Redesigning the Bay Corridor

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This report was produced through the UCSC Bicycle Planning Seminar with Professor Adam Millard-Ball.

Image via the Santa Cruz Sentinel

Executive Summary

Purpose

This report's purpose is to bring insight into alternative street designs for a major corridor that has the potential to significantly increase local bike ridership. Our team used recent collision data and knowledge of the city's street pavement priorities to select segments along Bay Street. Our study and recommendations span from the intersection at High St. to the intersection with the currently under-construction Rail Trail (near Redwood St.). Findings in the study observe areas of potential improvement for Bay St. infrastructure where the road is currently posing safety risks. While Bay St. is already a well-used commuting route by cars, cyclists, and buses, added safety measures can potentially incentivize even more cyclists. With the recommendations we provide, the redesign of the street should lead to increased use, especially by cyclists who will benefit from the added protection.

Content

Our report includes the following information:

- A report of current road conditions, including a focus on their compliance with relevant transportation planning standards
- Recommendations for improving the existing infrastructure in order to increase safety benefits for all street users

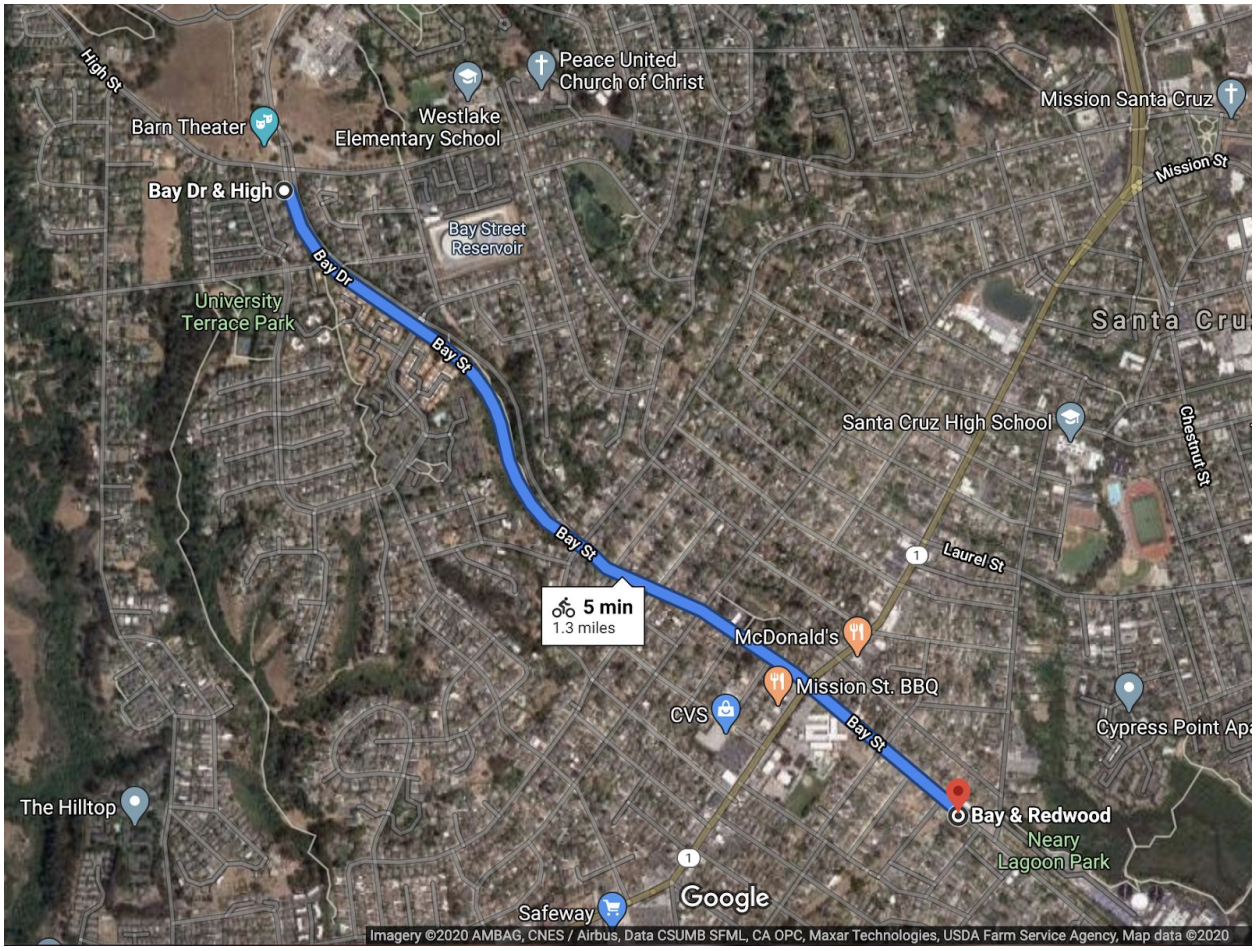


Figure 1. Aerial image of the Bay St. corridor that this report will focus on.

Introduction

Background and Purpose

The city of Santa Cruz has many corridors that provide integral commuting routes to residents. To ensure continued use and decreased collision, the city should implement best practice safety street designs, especially along high traffic corridors. This will encourage “interested but concerned” riders to consider biking as well as help current riders feel more comfortable consistently biking. Based on collision and speed data, the city of Santa Cruz Active Transportation plan and our own observations, we identified the Bay Corridor from High Street to the Rail Trail as an important corridor to implement protected bicycle lanes. This is because it serves as a major commuting route and has the potential to attract new users. A protected bike lane that connects to the Monterey Bay Rail Trail would also be substantial in ensuring a comprehensive bicycle network of safe and efficient bicycle infrastructure.

This report identifies the Bay corridor–compared to other similar corridors–as important and feasible for protected bicycle lanes. We rated corridors based on car speeds, parking, existing bike lanes, and necessary improvements. We used criteria including levels of traffic stress, a way to determine the impact of safety conditions on a road for bicyclists.

We recommend reducing the width of car lanes, creating physical and painted barriers to separate bikes from cars and minimal removal of parking along one three-block section of the Bay corridor. These improvements will ensure that collisions can decrease, intersections become safer, car users are less at risk of collisions and that the bicycle network in Santa Cruz is comprehensive and without significant gaps.

Existing Conditions

This section details the existing conditions of the Santa Cruz bike corridor we chose, Bay Drive starting at High Street to Bay Street and the intercepting Rail Trail, and shows why we picked that route by comparing it to several nearby corridors in the network. Our analysis shows the need for improvements along the Bay corridor based on data from the Santa Cruz Active Transportation Plan, collision data, our team's audits, and survey results from community members.

Setting

The City of Santa Cruz is in Santa Cruz County, California, with a total land area of 15.8 miles and a population of about 65,000 residents. The University of California, Santa Cruz is the main employer in the city, and many employees and students live off-campus. Bay Street is the main bike corridor that connects the UCSC campus to both Mission Street and the Boardwalk area, important economic and community zones, and is a main connecting route for daily commuters. Currently, Bay St. has extensive on-street bicycle lanes, but it lacks physical separation or buffer zones. Having a protected bike lane reaching the rail trail would help to both ensure the safety of the riders who already use the Bay corridor as well as encourage "interested but concerned" potential cyclists. A protected bike lane on Bay would also be essential for expanding upon the city's existing cycle paths such as the UCSC bike path and the West Cliff pedestrian and bike shared off-street path which intersects Bay Street.

Bay Street currently features several Jump Bike stations located at the Bay & High, Bay & King, and Bay & California intersections. Having access to bike-sharing in Santa Cruz is a great step for increasing alternative travel methods. Without a safer biking infrastructure, however, the "interested but concerned" community typically targeted by bike-sharing services will still not feel comfortable enough to change their primary transportation to biking.

Figure 2: A map of the existing bike paths from the Santa Cruz County Regional Transportation Commission (extent of the Bay Corridor being focused on in this report indicated by the blue arrows)

Levels of Traffic Stress

In this section, we will cover the different factors that contribute to determining the levels of traffic stress (LTS) in a given corridor.

This chart and the following criteria are taken from “Level of Traffic Stress Criteria” (Furth, 2012).

- LTS 1: Strong separation from all other modes of transport except low speed, low volume traffic. Simple crossings, suitable for children.
- LTS 2: Except in low speed/low volume traffic situations, cyclists have their own place to ride that keeps them from having to interact with traffic except at formal crossings. Physical separation from higher speed and multi-lane traffic. Crossings that are easy for an adult to negotiate. Corresponds to design criteria for Dutch bicycle route facilities. A level of traffic stress that most adults can tolerate, particularly those sometimes classified as “interested but concerned”.
- LTS 3: Involves interaction with moderate speed or multi-lane traffic, or close proximity to higher speed traffic. A level of traffic stress acceptable to those classified as “enthused and confident”.
- LTS 4: Involves interaction with higher speed traffic or close proximity to high-speed traffic. A level of stress acceptable only to those classified as “strong and fearless”.

Bay St by Street Segments								
	Street Width (thru lanes per direction)	Existing Bicycle Lane Width	Average Daily Traffic	Posted Speed Limits	85% speed	Bike Lane Blockages	Bicycle Collisions (2010-2015)	LTS Score
High-Escalona	2	4'6"	10,448	30mph	29mph	yes, roots and debris	17	3
Escalona-Mission	1	5'4"	12,226	25mph	30mph	n/a	22	2
Mission-Lennox	1	5'6"	7,808	25mph	30mph	n/a	n/a	2

Table 1. Level Of traffic stress table and rating. Widths highlighted in red are below NACTO recommendations (see Overview paragraph in the Recommendations section for background on NACTO). This chart shows that the Bay Corridor is a high priority setting for protected bicycle lanes because it does not protect everyone in its current incarnation.

