TECHNICAL MEMORANDUM

Date:	October 21, 2020	*Project Number:*	089-388
To:	Joanna X.J. Liu, P.E. Assistant Civil Engineer	*Project Name:*	East Avenue Corridor Study
From:	Ruta Jariwala Project Manager	*Jurisdiction:*	City of Livermore

Subject: ***Bicycle Level of Traffic Stress – East Avenue Corridor***

This memorandum assesses the Bicycle Level of Traffic Stress (BLTS or LTS) on East Avenue Corridor. The Bicycle LTS analysis methodology is adopted from the Livermore Bicycle, Pedestrian, & Trails Active Transportation Plan (ATP) and has been adjusted to reflect more in-depth analysis for the corridor.

INTRODUCTION

The Bicycle LTS approach quantifies the amount of discomfort that people feel when bicycling. It assigns a numeric stress level to roadway segments, trails, and intersections based on attributes such as motor vehicle speed, volume, number of lanes, lane blockage, on-street parking, and ease of intersection crossing. The higher the LTS, the higher the discomfort. The implication of higher LTS is the possibility for improving bicycle infrastructure to make such bicycle facility safe and comfortable for all types of users. The following describes the four LTS levels of bicycle facilities generally perceived from the user perspective:

- ***LTS 1:*** Very low traffic stress. Most children feel comfortable bicycling.
- ***LTS 2:*** Low traffic stress. The mainstream adult population feels comfortable bicycling.
- ***LTS 3:*** Moderate traffic stress. Bicyclists who are considered “enthused and confident” but still prefer having their own dedicated space feel comfortable while bicycling.

- ***LTS 4:*** High traffic stress. Only "strong and fearless" bicyclists feel comfortable while bicycling. These routes have high-speed limits, multiple travel lanes, limited or non-existent bicycle lanes and signage, and large distances to cross at an intersection.

LTS patterns are mapped spatially to identify stress islands and corridors. The purpose of the LTS analysis is to identify opportunities for infrastructure improvements that provide low-stress "bridges" between islands (Rodriguez, Fang, & Harvey, 2019).

Figure 1 Bicycle Level of Traffic Stress

In the ATP, East Avenue was classified as most stressful (LTS 4). The factors of analysis in ATP included speed limit, roadway width, number of lanes, intersection conditions, presence and character of bicycle facilities, and land use context. Furthermore, the intersections of East Avenue & Madison Avenue and East Avenue & Almond Avenue is classified as Least Stressful (LTS 1), remaining all the intersection were classified as most stressful (LTS 4).

To conduct a comprehensive and thorough analysis, the East Avenue Corridor is further divided into four homogenous segments based on adjacent land use and roadway geometrics as shown in **Figure 2**. Similar to the ATP, the BLTS analysis here is also divided into two parts:

- Street Segment Analysis
- Intersection and Crossing Analysis

Street Segment Analysis

The BLTS street segment methodology is adopted from Appendix G of the ATP. In addition to the parameters included in the ATP such as presence of bicycle facility, this analysis also considers vehicular volume and the presence of on-street parking. **Tables 1, 2 and 3** describes the additional criteria for evaluating the LTS score based on Average Daily Traffic (ADT) volume, and parking lane width (Maaza C. Mekuria, Peter G. Furth, & Hilary Nixon, 2012). Mixed traffic conditions are roadways without any bike markings (including widened shoulders not marked as bike lanes), or existing bike lanes with useable width less than 4 feet. Markings and signs give bicyclists more perceived safety and warn drivers about bicycles potentially being in the roadway, which tends to lower overall speeds. Mixed traffic segment criteria for urban/suburban sections are based on the speed limit or the prevailing speed if different, and the number of lanes by direction, and the two-way average daily traffic (ADT).

Table 1. BLTS Criteria based on Average Daily Traffic Volumes for Urban Mixed Traffic Segment

Number of Lanes	ADT (vpd)	Functional Class	Posted or Prevailing Speed (mph)				
			25	30	35	40	>45
1 through lane per direction	≤750	Local	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3
	750 - ≤1,500	Local/ Collector	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
	1,500 - ≤3,000	Collector	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
	>3,000	Arterial	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
2 through lane per direction	≤8,000	Arterial	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4
	>8,000	Arterial	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4
3+ through lanes per direction	Any ADT	Arterial	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4

Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis

The segment Livermore Ave to Madison Ave (1 and 2) can be considered as mixed traffic segment with no bike facility. The segment Madison Ave to Vasco Rd (3 and 4) has on an average 7 ft. wide bike lanes on both sides with no adjacent parking. **Table 4** summarizes the segment BLTS analysis for East Avenue.

Table 2. Criteria: Bike Lane alongside a Parking Lane

	1 lane per direction			≥ 2 lanes per direction	
Prevailing or Posted Speed	≥ 15’ bike lane + parking	14’ – 14.5’ bike lane + parking	≤ 13’ bike lane + parking or Frequent blockage	≥ 15’ bike lane + parking	≤ 14.5’ bike lane + parking or Frequent blockage
≤ 25 mph	LTS 1	LTS 2	LTS 3	LTS 2	LTS 3
30 mph	LTS 1	LTS 2	LTS 3	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 3	LTS 3	LTS 3
≥40 mph	LTS 2	LTS 4	LTS 4	LTS 3	LTS 4

Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis

Table 3. Criteria: Bike Lane with no adjacent Parking Lane

	1 lane per direction				*≥ 2 lanes per direction*	
Prevailing or Posted Speed	≥ 7’ (Buffered bike lane)	5.5’ – 7’ Bike lane	≤ 5.5’ Bike lane	Frequent bike lane blockage	≥ 7’ (Buffered bike lane)	<7’ bike lane or frequent blockage
≤30 mph	LTS 1	LTS 1	LTS 2	LTS 3	LTS 1	LTS 3
35 mph	LTS 2	LTS 3	LTS 3	LTS 3	LTS 2	LTS 3
≥40 mph	LTS 3	LTS 4	LTS 4	LTS 4	LTS 3	LTS 4

