APPENDIX C


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APPENDIX C.

Level of Traffic Stress

Building on the bicycling preference survey and user typologies, a Level of Traffic Stress analysis was conducted for Berkeley's roadway network. "Traffic stress" is the perceived sense of danger associated with riding in or adjacent to vehicle traffic; studies have shown that traffic stress is one of the greatest deterrents to bicycling.[1] The less stressful – and therefore more comfortable – a bicycle facility is, the wider its appeal to a broader segment of the population. A bicycle network is likely to attract a large portion of the population if it is designed to reduce stress associated with potential motor vehicle conflicts and connect people bicycling with where they want to go. Bikeways are considered low stress if they involve very little traffic interaction by nature of the roadway's vehicle speeds / volumes (e.g. a shared low-traffic neighborhood street) or, as traffic volumes and speeds increase, if greater degrees of physical separation are placed between the bikeway and traffic lane (e.g. a separated bikeway or cycle track on a major street). A Class I shared use pathway is completely separated from motor vehicles traffic and therefore a low stress facility, although within an urbanized bikeway network there are limited opportunities for these facilities and they also serve multiple non-motorized recreational users.

A Bicycle Level of Traffic Stress (LTS) Analysis is an objective, data-driven evaluation model which identifies streets with high levels of traffic stress, gaps in the bicycle network, and gaps between streets with low levels of traffic stress. The LTS analysis applied the methodology developed by the Mineta Transportation Institute *Report II-19: Low-Stress Bicycling and Network Connectivity* (2012). The Mineta LTS methodology was adapted to provide an objective data-driven approach to scoring the comfort of bicycle travel on shared roadways.

Models serve as an effective means to understand how factors in a complex system interact by providing a simplified version of the system for study. However, by definition, models are representations of reality and are constrained by the quality of available data and the complexity of the system under consideration. Throughout the modelling process, significant effort was made to collect the best data possible and follow existing methods while making small adaptations to existing methodologies to best reflect conditions in Berkeley.

C.1.1. Inputs

The street network is made up of two components: corridors and intersections. Corridors are the sections of uninterrupted roadway, and intersections are where two (or more) corridors cross. Using available data, corridors and intersections were classified into one of four LTS scores that can be used as a proxy to represent the top travel tolerance different types of people riding bicycles are willing to use: 1) All people riding

1 M. Winters, G. Davidson, D.N. Kao and K. Teschke, "Motivators and deterrents of bicycling: comparing influences on decisions to ride", Transportation 38, 153-168 (2011).

bicycles (including children), 2) Interested but Concerned, 3) Enthusiastic and Confident, and 4) Strong and Fearless.

The most desirable bicycling score, LTS 1, is assigned to roads and intersections that would be suitable for inexperienced adults riding bicycles, families with small children, and older children who have begun riding in the street; LTS 2 roads are those that could be comfortably ridden by the mainstream adult population; LTS 3 is the level assigned to roads that would be acceptable for bicycle travel by "enthusiastic and confident" bicyclists; and LTS 4 represents roads that are only acceptable to "strong and fearless" bicyclists who better tolerate roadways with higher motorized traffic volumes and speeds. There are some limitations to the methodology; LTS analysis does not take steep slope, availability of sidewalks, or side paths into account. The LTS factors are shown in **Table C-1**.

***Table C-1:** LTS Methodology Inputs and Factors*

INTERSECTIONS	
Unsignalized	
1.	Average daily traffic (ADT) of cross-traffic
2.	Number of travel lanes
3.	Bicycle/pedestrian refuge islands
4.	Presence of a traffic signal
5.	Right turn lanes
Signalized	
1.	Segment LTS criteria for bikeway approach
2.	ADT
3.	Number of travel lanes
4.	Presence and character of bicycle lanes
SEGMENTS	
1.	Average daily traffic (ADT)
2.	Number of travel lanes
3.	Presence and character of bicycle lanes

C.1.2. Identified Issues from Preliminary LTS Results

After conducting the preliminarily Berkeley LTS analysis (using the published MTI methodology), our team compared the results to our own local experience of using the Berkeley bikeway network. The Project Team found numerous locations where the LTS output scores did not align with levels of stress actually experienced in the field. In all cases these were locations where the analysis results gave a lower LTS score than actually experienced by users; for example a location identified as an LTS 1 (suitable for all users including children) whereas local experience indicates it is appropriate only for more confident adult riders (LTS 2/3). Thus, the initial LTS analysis results did not accurately reflect the experience of bicycling in Berkeley.

One explanation for why the initial Berkeley LTS results (using the MTI report input criteria) did not reflect the reality of cycling in Berkeley is local context. The MTI report was developed using the city of San Jose's roadway and bikeway network, and used street database inputs readily available in San Jose. Number of lanes, speed limit, and functional classification were primary data sources, and in San Jose these generally follow a traditional road classification hierarchy with residential streets being two lanes and posted 25 mph, and many arterial streets being multi lane and posted 40-45 mph. However, Berkeley does not have a traditional roadway hierarchy. Almost every street in Berkeley has a 25 mph posted speed limit, and a number of major streets like College Avenue or Dwight Way serve in an arterial function and carry high traffic volumes and higher speeds, but have a local residential street cross-section. [2]

Thus in order to more objectively compare the differences between the LTS model output and the actual user experience in Berkeley, our team recognized the need to "calibrate" the initial LTS results. The Project Teamused the community bike tour conducted on September 12, 2015 as an opportunity to obtain input from local cyclists on their own perceptions of stress using the Berkeley bike network so that the project team could look at ways to adjust the initial LTS analysis results. At a number of locations along the bike tour representing different roadway and intersection crossing types, the project team polled participants on their perceived level of stress using the same general categories as the LTS analysis (LTS 1 through 4).

The greatest discrepancy between the LTS results and user experience was found in the unsignalized arterial crossings along the Bike Boulevard network. The initial LTS results classified most of these locations as LTS 2, indicating suitability for the majority of the population. Input from the bike tour classified

2 This is consistent with the exceptions noted in the MTI report for cities with a low statutory speed limit of 30 mph in Boston and 25 mph in Berkeley. In this case, it is noted that an alternative measure to operating speed should be considered to more accurately quantify stress.

these locations generally as LTS 3/4, indicating that users experience them at a much higher stress level suitable for more experienced cyclists only.

Based on our bike tour calibration, the project team found that the primary factor influencing the discrepancy between the LTS results and the actual user perception in Berkeley was traffic volumes. The standard MTI methodology does not use traffic volumes as an input. Instead it uses posted speed limit (or observed travel speed) as well as number of lanes. As noted above, under a traditional roadway functional classification system this is logical: local roads (two lane, posted 25 mph) carry the least traffic, collectors (2-4 lanes, posted 30-35 mph) carry medium volumes, and arterials (generally multi-lane, posted 40-45 mph) carry the highest volumes. However, nearly all streets in Berkeley have a 25 mph posted speed limit, and a number of two-lane major streets serve in an arterial function and carry high traffic volumes

Therefore relying on posted speed limits as a primary Berkeley LTS input did not sufficiently differentiate between the higher volume (and higher stress) major roadways and those truly local and low-volume streets. Unsignalized crossings along the Bike Boulevard network that the model showed as LTS 2 are in some cases multi-lane crossings of roads with 15,000+ vehicles per day – a very high-stress situation.