Safety Risks

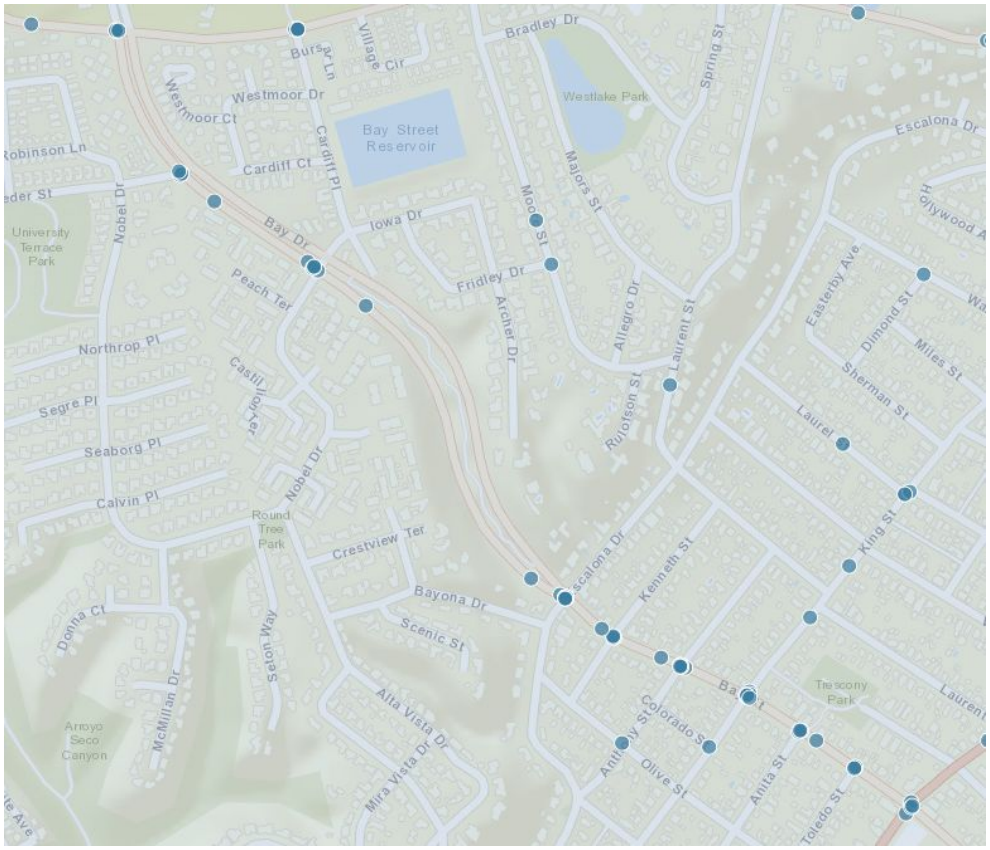


Figure 3 This map shows points of bicycle collisions for the surrounding region from 2008-2018. These points help to demonstrate the use of Bay St as a current passage used by cyclists and a valuable desired corridor for safe cycling and connectivity. **(**Source: tims.berkeley.edu)

Collisions

Cross-Streets	# of Collisions	Occurring At Intersection
High	3	3
Meder	4	2
Nobel	5	2
Escalona	5	3
Kenneth	4	2
Anthony	8	6
King	9	5
Anita	4	2
Toledo	2	2
Mission	4	4
Seaside	3	1
Mason	0	0
Lennox	0	0
Redwood	0	0

Table 2 Total: 51 reported bicycle collisions on Bay St from High to Mission, January 2008- December 2018. **(**Source: tims.berkeley.edu)

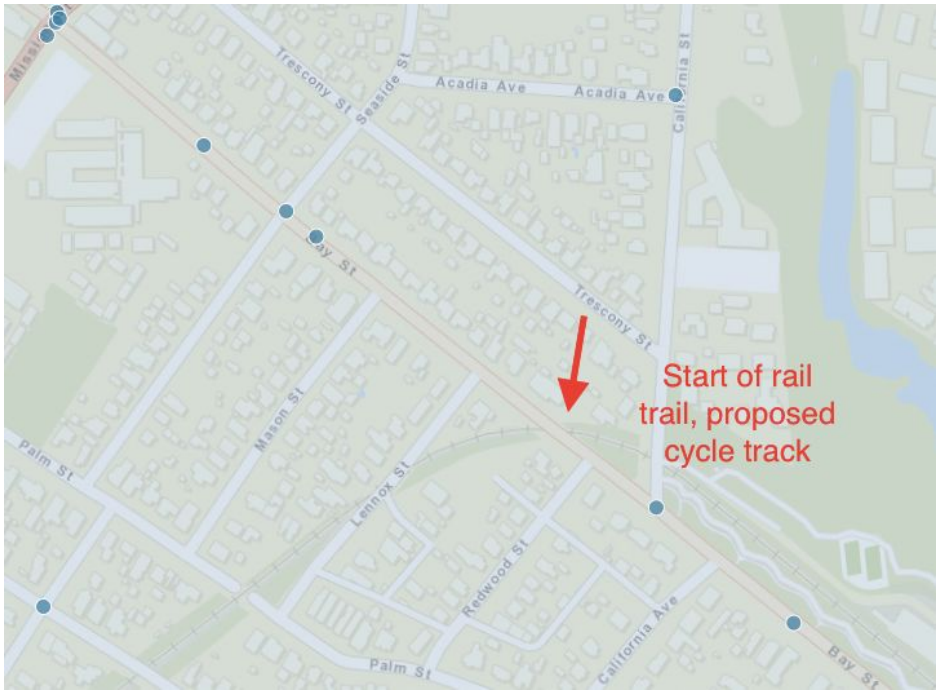


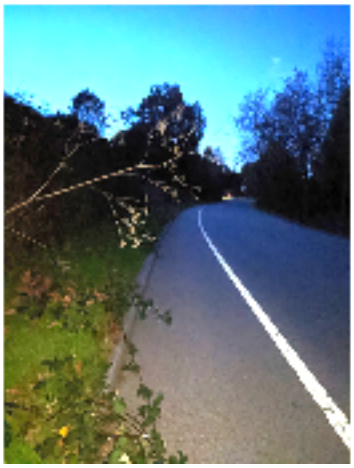
Figure 4 Collisions leading to the rail trail connection. **(**Source: tims.berkeley.edu)

The collision data above is relevant to the construction of the local Rail Trail which would cross Bay Street between Lennox and Redwood Streets. A protected bike lane that reaches this point would be substantial for ensuring a comprehensive network of safe and efficient bicycle infrastructure. It also has the potential to increase ridership by expanding the number of possible destinations one could reach with an LTS-1 or LTS-2 street.

FHWA Guidelines Comparison

The following table is modeled after the Federal Highway Administration (FHWA)'s guiding questions chart for bicycle lanes. We used prompts relevant to our corridor and included photographs of the corresponding descriptions as we saw appropriate. Our findings show multiple instances along Bay St. that pose safety risks to bicyclists. Many of the risks can be minimized or eliminated if a compliant protected bike lane where to be implemented along Bay St.

Prompt	Description	Photo
Does the design adhere to prevailing standards of design, comfort, and safety, or are there better methods that could be set into place?	There is a section of the Bay Corridor bike path (as seen in the photo to the right) that is less than the 3-foot minimum standard imposed by the NACTO design guidelines (see Overview paragraph in the Recommendations section for background on NACTO)	
Does the design favor prevailing speeds of cyclists?	-Going up Bay, the gradient would impact bicycle speed-need for additional width (FHWA guidelines)	
Would protected bicycle lanes improve safety for cyclists and if so, is there room on the street to implement these facilities?	On the stretch of Bay and High to Escalona, the street could be redesigned from two car lanes into one care lane and a protected bike lane	
Does parking adversely affect cycling?	On weekends, holidays, and after 6 PM on weekdays, bike lanes are obstructed by parking on the stretch of Bay St from Anthony St. to Mission St.	

Does debris accumulate in the area specified for cyclists?	On Bay St. from Meder to Escalona, debris and branches routinely obstruct the path	
Are there potholes or other road defects/is the riding surface smooth?	Trees and uneven payment make riding down Bay st from High to Escalona treacherous. Specifically, redwood growth at Meder and Cardiff Court as shown in photos	
Is the riding path adequately lit?	On Bay St. from Meder to Escalona, very low lighting; trees obstruct natural light, no lampposts or artificial light sources	

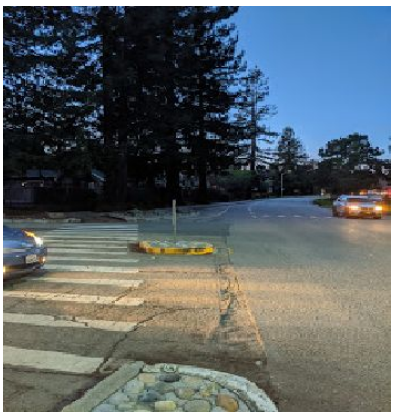
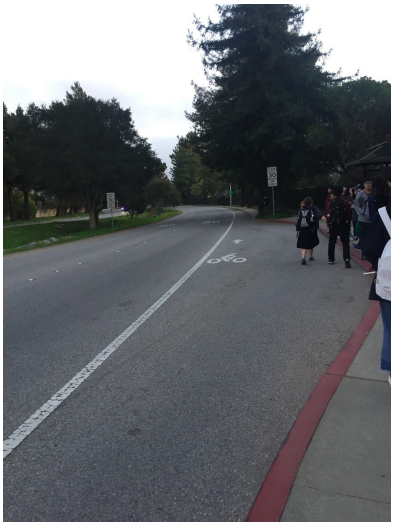
Are accommodations properly designed for approaches to and actual intersections and crossings?	King street intersection with Bay St is a popular left turn for bicyclists and is unprotected; Bike lane breaks at Bay and Nobel to allow cars to make a right turn onto Bay (See picture to the right →)	
Are transit facilities appropriate for cyclists and provide adequate separation for cyclists?	Bus stops force cyclists into lanes of traffic throughout the stretch of bike lane Total bus stops along Bay St. corridor being studied: 13	

Table 3 (Prompts based on FHWA guiding questions)

User Survey Data

A voluntary digital survey of cyclists and non-cyclists was distributed to UCSC affiliates from February 6th - February 13th. A total of 33 participants completed the 4-question survey and their responses were combined into the following graphs.

