City of Emeryville Pedestrian and Bicycle Plan

Appendices

May 2012

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Appendix A: Resources for Design of Pedestrian Facilities

Emeryville Pedestrian and Bicycle Plan

May 2012

Submitted by: Fehr & Peers

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Introduction

A well-connected pedestrian network is a vital component to livable communities, which thrive on multimodal travel for all roadway users, regardless of age or ability. Multimodal travel incorporates the needs of not just motor vehicles in roadway design, but the needs of pedestrians, bicyclists, and transit users as well. The primary goal of the this resource document is to assist the City of Emeryville in creating places that accommodate pedestrians through a set of recommended practices that enhance the walkability of all streets within the City. These guidelines will help the City make decisions about the preferred application of pedestrian treatments in the following areas:

- Special Pedestrian Needs
- Streets and Sidewalks
- Uncontrolled Intersections / Mid-block Crossing Treatments
- Controlled Intersections
- Design Review for Development Projects

The pedestrian enhancements described throughout these guidelines provide street design best practice guidance, which can enhance the safety, convenience, and mobility for pedestrians. In particular, they provide guidance on appropriate treatments for the various locations identified for pedestrian improvements throughout Emeryville. Potential treatment types for each of these areas include different design options for streets/sidewalks, pedestrian crossings, multimodal connections and community vitality.

The *Emeryville General Plan* (2009) defines the concept of "complete streets" as the following:

> "Complete streets are designed and operated to enable safe, attractive and comfortable access and travel for all users. Pedestrians, bicyclists, motorists and public transit users of all ages and abilities are able to safely and comfortably move along and across a complete street. Complete streets also create a sense of place and improve social interaction, while generally improving the values of adjacent property."

Complete streets practices improve the pedestrian realm because they encourage the design of streets with well-connected and comfortable sidewalks, traffic calming measures to manage vehicle speeds and enhanced pedestrian crossings. Incomplete streets—those designed primarily for automobile access—can be a barrier in any community, particularly for people with disabilities, older adults, and children. As noted in the *General Plan* the development of complete streets is essential to move the City towards an integrated pedestrian street network.

References

Federal Standards and Resource Documents:

Guide to the Development of Pedestrian Facilities, American Association of State Highway and Transportation Officials, 2000

Manual on Uniform Traffic Control Devices, Federal Highways Administration, December 2009.

Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, 2004.

Americans with Disabilities Act Accessibility Guidelines (ADAAG). United States Access Board.

California Standards and Resource Documents:

California Manual on Uniform Traffic Control Devices, Caltrans, January 2010.

Highway Design Manual, California Department of Transportation.

Other Guidelines and Resource Documents:

Emeryville Design Guidelines. City of Emeryville, December 2010.

Park Avenue District Plan. City of Emeryville, 2006.

Transit Cooperative Research Program (TCRP) Report 112/ National Cooperative Highway Research Program (NCHRP) Report 562: Improving Pedestrian Safety at Unsignalized Crossings. Washington D.C.: TCRP and NCHRP, 2006.

Pedestrian Technical Guideilnes: A Guide to Planning and Design for Local Agencies in Santa Clara City, Santa Clara Valley Transportation Authority, October 2003.

Routine Accommodations of Pedestrians and Bicyclists in the Bay Area, Metropolitan Transportation Commission, Available: http://www.mtc.ca.gov/planning/bicyclespedestrians/routine_accommodations.htm, 2006.

Pedestrian Safety Resource Guide, Metropolitan Transportation Commission Regional Pedestrian Committee, Available: http://www.mtc.ca.gov/planning/bicyclespedestrians/PEDSAFETYRESOURCEGUIDE.doc, 2004.

Emeryville Sustainable Green Streets and Parking Lots Design Guidebook, Emeryvillewide Water Pollution Prevention Program, First Edition: January 2009, Available: http://www.flowstobay.org/ms_sustainable_guidebook.php

Special Pedestrian Needs

As the City of Emeryville moves toward complete streets, the vision can expand even further. A complete street should offer equal accessibility for the young and old, disabled and not, and pedestrians, bicyclists, motorists, and transit riders. Designing streets for our most vulnerable populations means that they are safe and accessible for everyone. In addition, a complete street has the potential to contribute to the public health, ecological sustainability, and economic vitality of a community. Depending on the context, it may be a place for people to stroll, shop, rest, or socialize. It may be a major thoroughfare that brings people to their jobs each day. It can also be a quiet residential street where children can safely learn how to ride bikes. An expanded vision of Complete Streets can include policies that aim to improve air quality and reduce noise, provide opportunities for sidewalk cafes and plazas, and offer a roadmap for the sound management of surface runoff water on City streets.

Special Needs for Children

Discussion

Children have special needs in the pedestrian realm. This becomes apparent in school zones where a safe pedestrian environment is vital. Young children are often too small to be in the line of sight of drivers, so without proper designs, streets surrounding schools may not be safe for these young pedestrians. In addition, children walk slower than adults and may not be able to gauge the amount of time needed to cross an intersection. When streets surrounding schools have inadequate pedestrian facilities, parents may be reluctant to allow their children to walk to school, therefore driving children to school for even short distances.

Design Summary

Accommodating children and other vulnerable populations requires special provisions to remove barriers to pedestrian travel. These special provisions include measures such as reducing vehicle speeds and enhancing street crossings around schools. Reduced speed zones near schools, using striping patterns and colors to communicate to drivers that they are within a school zone, and traffic calming measures (described further in "Streets & Sidewalks" on page 6) can facilitate slower vehicle speeds. Reducing crossing lengths through bulb-outs, special crosswalk striping, and median refuges (described further in "Uncontrolled Crossing Treatments" on page 19) provide shorter crossings for children. Technical assistance and funding to implement these enhancements can be done through Safe Routes to School programs. Adequate sidewalk facilities and crosswalks are particularly important to separate children from vehicle traffic around school neighborhoods where children walk and ride their bicycles.

Example

Image Sources: Sacramento City Pedestrian Plan; Dan Burden

Special Needs for Seniors

Discussion

Poor sidewalk and crossing conditions may foster isolation with limited opportunities for seniors' mobility; they need travel options other than driving, whether it be walking or taking transit. Seniors have slower walking speeds and reaction times, and may have other impairments that restrict their mobility, vision, and hearing. Sidewalks and street crossings should be sensitive to these barriers and how they affect the aging population.

Design Summary

Opportunities to improve streets to provide senior mobility include:

- Shortening street crossings with median refuges, sidewalk bulb-outs and adequate curb ramps.
- Installing sidewalk furniture to make walking more comfortable by providing places to rest.
- Adjusting signal timing to account for slower walking speeds.

Treatments like pedestrian refuge islands are particularly important to help seniors cross a street since they tend to walk at slower speeds; if they are unable to make the crossing during the available signal time, a refuge provides a separated place to wait.

Each of these treatments is described in detail on later pages.

Example

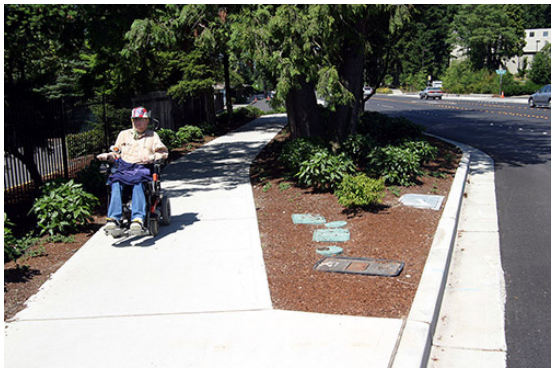


Image Sources: Dan Burden

Americans With Disabilities Act

Discussion

The Americans with Disabilities Act (ADA) protects the rights of people with disabilities, requiring public entities to develop transition plans to bring existing public facilities up to ADA standards. A key component to adequate ADA provision includes plans to improve curb ramps. It sets guidelines for people with disabilities to access public accommodations and commercial facilities. Disconnected sidewalks and unpaved surfaces can prove frustrating to disabled pedestrians. Additionally, pedestrian facilities may not address the needs of those with poor vision without audible or vibro-tactile enhancements. Creating a comfortable and well-connected pedestrian network is important for "complete streets", as well as focusing on the needs of users with disabilities.

Design Summary

Complete Streets strategies will improve intersection designs to expand access for all users. Best practices include improving curb ramps, providing adequate pedestrian clearance intervals, and addressing pedestrian network gaps and sidewalk conditions, which cover many aspects of ADA requirements. Obstacles on sidewalks, such as cracks or misplaced sidewalk amenities, are a primary barrier to pedestrians with visual impairments. Accessible pedestrian signals communicate information about crossings to pedestrians with visual impairments with audible tones or vibrating systems. These accessible pedestrian signals should be placed with guidance from the Accessibility Disability Commission. Truncated domes provide a tactile signal to the visually impaired as they transition between walking paths or sidewalks and conflict areas such as intersections. Direct curb ramps (i.e., two ramps per corner) are preferred whenever possible, to direct pedestrians into a crosswalk instead of the intersection. Bus stops should be located at the far sides of intersections to encourage pedestrians to cross behind vehicles where they are more visible.

Example

Image Sources: Fehr & Peers (top), Dan Burden (bottom)

Streets and Sidewalks

Streets and sidewalks should support the activities and pedestrian levels along the street. Streets should be well-connected to ensure that destinations are within walking distance. Sidewalks should be wide enough to support the expected pedestrian volumes according to the citywide design guidelines. The minimum width for the pedestrian pathway section of a sidewalk is six feet, wide enough for two people to walk side by side. However, sidewalks of this width assume minimal pedestrian traffic. This section provides guidelines to the design of sidewalk widths that meet walking demand and provide buffer space between motor vehicle lanes and sidewalks and space for walking, sitting, and lingering. The guidelines in this section reference and build upon those set forth in the *Emeryville Design Guidelines* (City of Emeryville, December 2010) and *Park Avenue District Plan* (August 2010).

The exhibit below from the *Emeryville Design Guidelines* show the three components of the design of a sidewalk area. These zones are discussed further in the Sidewalk Zones section.

This graphic shows the sidewalk as three distinct components. Area A shows the café entry and outdoor seating. Area B shows a clear travel lane for pedestrians. Area C shows street furniture and lush trees. The result is an active and vibrant sidewalk.

Source: Emeryville Design Guidelines, City of Emeryville, December 2010

Street Connectivity

Discussion

A well-connected street network has seamless connections for pedestrians through continuous sidewalks and pedestrian crossings. A grid-like street network is easy for pedestrians to navigate and distributes traffic evenly. In such a network, frequent crossings and short block lengths result in high connectivity. Travel times and distances for pedestrians decrease with connected streets because there are more opportunities for direct paths of travel.

Design Summary

Internal street connectivity provides connections between streets within a particular area, while external connectivity provides connections to other neighborhoods. New road and pedestrian paths can increase pedestrian activity by creating better connections. If possible, cul-de-sacs should be avoided. However, if dead ends are unavoidable, there are alternatives to provide pedestrian connections.