C.1.3. Calibrated Level of Traffic Stress Methodology

Based on the discrepancy in the comparison, the Project Team calibrated the LTS results using average daily traffic (ADT) volumes. The Calibrated Level of Traffic Stress analysis built on the MTI approach by incorporating the impact of traffic volumes on level of comfort. This Calibrated LTS methodology replaced speed limit (MPH) with average daily traffic volumes (ADT) to calibrate the level of traffic stress for unsignalized intersections, signalized intersections, and bikeway links to conditions observed in Berkeley. Descriptions for each calibration are described in the sections below.

At its core, the LTS scores show an increase in level of stress on segments and at intersections as motor vehicle traffic volumes increase and the separation between a person bicycling and motor vehicle traffic decreases. Likewise, the level of stress decreases as the amount of separation between a person bicycling and motor vehicle traffic increases.

INTERSECTIONS

For this Plan, the LTS analysis for key intersections were calibrated: bikeway/bikeway intersections and bikeway/major street intersections. These were the intersections that garnered the most public comments, including during the bike tour and field observations.

Unsignalized Intersections

Table C-2 shows the relationship between a typical posted speed limit, the posted speed limit in Berkeley, and the average daily traffic volume that will be used in substitution.

Table C-4 shows the LTS score for unsignalized crossings without a median refuge island, and Table 4 shows the LTS score for unsignalized crossings with a median refuge island. The LTS scores in **Table C-5** are based on Table 7 in the MTI report. The MTI report Table 7 includes street configurations (i.e. 6 lane streets with less than 1,500 ADT) that do not exist in Berkeley. Additionally, the bike tour did not survey LTS scores for intersections with less than 5,000 ADT. However, the bike tour calibration increased the scores for streets with up to three lanes and ADT higher than 5,000. As such, calibration is assumed to be needed for similar streets below 5,000 ADT.

Finally, LTS score is context sensitive. LTS 1 or LTS 2 intersections are determined on a case-by-case basis based on the specific traffic volume of the street being crossed.

Table C-4 will not be consistent with those in the MTI report; the scores have been calibrated based on feedback received from the Bike Tour. The calibrations are shown in **Table C-3**.

Table C-2: Street Typology, Speed Limit and Average Daily Traffic Range

STREET CLASSIFICATION[1]	TYPICAL POSTED MPH	BERKELEY POSTED MPH	AVERAGE DAILY TRAFFIC (ADT) RANGE[2]	LOCAL EXAMPLE
Local	25	25	0-1,500	Channing Way
Collector	30	25	1,501-5,000	Euclid Avenue
Minor Arterial	35	25	5,001 – 12,500	Cedar Street
Major Arterial	>40	25	>12,500	Sacramento Street

1. Street classifications are based on current Berkeley GIS data typology (local, connector, minor and major) and may differ from classifications in the Berkeley General Plan.

2. Traffic volume range is based on average daily traffic data for Berkeley. The street class and the traffic volume range are generally consistent, but there may be exceptions in each category.

***Table C-3:** Level of Traffic Stress Criteria for Unsignalized Crossings Bike Tour Calibration*

TRAFFIC VOLUME	WIDTH*	MTI SCORE	LTS+ SCORE	BIKE TOUR INTERSECTION AND BIKE TOUR SURVEYED SCORE
Without a Crossing Island				
5,001 – 12,500	Up to 3 lanes	2	3	Bowditch Street and Bancroft Way (4) Average LTS = 3.275
>12,500	Up to 3 lanes	3	4	Ashby Avenue and Hillegass Avenue (3.8) Virginia Street and MLK Jr. Way (3.2) Hillegass Avenue and Dwight Way (2.8) Shattuck Avenue and Russell Street (3.1)
5,001 – 12,500	4-5 lanes	3	N/A	(No calibration data from Bike Tour)
>12,500	4-5 lanes	4	4	Telegraph and Woolsey (X.X) MLK and Channing (X.X)
With a Crossing Island				
5,001 – 12,500	Up to 3 lanes		N/A	(No calibration data from Bike Tour)
>12,500	Up to 3 lanes		N/A	(No calibration data from Bike Tour)
5,001 – 12,500	4-5 lanes			Oxford and Hearst (X.X)**
>12,500	4-5 lanes			Sacramento and Virginia (X.X) Shattuck and Virginia (X.X)***

* Streets below 5,000 ADT were not considered as part of this Collector/Arterial street crossing analysis.

** Crossing island and four lanes on south leg of intersection only.

*** Influence of RRFB at this location is not yet fully understood; more study is required. This analysis assumes that because of the increased gaps in traffic it provides, it is equivalent to a crossing island.

***Table C-4:** Level of Traffic Stress Criteria for Unsignalized Crossings without a Crossing Island*

WIDTH OF STREET BEING CROSSED			
Traffic Volume (ADT)	**Up to 3 lanes**	**4-5 lanes**	**6+ lanes[1]**
<1,500[2]	LTS 1	LTS 2	LTS 4
1,501-5,000[2]	LTS 1 or 2[3]	LTS 2	LTS 4
5,001 – 12,500	LTS 3	LTS 3	LTS 4
>12,500	LTS 4[3]	LTS 4	LTS 4

1 This table is based on Table 7 in the MTI report, and some of these street configurations (i.e. 6 lane streets with less than 1,500 ADT) do not exist in Berkeley.

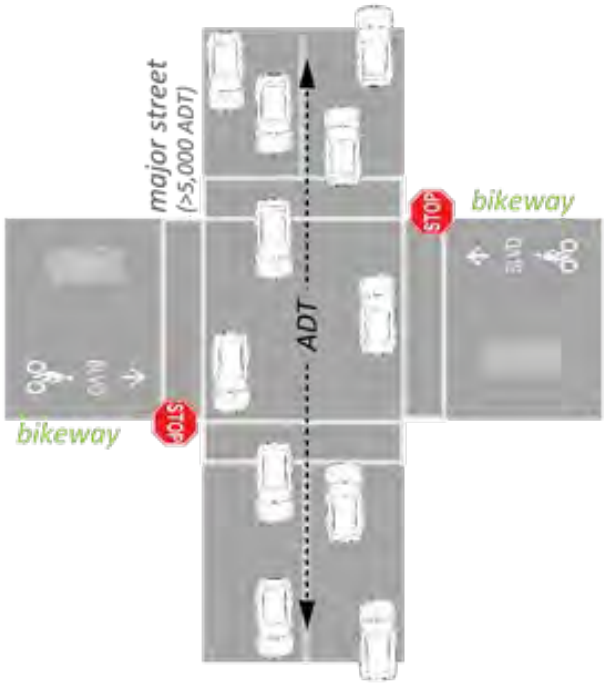
2 The Bike Tour did not survey LTS scores for intersections with less than 5,000 ADT. As such there is no data to calibrate these <5,000 ADT intersections. However, calibration increased the scores for those streets with up to three lanes and ADT higher than 5,000. As such, calibration is assumed to be needed for similar streets below 5,000 ADT.