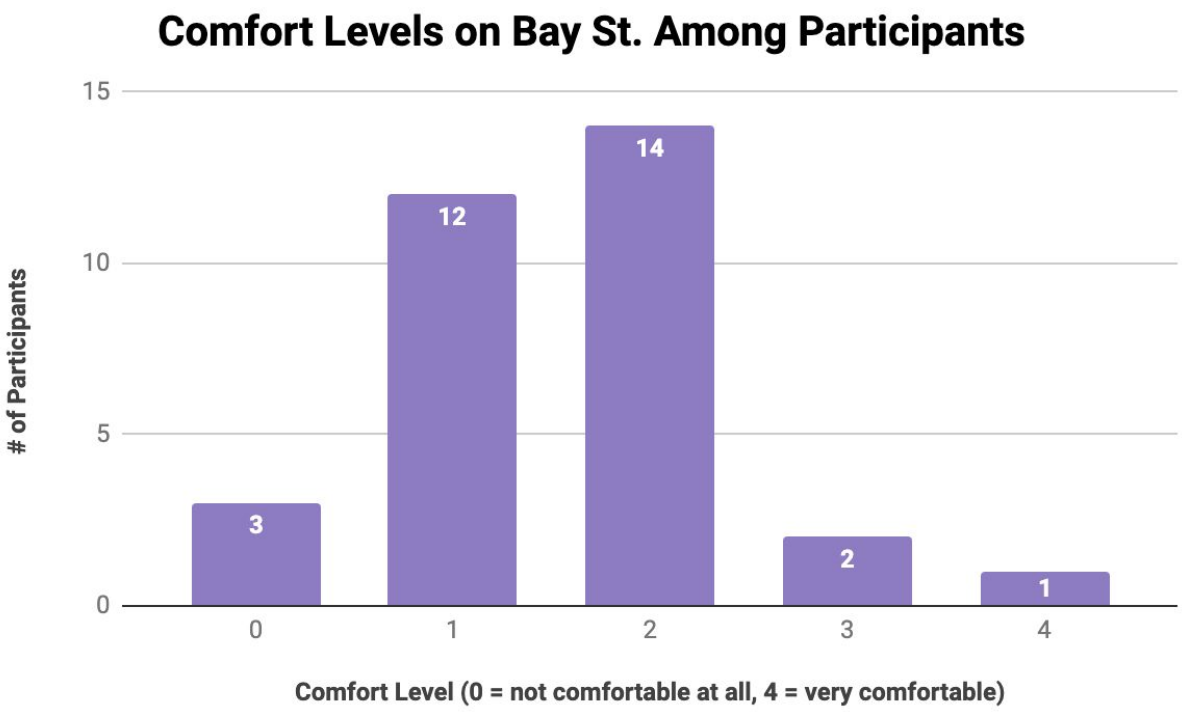
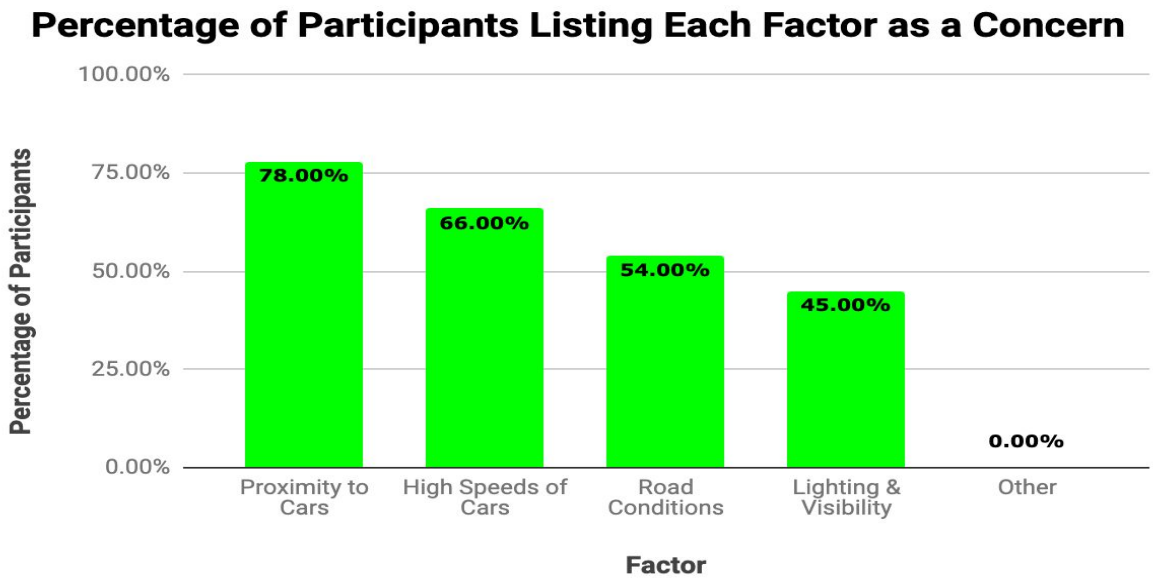


Figure 5. The results of this first graph show how all but a few outliers of cyclists and non-cyclists alike share concerns about their comfort levels about biking on Bay St. These results are to be expected due to the infrastructure not providing adequate protection for cyclists based on the speed and average daily traffic volumes of cars.



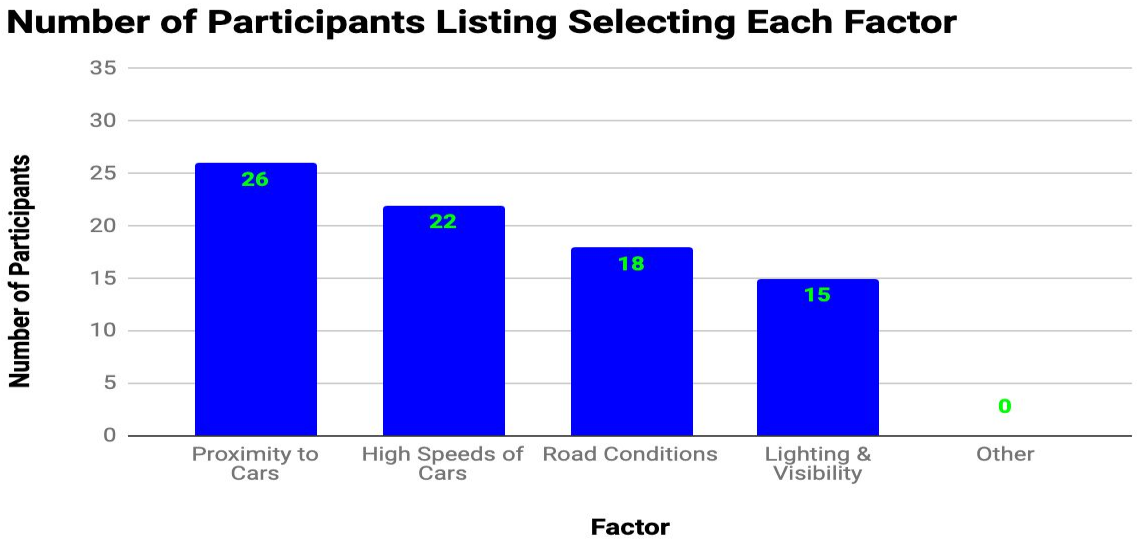


Fig. 6 and Fig. 7. In the above two graphs, it is clear that separation from cars is what would increase cyclists and non-cyclists comfort levels about biking on Bay St. However, these responses also show that road conditions, lighting, and visibility all play a role in feelings of comfort regarding biking on Bay St. If a protected bike lane is to be added to Bay St., it would be wise for improvements to be made to both the condition of the road and the lack of sufficient lighting available.

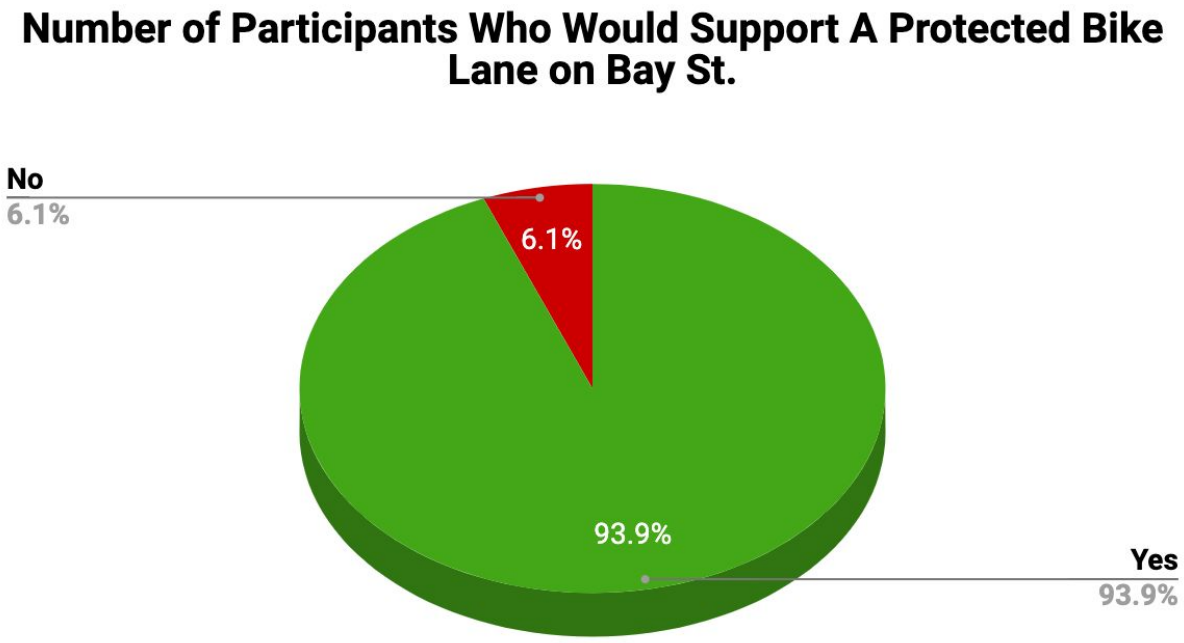


Figure 8 From these results, we can see that an overwhelming majority of surveyed cyclists and non-cyclists support the addition of a protected bike lane on Bay Street. Though it would have been helpful to see if there was a correlation between if non-cyclists would begin to ride if a protected bike lane is constructed on Bay St., these results still represent a statistically significant desire for such an infrastructure improvement. This strong support for cyclist protection is likely attributed to the high level of concern regarding proximity to cars, as shown above.

Recommendations

Overview

To begin our recommendations phase we will overview the most recent National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide guidelines for street design, as are relevant to Bay St. Given existing volume and speeds, physical protection is essential for achieving a network of LTS 1 or LTS 2 lanes. In this section, we will subdivide Bay St. into four distinct corridors, each with a unique set of design recommendations and additions. Our core goal is to convert the conventional southbound Bay St. bike lane into a protected cycle track. The best way to accomplish this would be to implement a road diet on the Bay St. corridor from High St. to the intersection at Escalona Dr. This would involve narrowing the two car lanes to accommodate a wider bike lane. To avoid potential clashes between cyclists and buses traveling down Bay St. we will seek to introduce floating bus stops along Bay St., modeled to NACTO standards. In order to increase cyclist visibility and provide a space for cyclists to conglomerate, we suggest adding a bike box at the intersection of Bay St. and King St. Finally, on the stretch of the corridor from Bay and Mission to the Rail Trail, we recommend shifting the street parking in between the bike lane and the car lane to act as a protective buffer for cyclists.

NACTO Descriptions:

Protected Cycle Track

- NACTO recommends a minimum width of 5 feet for a protected cycle track, 7 feet if cyclists are passing one another.
- For a painted buffer, NACTO recommends a minimum width of 3 feet. Bollards or signs can be placed within this buffer zone to give the buffer a physical presence.
- Cycle tracks should be cleared of all debris and motor vehicles seeking to cross over a protected cycle track should be constrained to reduce the risk of collision.
- Cycle tracks should be wider where gutter seam extends more than 12 inches from the curb.