- Pedestrian Pathways- Connects a pedestrian route to a building entrance when a direct connection is lacking.
- Cul-de-sac connectors- Pathways where streets dead-end to connect people on foot or bicycle to other streets or land uses.
- Avoid large blocks- Buildings on "superblocks" are less connected to the street. Connectivity is important along the street as well as between buildings. An intersection density of at least 150-400 intersections per square mile is recommended for pedestrian-friendly blocks and street networks.

Example

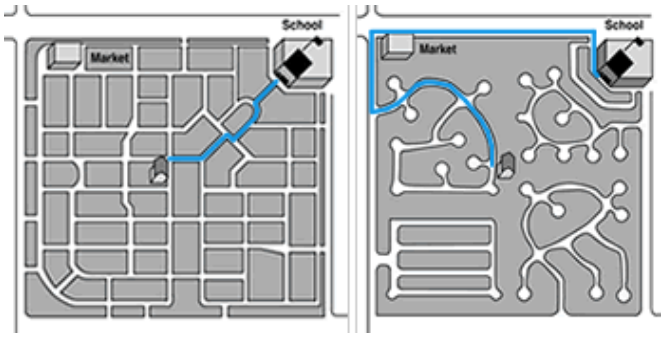


Image Source: http://www.saferoutesinfo.org

Traffic Calming

Discussion

High vehicle speeds reduce pedestrian comfort and increase injury severity in collisions. Controlling speeds is a critical element to ensure the pedestrian feels comfortable walking on a sidewalk or within a crosswalk. Traffic calming treatments are physical elements that alter the streetscape to manage vehicle speeds. As a result, driver awareness of pedestrians increases, and the improvements may have an effect on slowing speeds.

Design Summary

Speed tables/ raised crosswalk - An elevated surface above the travel lane attracts the attention of the driver and encourages lower speeds. It is useful in areas with high pedestrian activity by essentially raising the road surface over a short crossing distance.

Traffic Circles - Traffic circles are located in the middle of an intersection to slow traffic. Generally 10-20 feet in diameter, they typically have landscaping in the middle that reduces sight length down the street to slow vehicles. Traffic circles also manage speeds by forcing vehicles to drive around them.

Chokers/ Chicanes - These horizontal diversion treatments create "slow points" at mid-block locations by placing physical elements along the street to make vehicles slow down in order to maneuver around them. Chokers draw in the curb on both sides of a street to narrow the right of way, providing less space for vehicles to travel over a short distance, and facilitate a shorter pedestrian crossing. Chicanes are the same concept but the raised curb is offset to force vehicles to slightly turn, thus providing an additional speed reduction measure. It is important that they do not conflict with bicycle facilities.

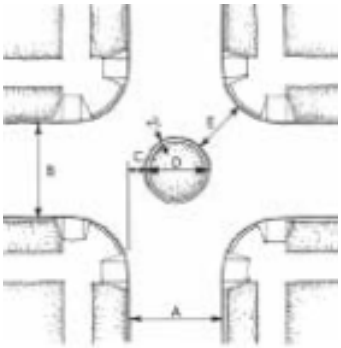
Pedestrian Bulb-outs - Extend sidewalks into the street to create shorter crossing distances for pedestrians and smaller vehicle turning radii at intersections. More detail may be found in the *Intersections Section.*

Refuge Islands - Provide a space in the middle of an intersection for pedestrian to comfortably wait until traffic clears and they can finish crossing the intersection. More detail may be found in *Intersections Section.*

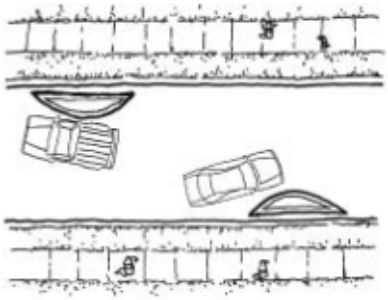
Example

Speed Table

Traffic Circle



Chicane



Source (Top and Bottom): Valley Transportation Authority Pedestrian Technical Guidelines; (middle) San Diego Street Design Manual

Sidewalk Zones

Discussion

The sidewalk zone is the portion of the street right-of-way between the curb and building front or front property line. Within this zone, there are four distinct areas that serve different organizational purposes.

Design Summary

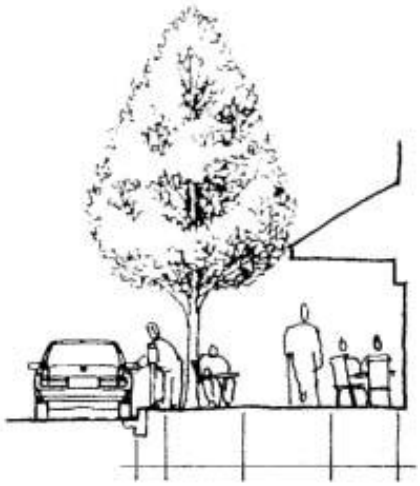
The *Emeryville Design Guidelines* note that at a minimum the sidewalks in the residential neighborhoods should include a six foot wide pedestrian pathway and a three foot landscaped buffer while other streets throughout Emeryville should include a seven and a half foot wide pedestrian pathway and a four foot landscaped buffer. These designs are a minimum for design in Emeryville, and ideally sidewalks should be 16 to 18 feet wide, and can include wider landscaped buffers, a seven and a half to 11 foot wide pedestrian pathway, and / or vegetative strips along the building face. The *Emeryville Design Guidelines* also specify minimum dimensions for sidewalks in various city districts.

- Building Entry / Public Space - This area borders the building façade, fence, or landscaped area. The primary purpose of this zone is to create a buffer between pedestrians walking in the throughway zone from people entering and exiting buildings. It provides opportunities for shops to place signs, planters, or chairs that do not encroach into the throughway zone.

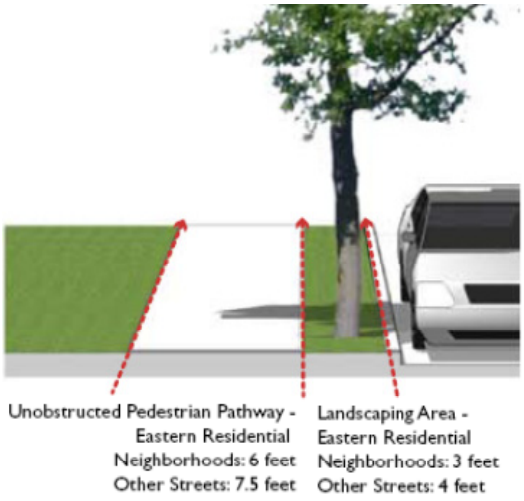
- Pedestrian Pathway - The minimum width of this zone should be at least 6 to 7.5 feet or wider for higher volume areas, as noted in the *Emeryville Design Guidelines*.

- Landscaping / Street Furniture - This area acts as a buffer between the curb and throughway zone. This is the areas where trees should be planted and benches should be located. Any sidewalk amenities should be located within this area and should not interfere with the throughway zone. Streets with higher speeds should have larger furnishing zones. At a minimum, such as in areas with lower pedestrian activity, there should be a 6-inch wide curb. Other areas, such as business districts, should have at least an extra foot to accommodate car doors to not conflict with the sidewalk.

Example



Landscaping / Street Furniture | Pedestrian Pathway | Building Entry / Public Space



Maintain an unobstructed pedestrian pathway and landscaping area.

Source: Valley Transportation Authority Pedestrian Technical Guidelines; Emeryville Design Guidelines, City of Emeryville, Decemebr 2010

Pedestrian Amenities

Discussion

Providing amenities for pedestrians along their route makes for a more enjoyable and comfortable walking experience, thus encouraging more walking. They are an essential element of street infrastructure which makes pedestrians a priority within the streetscape. These elements enhance the pedestrian realm by serving as functional aspects that serve the needs of walkers while enhancing the character of the street.

Design Summary

- Wayfinding & Signage - Wayfinding signage should cater to both vehicles and pedestrians, particularly in districts where there are high levels of walking activity. Signs and routes that direct pedestrians to specific destinations are key to providing adequate way finding for pedestrians. Wayfinding should be available on smart phones when possible.
- Street Furniture - Street furniture is normally placed on a sidewalk in the Frontage Zone to provide additional comfort for pedestrians and enhance place making within the pedestrian realm. Street furniture can include benches, specially designed newspaper racks, fountains, special garbage/recycling containers, etc. It is important that they do not conflict with the pedestrian travel path.
- Street Trees - *The Emeryville Design Guidelines* addresses the design and incorporation of street trees and stormwater management into transportation infrastructure through the treatment of runoff within different design scenarios. Some examples include vegetated swales, planters, rain gardens, pervious paving, stormwater curb extensions and curb cuts, and green gutters. Street trees are an important aspect to the pedestrian realm as they increase the comfort for pedestrians, providing shade and a buffer from vehicles, ultimately enhancing the streetscape. The *Guidelines* also note that trees should be placed an average of 25 feet apart to provide a continuous street canopy.
- Lighting - Pedestrian scale lighting provides a better-lit environment for pedestrians while improving visibility for motorists. Sidewalks with frequent nighttime pedestrian activity should have pedestrian lighting. Pedestrians tend to observe more details of the street environment since they travel at a slower pace than vehicles, and thus pedestrian scale lighting should have shorter light poles and shorter spacing between posts. A height of 12- 20 feet is common for pedestrian lighting. The level of lighting should reflect the location and existing or desired level of pedestrian activity.

Example

Wayfinding and Signage

High Quality Street Furniture

Pedestrian Scale Lighting

Median Island / Pedestrian Refuge – All Crossings

Discussion

Refuge islands provide a designated space in the middle of a crosswalk to allow pedestrians to wait halfway between crossings. Refuge islands are raised islands in the center of a roadway that separate opposing lanes of traffic with a cutout or ramp for an accessible pedestrian path. They reduce pedestrian exposure to motor vehicles, and allow a pedestrian to cross a roadway in two stages. Their application is most pertinent in higher traffic volume areas that have four-lane or wider streets or when crossing distances exceed 60 feet.

Design Summary

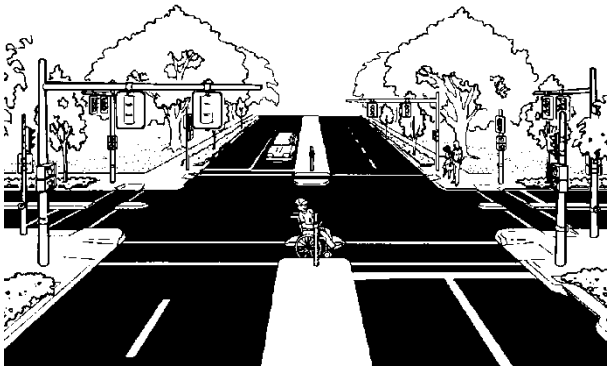
The minimum recommended width for a median island is 5-8 feet based on the average roadway speed, as shown in the table below. This minimum width accommodates bicyclists. In different contexts, the refuge island can be extended if there are higher amounts of pedestrian activity or additional travel lanes.