3 LTS score is context sensitive. In these cases LTS 1 or LTS 2 should be determined on a case-by-case basis based on the specific traffic volume of the street being crossed, including if there are breaks in the flow of traffic. A suggested break-point between LTS 1 and LTS 2 is 3,250 vehicles, median of 1the 1,501-5,000 range.

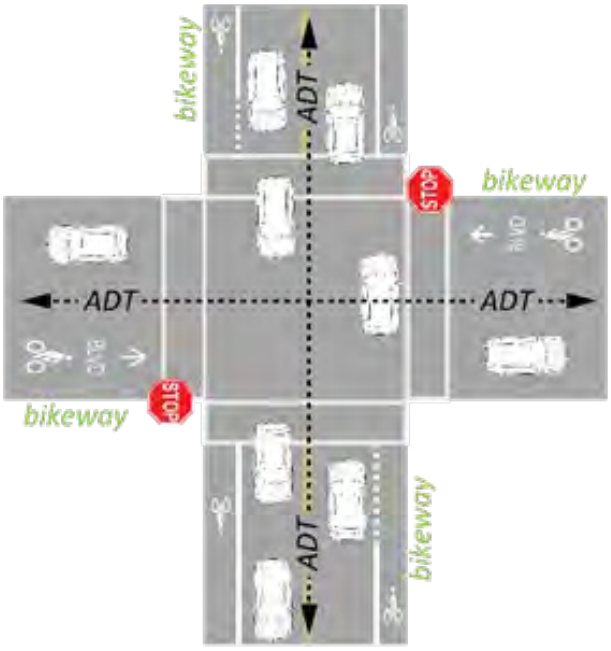
***Table C-5:** Level of Traffic Stress Criteria for Unsignalized Crossings with a Crossing Island at Least Six Feet Wide*

WIDTH OF STREET BEING CROSSED			
Traffic Volume (ADT)	**Up to 3 lanes**	**4-5 lanes**	**6+ lanes***
<1,500	LTS 1	LTS 1	LTS 2
1,501-5,000	LTS 1	LTS 2	LTS 3
5,001 – 12,500	LTS 2	LTS 3	LTS 4
>12,500	LTS 3	LTS 4	LTS 4

* This table is based on Table 8 in the MTI report, and some of these street configurations (i.e. 6 lane streets with less than 1,500 ADT) do not exist in Berkeley.



Unsignalized Intersection: Bikeway and Collector/Arterial Street. At the unsignalized intersection of a bikeway and a major street (>5,000 ADT), the ADT of the major street will influence the intersection's level of traffic stress score.



Unsignalized Intersection: Bikeway and Bikeway. At the unsignalized intersection of two bikeways, the bikeway with the highest ADT will influence the intersection's level of traffic stress score.

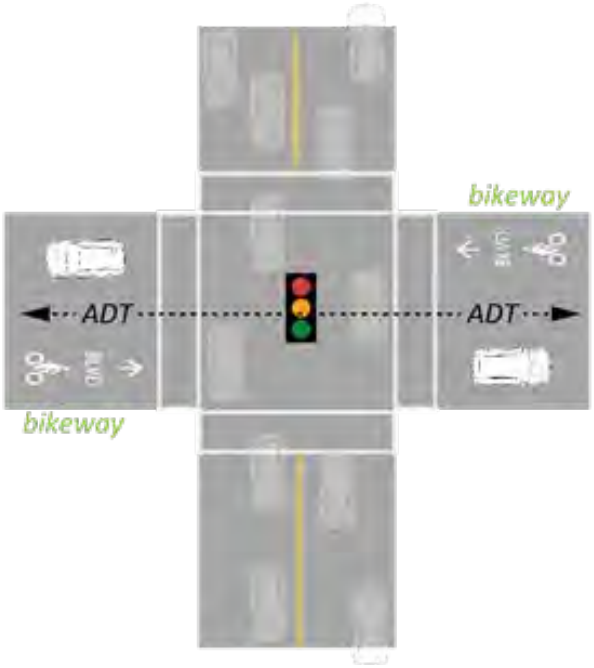
Table C-6 shows an example of the Calibrated LTS scoring methodology for an unsignalized intersection of a bikeway (Channing Way) and an arterial street (San Pablo Avenue). With the posted speed limit factor, this intersection would have scored a LTS 2, which would suggest it is appropriate for most bicyclists. However, when the project team replaced the posted speed limit with the ADT (26,500) of the cross-street (San Pablo Avenue), the intersection receives an LTS score of 4. For more detail about the other factors listed in Table C-6, please see the MTI Report.

***Table C-6:** Sample Scoring of Unsignalized Intersection Bikeway (Channing Way) and Other Street (San Pablo Avenue)*

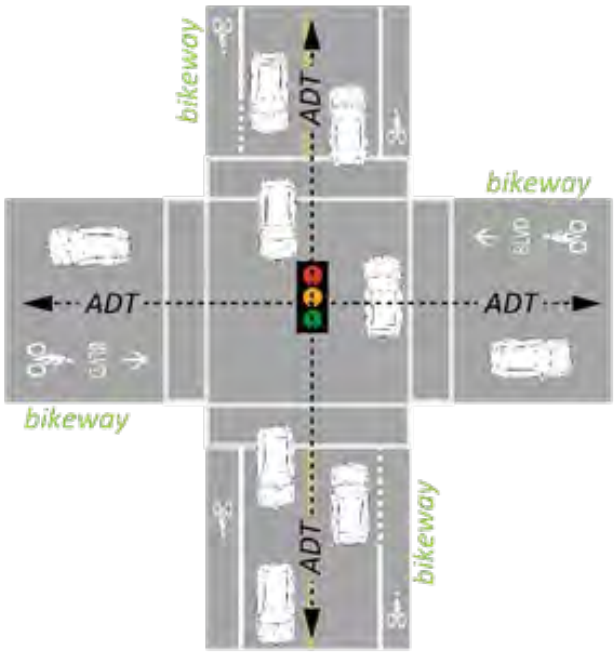
CHANNING WAY AND SAN PABLO STREET	LTS (MTI)		CALIBRATED LTS	
	VARIABLE	SCORE	VARIABLE	SCORE
Cross-street posted speed limit / ADT	25 MPH	2	26,500 ADT	4
Number of travel lanes	4	2	4	4
Bicycle/pedestrian refuge islands	No	n/a	No	n/a
Presence of a traffic signal	n/a	n/a	n/a	n/a
Right turn lane	None	n/a	None	n/a
Intersection Score		LTS 2		LTS 4

Signalized Intersections

The LTS scoring criteria from **Tables C-7**, **C-8**, and **C-9** were used to calibrate signalized intersections. The segment scoring criteria was used as a substitution for the pocket bike lane criterion used in the MTI Report because Berkeley has so few right turn lanes. The purpose of the pocket bike lane criterion was to evaluate the stress associated with the level of interaction between bicycles and motor-vehicles at an intersection approach. Interactions are precipitated by the need for bicyclists to merge across or into a motor-vehicle lane (or vice-versa). The LTS segment criteria on the approach served as a proxy for the pocket bike lane criterion because it measures the level of interaction between bicyclists and cars on an intersection approach. If the intersection includes the crossing of two bikeways, the intersection considered the leg with the highest LTS score. There are always other factors that affect the appeal and comfort of an intersection. The impact of additional elements not explicitly outlined here (e.g., wayfinding and striping) were assessed on a case-by-case basis.