Fig 9. Cyclist utilizing buffered one-way cycle track **Source** (NACTO, 2014)

Parking Lane Buffer

- NACTO recommends a minimum width of 11 feet for the combined parking lane and buffer zone in order to provide cyclists with adequate room to maneuver without fear of motor vehicle interference. Furthermore, this reduces the likelihood of cyclists riding into the passenger side door of a parked car.
- Preferably parking lanes begin and end at a minimum of 30 feet from an intersection as this increases cyclists' visibility to turning vehicles.
- Colorful yield lines and signage should clearly indicate that cyclists possess the right of way when entering or exiting traffic.

Fig 10. Parking protected bike lane on High St. **Source** Google Earth

Floating Bus Stop

- Floating bus stops allow buses to load passengers without turning into the adjacent bike lane.
- NACTO recommends that signage indicate a right of way for boarding passengers

Fig 11. Floating Bus Stop Diagram **Source (**NACTO, 2014)

Bike Box

- Bike boxes increase visibility and create valuable space for cyclists at intersections, particularly those less comfortable with vehicular cycling in areas of high traffic stress.
- Bike safety increases in numbers, thus bike boxes provide a clearly demarcated area for cyclists to gather at an intersection.
- NACTO guidelines recommend a typical bike box to have a depth of 10-16 feet. This allows cyclists to have a head start over cars at a traffic stop, greatly facilitating safe left turns across an intersection
- NACTO recommends “no turn on red” signs to prevent cars encroaching on bike boxes

Fig 12. A cyclist waits at an intersection in a green bike box **Source (**NACTO, 2014)

Recommendations Among Different Segments

The following table summarizes our integration of NACTO's recommendations in relation to 4 main segments that we unofficially divided the Bay corridor into.

Street Segment	Recommendation
High-Escalona	Protected bike lanes (w/ bollards) consistently, road diet, floating bus stops
Escalona-King	Buffered bike lanes, bike box at king/bay intersection for cyclists turning left
King-Mission	Remove parking, add buffers
Mission-Rail Trail	Parking protected lanes, remove bus stops or floating bus stops

Table 4

High to Escalona Recommendations

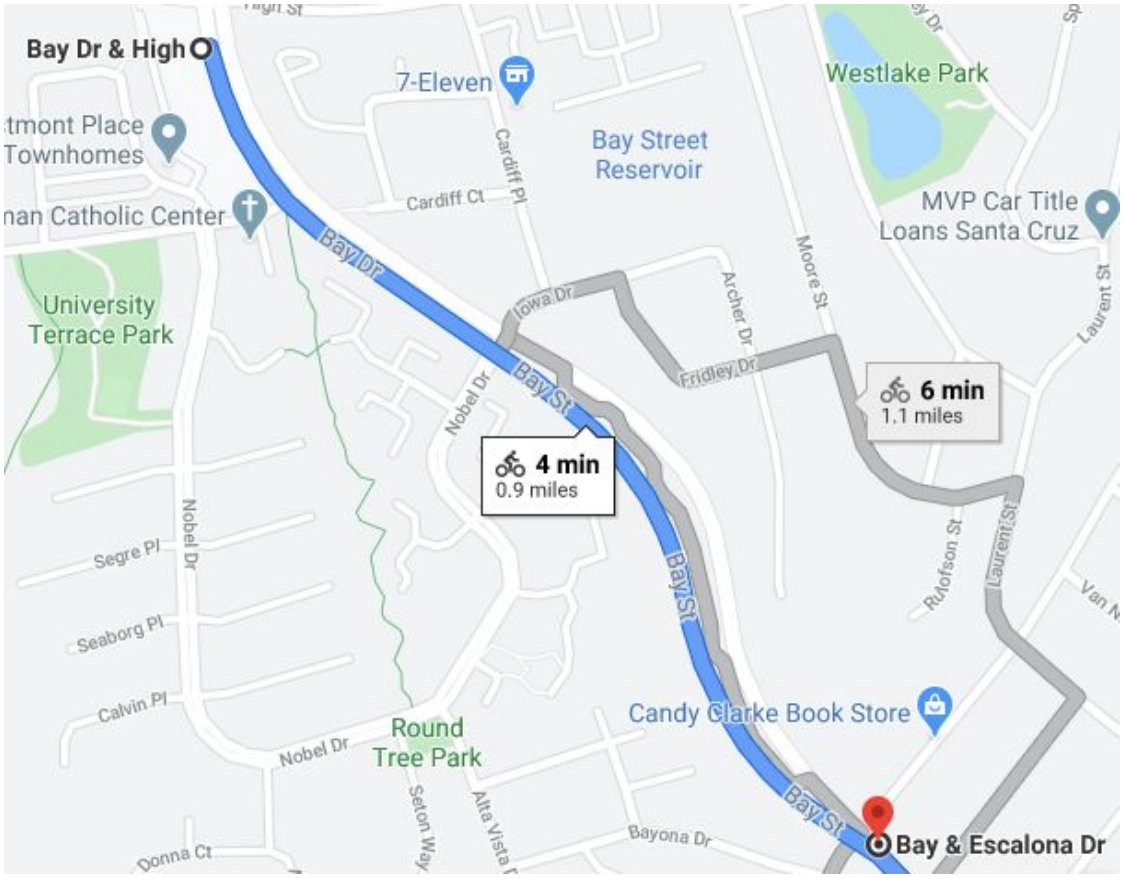


Figure 13 Bay St. from High to Escalona including Meder and Nobel/Iowa Intersections (Source: Google Maps)

This segment of the Bay corridor has four car lanes although the subsequent southbound segments sufficiently carry the same volume of cars with only two lanes. Based on our analysis of the existing conditions, we suggest this segment undergo a road diet. Redistributing the width of the secondary car lanes would allow for the implementation of floating bus stops. Rerouting bike lanes behind bus stops would allow for unrestricted cyclist flow and eliminate the need for cyclists to swerve into the oncoming traffic of adjacent car lanes when their bike lane is blocked by buses and pedestrians. From Nobel onward, the segment discontinues sidewalk access and provides only the sub-street-level walking path. However, this design hinders equitable access and is compromised by weather conditions. We recommend a fully protected bicycle and walking lane. The walking lane could either be raised or separate from the cycle track by a paint. The cycle track will feature lanes large enough to encourage passing and be physically protected by bollards. This segment is a high priority based on its speed limit, but also because the stretch is free of parking and driveway constraints.

Bay & High Intersection

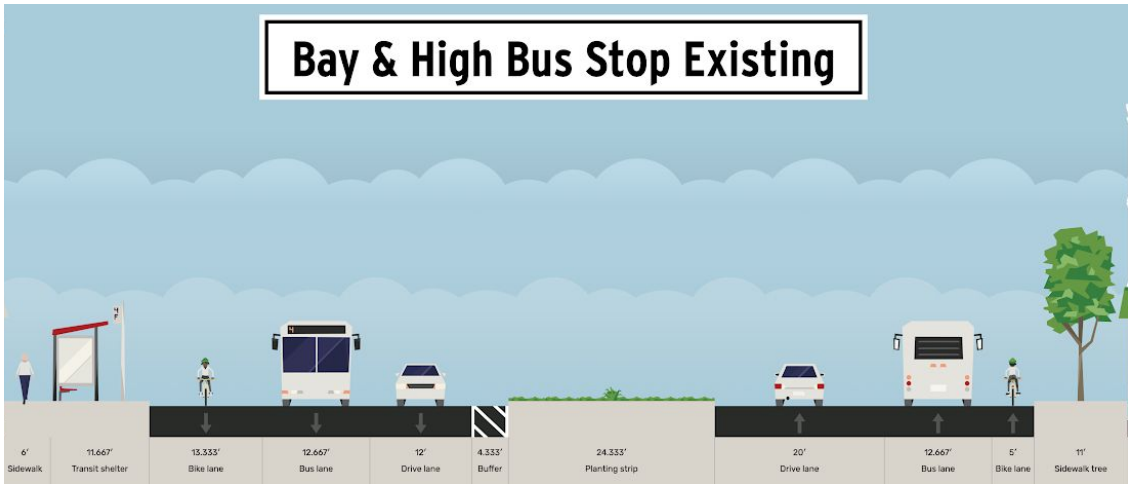


Figure 14 Existing Conditions of Bay and High Bus Stop cross-segment

- Available street width of 42 ft on southbound lanes left of planting strip and 38 on northbound lanes
- Bus stops and loads within the bike lane
- The left lane of northbound car lanes is approaching a left turn

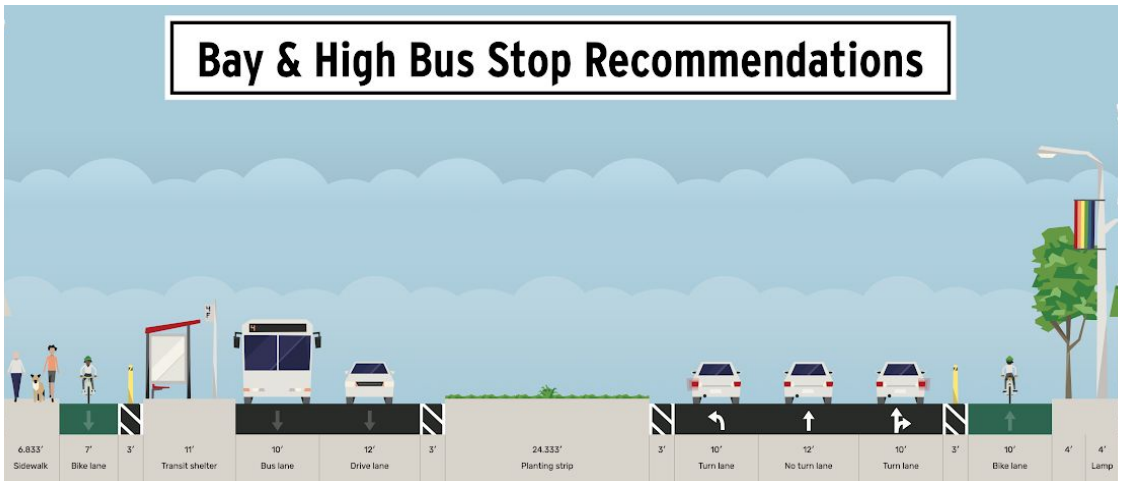


Figure 15 Recommended design with “road diet” and floating bus stops

Figure 16 Looking Southbound, two car lanes, bus loading zone placed inside of unprotected bike lane