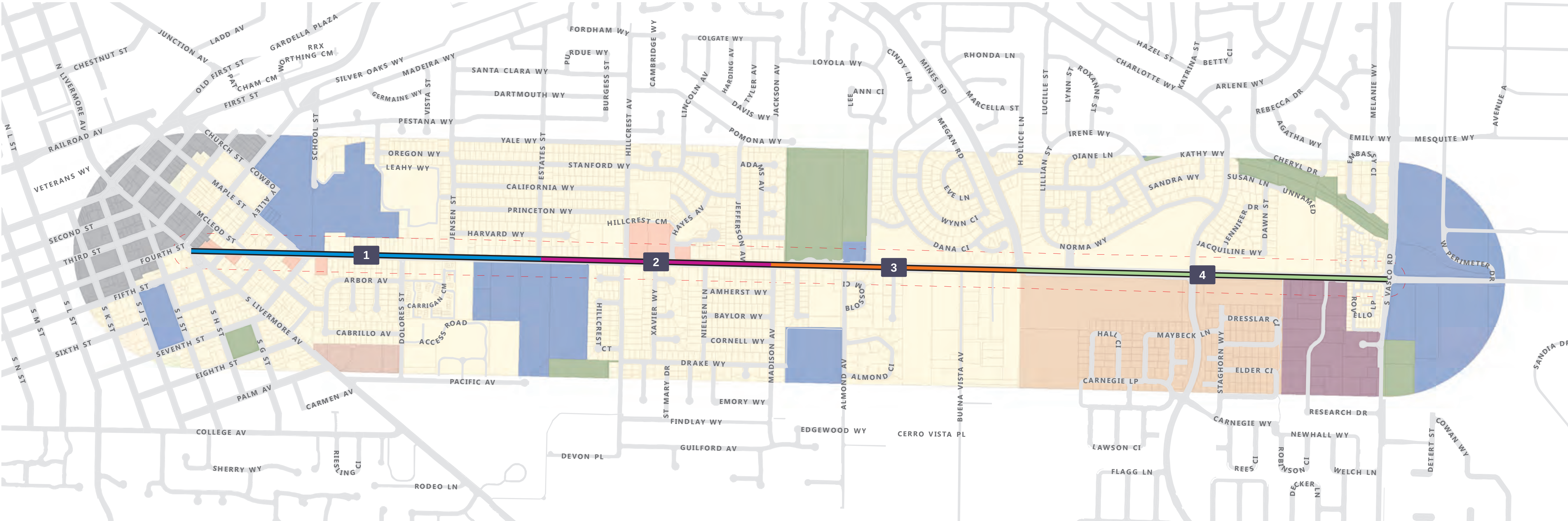
Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis

Table 4. Roadway Segment LTS Summary

#	Roadway Segment Limits	No. of Travel Lanes	Posted Speed Limits	On –Street Parking Lane (Width)	Average Daily Traffic1	Bicycle Lanes (Width)	BLTS
1	S. Livermore Ave to Estates St	4	30	Yes (8’)	21,269	No	4
2	Estates St to Madison Ave	4	30	Yes (8’)	17,842	No	4
3	Madison Ave to N. Mines Rd	4	Madison Ave to Loyola Way – 30 Loyola Way to N Mines Rd - 40	No	17,842	Yes (7’)	3
4	N. Mines Rd to S. Vasco Rd	4	40	No	11,032	Yes (7’)	3

[1] *The LTS criteria doesn’t require exact estimate but just to determine if the traffic is above 8,000 ADT.*

Roadway Segments



East Avenue Study Area	
1 S. Livermore Ave to Estates St	
2 Estate St to Madison Ave	
3 Madison Ave to N Mines Rd	
4 N. Mines Rd to Vasco Rd	
Commercial	Mixed Uses
Community Facility	Open Space
Downtown Area	Residential
Industrial	South Livermore Valley Specific Plan

Miles 0 ¼

EAST AVENUE CORRIDOR STUDY

Intersection, Approach and Crossing Analysis

The approach and crossings component of the intersection BLTS analysis is equally important for assessing street network comfort. The LTS methodology is adopted from the ATP with additional consideration provided to the signalized crossing, U-turn movements and crossing distance (Furth, 2017). Intersection approach criteria are based on the presence and type of right turn (vehicular) lanes. If there is no turn lanes on an approach, then this portion of the methodology is skipped. The crossing analysis uses "weakest link logic" meaning that whichever LTS is lowest, i.e. if the northbound crossing has a different LTS than WB crossing, whichever LTS is highest is the LTS that is reported (Mekuria, Furth, Nixon, 2012). Table 5 summarizes the right –turn lane BLTS approach criteria.

Table 5. BLTS Right Turn Lane Criteria (Approach)

Right turn lane configuration	*Right-turn lane length (ft.)*	*Bike lane approach alignment*	*Vehicle Turning Speed (mph)[1]*	*BLTS*
Straight Bike Lane Alignment	≤ 150	Straight	≤ 15	BLTS 2
Straight Bike Lane Alignment	> 150 to 500 max	Straight	≤ 20	BLTS 3
Left Bike Lane Alignment	< 150	Shift to Left	≤ 15	BLTS 3
Lane Drop –with a bike signal	NA	NA	NA	BLTS 1
Lane Drop –without a bike signal	NA	Straight	≤ 15	BLTS 3
Bike Lane Enters Shared Right Turn Lane	≤ 75	Straight	≤ 15	BLTS 2
Bike Lane Enters Shared Right Turn Lane	> 75 to 150 max	Straight	≤ 15	BLTS 3

Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis
[1] This is vehicle speed at the corner, not the speed crossing the bike lane. Corner radius can also be used as a proxy for turning speeds.

Signalized intersections do not create a barrier as the signal provides a protected way across, BLTS 1 is assumed for the crossing movements. However, signalized intersections with improper striping, ramps, and push button accommodations for bicyclists will be considered as BLTS 2 (Oregon Department of Transportation, 2020). **Table 6 and 7** provides the criteria for the unsignalized intersections.