Signalized Intersection: Bikeway and Other Street. At the signalized intersection of a bikeway and non-bikeway street, the LTS criteria for segments was used to evaluate the bikeway's approach to the intersection and the overall intersection LTS score.



Signalized Intersection: Bikeway and Bikeway. At the signalized intersection of two bikeways, the bikeway with the highest ADT determined the level of traffic stress score.

SEGMENTS

For the analysis, speed limit was replaced with ADT to calibrate the LTS of streets with bicycle facilities (the segments between intersections). For segments, level of comfort decreases with an increase in ADT. Level of comfort increases with an increase in separation between a person bicycling and adjacent motor vehicle traffic. Class I and Class IV bikeways are assumed to have the lowest level of traffic stress between intersections and are not listed in the tables below.

Generally speaking, the use of ADT in place of speed limit will provide Calibrated LTS results which confirm the Level of Comfort responses from the *City of Berkeley: Market for Bicycling Survey*. This survey asked respondents to score their level of comfort when bicycling in various roadway conditions. It should be noted that some of the scores in **Tables C-7**, **C-8**, and **C-9** will be different than those reported in the *City of Berkeley: Market for Bicycling Survey*. This discrepancy will be particularly noticeable for Class II Bicycle Lanes. The Calibrated LTS analysis results will show that any four-lane street with a bike lane in Berkeley is an LTS 4 because all of Berkeley's four-lane, bike lane streets are above 12,500 ADT and thus will fall into the LTS 4 category. However, in the Public Survey, the highest LTS score (the most stressful score) for a Class II Bicycle Lane on a four lane street was 2.8, not 4. LTS is context-sensitive, so some of these LTS 4 Class II Bicycle Lane streets will be manually calibrated to a less-stressful LTS score based on the responses from the Public Survey that show that a bike lane – while not offering the highest level of comfort – is far better than nothing at all, especially on Berkeley's busiest streets.

The tables below provide more detail on the criteria for determining the LTS for various types of bikeways.

***Table C-7:** Criteria for Class II Bikeways alongside a Parking Lane*

	LTS > 1	LTS > 2	LTS > 3	LTS > 4
Street width (through lanes per direction)	1	(no effect)	2 or more	(no effect)
Sum of bike lane parking lane width (includes marked buffer and paved gutter)	15 ft. or more	14 or 14.5 ft.	13.5 ft. or less	(no effect)
Average daily traffic (ADT) volume*	<1,500 ADT	1,501-5,000 ADT	5,001-12,500 ADT	>12,500 ADT
Bike lane blockage (typically applies in commercial areas)	rare	(no effect)	frequent	(no effect)

(no effect) = factor does not trigger an increase to this level of traffic stress.

* ADT replaces speed limit or prevailing speed from the MTI Report.

***Table C-8:** Criteria for Class II Bikeways Not Alongside a Parking Lane*

	LTS > 1	LTS > 2	LTS > 3	LTS > 4
Street width (through lanes per direction)	1	2, if directions are separated by a raised median	More than 2, or 2 without a separating median	(no effect)
Bike lane width (includes marked buffer and paved gutter)	6 ft. or more	5.5 ft. or less	(no effect)	(no effect)
Average daily traffic (ADT) volume*	1,501-5,000 ADT or less	(no effect)	5,001-12,500 ADT	>12,500 ADT
Bike lane blockage (typically applies in commercial areas)	rare	(no effect)	frequent	(no effect)

(no effect) = factor does not trigger an increase to this level of traffic stress.

*ADT replaces speed limit or prevailing speed from the MTI Report.

***Table C-9:** Criteria for Class III Bikeways*

TRAFFIC VOLUME (ADT)	2-3 LANES		4-5 LANES	6+ LANES
<1,500	1 or*	2	3	4
1,501-5,000	2 or*	3	4	4
5,001 – 12,500	4		4	4
>12,500	4		4	4

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

C.1.4. Calibrated LTS Factor Summary

For analyzing unsignalized intersections and segments, the Calibrated LTS methodology replaces posted speed limit from the original MTI LTS analysis with ADT. For signalized intersections, the Calibrated LTS methodology replaces right-turn lane and pocket bike lane variables with the segment criteria. **Table C-10** shows a comparison of methodology factors between the original MTI LTS analysis and Calibrated LTS.

***Table C-10:** LTS Methodology Factors for Original LTS and Calibrated LTS*

LTS (MTI)	CALIBRATED LTS
INTERSECTIONS	
Unsignalized	
1. Posted speed limit	1. Average daily traffic (ADT) of cross-traffic
2. Number of travel lanes	2. Number of travel lanes
3. Bicycle/pedestrian refuge islands	3. Bicycle/pedestrian refuge islands
4. Presence of a traffic signal	4. Presence of a traffic signal
5. Right turn lanes	5. Right turn lanes
Signalized	
1. Pocket bike lane	1. Segment LTS criteria for bikeway approach a. ADT b. Number of travel lanes c. Presence and character of bicycle lanes
2. Right turn lane	-
SEGMENTS	
1. Posted speed limit	1. Average daily traffic (ADT)
2. Number of travel lanes	2. Number of travel lanes
3. Presence and character of bicycle lanes	3. Presence and character of bicycle lanes

***Table C-11:** Level of Traffic Stress Definitions and Types of Bicyclists*

LTS LEVEL	DESCRIPTION	WILL THIS TYPE OF BICYCLIST RIDE ON THIS LTS FACILITY?		
		Strong & Fearless	**Enthusiastic & Confident**	**Interested but Concerned**
LTS 1	Presenting little traffic stress and demanding little attention from people riding bicycles, and attractive enough for a relaxing bicycle ride. Suitable for almost all people riding bicycles, including children trained to ride in the street and to safely cross intersections. On corridors, people riding bicycles 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 people ride bicycles alongside a parking lane, they have ample operating space outside the zone into which car doors are opens. Intersections are easy to approach and cross.	Yes	Yes	Yes
LTS 2	Presenting little traffic stress and therefore suitable to most adults riding bicycles but demanding more attention than might be expected from children. On corridors, people riding bicycles 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 bicycle lane lies between a through lane and a right-turn lane, it is configured to give people riding bicycles unambiguous priority where cars cross the bicycle lane and to keep car speed in the right-turn lane comparable to bicycling speeds. Crossings are not difficult for most adults.	Yes	Yes	Sometimes
LTS 3	More traffic stress than LTS 2, yet markedly less than the stress of integrating with multilane traffic. Offering people riding bicycles 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 reasonably safe for many adult pedestrians.	Yes	Sometimes	No
LTS 4	A level of stress beyond LTS 3. Includes roadways that have no dedicated bicycle facilities and moderate to higher vehicle speeds and volumes, as well as those with an exclusive riding zone (lane) but on a high speed and high volume road where there is a significant speed differential. Crossings are challenging and involve multiple lanes of traffic at higher speeds and volumes where gaps may be infrequent and motorists may not readily yield. Suitable for the "strong and fearless" only.	Yes	No	No

The level of stress scores, or relative user comfort, were mapped to illustrate the low stress connections and gaps throughout the City of Berkeley. It is important to note that people tolerate different levels of stress; a strong and fearless bicyclist will feel less stress than an interested but concerned bicyclist. The LTS results map is trying to capture the user experience for the majority of Berkeley residents, however people may have differing opinions of traffic stress depending on their own experience.