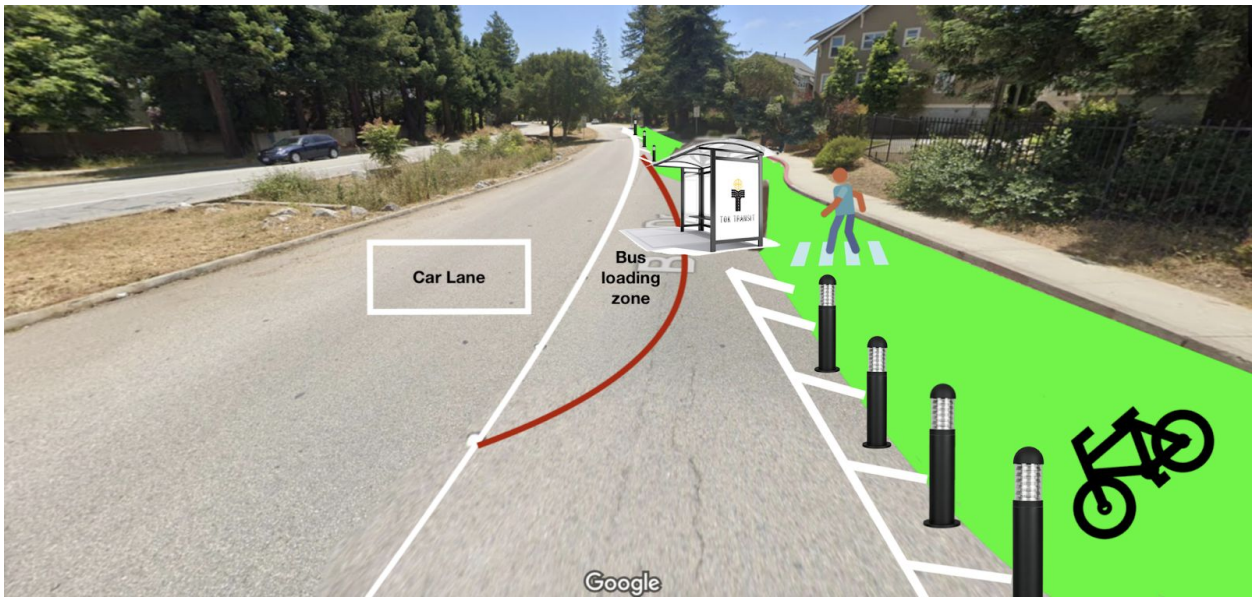


Figure 17 Implemented road diet, added floating bus stop with a pedestrian crossing, and bollards to illuminate and protect the bike lane

Bay & Nobel/Iowa Intersection

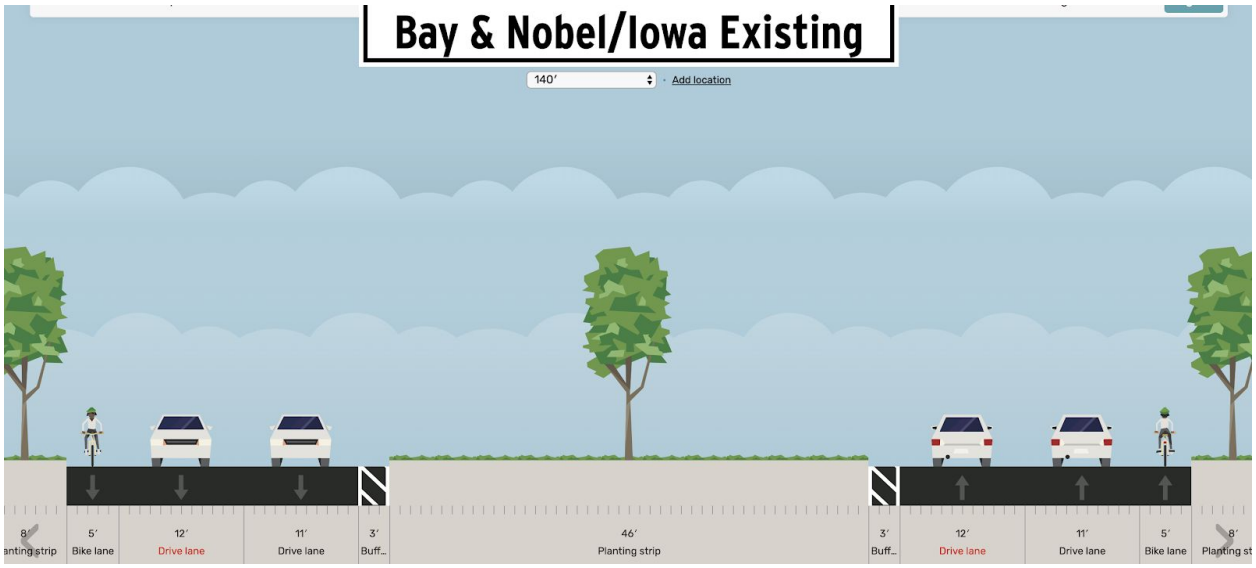


Figure 18 Existing conditions of an average cross-section between Nobel and Escalona (the measurement of center planting strip/pedestrian walkway has been artificially reduced to better visualize car & bike lane widths)

- Bike lanes below NACTO recommended widths and unprotected from fast traffic
- Walking path experiences routine flooding in winter months, general deterioration, lack of adequate lighting, and is not a direct path for time-sensitive transportation; all of which may encourage pedestrians to walk in the bike lanes
    - The lack of sidewalks is a safety hazard for pedestrians, especially those of which require flat pavement for wheelchair accessibility

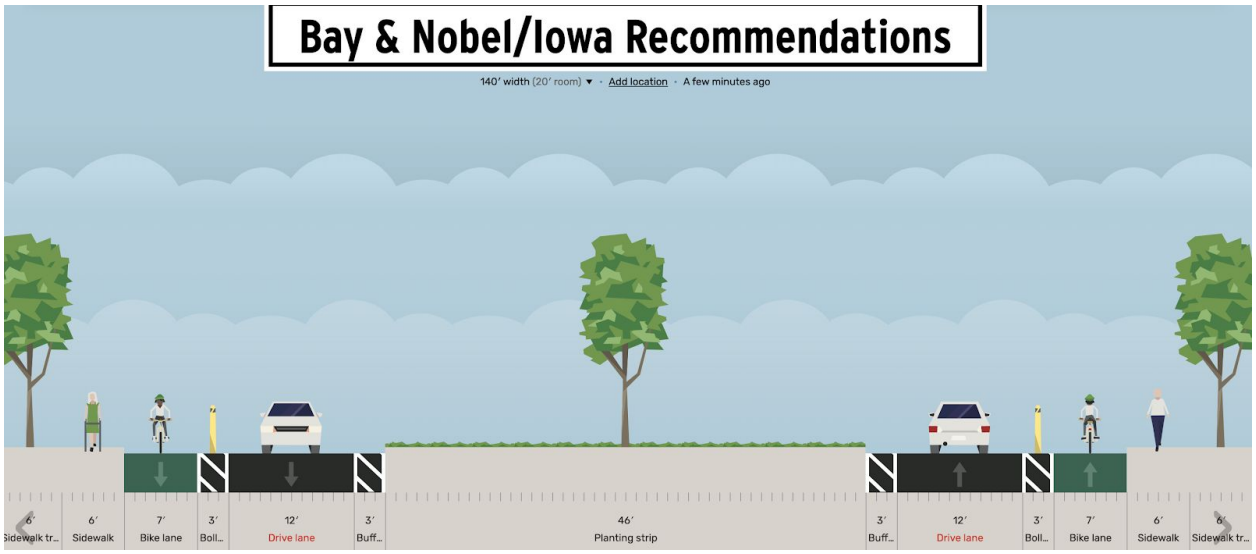
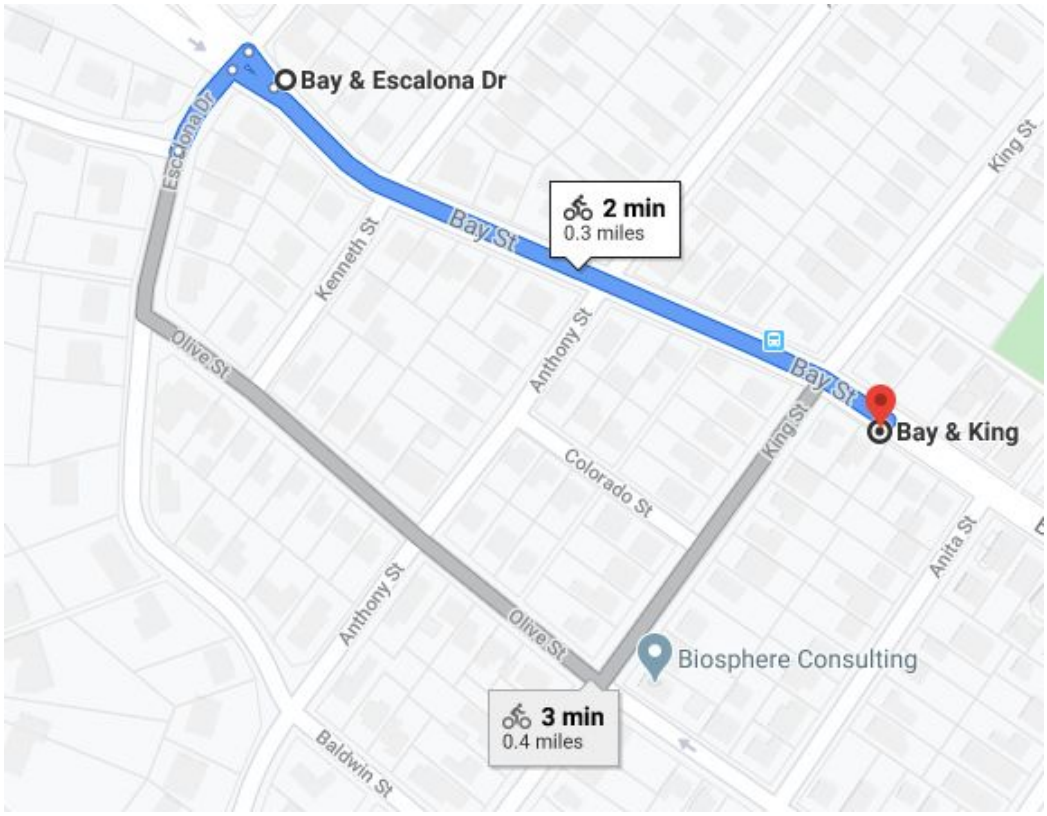


Figure 19 Recommended design for Nobel/Iowa to Escalona

- Bike lanes are protected and illuminated by bollards, while widths welcome passing movement of faster riders
- Equitable pedestrian access added, could be separated from bike lane by raised cement or painted line
- Driving lanes are wide enough for cars and buses to drive comfortably

Escalona to King Segment Recommendations



Figures 20 Bay St. from Escalona to King including Kenneth and Anthony Intersections (Source: Google Maps)

This segment provides 5-foot bike lanes, however, a speed of 25 mph and volume of 10,000 qualifies this stretch for a separated cycle track. This segment already restricts parking but does feature driveways and a bus stop. The width of this street does not constitute space for a floating bus stop. We recommend narrowing the car lanes to 10 feet and repurposing the space for a 3-foot buffer for bike lanes.

