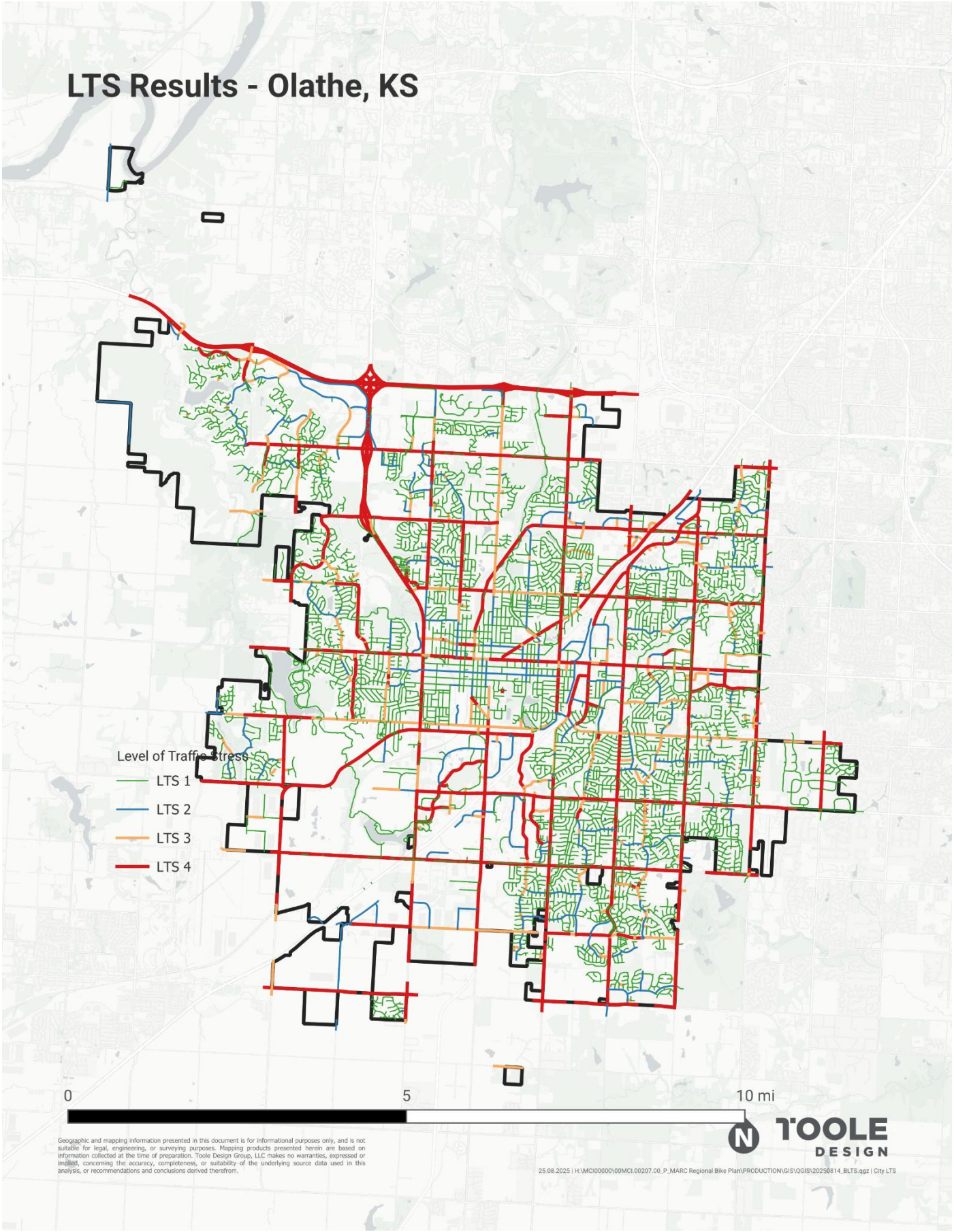

Figure 18: Level of Traffic Stress – Olathe, KS