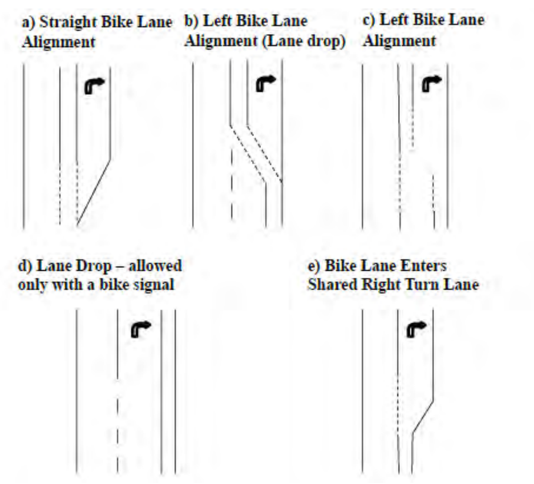


Figure III Right Turn Lane Types

Table 6. BLTS Criteria for Unsignalized Intersection Crossing Without a Median Refuge[1]

Prevailing Speed or Speed Limit (mph)	*Total Through/Turn Lanes Crossed (Both Directions)*					
	≤ 3 lanes			4-5 Lanes		≥6 Lanes
	Functional Class/ ADT (vpd)					
	Local	Collector	Arterial	Arterial		Arterial
	≤ 1,200	1,200 - 3000	> 3,000	≤ 8,000	> 8,000	Any ADT
≤ 25	BLTS 1	BLTS 1	BLTS 2	BLTS 3	BLTS 4	BLTS 4
30	NA	BLTS 1	BLTS 3	BLTS 3	BLTS 4	BLTS 4
35	NA	BLTS 2	BLTS 3	BLTS 4	BLTS 4	BLTS 4
≥ 40	NA	BLTS 3	BLTS 4	BLTS 4	BLTS 4	BLTS 4

Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis
[1]For Street being crossed.

Table 7. BLTS Criteria for Unsignalized Intersection Crossing With a Median Refuge[2]

Prevailing Speed or Speed Limit (mph)	Maximum Through/Turn Lanes Crossed per Direction			
	1 Lane	2 Lane	3 Lane	4+ Lane
≤ 25	BLTS 1	BLTS 2	BLTS 2	BLTS 3
30	BLTS 1	BLTS 2	BLTS 3	BLTS 3
35	BLTS 2	BLTS 3	BLTS 4	BLTS 4
≥ 40	BLTS 3	BLTS 4	BLTS 4	BLTS 4

Source: Oregon Department of Transportation. (2020). Analysis Procedures Manual. Chapter 14 Multimodal Analysis
[2] Refuge should be at least 10 feet to accommodate a wide range of bicyclists (i.e. bicycle with a trailer) for BLTS 1, otherwise BLTS=2 for refuges 6 to <10 feet.

Based on engineering judgment, we have lowered the BLTS at crossing with pedestrian flashing beacons.

Limitations

Different LTS methods, developed in order to facilitate analyses with different data needs, in different geographies, or with updated understandings of what constitutes bikeability, have led to diverse definitions of LTS levels. Different data sources that offer varying levels of precision, or require assumptions to fill missing data, can also dramatically affect LTS outcomes. LTS levels can also be easily misinterpreted as a continuous scale, implying that the degree of improvement is consistent between sequential levels. Because LTS levels result from combinations of variables, it can also be difficult to interpret which specific variables might have the greatest influence on cycling quality (Rodriguez, Fang, & Harvey, 2019).

Table 8 provides the intersection level of traffic stress summary.

Table 8. Study Intersection Data Summary

#	Intersection	Intersection Type	Leg Crossing Used	Median Refuge > 6ft.[1]	LOS Based on Crossing/ Right Turn Approach	BLTS
1	East Ave/Fourth St and S. Livermore Ave/H St	Signalized	East Leg	No	Crossing	2
2	East Ave and Fifth St	Unsignalized	South leg	No	Crossing	2
3	East Ave and Sixth St	Unsignalized	North leg	No	Crossing	2
4	East Ave and Maple St	Signalized	North leg	Yes	Crossing	1
4	East Ave and Maple St	Signalized	East leg	No	Crossing	1
5	East Ave and Seventh St	Unsignalized	South Leg	No	Crossing	2
6	East Ave and Dolores St	Signalized	East Leg	No	Crossing	2
7	East Ave and Jensen St	Unsignalized	North Leg	No	Crossing	1
7	East Ave and Jensen St	Unsignalized	East leg	No	Crossing	3
8	East Ave and Estates St	Unsignalized	North Leg	No	Crossing	1
8	East Ave and Estates St	Unsignalized	East leg	No	Crossing	3
9	East Ave and Hillcrest Ave	Signalized	East/West leg	No	Crossing	1
10	East Ave and Xavier Wy	Unsignalized	South Leg	No	Crossing	2
11	East Ave and Hayes Ave	Unsignalized	North Leg	No	Crossing	1
12	East Ave and Nielsen Ln	Unsignalized	South Leg	No	Crossing	1
12	East Ave and Nielsen Ln	Unsignalized	West Leg	No	Crossing	3
13	East Ave and Jefferson Ave	Unsignalized	North Leg	No	Crossing	2
14	East Ave and Madison Ave	Signalized	West Leg	No	Crossing	1
15	East Ave and Auburn St	Unsignalized	South Leg	No	Crossing	1
16	East Ave and Almond Ave	Unsignalized	South Leg	No	Crossing	1
17	East Ave and Loyola Wy	Signalized	West Leg	No	Crossing	2
18	East Ave and Buena Vista Ave	Unsignalized	South Leg	No	Crossing	1
19	East Ave and Calvary Ln	Unsignalized	South Leg	No	Crossing	1
20	East Ave and North Mines Rd	Signalized	West Leg	No	Crossing	2
21	East Ave and Mitra St	Unsignalized	East Leg	No	Crossing	4
21	East Ave and Mitra St	Unsignalized	North Leg	Yes	Crossing	3
22	East Ave and Charlotte Wy	Signalized	West/East leg	No	Approach	3
23	East Ave and Research Dr	Unsignalized	East Leg	No	Crossing	3
23	East Ave and Research Dr	Unsignalized	South Leg	No	Crossing	1
24	East Ave and Birchwood Common	Unsignalized	North Leg	No	Crossing	1

#	Intersection	Intersection Type	Leg Crossing Used	Median Refuge > 6ft.[1]	LOS Based on Crossing/ Right Turn Approach	BLTS
25	East Ave and Rovello Loop	Unsignalized	South Leg	No	Crossing	1
26	East Ave and Vasco Rd	Signalized	North Leg	Yes	Approach	3

[1] The distance were measured on the latest google imagery.