C.1.5. LTS Findings

Many of the existing bicycle network segments in the City of Berkeley score in the LTS 1 or LTS 2 classification, in other words relatively low stress streets that are acceptable for travel by some children (LTS 1) and the majority of adults (LTS 2). These are primarily neighborhood street Bicycle Boulevards. However, high stress roadways and intersections bisect this low stress network and create barriers for people who bike along the Bicycle Boulevards, cross major roadways, or want to access major service and commercial corridors, effectively lowering the corridor LTS score and dramatically reducing comfort.

Figure C-1 shows the Level of Traffic Stress (LTS) results of the major roadways and bicycle network in Berkeley. Major roadways, such as San Pablo Avenue and Martin Luther King Jr. Way have a high LTS score, which indicates they are the most stressful for people riding bicycles. Low-speed and low-volume streets such as Channing Way and Russell Street have low LTS scores, which indicates they are more comfortable for younger people riding bicycles and cautious adults riding bicycles. The following maps show a breakdown of the results and the implications of the high stress streets on the City's generally low stress bikeway network.

The low stress streets that have an LTS score of 1 or 2 are shown in **Figure C-2**. These are the streets on which nearly all types of people riding bicycles should feel comfortable. As shown, Berkeley has a well-connected network of low stress bikeways. California Street, 9th Street and Hillegass Avenue provide north-south connections; Virginia Street, Channing Way and Russell Street provide east-west connections. However, there are gaps in the low stress network, including a section on the Milvia Street Bicycle Boulevard, and a lack of low stress connections north and south of Virginia Street, and between Channing Way and Russell Street, and surrounding the UCB campus.

Figure C-3 shows high-stress (LTS 3 or 4) streets and intersections along the existing bikeway network. High-stress intersections are often a result of a bikeway crossing a major roadway

where the intersection design or stop-control is insufficient. For example, Channing Way, an LTS 2 Bicycle Boulevard, crosses Sacramento Street, which is a high-volume roadway. Sacramento Street traffic does not stop, and people riding bicycles must traverse multiple lanes of traffic to continue. As such, an "Interested but Concerned" cyclist may feel comfortable biking on Channing Way, but his/her journey becomes far more stressful upon reaching Sacramento Street. While many "enthusiastic and confident" or "interested but concerned" Berkeley residents endure such stressful crossing conditions out of necessity, only the three percent of Berkeley residents who identify as "strong and fearless" would actually feel comfortable bicycling on Channing Way across Sacramento Street. High-stress intersections become impediments for individuals traveling on the bike network, and likely inhibit the 16 percent of "enthusiastic and confident" and the 71 percent of "interested but concerned" residents from biking more frequently, or at all. As is, there are very few continuous low stress segments that provide access entirely across Berkeley.

Finally, **Figure C-4** shows low stress (LTS 1 and 2) streets and intersections with high stress (LTS 4) gaps. This map helps illustrate how low stress streets in Berkeley's network are often disconnected by high stress roadways and intersections. A continuous low stress network is essential for bicyclists of all abilities to travel easily throughout the street network.