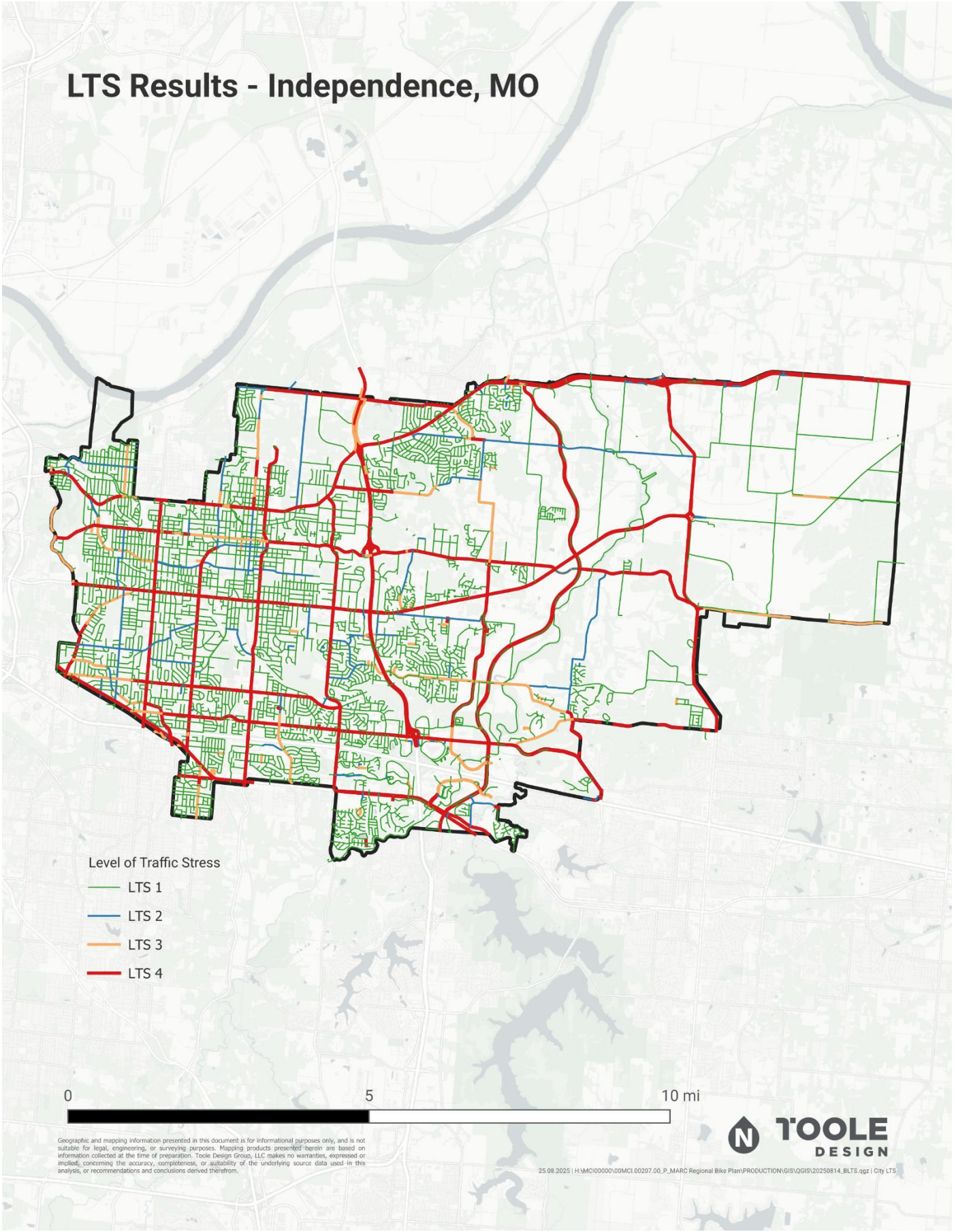

Figure 19: Level of Traffic Stress – Independence, MO