FINDINGS AND CONCLUSION

Figure 4 demonstrates the LTS results on East Avenue. Roadway segment between Madison Ave and N. Mines Rd has slightly better conditions for biking than the remaining study corridor. Similarly, intersections on and near this segment have Low-to-moderate stress. The results shown in this analysis concur with the ones presented in ATP. It can be concluded that the existing road conditions are less desirable and uncomfortable for the bicyclists. The major factors that might be considered leading to the poor LTS levels are lack of bicycle facilities, presence of on-street parking, higher speed, and lack of median refuge.

LTS system is designed to provide local agencies with guidance to prioritize bicycle infrastructure development. This analysis should still be validated with the community survey inputs and limitations of LTS methodology must be accounted.

The data input summary tables and ATP Bicycle LTS Methodology are provided in the **Appendix**.

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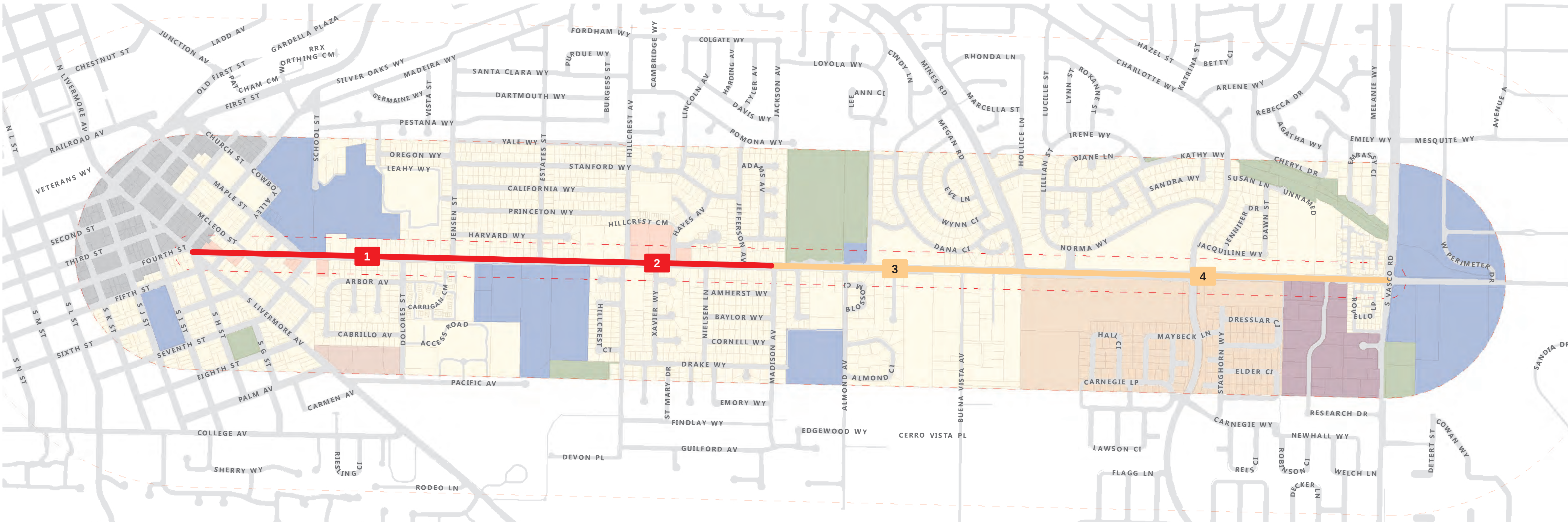
Bicycle Level of Traffic Stress - Roadway Segment



LTS 1 LEAST STRESSFUL
LTS 2
LTS 3
LTS 4 MOST STRESSFUL
X Segment ID

East Avenue Study Area
Commercial
Community Facility
Downtown Area
Industrial

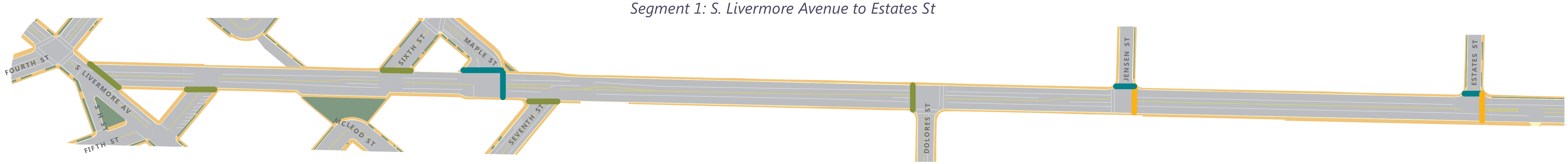
Mixed Uses
Open Space
Residential
South Livermore Valley Specific Plan