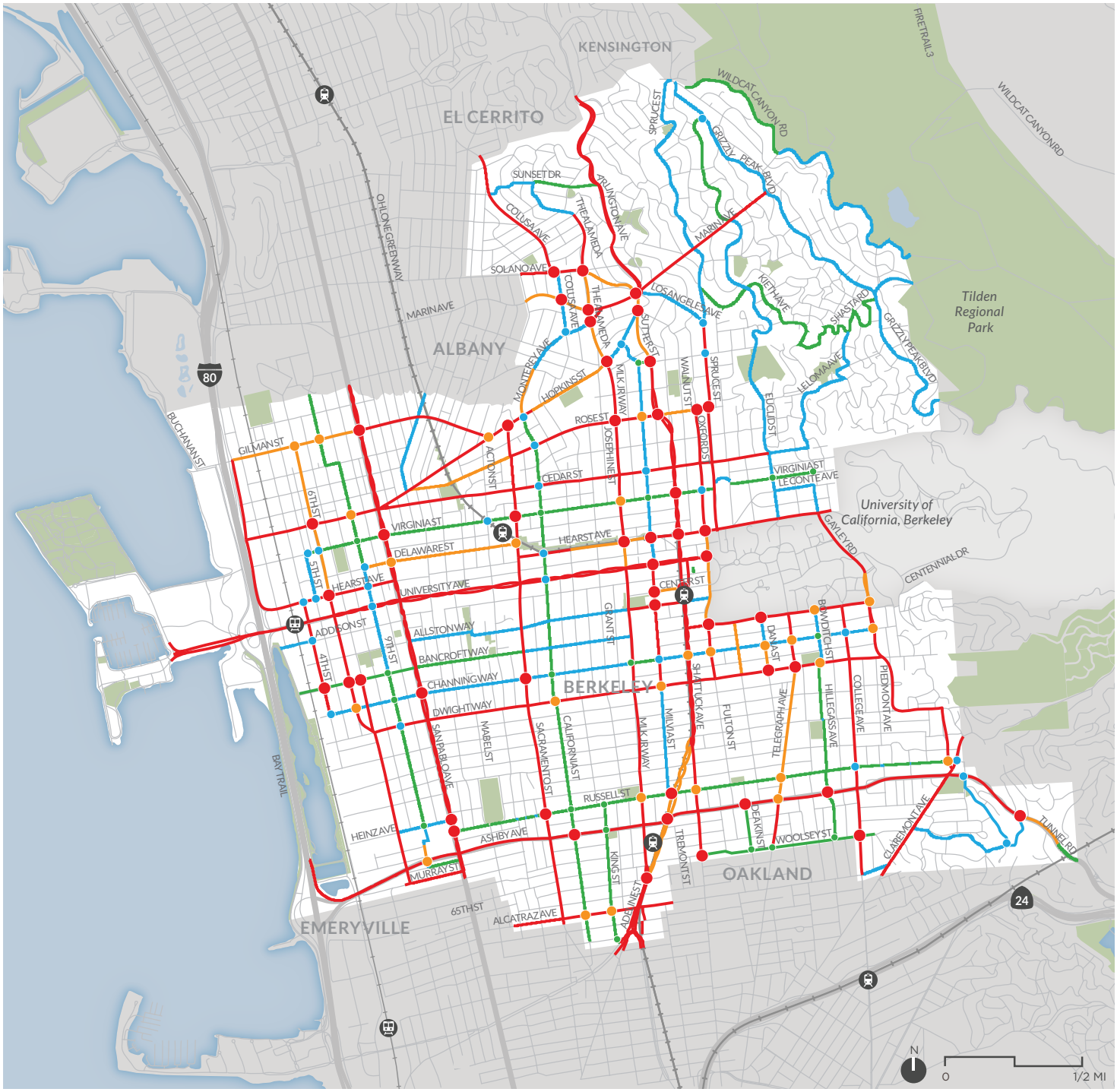


FIGURE C-1: LEVEL OF TRAFFIC STRESS

CORRIDORS

- LTS 1 - ALL AGES AND ABILITIES *(Up to 90% of Berkeley residents)*
- LTS 2 - INTERESTED BUT CONCERNED *(Up to 79% of Berkeley residents)*
- LTS 3 - ENTHUSIASTIC AND CONFIDENT *(Up to 16% of Berkeley residents)*
- LTS 4 - STRONG AND FEARLESS *(Up to 3% of Berkeley residents)*

INTERSECTIONS

- LTS 1 - ALL AGES AND ABILITIES *(Up to 90% of Berkeley residents)*
- LTS 2 - INTERESTED BUT CONCERNED *(Up to 79% of Berkeley residents)*
- LTS 3 - ENTHUSIASTIC AND CONFIDENT *(Up to 16% of Berkeley residents)*
- LTS 4 - STRONG AND FEARLESS *(Up to 3% of Berkeley residents)*

PARK/REC RAILROAD BART STATION AMTRAK STATION

FIGURE C-2: LOW STRESS NETWORK COVERAGE

CORRIDORS

LTS 1 - ALL AGES AND ABILITIES

LTS 2 - INTERESTED BUT CONCERNED

INTERSECTIONS

LTS 1 - ALL AGES AND ABILITIES

LTS 2 - INTERESTED BUT CONCERNED

PARK/REC

RAILROAD

BART STATION

AMTRAK STATION

FIGURE C-3: HIGH STRESS NETWORK AND HIGH STRESS INTERSECTIONS

along the Existing Bikeway Network

CORRIDORS

LTS 3 - ENTHUSIASTIC AND CONFIDENT

LTS 4 - STRONG AND FEARLESS

PARK/REC

RAILROAD

INTERSECTIONS

LTS 3 - ENTHUSIASTIC AND CONFIDENT

LTS 4 - STRONG AND FEARLESS

BART STATION

AMTRAK STATION

FIGURE C-4: LOW STRESS NETWORK & INTERSECTIONS WITH HIGH STRESS NETWORK & INTERSECTION GAPS

CORRIDORS

- LTS 1 - ALL AGES AND ABILITIES
- LTS 2 - INTERESTED BUT CONCERNED

NETWORK GAPS

- LTS 3 - ENTHUSIASTIC AND CONFIDENT
- LTS 4 - STRONG AND FEARLESS

INTERSECTIONS

- LTS 1 - ALL AGES AND ABILITIES
- LTS 2 - INTERESTED BUT CONCERNED

INTERSECTION GAPS

- LTS 3 - ENTHUSIASTIC AND CONFIDENT
- LTS 4 - STRONG AND FEARLESS

PARK/REC · RAILROAD · BART STATION · AMTRAK STATION

C.1.6. LTS Conclusion

The Level of Traffic Stress results demonstrate the importance of assessing a citywide bikeway not only for connectivity but also for its ability to serve the diverse needs of its users. Although the current Berkeley bikeway network has a seemingly well-connected network of low stress bikeways, the high-stress gaps (segments and intersections) likely inhibit the 87 percent of Berkeley residents who identify as "enthusiastic and confident" and "interested but concerned" from bicycling. The implications of this finding are significant. To serve all types of people riding bicycles, a bikeway network should consist of continuous low stress LTS 1 and LTS 2 segments and intersections. By pinpointing and prioritizing the exact locations that likely dissuade people riding bicycles, this Plan can focus on identifying the improvements that will bring the high-stress LTS 3 and LTS 4 gaps down to low stress LTS 1 and LTS 2 levels, thereby removing the barriers to bicycling for a large proportion of Berkeley residents. The following section identifies the gaps in the low stress Berkeley bikeway network.

C.2. BIKEWAY NETWORK GAPS

A well-connected bikeway network has low stress bikeways that link to destinations across the City, including schools, libraries, parks, major commercial corridors, and employment centers. This section assesses the connectivity and continuity of the low stress bikeway network by identifying high-stress gaps within that network. There are two types of gaps when considering a citywide bikeway network.

1. **High-stress gaps** occur on the bikeway network where a bikeway segment or intersection has a high-stress score of LTS 3 or LTS 4. On the Bicycle Boulevard network, any bikeway segment or intersection with a score of LTS 2 or above is considered a high-stress gap; the Bicycle Boulevard network is presumed to be a primarily low stress network for bicyclists of all ages.
2. **Bikeway network demand gaps** are missing bikeway segments where there is high demand but no existing bikeway. Examples include a neighborhood with a deficiency of bikeway access, or a commercial street that has a density of destinations but lacks a bikeway. These activity generators are the locations that generate the highest demand for bicycling.

In comparing the City's bikeway LTS results, existing bikeway network extents and existing land uses, the project team can identify if the existing network is serving major land uses and destinations for all types of bicyclists. The gaps in the existing low stress bikeway network and bikeway demand gaps are listed in **Table C-12** and **Table C-13**. Subsequent chapters of this plan will prioritize these gaps for implementation.

The most notable network gaps include the bikeway segments that score as LTS 3 and LTS 4 in the LTS analysis, and the major commercial and retail corridors and areas, including Shattuck Avenue, University Avenue, San Pablo Avenue, Telegraph Avenue, and Adeline Street.