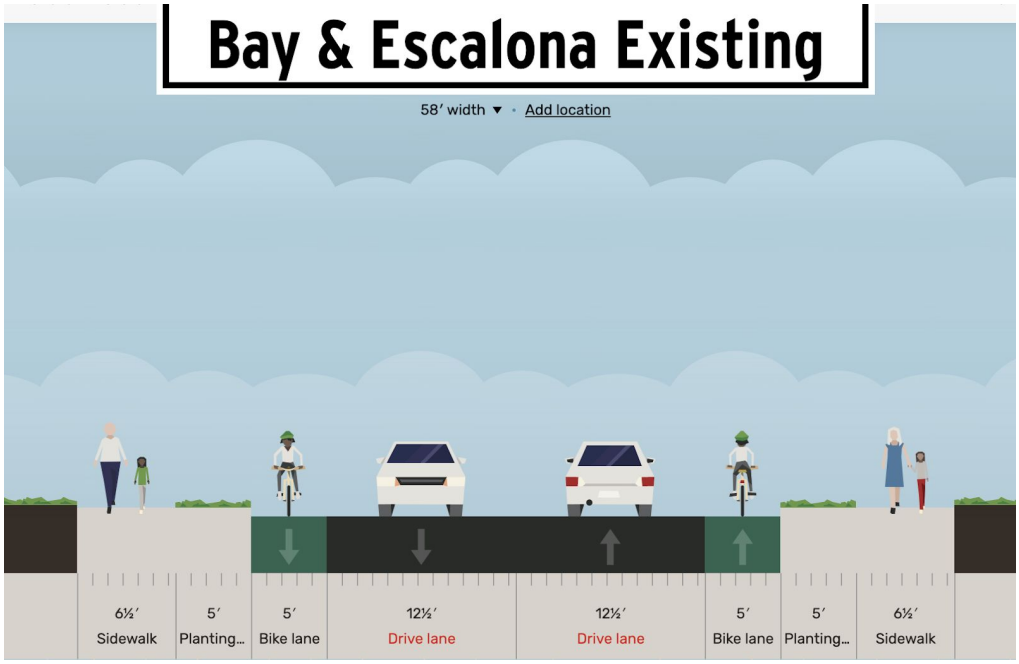


Figure 21 Existing conditions between average cross-sections of Escalona to King

- 58 feet of available space
- 12 ½ foot car lanes highlighted in red exceed the recommended width of the U.S. Interstate Highway standard

Figure 22 Trash cans crowding the bike lane along Bay St from King to Escalona

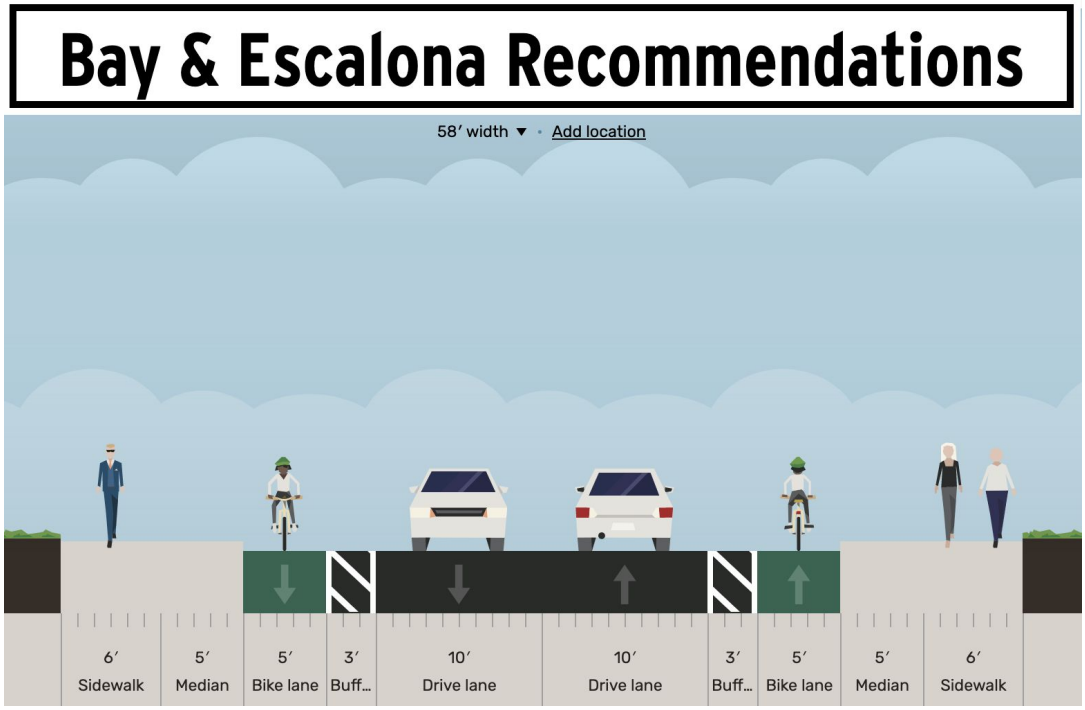


Figure 23 Recommended Design for Escalona to King cross-sections

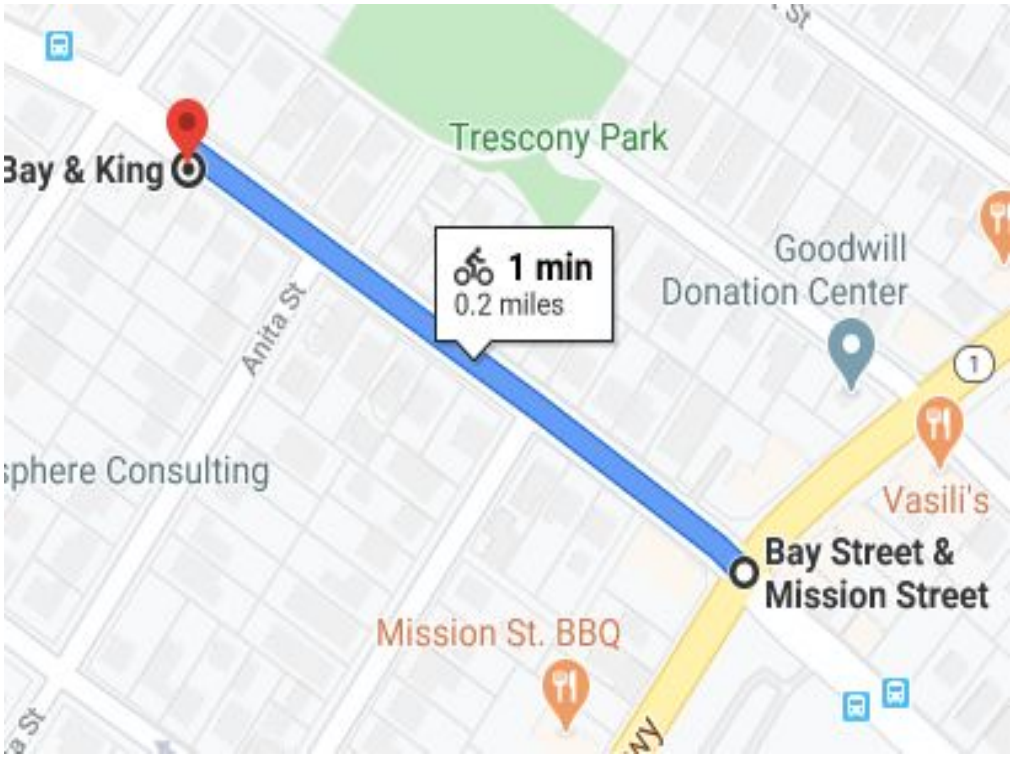
- Reduced car lane widths for safer driving
- The addition of 3 ft buffer zones and solid green color that warn cars pulling into driveways
- We also recommend that the 5 ft planted sections of the sidewalk have gravel or cemented cut-outs for designated trash can placement

Figure 24 Looking Southbound, one car lane in each direction, painted bike lanes without protections for turns (conflict zones)

Figure 25 Proposed buffered bike lanes and bike box at the intersection of Bay & King

- Increases visibility and gathers cyclists into a single, well-marked area
- Helps cyclists make left turns onto King Street
- Pulling back car stopping line and adding bike box provides needed separation between bicycles and cars

King Street to Mission Street Recommendations



Figures 26 Bay St. from King to Mission including Anita and Toledo Intersections (Source: Google Maps)

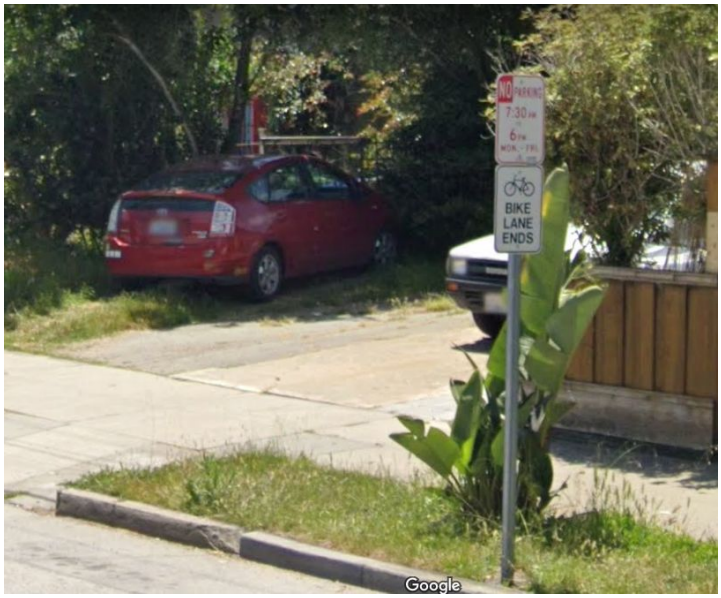


Figure 27 A sign displaying the 3 block stretch's policy from allowing for "part-time" bike lane parking

This segment currently allows for parking between the hours of 6 PM to 7:30 AM. Within these hours the bike lane is dropped with little warning. We recommend that this 3 block section remove parking to allow for the continuation of a safe and convenient bike lane. To address the potential impact on parking, the following two factors were considered: the number of cars routinely parking in the Bay St. bike lane and the number of available parking spots on connecting streets.