Recommended Median Widths	
Speed	Width
25-30 MPH	5 Feet
30-35 MPH	6 Feet
35-45 MPH	8 Feet

A special application of the median island is the two-stage crossing where the crosswalk is staggered such that a pedestrian crosses the street halfway and then is directed to walk towards the direction of traffic to reach the second half of the crosswalk. This channelization effect, typically described as a split-pedestrian cross-over, allows for the pedestrian to easily view traffic while completing the second part of the crossing.

Example

Pedestrian Refuge Island



Split Pedestrian Cross-Over

Image Sources: www.tfhrc.gov, www.flickr.com/photos/luton

High Visibility Crosswalk Striping – Level 1

Discussion

In areas with high pedestrian volumes and where land uses may generate significant pedestrian activity (at least 15 pedestrians per hour), high visibility striping is a tool that brings attention to pedestrians crossing typically at an uncontrolled or mid-block location. This highest-visibility markings include the "ladder" and the "continental." It should be used in combination with other design treatments, like refuge islands, bulb-outs, and other active device enhancements for roadways with more than 4 lanes or speeds over 40 mph. They help to direct pedestrian traffic to specific locations.

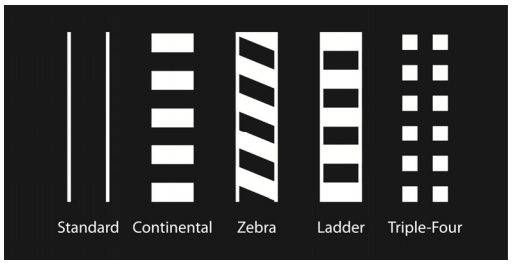
Design Summary

The use of high visibility striping is recommended at uncontrolled crossing locations, and other locations as traffic volumes, speeds, and vehicle-pedestrian conflicts require. There are several treatments for high visibility markings, including the ladder, continental, and zebra designs. Communities should choose a preferred style to use in these circumstances so it is consistently applied. Continental striping is often chosen to communicate sensitive pedestrian crossing areas as the designated high visibility tool.

The City of Sacramento, for example, developed its own standard high visibility striping treatment for uncontrolled locations called the triple-four (shown in the example illustration). The City has implemented this treatment citywide, involving three four-foot segments, two dashed lines on the outside with a clear space in the center to direct pedestrian traffic.

Example

Example Crosswalk Types



Continental Crosswalk in Emeryville

Image Sources: Fehr & Peers

Advance Yield or Stop Lines – Level 1

Discussion

Standard white stop or yield limit lines are placed in advance of marked, uncontrolled crosswalks. In California, yield lines are used, as state law requires drivers to yield, not stop, for pedestrians in crosswalks.

Design Summary

This measure increases the pedestrian's visibility to motorists, reduces the number of vehicles encroaching on the crosswalk, and improves general pedestrian conditions on multi-lane roadways. It is useful in areas where pedestrian visibility is low and in areas with aggressive drivers, as advance limit lines help prevent drivers from encroaching on the crosswalk. It also addresses the multiple-threat collision on multi-lane roads.

Example

Image Sources: Fehr & Peers

High Visibility Signage – Level 1

Discussion

This tool involves two key types of high-visibility signage:

- In-Street Signage – These involve the placement regulatory pedestrian signage in the middle of the roadway centerline, either in front or behind the crosswalk. It is MUTCD-approved and assists to remind road users of laws regarding to the right of way at unsignalized pedestrian crossings.
- Other Warning Signs - High-visibility fluorescent yellow green signs are made of the approved fluorescent yellow-green color and posted at crossings to increase the visibility of a pedestrian crossing.

Design Summary

Signs may be placed on the roadway centerline directly, as in the picture to the right, or on the side of the roadway depending of the type of signage. Careful placement is necessary to avoid maintenance issues with vehicles knocking down the sign. One option for in-street signs is to temporarily place the sign during specific time periods, such as when school is in session. Another option is to put the sign within a raised median or place in-pavement raised markers around the sign. They can be placed either at mid-block locations or intersections with significant pedestrian activity, such as near transit stations or schools.

Example

In-Street Signage

Other Warning Signage

Image Sources: Fehr & Peers

Curb Extensions, Bulb Outs, and Reduced Curb Radii – Level 2

Discussion

At uncontrolled locations, enhanced treatments beyond striping and signing may be needed for candidate marked crosswalk locations under the following conditions:

- Streets with moderate expected motorist compliance; or
- Streets with high expected motorist compliance operating poorly.

Design Summary

The following treatments are methods to enhance Level 2 uncontrolled crossing locations:

Curb Extension / Bulb Outs

Also known as curb extensions, bulb-outs increase driver awareness of pedestrians and help slow traffic. They provide a larger space for pedestrians to wait before crossing an intersection and prevent cars from parking near the crosswalk. Bulb-outs are highly beneficial in business district or transit station areas, which generate significant pedestrian activity. They may also be beneficial in school zones or neighborhood districts, which have vulnerable pedestrians, such as children or older adults who would benefit from an enhanced treatment that reduces crossing distances.

Bulb-outs involve extending the curb space into the street to create a shorter pedestrian crossing. They should not extend into the bicyclist line of travel to avoid impeding bicyclists and motorists. They may require removal of on street parking.

Landscaping within bulb-outs, as depicted at right, can further enhance the character and comfort of the pedestrian realm. Bulb-outs may also create space for pedestrian amenities or bicycle parking.

Reduced Curb Radii

Shorter radii narrow the distance that pedestrians have to cross and reduce traffic speeds. Like curb extensions, they increase driver awareness, but are less difficult and expensive to implement.

This measure would be beneficial on streets with high pedestrian activity, on-street parking, and no curb-edge transit service. It is more suitable for wider roadways and roadways with low volumes of heavy truck traffic.

Example

Curb Extension / Bulb Outs

Reduced Curb Radii

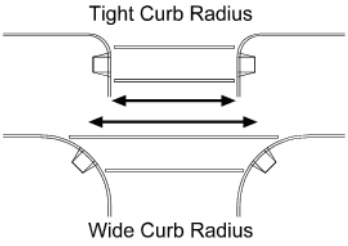


Image Source: Dan Burden (top), www.ci.austin.tx.us *(bottom)*

Enhanced Uncontrolled Crossing Treatments – Level 3+

Discussion

At uncontrolled locations, enhanced treatments beyond striping and signing may be needed for candidate marked crosswalk locations under the following conditions:

- Multi-lane streets (three or more lanes); or
- Two-lane streets with average daily traffic volumes (ADT) greater than 12,000; or
- Posted speed limit exceeding 30 miles per hour.

Design Summary

The following treatments are methods to enhance Level 3 or higher crossings:

In-Pavement flashers – Level 3

This enhanced treatment helps to improve the visibility of pedestrians at uncontrolled crosswalks. In-pavement markers are lined on both sides of a crosswalk, often containing an amber LED strobe light. They can either be actuated by a push-button or using remote pedestrian detection. The benefits of this measure are that it provides a dynamic visual cue, and is effective in bad weather.

The best application for this measure is in locations with low bicycle ridership, as the raised markers present a hazard to bicyclists. First-generation in-roadway warning lights have high maintenance costs. May not be appropriate for locations with bright sunlight (e.g. east-west roads). The lights may cause confusion when pedestrians fail to activate them or if they falsely activate

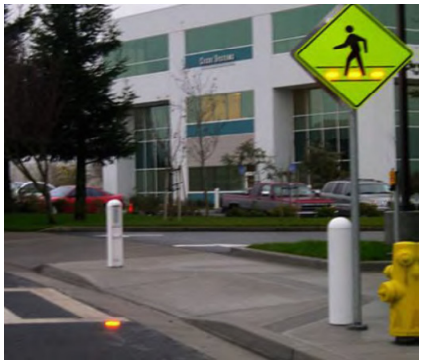
Flashing Beacons – Level 3

This treatment enhances driver visibility of pedestrians by installing flashing amber lights either overhead or on a post-mounted sign before a vehicle approaches the crosswalk or at the crossing. The benefit of this measure is that the blinking lights during pedestrian crossing times increase the number of drivers yielding for pedestrians and reduce pedestrian-vehicle conflicts. This measure can also improve conditions on multi-lane roadways.

The best application for this measure is in places where motorists cannot see a traditional sign due to trees or other barriers.

Example

In-Pavement Flashers



Overhead Flashing Beacon

Enhanced Uncontrolled Crossing Treatments – Level 3+

Rectangular Rapid Flashing Beacon (RRFB)

The RRFB, also known as a stutter flash, enhances the flashing beacon by replacing the slow flashing incandescent lamps with rapid flashing LED lamps. The lights can be activated either by a push-button or with remote pedestrian detection. This treatment is included in the 2009 Federal MUTCD, but has not yet been approved for use in California. There are also versions with LED lights placed within the pedestrian crossing sign.

Initial studies suggest the Rapid Rectangular Flashing Beacon (RRFB) is very effective as measured by increased driver yielding behavior. Solar panels reduce energy costs associated with the device. This device is appropriate for multi-lane roadways.

High- Intensity Activated Crosswalk (HAWK)

This enhanced signal treatment is used in circumstances where there are high vehicle speeds as well as a high demand for pedestrian crossings. It combines the beacon flasher with a traffic control signal to generate a higher driver yield rate. They are pedestrian activated and will display a yellow indication to warn vehicles, then a solid red light. While pedestrians are crossing, the driver sees a flashing red light in a "wig wag" pattern until the pedestrian clearance phase has ended, then returns to a dark signal. The HAWK is included in the 2009 Federal MUTCD, but not yet approved for use in California. This measure has been proven to reduces pedestrian-vehicle conflicts and slows traffic speeds. The most appropriate application for this device is in areas where it is difficult for pedestrians to find gaps in automobile traffic to cross safely, but where conventional signal warrants are not satisfied. This device is appropriate for multi-lane roadways.

Mid-Block Pedestrian Signal

A pedestrian signal may be use to provide the strictest right-of-way control at a pedestrian crossing. Warrants for placement are defined within the MUTCD (a new warrant is provided in the 2009 Federal MUTCD).

Rectangular Rapid Flashing Beacon

HAWK Signal

Mid-Block Pedestrian Signal

Image Sources: Fehr & Peers

Grade Separated Crossing

Discussion

A grade-separated pedestrian crossing provides a complete separation of pedestrians from vehicles through a pedestrian-only overpass or underpass (generally bicycles are permitted as well). Grade separations are a tool to help overcome barriers and help pedestrians connect to sidewalks, off-road trails and paths. It should be used where topography is supportive and no other pedestrian facility is available.