***Table C-12:** Low Stress Bikeway Corridor Gaps*

LOCATION	BIKEWAY FACILITY	BIKE BLVD	EXTENTS		LEVEL OF TRAFFIC STRESS SCORE
			From	To	
Corridors					
Gilman Street	Class IIA – Standard bike lane		I-80	San Pablo Avenue	LTS 3
Gilman Street	Class IIIC - Sharrows		San Pablo Avenue	Hopkins Street	LTS 4
6th Street	Class IIA – Standard bike lane		Gilman Street	Hearst Avenue	LTS 3
Monterey Avenue	Class IIA – Standard bike lane		Hopkins Street	Posen Avenue	LTS 3
Marin Avenue	Class IIA – Standard bike lane		Sutter Street	The Alameda	LTS 3
Marin Avenue	Class IIA – Standard bike lane		The Alameda	Tulare Avenue	LTS 4
Hopkins Street	Class IIA – Standard bike lane		Monterey Avenue	The Alameda	LTS 3
Hopkins Street	Class IIIA – Signage-only		Gilman Street	Monterey Avenue	LTS 4
Sutter Street	Class IIA – Standard bike lane		Eunice Street	Los Angeles Avenue	LTS 3
Rose Street	Class IIIA – Signage-only		Monterey Avenue	Spruce Street	LTS 4
The Alameda	Class IIA – Standard bike lane		Solano Avenue	Hopkins Street	LTS 3
Hearst Street	Class IIA – Standard bike lane		Sacramento Street	McGee Avenue	LTS 4
Hearst Street	Class IIA – Standard bike lane		McGee Avenue	Milvia Street	LTS 3
Hearst Street	Class IIA – Standard bike lane		Milvia Street	Shattuck Avenue	LTS 4

***Table C-12:** Low Stress Bikeway Corridor Gaps Continued*

LOCATION	BIKEWAY FACILITY	BIKE BLVD	EXTENTS		LEVEL OF TRAFFIC STRESS SCORE
			From	To	
Corridors					
Delaware Street	Class IIA – Standard bike lane		9th Street	Sacramento Street	LTS 3
Oxford Street	Class IIA – Standard bike lane		Bancroft Way	Hearst Street	LTS 3
Center Street	Class IIA – Standard bike lane		Milvia Street	Shattuck Avenue	LTS 3
Gayley Road	Class IIA – Standard bike lane		Bancroft Way	Stadium Rim Way	LTS 3
Tunnel Road	Class IIB – Upgraded bike lane		Bridge Road	Tunnel Road	LTS 3
Tunnel Road	Class IIIC - Sharrows		Vicente Road	Bridge Road	LTS 4
Telegraph Avenue	Class IIA – Standard bike lane		Ashby Avenue	Dwight Way	LTS 3
Telegraph Avenue	Class IIIC - Sharrows		Woolsey Street	Ashby Avenue	LTS 4
Milvia Avenue	Class IIA – Standard bike lane, Bicycle Boulevard	Bike Blvd	Allston Way	Channing Way	LTS 4
Milvia Avenue	Class IIIA – Bicycle Boulevard	Bike Blvd	University Avenue	Allston Way	LTS 4
4th Street	Class IIIC - Sharrows		Hearst Ave	Channing Way	LTS 4
Hearst Avenue	Class IIIC - Sharrows		4th Street	5th Street	LTS 4
9th Street	Class IIIA – Bicycle Boulevard	Bike Blvd	Anthony Street	Ashby Avenue	LTS 3
Adeline Street	Class IIA – Standard bike lane		Alcatraz Avenue	Shattuck Avenue	LTS 3
Dana Street	Class IIA – Standard bike lane		Dwight Way	Channing Way	LTS 3
Bowditch Street	Class IIA – Standard bike lane	Bike Blvd	Dwight Way	Bancroft Way	LTS 2
Channing Way	Class IIIA – Bicycle Boulevard	Bike Blvd	4th Street	Piedmont Avenue	LTS 2
Milvia Street	Class IIIA – Bicycle Boulevard	Bike Blvd	Hopkins Street	University Avenue	LTS 2
Milvia Street	Class IIIA – Bicycle Boulevard	Bike Blvd	Dwight Way	Russell Street	LTS 2
9th Street	Class IIA – Standard bike lane	Bike Blvd	Delaware Street	Bancroft Way	LTS 2
Heinz Avenue	Class IIA – Standard bike lane	Bike Blvd	7th Street	San Pablo Avenue	LTS 2
9th Street	Class IIA – Standard bike lane	Bike Blvd	Heinz Avenue	Anthony Street	LTS 2

***Table C-13:** Low Stress Bikeway Intersection Gaps*

LOCATION	BIKEWAY FACILITY	CROSS STREET	LTS	BIKE BLVD
6th Street	Class IIA – Standard bike lane	Cedar Street	LTS 4	
6th Street	Class IIA – Standard bike lane	Hearst Street	LTS 4	
9th Street	Class IIA – Standard bike lane	Hearst Avenue	LTS 2	Bike Blvd
9th Street	Class IIA – Standard bike lane	University Avenue	LTS 2	Bike Blvd
9th Street	Class IIIE – Bicycle Boulevard	Delaware Street	LTS 2	Bike Blvd
9th Street	Class IIIE – Bicycle Boulevard	Dwight Way	LTS 2	Bike Blvd
9th Street	Class IIIE – Bicycle Boulevard	Cedar Street	LTS 3	Bike Blvd
9th Street	Class IIIE – Bicycle Boulevard	Ashby Avenue	LTS 3	Bike Blvd
Adeline Street	Class IIA – Standard bike lane	Ashby Avenue	LTS 4	
Adeline Street	Class IIA – Standard bike lane	Russell Street	LTS 4	
Bancroft Way	Class IIIA – Signage-only	4th Street	LTS 4	
Bancroft Way	Class IIIA – Signage-only	6th Street	LTS 4	
Bancroft Way	Class IIIA – Signage-only	7th Street	LTS 4	
Bowditch Street	Class IIA – Standard bike lane	Bancroft Way	LTS 3	Bike Blvd
Bowditch Street	Class IIA – Standard bike lane	Dwight Way	LTS 3	Bike Blvd
California Street	Class IIA – Standard bike lane	Hopkins Street	LTS 2	Bike Blvd
California Street	Class IIA – Standard bike lane	Rose Street	LTS 2	Bike Blvd
California Street	Class IIA – Standard bike lane	Cedar Street	LTS 2	Bike Blvd
California Street	Class IIA – Standard bike lane	Hearst Avenue	LTS 2	Bike Blvd
California Street	Class IIA – Standard bike lane	University Avenue	LTS 2	Bike Blvd
California Street	Class IIA – Standard bike lane	Dwight Way	LTS 3	Bike Blvd
California Street	Class IIA – Standard bike lane	Alcatraz Avenue	LTS 3	
California Street	Class IIA – Standard bike lane	Ashby Avenue	LTS 4	
Center Street	Class IIA – Standard bike lane	Shattuck Avenue	LTS 4	
Channing Way	Class IIA – Standard bike lane	Milvia Street	LTS 2	Bike Blvd
Channing Way	Class IIA – Standard bike lane	College Avenue	LTS 2	Bike Blvd
Channing Way	Class IIIE – Bicycle Boulevard	4th Street	LTS 2	Bike Blvd