Parking Audit

The following table shows the number of cars parked in the Bay St. bike lane between 8 and 8:30 pm over a three-day span.

Date	Time	Total # of cars parked in bike lane from King St. to Mission St.
01/31/20	6:30- 7 PM	14 cars
02/11/20	7-7:30 PM	11 cars
02/13/20	8:30-9 PM	9 cars

Table 5 Parking counts collected by our team

When conducting our parking audit, we looked at King St., Anita St., and Toledo St as potential alternative parking. Our team's observation qualitatively assessed the level of parking occupancy along the stretch of Mission and King as very low. All housing units on Bay Street provide driveways that on average stretched to the back of the property to fit several cars. As a quantitative backing, we counted the number of cars that were parked along the street blocks in conflict (Fig. 27) and then observed a one-block stretch of parking on each side street (Fig. 28) and counted the number of available parking spaces. As a discretion, empty spaces were only counted if they could comfortably fit an average midsize family car.

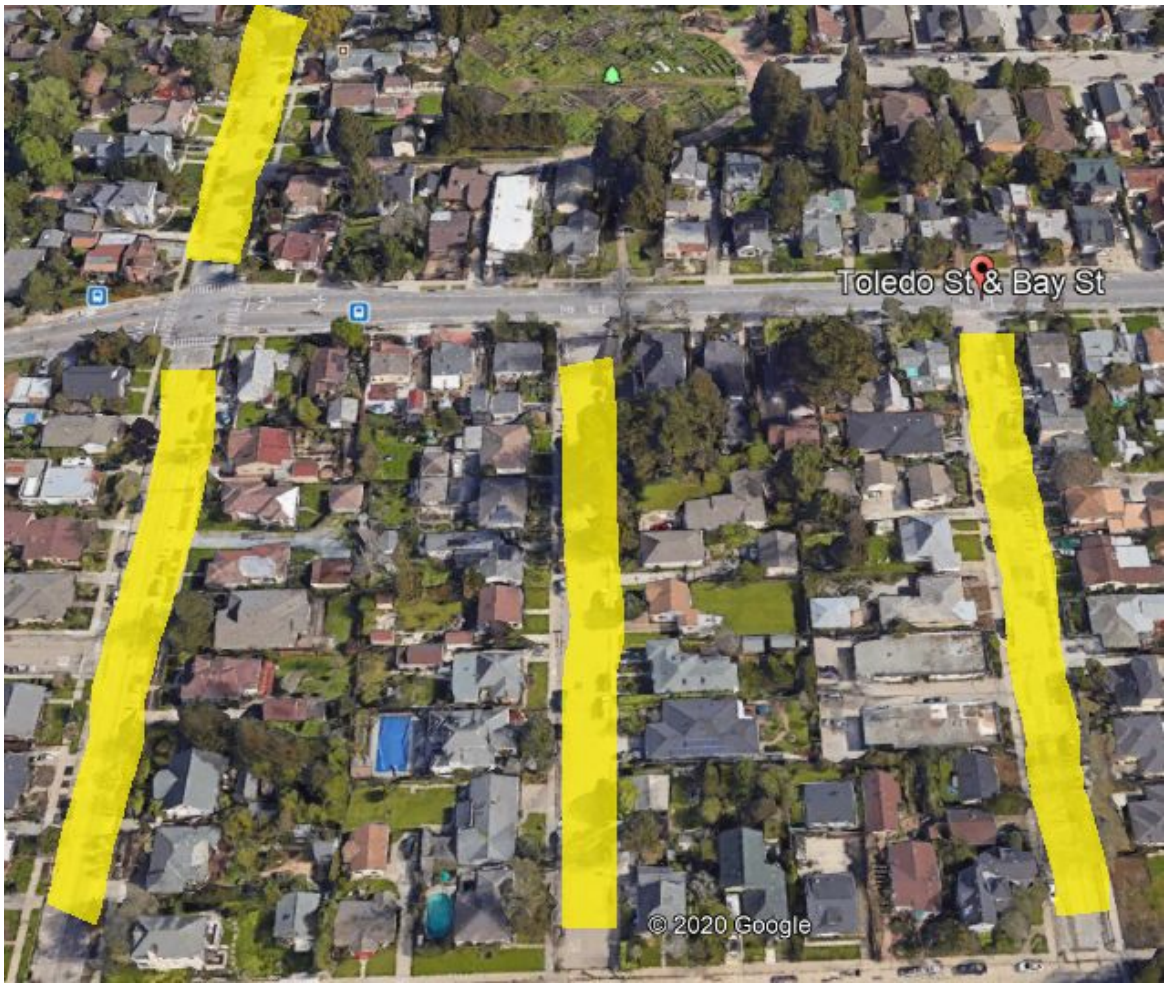


Figure 28 Highlighted area of potential alternative parking surveyed

Street	Available Parking Spots
Toledo St.	11
King St.	22
Anita St.	9

Table 6 Available side street parking spaces observed on February 13th from 8:30-9 PM

This table shows that there was an ample amount of space on side streets within reasonable proximity to hold all cars currently parked on this segment of Bay St. Additionally, a surplus of spots were still available to provide for a possible extended need.

Figure 29 Existing conditions of King to Mission cross-sections

- Bike lanes become parking lanes after 6 PM forcing bikes to ride in motor traffic leaving and approaching Mission St, one of the cities most trafficked corridors

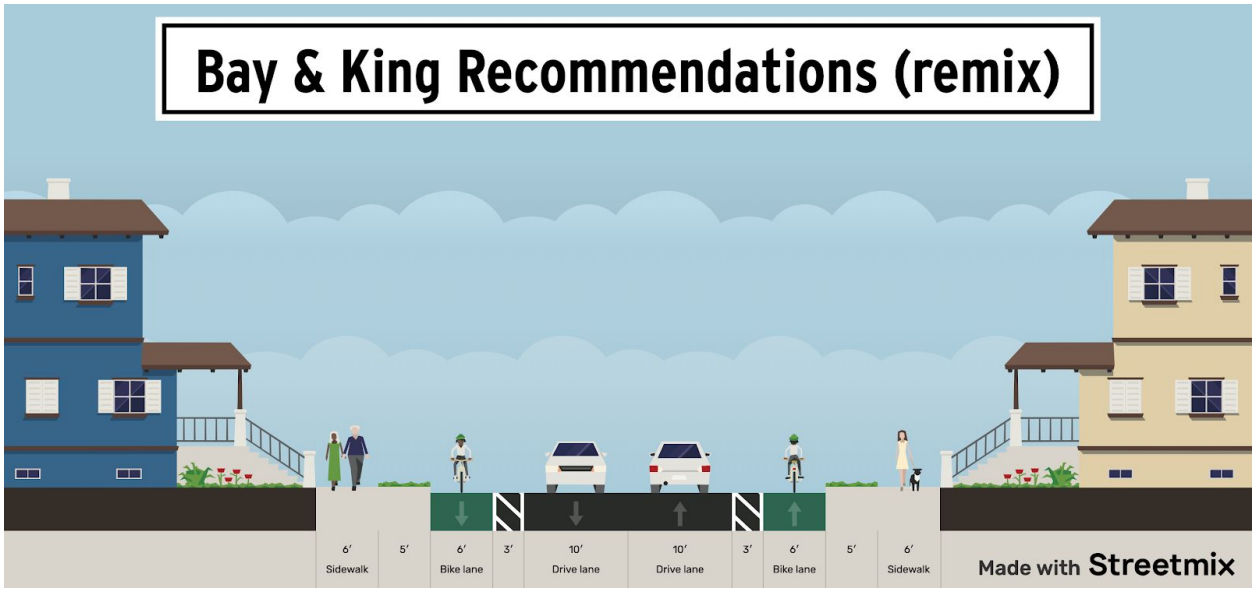


Figure 30 Recommended design with removed parking

- Full removal of parking to grant continuous bike lanes
- Narrowed lanes open 4 feet for buffers, and 2 extra feet are taken out of the parking lane in a bike lane conversion

Mission St. to Redwood St. (the Rail Trail)

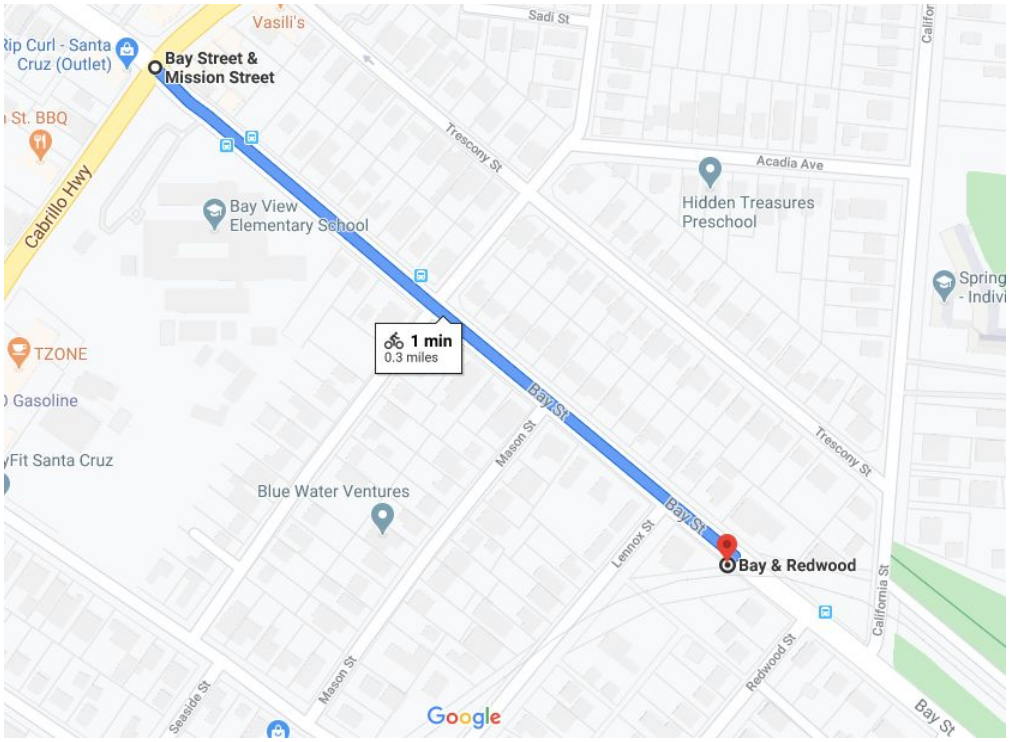


Figure 31 Bay St. from Mission to Redwood including Seaside, Mason, Lennox, and currently under-construction Rail Trail Intersections (Source: Google Maps)

Figure 32 Unprotected bike lane that is also within a bus loading zone in front of Bay View Elementary

This segment delineates the stretch of Bay St. from the intersection at Mission St. to Redwood Dr. It is an especially high priority corridor, particularly because of the corridor's proximity to Bay View Elementary; many Bay View students bike to and from school each day. In order to promote security and incentivize continued ridership, we advise that the southbound bike lane be outfitted with a raised cycle track, acting as a physical distinction between the bike lane and vehicular traffic, while the northbound lane is moved between the parking lane and the sidewalk.