Design Summary

Grade separated crossings should be constructed within the most direct path of a pedestrian. They should have visual appeal and entrances that are visible so pedestrians feel safe and not isolated from others.

Because they can be costly (typically from $2M to $8M or more), it is recommended that grade separated crossings be used in instances where there are unsafe vehicle speeds and volumes or no feasible substitute for the pedestrian.

Example

Image Sources: Fehr & Peers
http://www.walkinginfo.org/library/details.cfm?id=2882
http://www.opacengineers.com/features/BerkeleyPOC

Bicycle and Pedestrian Trail Crossing

See the Appendix B for a detailed description of this treatment.

Controlled Crossing Treatments / Intersection Design

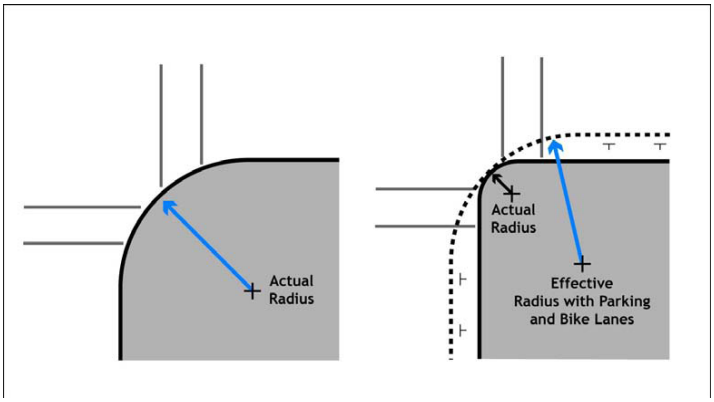
Pedestrian treatments at signalized locations throughout Emeryville may be used to:

- Improve the visibility of pedestrians to motorists and vice-versa
- Communicate to motorists and pedestrians who has the right-of-way
- Accommodate vulnerable populations such as people with disabilities, children, and seniors
- Reduce conflicts between pedestrians and vehicles
- Reduce vehicular speeds at locations with potential pedestrian conflicts

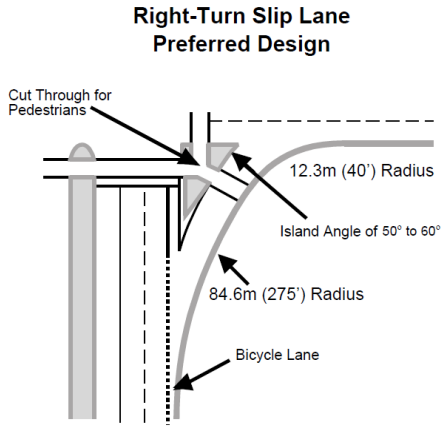
Improving Pedestrian Visibility – Shorten Crossing Distance

Intersections should be as compact as possible to minimize pedestrian crossing distances. Shorter crossing distances ultimately reduce the exposure time of pedestrians within the roadway and are easier to navigate. Consequently, compact intersections are more comfortable for pedestrians and improve visibility between motorists and pedestrians.

Reducing turning radii is one tool to foster compact intersection design and improve sight distance, in which dimensions of the curb at the intersection directly affects the speed of the approaching vehicle. A large turning radius (generally 30 feet or greater) allows vehicles to turn at high speeds. Reducing the radius forces approaching vehicles to slow down while still accommodating larger vehicles, thus reducing the frequency and severity of pedestrian collisions at intersections. As shown below, on-street parking and bicycle lanes can allow for smaller curb radii while maintaining the same effective curb radius. Note that on-street parking should be restricted in at least 30 feet in advance of the intersection, to improve visibility for pedestrians.



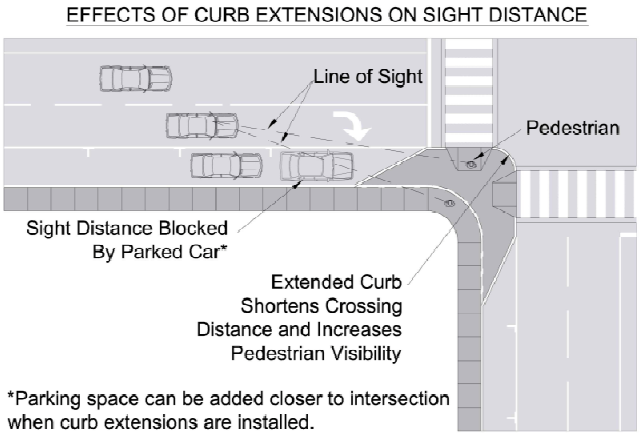
Free right turns should be restricted whenever possible as they encourage fast turning movements and present a challenging uncontrolled crossing for pedestrians. When they are necessary, design strategies can enhance the pedestrian crossing and improve visibility of bicyclists on intersecting streets (illustrated below).



Source: Fehr & Peers

Improving Pedestrian Visibility – Reducing Sight Distance Barriers

Compact intersection design can also improve pedestrian visibility by removing barriers to sight distance, including parked cars, roadway geometry, terrain, vegetation, sun glare, insufficient building setbacks, inadequate roadway lighting, poor signal visibility, signal controller cabinets/poles, and cluttered signage. Improving sight distances gives motorists a clear view of pedestrians, while allowing the pedestrian to observe and react to any hazards. Free vehicle right turns and permitted lefts are two situations that often create conflicts with pedestrians. Ensuring proper sight distances between pedestrians and vehicles can decrease the rate and severity of turning related pedestrian-vehicle collisions.



Source: Sacramento City Pedestrian Master Plan

Removing barriers to sight distance requires careful design when vehicles approach other vehicles and pedestrians. Design elements should be considered at intersections as well as mid-block crossings. Designers must particularly consider the needs of those pedestrians with special needs, including older adults, children, and people with disabilities. For example, children and people using wheelchairs have a lower eye height than standing adults.

Standard Crosswalk Striping

Discussion

Crosswalks should be marked on *all approaches* where feasible to delineate space for pedestrians to cross. While heavy vehicle volumes may present an exception, exceptions are discouraged and should only be considered when all other options to accommodate motor vehicle demand have been considered.

At intersections, crosswalks are essentially an extension of the sidewalk. If the sidewalk provides a path of travel for the pedestrian to the intersection, proper striping should continue to direct the pedestrian to the other side of the intersection.

Advanced stop bars are another standard crosswalk treatment to discourage vehicles from encroaching into the crosswalk. They may be useful at signalized intersections and stop controlled intersections with multiple lanes. A yield line should be used as a replacement at uncontrolled intersections.

Design Summary

Standard dual white lane stripes are recommended for pedestrian crossings at signalized intersections. These bars should be one foot wide and extend from curb ramp to curb ramp.

Advanced stop or yield limit lines are solid white lines extending through the traffic lane to communicate to drivers where they should stop. MUTCD requires they be placed at least 4 feet before the crosswalk, although placement at greater distances can enhance pedestrian visibility and vehicle reaction times.

Example

Standard Crosswalk at Signalized Intersection

Crosswalk with Advance Stop Bar

Sources: Fehr & Peers (above), Sacramento City Pedestrian Plan (below)

Special Paving Treatments

Discussion

Special paving treatments include adding texture to surfaces or coloring pavement to distinguish the sidewalk or crosswalk. This treatment enhances the character of the overall pedestrian environment. The rougher roadway surface may also slow vehicles and draw more attention to the pedestrian realm.

Design Summary

Types of special paving treatments typically include:

- Bricks, pavers, or colored concrete
- Stamped asphalt or concrete that is then painted to resemble bricks.
- Pavement stencils

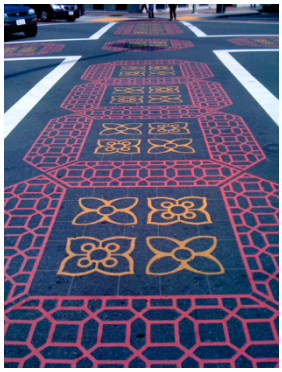
Designers must be careful to not confuse the visually impaired and cause problems for people with disabilities. Surfaces should be adapted to accommodate people using wheelchairs. A standard white stripe is recommended on either side of the crosswalk even when special paving treatments are used to enhance the contrast between the crossing and the roadway.

Example

Brick Paver Streetprint Design

Brick Pavers and Concrete

Decorative Streetprint



Sources: Fehr & Peers, http://www.visualtexture.net/page/2/

Curb Ramps

Discussion

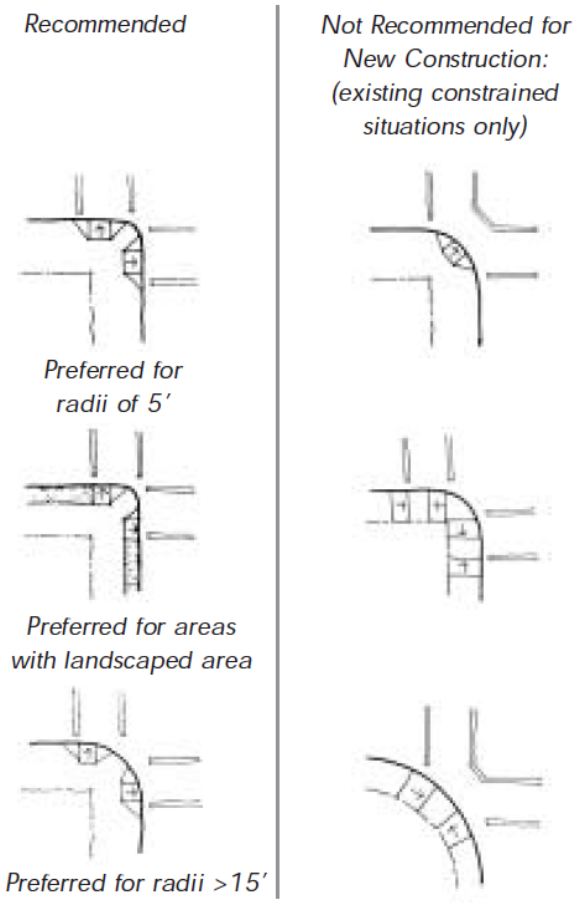
Pedestrians with mobility impairments, such as people using wheelchairs or those with canes, need curb ramps to safely access a sidewalk.

Design Summary

The appropriate curb ramp design depends on the geometry of the intersection. Recommended practices for various sidewalk conditions are shown to the right. As depicted in the illustration, directional ramps are preferred over diagonal ramps as they provide direct access to each crosswalk. Curb ramps should be ADA compliant to accommodate mobility and visually impaired pedestrians. Detectable warnings are required by the ADA Accessibility Guidelines with any new curb ramp or reconstruction. These guidelines call for raised truncated domes of 23 mm diameter and 5mm height. Curb ramps should align in the direction of the crosswalk and have enough clear space beyond the curb line so the pedestrian is not drawn right into the line of traffic.