Miles 0 ¼
Date: 10/17/2020

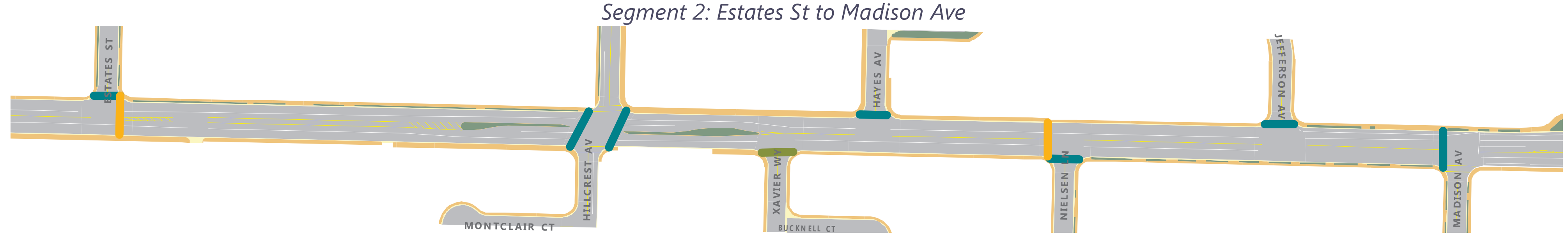
EAST AVENUE CORRIDOR STUDY

Bicycle Level of Traffic Stress - Intersection

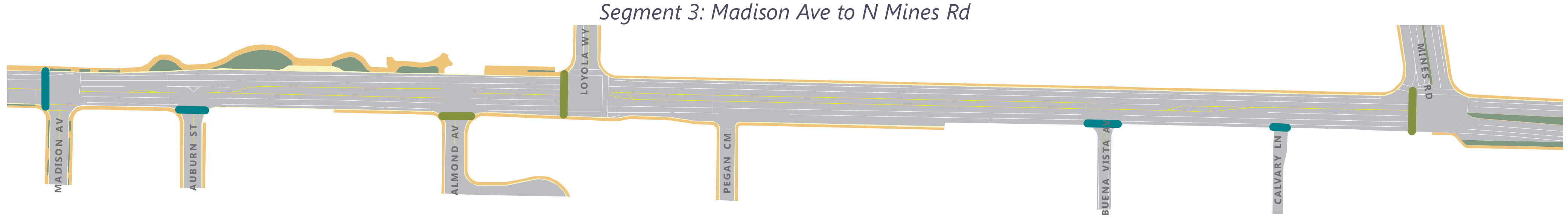
Segment 1: S. Livermore Avenue to Estates St



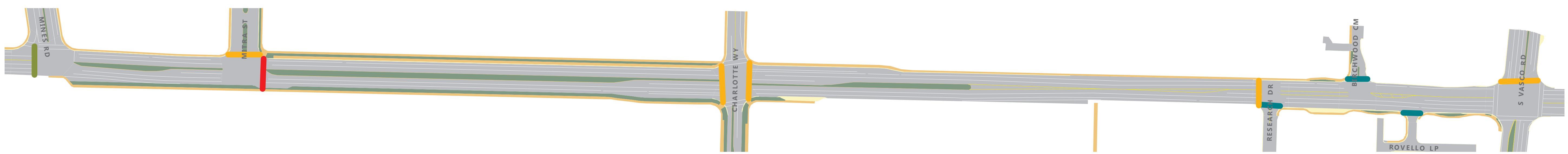
Segment 2: Estates St to Madison Ave



Segment 3: Madison Ave to N Mines Rd



Segment 4: N. Mines Rd to Vasco Rd



- LTS 1 LEAST STRESSFUL
- LTS 2
- LTS 3
- LTS 4 MOST STRESSFUL

Feet 0 200

Date: 10/21/2020

REFERENCES

Furth, P. G. (2017). *Level of Traffic Stress Criteria.* Northeastern University College of Engineering. Retrieved May 18, 2020, from http://www.northeastern.edu/peter.furth/research/level-of-traffic-stress/ http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables1.pdf

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APPENDIX

APPENDIX G BICYCLE LEVEL OF TRAFFIC STRESS ANALYSIS

This appendix describes in further detail the Bicycle Level of Traffic Stress (BLTS) analysis discussed in Chapter 4.

Traffic stress is the perceived sense of danger associated with bicycling in, or adjacent to, vehicle traffic. A BLTS analysis is an objective, data-driven evaluation which classifies road segments and intersections into four levels of traffic stress from LTS 1 (least stressful) to LTS 4 (most stressful):

- **LTS 1:** Presenting little traffic stress and demanding little attention from bicyclists, and attractive enough for a relaxing bike ride. Suitable for almost all bicyclists, including children trained to safely cross intersections. On links, bicyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a slow traffic stream with no more than one lane per direction, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where bicyclists ride alongside a parking lane, they have ample operating space outside the zone into which car doors are opened. Intersections are easy to approach and cross.
- **LTS 2:** Presenting little traffic stress and therefore suitable for most adult bicyclists but demanding more attention than might be expected from children. On links, bicyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a well-confined traffic stream with adequate clearance from a parking lane, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where a bike lane lies between a through lane and a right-turn lane, it is configured to give bicyclists unambiguous priority where cars cross the bike lane and to keep car speed in the right-turn lane comparable to bicycling speeds. Crossings are not difficult for most adults.
- **LTS 3:** More traffic stress than LTS 2, yet markedly less than the stress of integrating with multilane traffic, and therefore tolerable to many people currently riding bikes in American cities. Offering bicyclists either an exclusive riding zone (lane) next to moderate-speed traffic or shared lanes on streets that are not multilane and have moderately low speed. Crossings may be longer or across higher-speed roads than allowed by LTS 2, but are still considered acceptably safe to most adults.
- **LTS 4:** A level of stress beyond LTS 3.

For a bicycle network to attract the broadest segment of the population, it must provide a continuous and connected low-stress experience for users. Continuous and connected low-stress bicycle networks allow for citizens of all ages and abilities to better consider bicycling as a viable and safe form of transportation. Disconnected low-stress bicycle facilities constrain users who wish to travel across the city.

The BLTS analysis is divided into two parts:

- **Street Segment Analysis** – scores street segments based on the perceived level of stress for bicyclists along a roadway at the block level

- **Intersection & Crossing Analysis** – scores intersections and crossings based on the perceived level of stress for bicyclists passing through an intersection

GENERAL METHODOLOGY

The methods used for the BLTS 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 comfort level.

A comprehensive city-wide inventory of all roadways in the City of Livermore was conducted using high-quality fly-over imagery and an on-site field survey. This inventory included collecting detailed attribute information about the presence of on-street bike facilities, parking lanes, turn lanes, medians, and signalized intersections.

STREET SEGMENT ANALYSIS

The BLTS street segment scoring methodology varies depending on a variety of factors that influence a bicyclist's perceived level of stress along a roadway and are outlined in Table G-1, Table G-2, and Table G-3.

Table G-1: BLTS Scoring Criteria for Bike Lanes Alongside a Parking Lane[1]

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (through lanes per direction)	1	(no effect)	2+	(no effect)
Sum of bike lane and parking lane width (including marked buffer and paved gutter)	≥15 ft	14 – 14.5 ft*	≤13.5 ft	(no effect)
Speed limit or prevailing speed	≤25 mph	30 mph	35 mph	≥40 mph
Bike lane blockage (typically applies in commercial areas)	Rare	(no effect)	Frequent	(no effect)

Notes: (no effect) means the factor does not trigger an increase to this level of traffic stress

**If speed limit is <25 mph or street class is residential then any width is acceptable for LTS 2*

[1] Ibid.