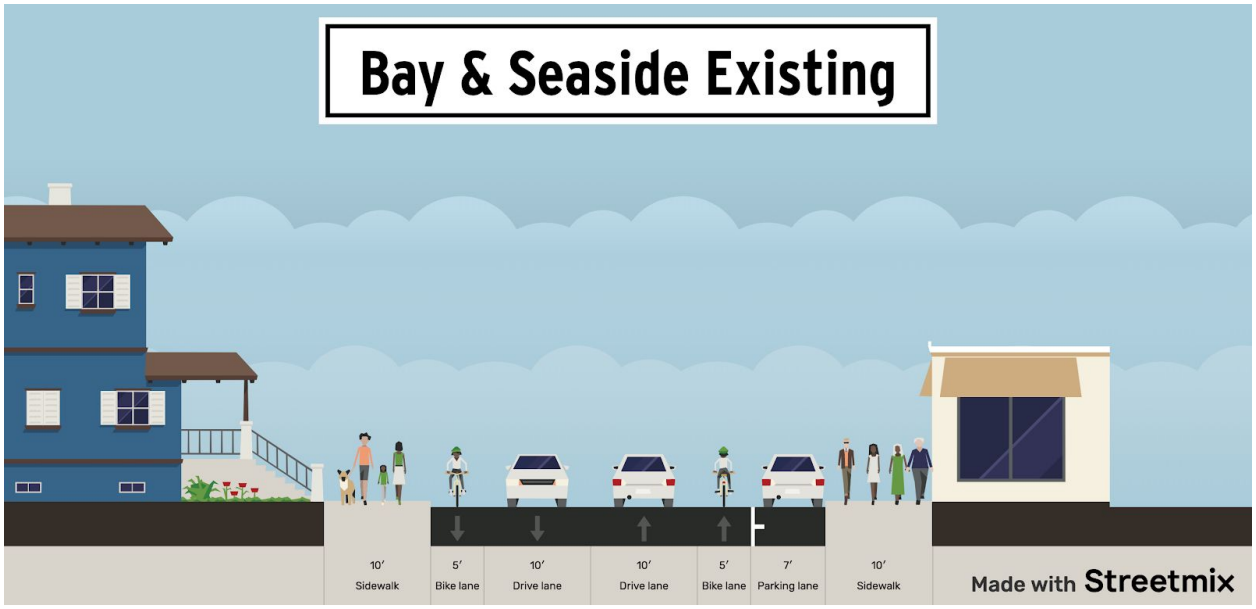


Figure 33 Existing Conditions of average cross-section widths from

- Bike lane to the left of parking lane risks dooring
- Southbound bike lane runs along Bay View Elementary School, yet provides no physical barrier for child cyclists

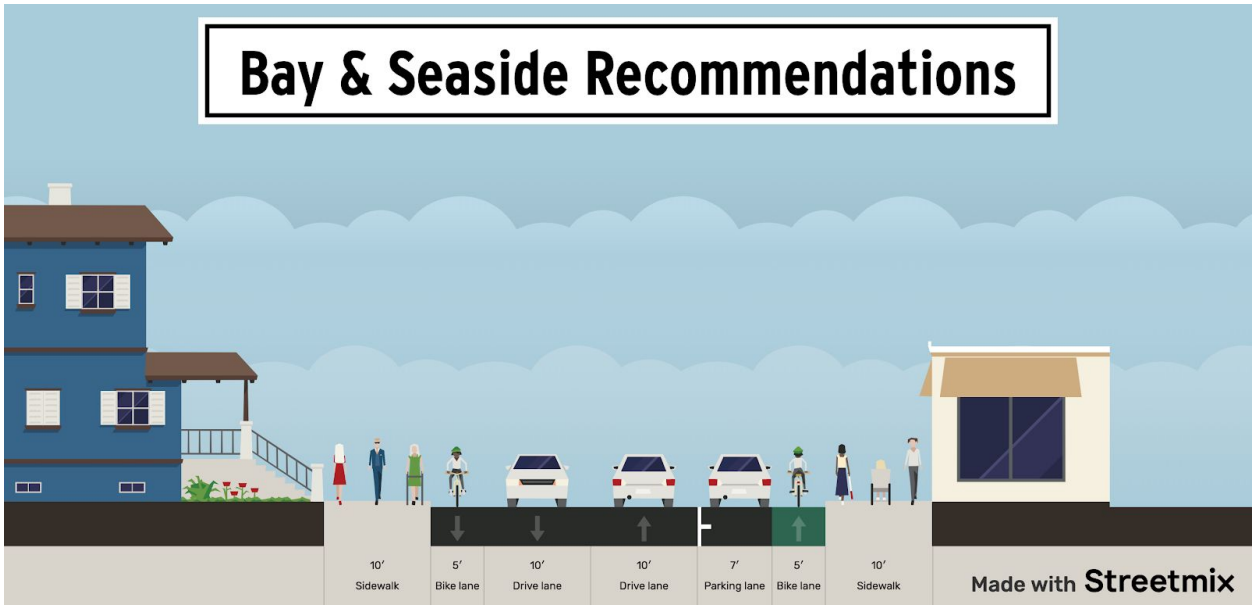


Figure 34 Recommended rerouting of the northbound bike lane between the parked car lane & sidewalk

- Parking protected northbound bike lane and raised cycle track for the southbound lane
    - This design does not uphold NACTO recommendations that state a desired 3-foot buffer between the parking lane and the bike lane

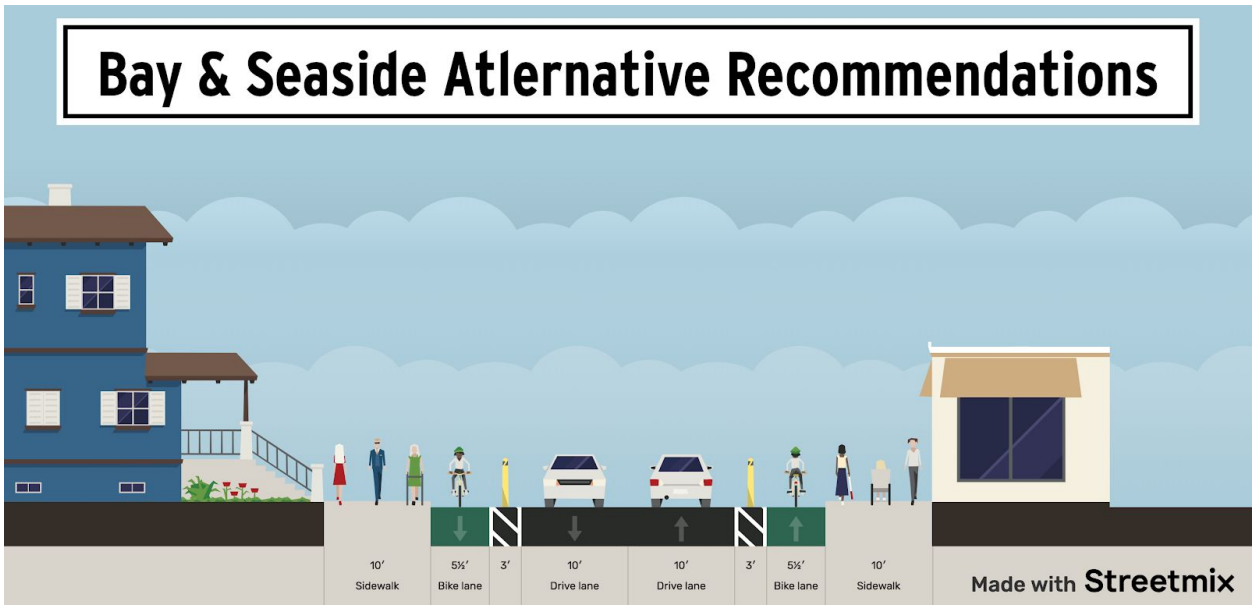


Figure 35 Alternate recommendation with removed parking

- Parking is removed to reduce risk of dooring and bollards are placed on either side to protect bike lanes

Conclusion

For a socially progressive and environmentally conscious city, Santa Cruz lacks much of the critical bicycle infrastructure that would allow people to view it as a “biking town.” Additions such as the parking-protected bike lane along the Bay Street corridor proposed in this report can both fulfill a social good and provide a needed service for the currently underserved cycling community of Santa Cruz. Our report shows that Bay Street as it currently stands does not live up to NACTO recommendations; collision data suggests it is not safe to cycle along, survey data suggests that the bike lane’s proximity to fast cars actively dissuades cyclists from using it, and field measurements suggest that the car lanes are unnecessarily wide. With this in mind, we feel comfortable recommending the following changes: restricting the two car lanes to one lane, adding bollards and widening the existing bike lane, and converting bus stops to floating bus stops where street space is provided from Bay Dr and High St to the Bay St and Escalona Dr intersection, widening the existing bike lane and adding buffers from Bay St and Escalona Dr to Bay St and Mission St where driveways compromise bollards, and moving the bike lane spanning Bay St and Mission St to Bay St and Redwood St to the outside of the parking lane. Such improvements would improve the biking accessibility of the Bay Street corridor at minimal cost to the city, and set an important precedent for prioritizing cycling in Santa Cruz.

By expanding upon the cycling features already in place, our proposed design will increase the number of possible destinations one could reach with an LTS-1 or LTS-2 street. This corridor is also highlighted as a priority because it will complete a network of fully separated cycle paths: the UCSC bike path, Monterey Bay Sanctuary Scenic TraiL, West Cliff shared use path. Added infrastructure proposed in this document will encourage and expand upon existing transit facilities such as two bike-sharing stations located directly on Bay Street, and three bus routes that travel along the corridor. This is crucial for providing healthy and safe transportation to UCSC, Bay View Elementary, and Mission Hill Middle. Our report acknowledges safer cycling conditions as the main reason for more cycling, and therefore attracts new users and more ridership.

Sources

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