Pedestrian bulb outs are appropriate to combine with curb ramps as described in the Uncontrolled Crossing section.

Example



Sources: Valley Transportation Authority Technical Pedestrian Guidelines, Fehr & Peers

Pedestrian Friendly Signal Treatments

Discussion

There are several innovative treatments that enhance the visibility and convenience of pedestrian crossings at traffic signals. These treatments can be applied in a variety of contexts depending on the pedestrian demand and vehicle movement within the streetscape.

Design Summary

Leading Pedestrian Intervals

An enhanced pedestrian treatment that gives pedestrians a walk indication while other approaches are red to prevent advancing. Crossing with this "head start" allows pedestrians to be more visible to motorists approaching an intersection.

- Should be used at locations with heavy right turn vehicle volumes as well as frequent pedestrian crossings.
- Vehicles are stopped for 2-4 seconds while pedestrians are allowed to begin crossing.
- May require restricting right-turn on red at some locations.

Countdown signals

Displays a "countdown" of the number of seconds remaining for the pedestrian crossing interval.

- Information about the amount of time left to cross is particularly helpful when crossing multi-lane arterials.
- Can improve pedestrian compliance while reducing the amount of pedestrians "dashing" across an intersection.

Scramble Phasing

This enhanced crossing treatment allows pedestrians to walk in all directions while all vehicle approaches have a red phase. Pedestrians may cross the street orthogonally or diagonally, providing a direct and efficient walking route.

Audible Signal

Pedestrian phases are typically difficult for those with visual impairments to recognize. MUTCD 2003, Section 4A.01 specifies that signals that communicate to pedestrians in a non-visual way can include verbal messages or vibrating surfaces.

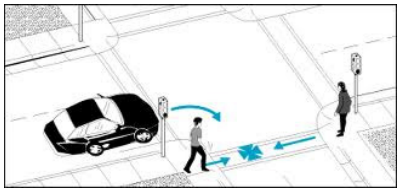
- Should be implemented on a separate pole close to the crosswalk line. If two are placed on the same corner, they should be 10 feet apart to distinguish between directions.
- Speaker on top of the signal can give bell, buzzer, speech message during walk interval or vibrate when walk signal is on. Or a personal individual receiver can communicate by infrared or LED to the signal.

Pedestrian Friendly Signal Timing

See "Pedestrian Friendly Signal Phasing" below.

Example

Leading Pedestrian Interval



Countdown Signal

Scramble Phasing

Sources: http://www.walkinginfo.org, Fehr & Peers, www.streetswiki.wikispaces.com

Pedestrian Friendly Signal Phasing

Discussion

Left- and right-turning vehicles are required to yield to pedestrians in the crosswalk. Different signal phasing sequences accommodate pedestrian crossing intervals differently:

- Protected left turns allow vehicles turning left an exclusive phase, ultimately eliminating conflicts between pedestrians in the crosswalk; left-turning vehicles will never cross at the same time as the pedestrian signal.
- Split phasing allows each intersection approach to receive a dedicated phase. Pedestrian phases for parallel crosswalks will be activated at different times. This phasing can reduce intersection capacity.
- Permitted left turn phasing, where vehicles turning must yield to through traffic and pedestrians, can reduce pedestrian delay and improve traffic operational efficiency by minimizing the impact of pedestrian timing through allowing two pedestrian crossings at once.

Other types of pedestrian signal phasing, including "scramble" phasing and leading pedestrian intervals, are described in the "Pedestrian Friendly Signal Treatments" guideline above.

Design Summary

Where pedestrian volumes are high, using permitted signal phasing is generally preferred because it reduces pedestrian delay. Providing protected left-turn phasing to eliminate pedestrian-vehicle conflicts is recommended where feasible.

At intersections with heavy vehicle traffic volumes, providing convenient and comfortable pedestrian crossings must be balanced with the need to maintain intersection capacity and operations for automobiles. In these instances, it is important to incorporate additional treatments to enhance pedestrian visibility, such as special striping or signage. If a permitted left turn phase is used, the traffic and pedestrian signal should be located next to each other on the corner pole (as depicted in the picture) to attract driver's attention.

Example

Example of a Pedestrian Signal Head Mounted on a Signal Pole

Pedestrian Friendly Signal Timing

Discussion

Signal timing typically favors vehicle travel. However, in areas with high pedestrian activity, there are methods to alter signals to better meet the needs of pedestrians. The walk interval of a pedestrian phase is, at a minimum, four to seven seconds, followed by a pedestrian clearance interval, called the "flash don't walk" (FDW) phase. The FDW phase uses a standard rate to determine the amount of time provided for the pedestrian to clear an intersection. It is determined by dividing the width of an intersection by the pedestrian walking speed. The solid "Don't Walk" sign typically coincides with the yellow vehicle signal. The pedestrian timing is an important element to traffic signals since the green time for cars might not be sufficient for pedestrians to cross an intersection.

Design Summary

The standard for walking speeds at signalized intersections has changed from 4 feet per second to 3.5 feet per second to more accurately reflect the average pedestrian walking speed and aging population. The 2009 Federal MUTCD requires this reduction, although the change has not yet been adopted in California.

A slower walking rate of 2.8 feet per second (MUTCD 4E.10(CA)) is recommended in areas with a high number of children, older adults, or disabled pedestrians crossing. Pre-timed signals may warrant a longer walk phase in order to accommodate pedestrians.

Example

Source: Dan Burden

Roundabouts

See the Appendix B for a detailed description of this treatment.

Implementation Checklists

The purpose of a Implementation Checklist is to ensure that pedestrian needs are being considered in the planning, design, and construction of all transportation projects and new land use development. Also known as "Routine Accommodation" guidelines, these checklists can be used to ensure projects foster pedestrian safety and provide access in all roadways. Routine accommodation policies are included as part of the federal surface transportation act (SAFETEA-LU). Additionally, Caltrans Deputy Directive 64 (DD64-R1) requires the accommodation of pedestrians in all projects. In June 2006, the Metropolitan Transportation Commission (MTC) adopted regional policies to accommodate pedestrians through the Resolution No. 3765, which promotes the routine accommodation of all non-motorized travelers.

Documenting how well a project meets the City's goals to accommodate pedestrians within the transportation network is a valuable process, particularly in future funding applications. The following section includes two resources to adequately consider pedestrian and bicycles as part of the project and land use planning process:

- **Design Summary for Pedestrian Accommodations:** This summary lists pedestrian-supportive treatments identified throughout this document to ensure a broad range of applications are considered within streets, sidewalks, controlled intersections/ crossings, and uncontrolled intersections/ crossings.
- **Emeryville Project Development Review Checklist for Bicycles and Pedestrians:** This checklist for bicycles and pedestrians is a sample set of questions for Emeryville to use with future transportation infrastructure and land use development projects.

Design Summary for Pedestrian Accommodations

Streets and Sidewalks

- Design "complete streets" which accommodate all pedestrians, paying special attention to vulnerable populations such as children, older adults, and the disabled.
- Ensure a continuous network of sidewalks with appropriate widths depending on the pedestrian demand and surrounding land uses.
- Provide pedestrian amenities, including street trees, furniture, and pedestrian-scale lighting within the sidewalk where appropriate.
- Develop a connected and fine-grained street network, providing pedestrian paths where possible.
- Install traffic calming treatments where pedestrian activity is high but vehicle volumes and/or travel speeds are also high.
- Install curb ramps with truncated domes to facilitate a transition from street to sidewalk.
- Place buildings adjacent to the street when possible, avoiding placing large parking lots in front of buildings.

Uncontrolled Intersections

- Incorporate high visibility striping to enhance pedestrian crossings

- Install median islands where feasible, especially where there are long pedestrian crossings
- Installing innovative crossing treatments and special paving techniques in areas with high pedestrian demand
- Install in-street pedestrian crossing signs nears schools and senior center
- Build grade separated crossings where there are no feasible alternatives to directly cross pedestrians on the street
- Install enhanced mid-block crossings at locations where pedestrian demands are supportive

Controlled Intersections

- Design compact intersections with tight curb radii
- Reduce sight barriers
- Install advanced stop bars at intersections
- Install pedestrian friendly signal treatments to accommodate pedestrians at the appropriate level of demand (example: pedestrian scramble at high demand areas)
- Mark crosswalks with standard dual white lines or preferred standard markings at all approaches
- Install countdown signals at signalized intersections and consider slower walking speeds where applicable
- Establish clear right-of-way control for pedestrian crossings to avoid conflicts with vehicle left or free right turns
- Install bulb-outs where there is a need to decrease traffic speeds and create more sidewalk space
- Incorporate ADA-compliant practices at intersections routinely
- Consider installing roundabouts at strategic locations, ensuring safe pedestrian designs

Emeryville Project Development Review Checklist for Bicycles and Pedestrians

Discussion:

Recent federal, state and regional policies call for the routine consideration of bicyclists and pedestrians in the planning, design and construction of all transportation projects. These policies—known as "Routine Accommodation" guidelines—are included in the federal surface transportation act (SAFETEA-LU), Caltrans Deputy Directive 64, and MTC Resolution 3765.

This checklist was developed for project sponsors to document how the needs of bicyclists and pedestrians are being considered in the process of planning and/or designing of their project(s). For projects that do not accommodate bicyclists and pedestrians, project sponsors must document why not. Besides documenting how a project would meet a local jurisdiction's adopted goals for encouraging active, non-motorized transportation (e.g., walking and biking), the checklist can also be used to help develop funding applications for bicycle and pedestrian projects that would benefit a project.

This checklist is intended for use on projects at their earliest conception or design phase; however, some of the responses to questions in this checklist may be included in any transportation impact study prepared for a project. For projects that require substantial design work, this checklist should be completed and submitted to City staff before projects reach later design phases. City transportation engineers and planning staff, Bicycle/Pedestrian Advisory Committees (BPAC) and other relevant commissions should be responsible for reviewing the answers submitted by project sponsors.

Design Summary:

Project sponsors should provide detailed answers to the following questions. Where appropriate, answers should include or reference project plans or design documents that illustrate how a project accommodates bicycles and pedestrians.

1. What existing accommodations for bicycles and pedestrians are provided at the project site and on the adjacent streets? Please include a description of pedestrian and bicycle facilities located within 1,000 feet of the project site.

- *The response to this question should identify any crosswalks, sidewalks, bike lanes, bike routes or shared-use paths.*
- *Describe any pedestrian generating amenities or uses near the project site, including schools, recreational centers, public facilities, parks, job centers, or commercial areas.*
- *Please describe any particular pedestrian or bicycle uses or needs along the project corridor that you have observed or of which you have been informed. Please include any deficiencies, including missing sidewalks or proposed bicycle or pedestrian facilities that have not been constructed.*
- *If there are no existing pedestrian or bicycle facilities, how far from the proposed project are the closest parallel bikeways and walkways?*

2. Describe to what extend the proposed project would generate trips by non-auto modes (e.g., attract walking or bicycling customers, employees, students, visitors or others). If the project is required to prepare a transportation impact study, has the study attempted to estimate the number of new walkers or bikers to the site?