Table G-2: BLTS Scoring Criteria for Bike Lanes Not Alongside a Parking Lane[2]

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (through lanes per direction)	1	2, if directions are separated by a raised median	2+, or 2 without a separating median	(no effect)
Sum of bike lane and parking lane width (including marked buffer and paved gutter)	≥6 ft	≤5.5 ft	(no effect)	(no effect)
Speed limit or prevailing speed	≤30 mph	(no effect)	35 mph	≥40 mph
Bike lane blockage (typically applies in commercial areas)	Rare	(no effect)	Frequent	(no effect)

Table G-3: BLTS Scoring Criteria for Mixed Traffic[3]

SPEED LIMIT	STREET WIDTH		
	2-3 LANES	4-5 LANES	6+ LANES
Up to 25 mph	LTS 1* or 2*	LTS 3	LTS 4
30 mph	LTS 2* or 3*	LTS 4	LTS 4
35+ mph	LTS 4	LTS 4	LTS 4

**Use lower value for streets without marked centerlines or classified as residential and with fewer than 3 lanes. Otherwise use higher value.*

At its core, as the BLTS scoring increases, cycling comfort decreases (1 is the highest comfort level and 4 is the lowest comfort level). Additionally, the number of factors that influence the overall segment BLTS score decreases as speed limit increases. This is in line with research that indicates vehicle speed is the largest influence on a bicyclist's perceived level of comfort. This is an important point because it speaks to the need for the city to consider improving bicycle facilities both on low-stress streets with lower vehicle speeds and on high speed arterial and collector roadways.

[2] Ibid.

[3] Ibid.

INTERSECTION AND CROSSING ANALYSIS

The intersection and crossings component of the BLTS analysis is equally important to assessing street network comfort. Most of Livermore's bicycle collisions occurred at intersections. Improving the safety of these high-stress intersections can greatly reduce the stress felt by bicyclists as they approach and pass through an intersection or crossing.

Unsignalized crossings increase stress for cyclists along otherwise low-stress routes. An intersection level of service analysis was completed to identify challenging or uncomfortable crossings. Crossing comfort decreases as the number of lanes and posted speed increase. The BLTS intersection and crossing scoring methodology varies depending on a variety of factors that influence a bicyclist's perceived level of stress while biking through an intersection, as outlined in Table G-4, Table G-5, Table G-6, and Table G-7.

Table G-4: LTS Criteria for Pocket Bike Lanes[4]

CONFIGURATION	LTS
Single right-turn lane up to 150 ft long, starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius such that turning speed is ≤15 mph	≥2
Single right-turn lane longer than 150 ft starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius such that turning speed is ≤20 mph	≥3
Single right-turn lane in which the bike lane shifts to the left but the intersection angle and curb radius are such that turning speed is ≤15 mph	≥3
Single right-turn lane with any other configuration; dual right-turn lanes; or right-turn lane along with an option (through-right) lane	4

Table G-5: BLTS Criteria for Mixed Traffic in the Presence of a Right-Turn Lane[5]

CONFIGURATION	LTS
Single right-turn lane with length ≤75 ft and intersection angle and curb radius that limit turning speed to 15 mph	(no effect)
Single right-turn lane with length between 75 and 150 ft, and intersection angle and curb radius that limit turning speed to 15 mph	≥3
Otherwise	4

Table G-6: BLTS Criteria for Unsignalized Crossings Without a Median Refuge[6]

SPEED LIMIT	STREET WIDTH		
	UP TO 3 LANES	4-5 LANES	6+ LANES
Up to 25 mph	LTS 1	LTS 2	LTS 4
30 mph	LTS 1	LTS 2	LTS 4
35 mph	LTS 2	LTS 3	LTS 4
40+ mph	LTS 3	LTS 4	LTS 4

Table G-7: BLTS Criteria for Unsignalized Crossings With a Median Refuge at Least Six Feet Wide[7]

SPEED LIMIT	STREET WIDTH		
	UP TO 3 LANES	4-5 LANES	6+ LANES
Up to 25 mph	LTS 1	LTS 1	LTS 2
30 mph	LTS 1	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 4
40+ mph	LTS 3	LTS 4	LTS 4

[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] Ibid.

RESULTS

The results of the BLTS analysis can be seen in Figure G-1. Roadways and intersections with the highest level of bicycle comfort are shown in dark green. These roadways and intersections include a majority of neighborhood residential streets due to their low vehicle speeds and two-lane roadways. Bright green and yellow-green roadway segments and intersections indicate slightly higher stress conditions than the dark green segments, but are still generally comfortable for bicyclists. Moderate to high stress segments and intersections for bicyclists are shown in yellow, orange, and red. Higher stress segments and intersections include corridors where there is no dedicated space for bicycling and high traffic speeds, or where conventional bike lanes do not provide sufficient comfort given the context of multiple lanes and higher traffic speeds.

Table G-8 outlines the total mileage and percentage of the City of Livermore's roadway and trail network by BLTS segment score. All paved off-street paths (trails) are assigned an LTS segment score of 1.