***Table C-13:** Low Stress Bikeway Intersection Gaps Continued*

LOCATION	BIKEWAY FACILITY	CROSS STREET	LTS	BIKE BLVD
Channing Way	Class IIA – Standard bike lane	Shattuck Avenue	LTS 3	Bike Blvd
Channing Way	Class IIA – Standard bike lane	Fulton Street	LTS 3	Bike Blvd
Channing Way	Class IIA – Standard bike lane	Dana Street	LTS 3	Bike Blvd
Channing Way	Class IIA – Standard bike lane	Telegraph Avenue	LTS 3	Bike Blvd
Channing Way	Class IIA – Standard bike lane	Piedmont Avenue	LTS 3	Bike Blvd
Channing Way	Class IIIE – Bicycle Boulevard	6th Street	LTS 3	Bike Blvd
Channing Way	Class IIIE – Bicycle Boulevard	San Pablo Avenue	LTS 4	Bike Blvd
Channing Way	Class IIIE – Bicycle Boulevard	Sacramento Street	LTS 4	Bike Blvd
Colusa Avenue	Class IIA – Standard bike lane	Solano Avenue	LTS 4	
Colusa Avenue	Class IIA – Standard bike lane	Marin Avenue	LTS 4	
Dana Street	Class IIA – Standard bike lane	Bancroft Way	LTS 4	
Dana Street	Class IIA – Standard bike lane	Dwight Way	LTS 4	
Deakin Street	Class IIIA – Signage-only	Ashby Avenue	LTS 4	
Delaware Street	Class IIA – Standard bike lane	Sacramento Street	LTS 3	
Delaware Street	Class IIA – Standard bike lane	San Pablo Avenue	LTS 3	
Gilman Street	Class IIA – Standard bike lane	6th Street	LTS 3	
Gilman Street	Class IIA – Standard bike lane	9th Street	LTS 3	
Gilman Street	Class IIIC – Sharrows	Hopkins Street	LTS 3	
Gilman Street	Class IIA – Standard bike lane	San Pablo Avenue	LTS 4	
Hearst Street	Class IIA – Standard bike lane	Shattuck Avenue	LTS 4	
Hearst Street	Class IIA – Standard bike lane	Milvia Avenue	LTS 4	
Hearst Street	Class IIA – Standard bike lane	Martin Luther King Jr Way	LTS 4	
Heinz Avenue	Class IIIE – Bicycle Boulevard	San Pablo Avenue	LTS 4	Bike Blvd
Hillegass Avenue	Class IIIE – Bicycle Boulevard	Ashby Avenue	LTS 3	Bike Blvd
Hopkins Street	Class IIA – Standard bike lane	The Alameda	LTS 4	
Hopkins Street	Class IIA – Standard bike lane	Sutter Street	LTS 4	
Hopkins Stree	Class IIIA – Signage-only	Sacramento Street	LTS 4	
King Street	Class IIIE – Bicycle Boulevard	Alcatraz Avenue	LTS 3	Bike Blvd

***Table C-13:** Low Stress Bikeway Intersection Gaps Continued*

LOCATION	BIKEWAY FACILITY	CROSS STREET	LTS	BIKE BLVD
Marin Avenue	Class IIA – Standard bike lane	Sutter Street	LTS 4	
Milvia Avenue	Class IIIE – Bicycle Boulevard	Cedar Street	LTS 2	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	Channing Way	LTS 2	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	Dwight Way	LTS 3	Bike Blvd
Milvia Avenue	Class IIA – Standard bike lane	Allston Way	LTS 4	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	Hearst Avenue	LTS 4	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	University Avenue	LTS 4	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	Center Street	LTS 4	Bike Blvd
Milvia Avenue	Class IIIE – Bicycle Boulevard	Russell Street	LTS 4	Bike Blvd
Milvia Street	Class IIIE – Bicycle Boulevard	Hopkins Street	LTS 2	Bike Blvd
Milvia Street	Class IIIE – Bicycle Boulevard	Rose Street	LTS 3	Bike Blvd
Oxford Street	Class IIA – Standard bike lane	Hearst Avenue	LTS 4	
Oxford Street	Class IIA – Standard bike lane	Bancroft Way	LTS 4	
Oxford Street	Class IIA – Standard bike lane	University Avenue	LTS 4	
Rose Street	Class IIIA – Signage-only	Shattuck Avenue	LTS 3	
Rose Street	Class IIIA – Signage-only	Spruce Street	LTS 4	
Rose Street	Class IIIA – Signage-only	Oxford Street	LTS 4	
Rose Street	Class IIIA – Signage-only	Martin Luther King Jr Way	LTS 4	
Russell Street	Class IIIE – Bicycle Boulevard	Claremont Avenue	LTS 2	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	College Avenue	LTS 2	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	Shattuck Avenue	LTS 3	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	Martin Luther King Jr Way	LTS 3	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	Telegraph Avenue	LTS 4	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	Adeline Street	LTS 4	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	Sacramento Street	LTS 4	Bike Blvd
Russell Street	Class IIIE – Bicycle Boulevard	San Pablo Avenue	LTS 4	Bike Blvd
Sutter Street	Class IIA – Standard bike lane	Eunice Street	LTS 4	
Sutter Street	Class IIA – Standard bike lane	Los Angeles Street	LTS 4	

***Table C-13:** Low Stress Bikeway Intersection Gaps Continued*

LOCATION	BIKEWAY FACILITY	CROSS STREET	LTS	BIKE BLVD
The Alameda	Class IIA – Standard bike lane	Solano Avenue	LTS 4	
The Alameda	Class IIA – Standard bike lane	Marin Avenue	LTS 4	
The Alameda	Class IIA – Standard bike lane	Monterey Avenue	LTS 4	
Tunnel Road	Class IIIC – Sharrows	The Uplands	LTS 4	
Virginia Street	Class IIIE – Bicycle Boulevard	Oxford Street	LTS 2	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	Acton Street	LTS 2	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	San Pablo Avenue	LTS 2	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	6th Street	LTS 2	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	5th Street	LTS 2	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	Martin Luther King Jr Way	LTS 3	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	Shattuck Avenue	LTS 4	Bike Blvd
Virginia Street	Class IIIE – Bicycle Boulevard	Sacramento Street	LTS 4	Bike Blvd
Woolsey Street	Class IIIA – Signage-only	College Avenue	LTS 4	
Woolsey Street	Class IIIA – Signage-only	Shattuck Avenue	LTS 4	

The bikeway demand gaps are locations where there is high demand but no existing bikeway facility. The bikeway demand gaps have been identified based on the demand analysis and public feedback discussed in Chapter 4. These are locations where bicyclists are likely already traveling (potentially unsafely or unlawfully).

***Table C-14:** Bikeway Demand Gaps*

LOCATION	EXTENTS	DEMAND	LEVEL OF TRAFFIC SCORE
University Avenue	I-80 to Oxford Street	High demand commercial corridor	LTS 4
Shattuck Avenue	Rose Street to Adeline Street	High demand commercial corridor	LTS 4
Sacramento Street	Allston Way to Hopkins Street	High demand commercial corridor	LTS 4
Ashby Avenue	King Street to Claremont Avenue	High demand commercial corridor	LTS 4
Bancroft Avenue	Bowditch Street to Oxford Street	High demand commercial corridor, UCB Access	LTS 4
San Pablo Avenue	Albany City limits to Oakland City limits	High demand commercial corridor	LTS 4
College Avenue	Bancroft Way to Alcatraz Avenue	High demand commercial corridor	LTS 4
Hearst Avenue	Shattuck Avenue to Gayley Road	UCB Access	LTS 4

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