3. Is the project adjacent to any intersections within a quarter mile that have reported collisions involving bicyclists or pedestrians? If so, describe where these collisions have occurred in respect to the project site, and

Emeryville Project Development Review Checklist for Bicycles and Pedestrians

describe whether or not the project would address these locations?

4. Do any adopted City or regional plans call for the development of bicycle or pedestrian facilities on, crossing or adjacent to the proposed project? If yes, list the applicable plan(s). Is the proposed project consistent with these plans? To respond to this question, the project sponsor should reference any regional transportation plan, City plan, and any applicable special area plans.

5. Please describe the public outreach that has been conducted to date for the proposed project, and what comments have been made regarding bicycle and pedestrian accommodations.

6a. What bicycle or pedestrian accommodations are included in the proposed project design?

- *This response should clearly document how pedestrians and bicyclists would access and maneuver on the project site, even if the project site does not propose new bicycle or pedestrian facilities.*
- *Please include a proposed project site plan that identifies on-site bicycle and pedestrian circulation. The plan should identify pedestrian entrances to any structure, bicycle parking areas, pedestrian walkways in parking areas and service loading docks. If the project includes additional elements that serve bicycle commuters, such as employee locker rooms, those areas should also be shown on the site plan.*
- *If the proposed project does not incorporate both bicycle and pedestrian facilities list reasons why the project is being proposed without them.*

6b. What would be the cost of the bicycle and/or pedestrian facilities included in the project description, and what is the cost of these facilities in proportion of the total project cost? If right-of-way acquisition is required, please describe land acquisition separately. If the project does not include bicycle and pedestrian accommodations, identify if cost was a primary factor when they were removed from the project description.

7. If the project includes bicycle or pedestrian facilities, what applicable design standards or guidelines have been followed? If the project designed facilities using standards not identified in the design standards included in the City's plan (where applicable), please describe what design standards where used for these facilities.

8. Will the proposed project remove an existing bicycle or pedestrian facility or block or hinder bicycle or pedestrian movement? If yes, please describe situation in detail. Include a list of reasons why the project is being proposed as designed.

- *If the project is proposing any new driveways (i.e., curb cut), please describe how pedestrians and bicyclists will be accommodated. Discuss whether or not the driveway would result in additional conflicts between drivers and bicyclists in an existing or proposed on-street bicycle facility. If the driveway will cross an existing or proposed sidewalk or pedestrian path, describe whether or not vehicles would need to block the sidewalk in order to exit the site.*

9. How will access around the project site for bicyclists and pedestrians be maintained during project construction? Describe if the project construction will require any temporary sidewalk or lane closures.

10. What agency will be responsible for ongoing maintenance of existing and proposed bicycle and pedestrian facilities at the project site and how will this be budgeted?

Appendix B. Resources for the Design of Bicycle Facilities

Emeryville Pedestrian and Bicycle Plan

May 2012

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Table of Contents

Introduction

This appendix presents an overview of bicycle facility designs, based on appropriate Manual on Uniform Traffic Control Devices (MUTCD) and Highway Design Manual (HDM), and as supplemented by American Association of State Highway and Transportation Officials (AASHTO) best practices and Emeryville-specific design guidelines. The purpose is to provide readers and project designers with an understanding of the facility types that are proposed in the Pedestrian and Bicycle Master Plan.

The design concepts presented in this document are based on bikeway and bike path design guidelines provided in federal, state, and local design and standards documents, as well as best practices from communities throughout the world. The bicycle design guidelines are intended to provide solutions to the problem of providing high-quality bicycle facilities in a wide variety of conditions.

In California, roadway design, including bikeway design, is governed by the California MUTCD, which is based on the Federal Highway Administration's MUTCD. As of April 2011, the California Department of Transportation (Caltrans) is using CA MUTCD 2009 Edition, and has issued a draft CA MUTDC 2011 Edition, which incorporates the Federal Highway Administration's MUTCD 2009 Edition.

Not all of the design treatments described in these appendices are compliant with the CA MUTCD. In the event that a specific treatment is not in the California MUTCD, it may be necessary to go through experimental testing procedures. Experimental testing is overseen by the California Traffic Control Devices Committee.

Key Principles

The following are key principles for these bicycle guidelines:

- **The bicycling environment should be safe.** Bicycle routes and bike paths should be designed and built to be free of hazards and to minimize conflicts with external factors such as vehicles and buildings.
- **The bicycle network should be accessible.** Bicycle routes and bike paths should permit the mobility of community members and visitors of all ages and abilities. Bicyclists have a range of skill levels, and facilities should be designed with a goal of providing for inexperienced/recreational bicyclists (especially children and seniors) to the greatest extent possible.
- **The bicycling environment should be clear and easy to use.** Bicycle routes and bike paths should be designed so bicyclists can easily find a direct route to a destination and so delays are minimized.
- **The bicycling environment should enhance community livability.** Good design should integrate with, and support the development of, complementary uses and should encourage preservation and construction of art, landscaping and other items that add value to public ways. A complete network of on-street bicycling facilities should connect seamlessly to the existing and proposed off-street pathways to complete recreational and commuting routes around the city.
- **Bicycle improvements should be economical.** Bicycle improvements should be designed to achieve the maximum benefit for their cost, including initial cost and maintenance costs as well as reduced reliance on more expensive modes of transportation. Where possible, public improvements in the right-of-way should stimulate, reinforce and connect with adjacent private improvements.
- **Design guidelines are intended to be flexible and to be applied with professional judgment.** Specific national and state guidelines are identified in this document, as well as design treatments

that may exceed these guidelines. It is recognized that statutory and regulatory guidance may change. For this reason, among others, it is noted that the guidance and recommendations in this document are meant to complement the other resources considered during the design process.

References

The following is a list of references and sources utilized to develop these design guidelines. Many of these documents are available online and are a wealth of information and resources available to the public.

Federal Guidelines

- 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design, 2010. Department of Justice. http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm#curbramps
- AASHTO Guide for the Development of Bicycle Facilities,[1] 1999. American Association of State Highway and Transportation Officials, Washington, DC. www.transportation.org
- AASHTO Policy on Geometric Design of Streets and Highways, 2001. American Association of State Highway and Transportation Officials, Washington, DC. www.transportation.org
- Accessibility Guidelines for Buildings and Facilities, 2002. United States Access Board, Washington, D.C. http://www.access-board.gov/adaag/html/adaag.htm
- Manual on Uniform Traffic Control Devices (MUTCD), 2009. Federal Highway Administration, Washington, DC. http://mutcd.fhwa.dot.gov
- Public Rights-of-Way Accessibility Guidelines (PROWAG), 2007. United States Access Board, Washington, D.C. http://www.access-board.gov/PROWAC/alterations/guide.htm

State and Local Guidelines

- California Department of Transportation. (2006). *Highway Design Manual* (HDM), *Chapter 1000: Bikeway Planning and Design.* http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp1000.pdf
- California Department of Transportation. (2009). *California Manual of Uniform Traffic Control Devices for Streets and Highways, Part 9: Traffic Controls for Bicycle Facilities* http://www.dot.ca.gov/hq/traffops/signtech/mutcdsupp/pdf/camutcd2010/Part9.pdf
- California Department of Transportation. (2005) *Pedestrian and Bicycle Facilities in California: A Technical Reference and Technology Transfer Synthesis for Caltrans Planners and Engineers.* http://www.dot.ca.gov/hq/traffops/survey/pedestrian/TR_MAY0405.pdf

Best Practices Documents

- Bicycle Parking Guidelines, 2nd Edition. (2010). Association of Pedestrian and Bicycle Professionals (APBP). http://www.apbp.org/resource/resmgr/webinars/bpg_exec_summary_4-21-10.pdf
- Designing Sidewalks and Trails for Access. (2001). FHWA. http://www.fhwa.dot.gov/environment/sidewalk2/contents.htm
- National Association of City Transportation Officials (NACTO). (2011). Urban Bikeway Design Guide. http://nacto.org/cities-for-cycling/design-guide/
- Portland Bicycle Master Plan for 2030. (2010). City of Portland, Oregon Department of Transportation. http://www.portlandonline.com/transportation/index.cfm?c=44597&a=289122

[1] The Guide for the Development of Bicycle Facilities is currently being updated, and the new document cannot be quoted at the time of this writing. However, many of the facilities under consideration for the update are included in these design guidelines.

- Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations. (2005). FHWA Report HRT-04-100 http://www.tfhrc.gov/safety/pubs/04100/

Bicycle Facilities

The following sheets detail guidance for the design of bicycle facilities.

Bikeway Classification Overview

Discussion

Caltrans has defined three types of bikeways in Chapter 1000 of the Highway Design Manual: Class I/shared use path, Class II/Bike Lane, and Class III/Bike Route. This document uses the generic terms "shared use path", "bike lane" and "bike route".

Design Summary

Class I Path Width:

8 feet is the minimum allowed for a two-way bicycle path and is only recommended for low traffic situations.

10 feet is recommended in most situations and will be adequate for moderate to heavy use.

12 feet is recommended for heavy use situations with high concentrations of multiple users such as joggers, bicyclists, rollerbladers and pedestrians. A separate track (5' minimum) can be provided for pedestrian use.

Class II Bike Lane Width with Adjacent On-Street Parking:

5' minimum recommended when parking stalls are marked

Bike Lane Width without Adjacent Parking:

4' minimum when no gutter is present (rural road sections)

5' minimum when adjacent to curb and gutter (3' more than the gutter pan width if the gutter pan is greater than 2')

Recommended Width: 6' where right-of-way allows

Class III Lane Width for Bicycle Route With Wide Outside Lane:

Fourteen feet (14') minimum is preferred. Fifteen feet (15') should be considered if heavy truck or bus traffic is present. Bike lanes should be considered on roadways with outside lanes wider than 15 feet. This treatment is found on all residential streets, collectors, and minor arterials.