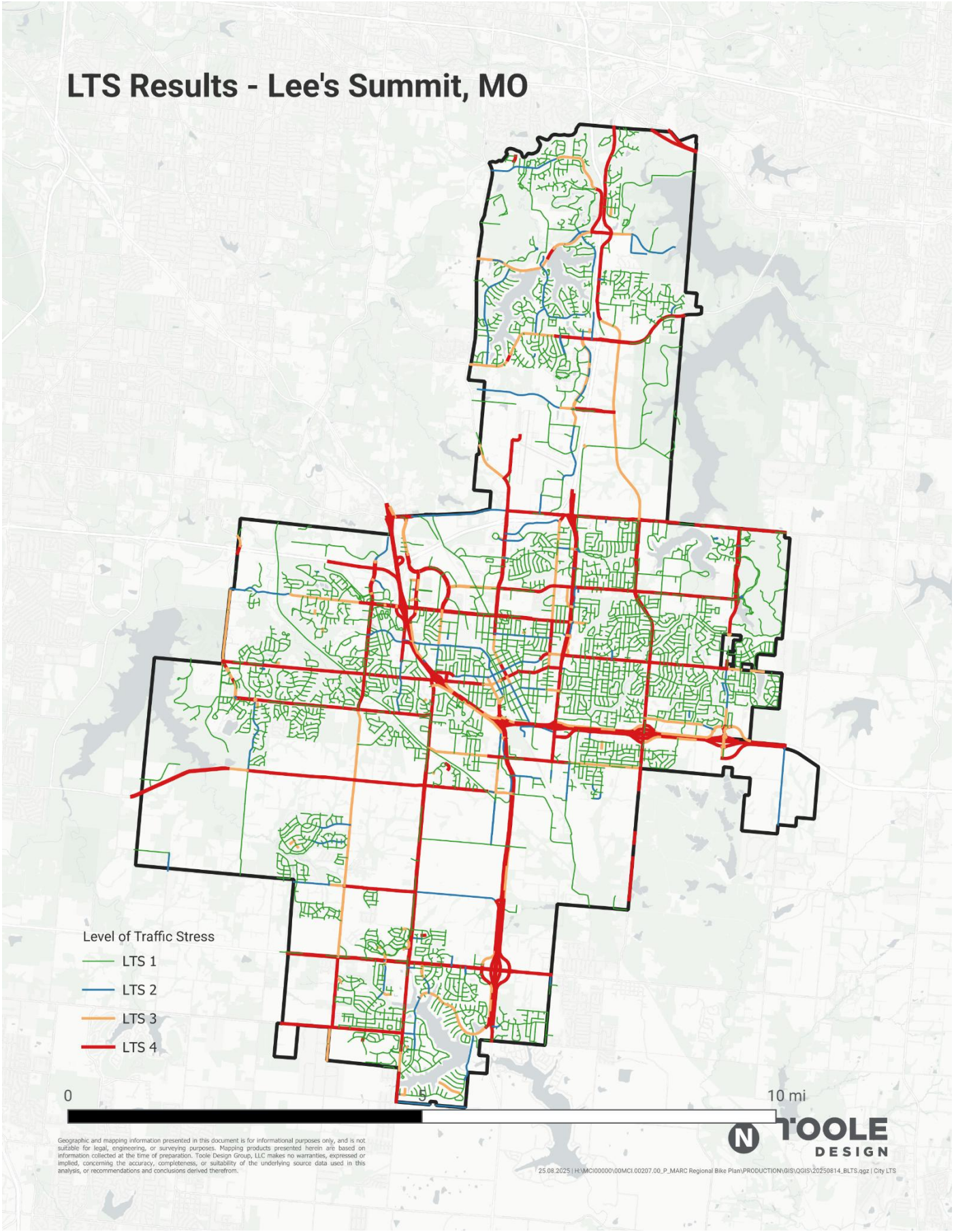

Figure 20: Level of Traffic Stress – Lees's Summit, MO