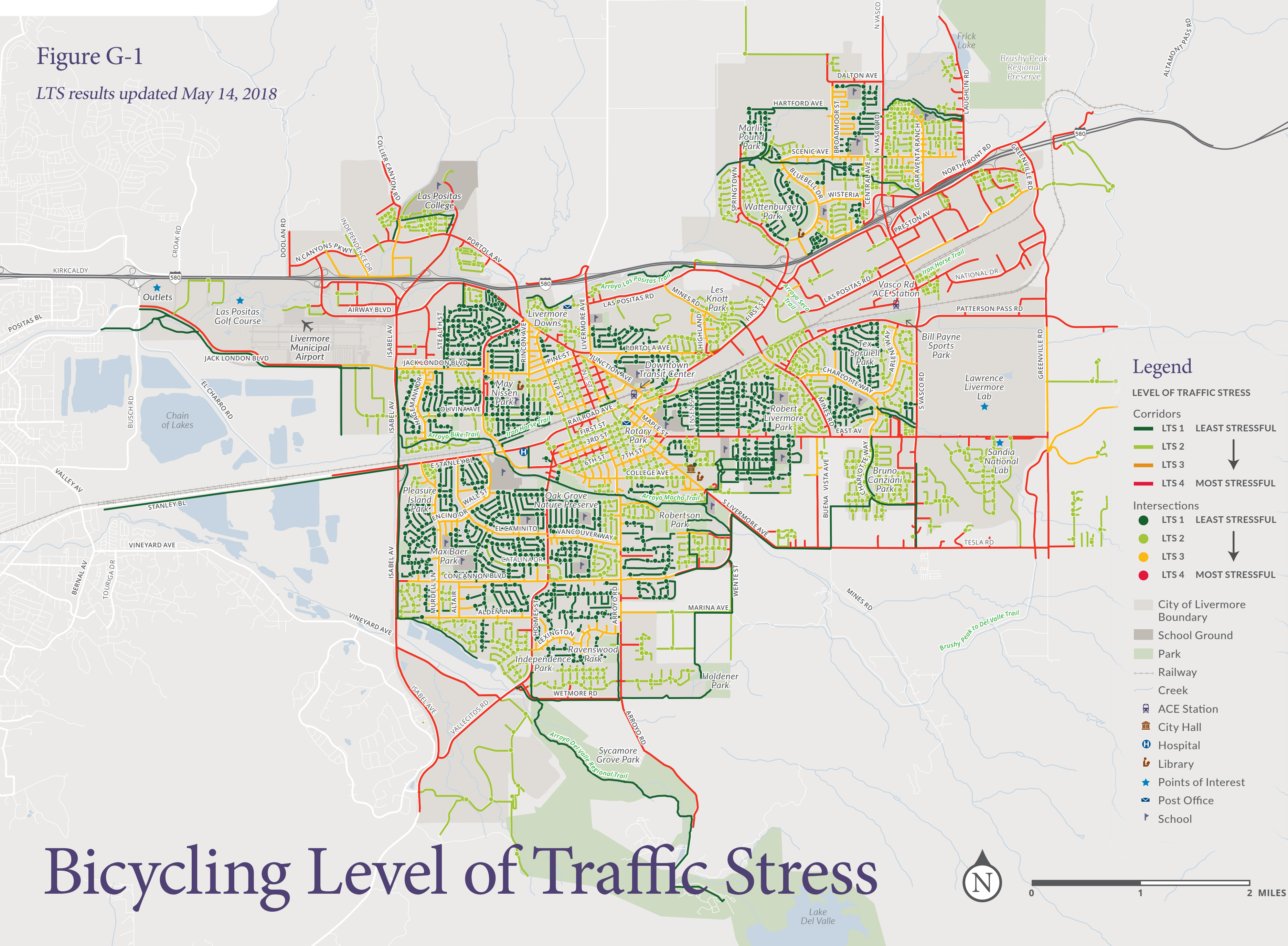
Table G-8: BLTS Results – Summary Statistics

SEGMENT SCORE	TOTAL MILEAGE	% OF TOTAL ROADWAY AND TRAIL NETWORK
LTS 1	104	25.81%
LTS 2	148	36.72%
LTS 3	62	15.38%
LTS 4	89	22.08%

LIVERMORE
CALIFORNIA

Figure G-1

LTS results updated May 14, 2018



Bicycling Level of Traffic Stress

Bicycle Intersection Level of Traffic Stress

Analyst Name:	Jasmine Stitt
Date:	9/24/2020
Analysis Scenario Name:	Existing Conditions
Analysis Year:	2020

	Summary Scoring Totals						
Intersection Name	*East Ave/Fourth St and S. Livermore Ave/H St*	*East Ave and Fifth St*	*East Ave and Sixth St*	*East Ave and Maple St*	*East Ave and Maple St*	*East Ave and Seventh St*	*East Ave and Dolores St*
Intersection Type	Signalized	Unsignalized	Unsignalized	Signalized	Signalized	Unsignalized	Signalized
	with no median refuge	with no median refuge	with no median refuge	with median refuge	with no median refuge	with no median refuge	with no median refuge
Prevailing Speed or Speed Limit	36	≤25	≤25	≤25	36	≤25	36
Maximum Through/ Turn Lanes Crossed	East Leg	South leg	North leg	North leg	East Leg	South Leg	East Leg
	4 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)	3 lane (both directions)	4 lane (both directions)	<3 lane (both directions)	5 lanes (both directions)
Crossing Distance (ft.)	100	80	80	100	70	80	70
ADT (vpd)	21,269	< 1,200	< 1,200	5,000 - 9,000	21,269	< 1,200	21,269
	Arterial	Local	Local	Collector	Arterial	Local	Arterial
Note	Improper push button accommodation	Unmarked crosswalk and longer crossing distance	Unmarked crosswalk and longer crossing distance	Marked crosswalk (Yellow)	Marked crosswalk (Yellow)	Marked crosswalk (Yellow) and longer crossing distance	Improper push button accommodati on
LTS based on	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing
Right Turn Lane Impacts	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Criteria used	Signalized intersection	Table 6	Table 6	Signalized intersection	Signalized intersection	Table 6	Signalized intersection
BLTS Score	**BLTS 2**	**BLTS 2**	**BLTS 2**	**BLTS 1**	**BLTS 1**	**BLTS 2**	**BLTS 2**

Note: *For prevailing speed at East Ave, 85th percentile speeds were considered*
Crossing distance rounded off to nearest 5 ft.
All unmarked crosswalk above 60 ft. in length were updated to next BLTS calculated
All crosswalk with pedestrian flashing beacon were lowered one BLTS level

Bicycle Intersection Level of Traffic Stress

Analyst Name: Jasmine Stitt
Date: 9/24/2020
Analysis Scenario Name: Existing Conditions
Analysis Year: 2020