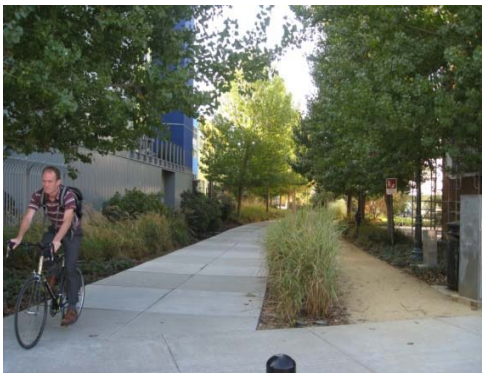
Emeryville Greenway

The off-street portion of the Emeryville Greenway is a multi-use path consisting of a 10-foot concrete bikeway and 6-foot wide decomposed granite walking path. These are separated by a 4-foot wide planting strip

Guidance

- Caltrans *Highway Design Manual* (Chapter 1000: Sections 1003.1(1) and (2), 1003.2(1), 1003.3(1), and 1003.5)
- California MUTCD Chapter 9
- AASHTO Guide for the Development of Bicycle Facilities, Chapter 2

Design Example



Class I Shared Use Bike Path

Class II Bike Lane

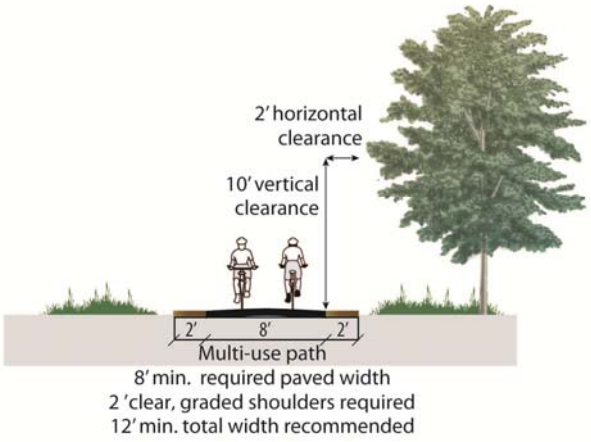
Class III Bike Route

Bikeway Classification Overview

Recommended Design

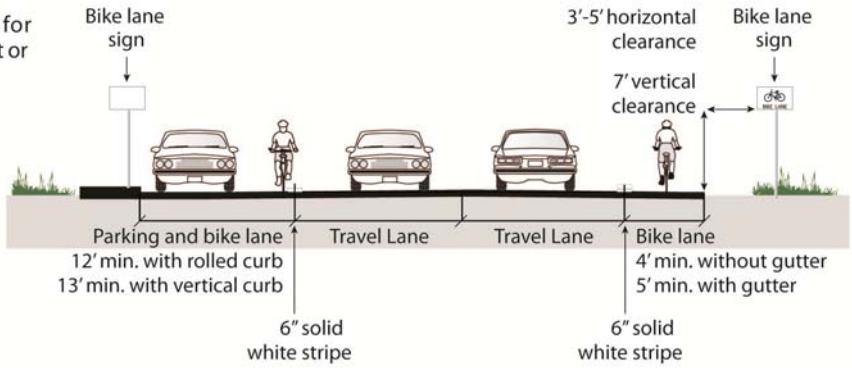
CLASS I
Multi-Use Path

Provides a completely separated right of way for the exclusive use of bicycles and pedestrians with crossflow minimized.



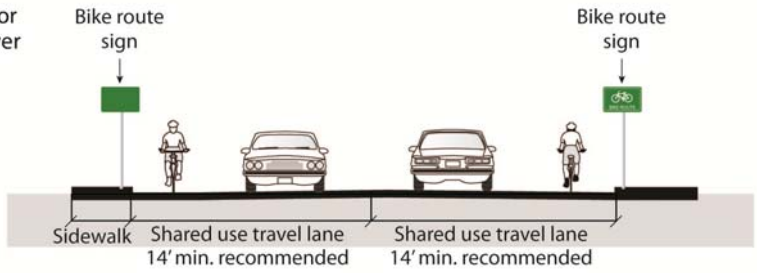
CLASS II
Bike Lane

Provides a striped lane for one-way bike travel on a street or highway.



CLASS III
Bike Route
Signed Shared Roadway

Provides for shared use with pedestrian or motor vehicle traffic, typically on lower volume roadways.



Bike Routes

Discussion

The Caltrans Highway Design Manual (HDM) Chapter 1000 defines Class III bicycle facilities as bikeways shared with motor vehicles. They are typically located on roads with low speeds and traffic volumes; however, they can be used on higher volume roads with wide outside lanes or with shoulders.

Shared roadways are indicated exclusively by signs that identify the street as a bike route (see right). Wayfinding signs can also be used to indicate connections to destinations and paths (see Section 0), and shared lane markings or bicycle boulevard treatments can be used to enhance shared roadways.

Design Summary

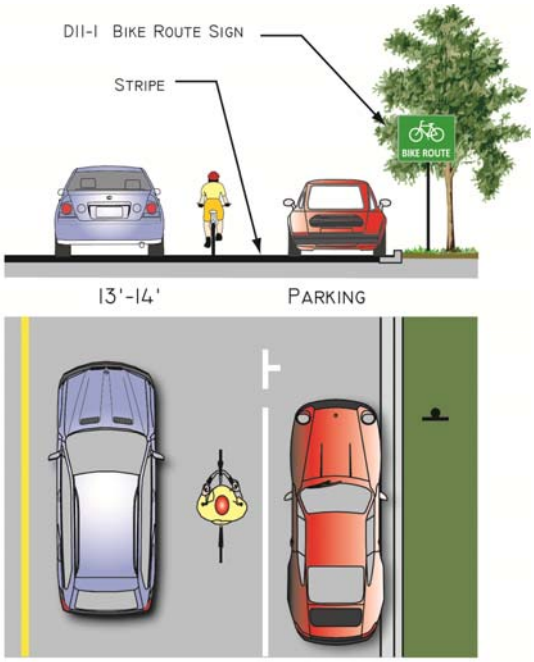
- Use D11-1 Bike Route Sign at:
  - Beginning or end of bike route
  - Entrance to bike path (Class I) – optional.
  - At major changes in direction or at intersections with other bike routes (with applicable arrow or directional sign).

At intervals along bike routes not to exceed ½ mile.

Guidance

- Caltrans Highway Design Manual Chapter 1000
- AASHTO Guide for the Development of Bicycle Facilities
- *MUTCD* – California Supplement 2011 Draft Edition

Design Example



Shared roadway recommended configuration.

D11-1 "Bike Route" sign should be used along designated shared roadways.

Additional Bike Route Signage

Discussion

'Share the Road' signs are intended to reduce motor vehicle/bicyclist conflict and are appropriate to be placed on routes that lack paved shoulders or other bicycle facilities. They typically work best when placed near activity centers such as schools, shopping centers and other destinations that attract bicycle traffic.

Many cities around the country have been experimenting with a new type of signage that encourages bicyclists to take the lane when the lane is too narrow. This type of sign is becoming known as BAUFL (Bikes Allowed Use of Full Lane). This can be quantified to lanes being less than 14 feet wide with no parking and less than 22 feet wide with adjacent parallel parking. The 2009 update to the MUTCD recognizes the need for such signage and has designated the white and black sign at right (R4-11). The 2010 CA MUTCD states that Shared Lane Markings (which serve a similar function as Bikes May Use Full Lane signage) should not be placed on roadways that have a speed limit above 40 mph. Dedicated bicycle facilities are recommended for roadways with speed limits above 40 mph where the need for bicycle access exists.

Design Summary

Placement:

- At the beginning of the bikeway
- When a bikeway turns (particularly in advance of left turns to allow a bicyclist time to merge for the turn)
- When bikeways intersect
- At intervals of ½ to one mile (based on density of streets) along routes with no designated bicycle facilities.

Guidance

- MUTCD – California Supplement 2011 Draft Edition
- City of Oakland. 2009. Guidelines for Bicycle Wayfinding Signage

Design Example

R4-11

Share The Road Signs (CA MUTCD 2011 Draft)

Shared Lane Markings

Discussion

Shared lane markings are high-visibility pavement markings that help position bicyclists within the travel lane. These markings are often used on streets where dedicated bike lanes are desirable but are not possible due to physical or other constraints. Shared lane markings are placed strategically in the travel lane to alert motorists of bicycle traffic, while also encouraging cyclists to ride at an appropriate distance from the "door zone" of adjacent parked cars. Placed in a linear pattern along a corridor, shared lane markings also encourage cyclists to ride in a straight line so their movements are predictable to motorists.

Shared lane marking stencils (also called "sharrows") have been introduced for use in California as an additional treatment for Class III facilities. The stencil can serve a number of purposes, such as making motorists aware of bicycles potentially in their lane, showing bicyclists the direction of travel, and, with proper placement, reminding bicyclists to bike further from parked cars to prevent "dooring" collisions.

Design Summary

- Use D11-1 "Bike Route" Sign as specified for shared roadways.
- Place shared lane markings in a linear pattern along a corridor (typically every 100-200').
- Centered at least 11' from face of curb (or shoulder edge) on streets with on-street parking.
- At least 4' from face of curb (or shoulder edge) on streets without on-street parking.
- Shared lane markings should not be placed on roadways with a speed limit over 40 mph (CA MUTCD 2011 Draft).
- Marking should be placed immediately after an intersection and spaced at intervals no greater than 250' thereafter (CA MUTCD 2011 Draft).

Guidance

- Use of shared lane markings was adopted by Caltrans in 2005 as California MUTCD Section 9C.103 and Figure 9C-107.
- AASHTO Guide for the Development of Bicycle Facilities.
- Caltrans *Highway Design Manual* (Chapter 1000).
- NACTO Urban Bikeway Design Guide.

Design Example

Shared lane marking placement guidance for streets with on-street parking.

Shared lane markings were first tested in San Francisco

Bike Lanes

Discussion

Bike lanes or Class II bicycle facilities (Caltrans designation) are a portion of the roadway that has been designated by striping, signage, and pavement markings for the preferential or exclusive use of bicyclists. Bike lanes are generally found on connector or transit streets and are 5-8 feet wide. Bike lanes can be found in a large variety of configurations, and can have special characteristics including coloring and placement if beneficial.

Bike lanes enable bicyclists to ride at their preferred speed without interference from prevailing traffic conditions and facilitate predictable behavior and movements between bicyclists and motorists. Bicyclists may leave the bike lane to pass other cyclists, make left turns, avoid obstacles or debris, and to avoid other conflicts with other roadway users.

Design Example

Approved R81(CA) Sign.

Approved California bike lane stencils

Design Summary

- Width: 5-8′ measured from edge of gutter pan. Varies depending on roadway configuration; see following pages for design examples.
- Use dashed white stripe in the following locations:
  - Vehicle merging area (optional)
  - Approach to intersections: 100-200′
  - Delineate conflict area in intersections (optional): Length of conflict area.
- Signing: use R81(CA) Bike Lane Sign at:
  - Beginning of bike lane
  - At approaches and at far side of all arterial crossings
  - At major changes in direction
  - At intervals not to exceed ½ mile
- Use the bike lane stencil with directional arrow to be used at:
  - Beginning of bike lane
  - At approaches and at far side of all arterial crossings
  - At major changes in direction
  - At intervals not to exceed ½ mile
  - At beginning and end of bike lane pockets at approach to intersection

Guidance

- AASHTO Guide for the Development of Bicycle Facilities.
- Caltrans *Highway Design Manual* (Chapter 1000)
- *MUTCD* – California Supplement
- NACTO Urban Bikeway Design Guide.
- Additional standards and treatments for bike lanes are provided in the following pages.