Summary Scoring Totals

East Ave and Jensen St	*East Ave and Jensen St*	*East Ave and Estates St*	*East Ave and Estates St*	*East Ave and Hillcrest Ave*	*East Ave and Xavier Wy*	*East Ave and Hayes Ave*	*East Ave and Nielsen Ln*
Unsignalized	Unsignalized	Unsignalized	Unsignalized	Signalized	Unsignalized	Unsignalized	Unsignalized
with no median refuge	with no median refuge	with no median refuge	with no median refuge	with median refuge less than 6 feet	with no median refuge	with no median refuge	with no median refuge
36	25	25	36	36	≤25	≤25	25
East leg	North Leg	North Leg	East leg	East/West leg	South Leg	North Leg	South Leg
5 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)	5 lanes (both directions)	5 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)	<3 lane (both directions)
70	50	50	70	90	60	55	55
21,269	<1,200	<1,200	21,269	17,842	< 1,200	< 1,200	< 1,200
Arterial	Local	Local	Arterial	Arterial	Local	Local	Local
High visibility crosswalk; Pedestrian Flashing Beacon	Marked crosswalk	Marked crosswalk (Yellow)	High visibility crosswalk (Yellow); Pedestrian Flashing Beacon	Marked crosswalk (Yellow)	Unmarked crosswalk	Unmarked crosswalk	Unmarked crosswalk
Crossing	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Table 6	Table 6	Table 6	Table 6	Signalized intersection	Table 6	Table 6	Table 6
BLTS 3	**BLTS 1**	**BLTS 1**	**BLTS 3**	**BLTS 1**	**BLTS 2**	**BLTS 1**	**BLTS 1**

Note: *For prevailing speed at East Ave, 85th percentile speeds were considered*
Crossing distance rounded off to nearest 5 ft.
All unmarked crosswalk above 60 ft. in length were updated to next BLTS calculated
All crosswalk with pedestrian flashing beacon were lowered one BLTS level

Bicycle Intersection Level of Traffic Stress

Analyst Name: Jasmine Stitt
Date: 9/24/2020
Analysis Scenario Name: Existing Conditions
Analysis Year: 2020

Summary Scoring Totals

East Ave and Nielsen Ln	*East Ave and Jefferson Ave*	*East Ave and Madison Ave*	*East Ave and Auburn St*	*East Ave and Almond Ave*	*East Ave and Loyola Wy*	*East Ave and Buena Vista Ave*	*East Ave and Calvary Ln*
Unsignalized	Unsignalized	Signalized	Unsignalized	Unsignalized	Signalized	Unsignalized	Unsignalized
with no median refuge	with no median refuge	with no median refuge	with no median refuge	with no median refuge	with no median refuge	with no median refuge	with no median refuge
36	≤25	36	≤25	≤25	36	≤25	≤25
West Leg	North Leg	West Leg	South Leg	South Leg	West Leg	South Leg	South Leg
5 lanes (both directions)	<3 lane (both directions)	5 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)	6 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)
70	60	70	55	65	85	50	30
17,842	< 1,200	17,842	< 1,200	< 1,200	17,842	< 1,200	< 1,200
Arterial	Local	Arterial	Local	Local	Arterial	Local	Local
High visibility crosswalk; Pedestrian Flashing Beacon	Unmarked crosswalk	Marked crosswalk (Yellow)	Unmarked crosswalk	Marked Crosswalk; Lane drop	Marked Crosswalk	Unmarked crosswalk	Unmarked crosswalk
Crossing	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing	Crossing
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Table 6	Table 6	Signalized intersection	Table 6	Table 6	Signalized intersection	Table 6	Table 6
BLTS 3	**BLTS 1**	**BLTS 1**	**BLTS 1**	**BLTS 2**	**BLTS 2**	**BLTS 1**	**BLTS 1**

Note: *For prevailing speed at East Ave, 85th percentile speeds were considered*
Crossing distance rounded off to nearest 5 ft.
All unmarked crosswalk above 60 ft. in length were updated to next BLTS calculated
All crosswalk with pedestrian flashing beacon were lowered one BLTS level

Note:

Bicycle Intersection Level of Traffic Stress

Analyst Name: Jasmine Stitt
Date: 9/24/2020
Analysis Scenario Name: Existing Conditions
Analysis Year: 2020

Summary Scoring Totals

East Ave and North Mines Rd	*East Ave and Mitra St*	*East Ave and Mitra St*	*East Ave and Charlotte Wy*	*East Ave and Research Dr*	*East Ave and Research Dr*	*East Ave and Birchwood Common*	*East Ave and Rovello Loop*	*East Ave and Vasco Rd*
Signalized	Unsignalized	Unsignalized	Signalized	Unsignalized	Unsignalized	Unsignalized	Unsignalized	Signalized
with no median refuge	with median refuge	with median refuge less than 6 feet	with median refuge	with no median refuge	with no median refuge	with median refuge less than 6 feet	with no median refuge	with median refuge
44	≤25	44	44	≤25	44	≤25	≤25	44
West Leg	North Leg	East Leg	west/east leg	South Leg	East Leg	North Leg	South Leg	North Leg
5 lanes (both directions)	4 lane (both directions)	5 lanes (both directions)	6 lanes (both directions)	<3 lane (both directions)	5 lanes (both directions)	<3 lane (both directions)	<3 lane (both directions)	6 lanes (both directions)
75	100	85	110	70	80	70	45	120
17,842	< 1,200	17,842	11,032	< 1,200	11,033	< 1,200	< 1,200	11,032
Arterial	Local	Arterial	Arterial	Local	Arterial	Local	Local	Arterial
Improper push button accommodation	Marked Crosswalk	Marked Crosswalk	SB bike lane approach alignment drops	Unmarked crosswalk	Marked crosswalk; Pedestrian Flashing Beacon	Marked Crosswalk	Marked Crosswalk	SB bike lane approach alignment shift to left
Crossing	Crossing	Crossing	Approach	Crossing	Crossing	Crossing	Crossing	Approach
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Signalized intersection	Table 7	Table 7		Table 6	Table 6	Table 7	Table 7	Table 5
BLTS 2	**BLTS 3**	**BLTS 4**	**BLTS 3**	**BLTS 1**	**BLTS 3**	**BLTS 1**	**BLTS 1**	**BLTS 3**

For prevailing speed at East Ave, 85th percentile speeds were considered
Crossing distance rounded off to nearest 5 ft.
All unmarked crosswalk above 60 ft. in length were updated to next BLTS calculated
All crosswalk with pedestrian flashing beacon were lowered one BLTS level