Bike Lane Adjacent to On-Street Parallel Parking

Discussion

Bike lanes adjacent to parallel parking should be designed to be wide enough to allow bicyclists to ride outside of the "door zone" (i.e., five feet minimum).
Treatments to encourage bicyclists to ride away from the "door zone" include:

- Installing parking "T's" and smaller bike lane stencils placed to the left (see graphic at top).
- Using diagonal stripes to encourage cyclists to ride on the left side of the bike lane (shown middle; this treatment is not standard and should be studied before use).
- Provide a buffer zone (preferred design; shown bottom). Bicyclists traveling in the center of the bike lane will be less likely to encounter open car doors. Motorists have space to stand outside the bike lane when loading and unloading.

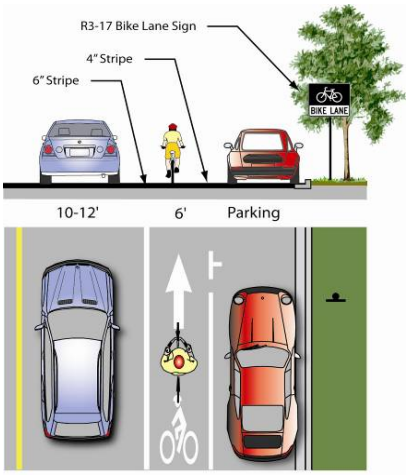
Design Summary

- Width:
  - 6" recommended when parking stalls are marked (5' minimum)
  - 7' maximum (greater widths may encourage vehicle loading in bike lane).
- Shared bike and parking lane width:
- 12 feet for a shared lane adjacent to a curb face (13 feet is preferred where parking is substantial or turnover is high), or 11' minimum for a shared bike/parking lane on streets without curbs where parking is permitted.

Guidance

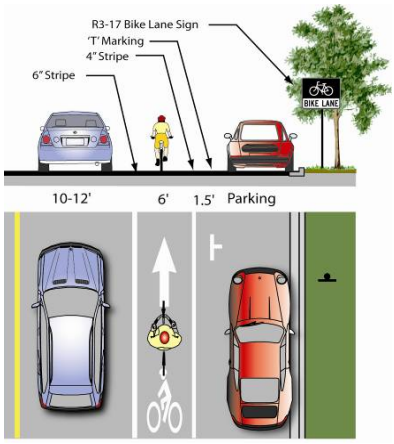
- AASHTO Guide for the Development of Bicycle Facilities
- Caltrans *Highway Design Manual* (Chapter 1000)
- MUTCD – California Supplement 2011 Draft Edition

Design Example



Parking 'T' bike lane design.

Diagonal stripe bike lane design (maximum width).



Parking buffer bike lane design.

Bike Lane Adjacent to On-Street Diagonal Parking

Discussion

In areas with high parking demand, diagonal parking can be used to increase parking supply. Conventional "head-in" diagonal parking is not recommended in conjunction with high levels of bicycle traffic or with the provision of bike lanes as drivers backing out of conventional diagonal parking spaces have poor visibility of approaching bicyclists.

"Back-in diagonal parking" or "reverse angled parking" improves sightlines between drivers and bicyclists and provides benefits to motorists including: loading and unloading of the trunk occurs at the curb rather than in the street, passengers (including children) are directed by open doors towards the curb. While there may be a learning curve for some drivers, using back-in diagonal parking is typically an easier maneuver than conventional parallel parking.

Emeryville's past experiments with back-in diagonal parking have been discontinued due to motorist confusion over the proper way to use the parking. Any future treatments should include significant public outreach and education.

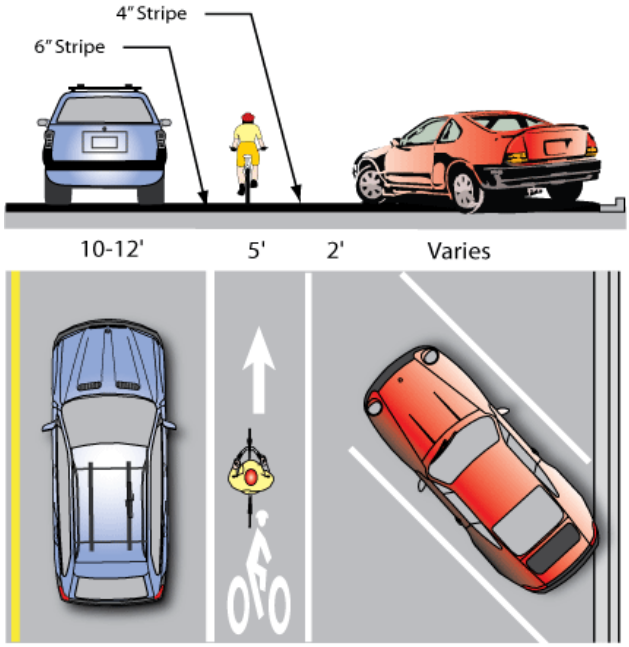
Design Summary

- Width:
  - 5' minimum.
  - White 4" stripe separates bike lane from parking bays.
  - Parking bays are sufficiently long to accommodate most vehicles (vehicles do not block bike lane).

Guidance

- Slated for inclusion in the upcoming update of the AASHTO *Guide for the Development of Bicycle Facilities.*

Design Example



Recommended bike lane adjacent to on-street diagonal parking design.

'Back-in' diagonal parking is safer for cyclists than 'head-in' diagonal parking due to drivers' visibility as they exit the parking spot..

Bike Lane Without On-Street Parking

Discussion

Recommended bicycle lane width is 5 feet minimum when adjacent to curb and gutter. Wider bicycle lanes are desirable in certain circumstances such as on higher speed or volume streets (30 mph+) where a wider bicycle lane can increase separation between passing vehicles and bicyclists. Appropriate signing and stenciling is important with wide bicycle lanes to ensure motorists do not mistake the lane for a vehicle lane or parking lane. Bicycle lanes wider than seven feet are not recommended.

Design Summary

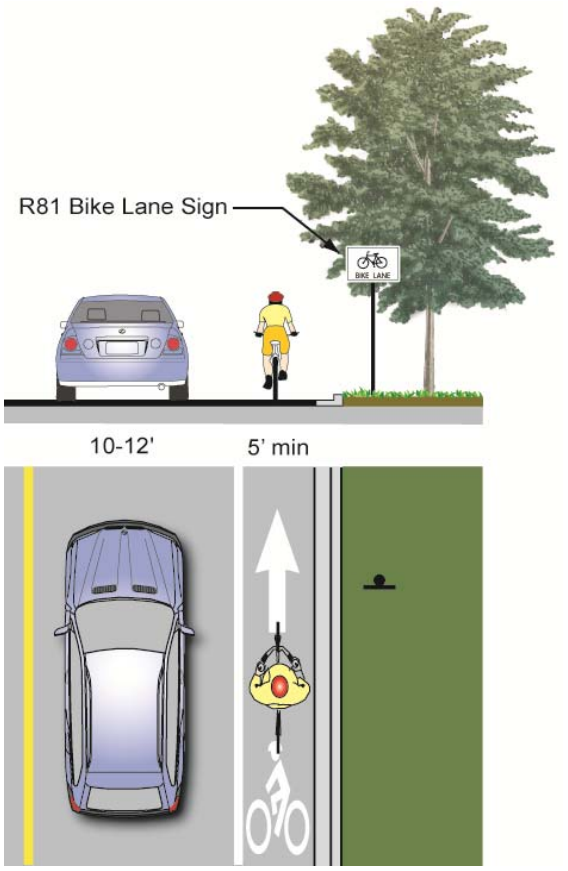
- Width:
  - 4′ minimum when no curb & gutter is present
  - 5′ minimum when adjacent to curb and gutter (3′ more than the gutter pan width if the gutter pan is wider than 2′).
  - 6′ recommended where right-of-way allows.

7′ maximum adjacent to high speed streets

Guidance

- AASHTO Guide for the Development of Bicycle Facilities
- Caltrans *Highway Design Manual* (Chapter 1000)
- MUTCD – California Supplement 2011 Draft Edition

Design Example



Recommend bike lane without on-street parking design.

Where on-street parking is not allowed adjacent to a bike lane, bicyclists do not require additional space to avoid opened car doors.

Buffered Bike Lanes

Discussion

Bike lanes on high-volume or high-speed roadways can be dangerous or uncomfortable for cyclists, as automobiles pass or are parked too close to bicyclists. Buffered bike lanes are designed to increase the space between the bike lanes and the travel lane or parked cars.

This treatment is appropriate on roads with high automobile traffic volumes and speed or high volumes of truck or oversized vehicles, and on bike lanes adjacent to parked cars. If there is a high frequency of right turns by motor vehicles at major intersections, buffer striping should be truncated approaching the intersection.

Advantages of buffered bike lanes:

- Provides cushion of space to mitigate friction with motor vehicles.
- Provides space for cyclists to pass one another without encroaching into the travel lane.
- Provides space for cyclists to avoid potential obstacles in the bike lanes, including drainage inlets, manholes, or debris.
- Parking side buffer provides cyclists with space to avoid the 'door zone' of parked cars.
- Provides motorists greater shy distances from cyclists in the bike lane.

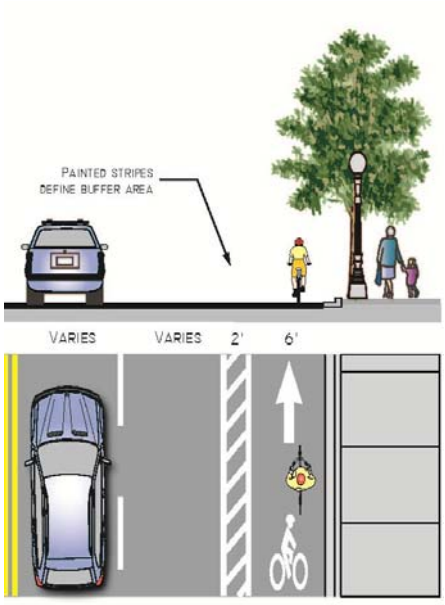
Disadvantages / potential hazards:

- Requires additional roadway space.
- Requires additional maintenance for the buffer striping.
- Frequency of parking turnover should be considered prior to installing buffered bike lanes.

Design Summary

- Width: 6' recommended
- Minimum of 2' buffer area

Design Example



Recommended buffered bike lane design.

Buffered bike lanes in San Rafael, CA

Guidance

- City of Portland, OR Bikeway Design Best Practices for the 2030 Bicycle Master Plan
- NACTO. Urban Bikeway Design Guide

Contraflow Bike Lane

Discussion

Contraflow bike lanes provide bi-directional bicycle access along a roadway that is one-way for automobile traffic. This treatment can provide direct access and connectivity for bicyclists, avoiding detours and reducing travel distances for cyclists.

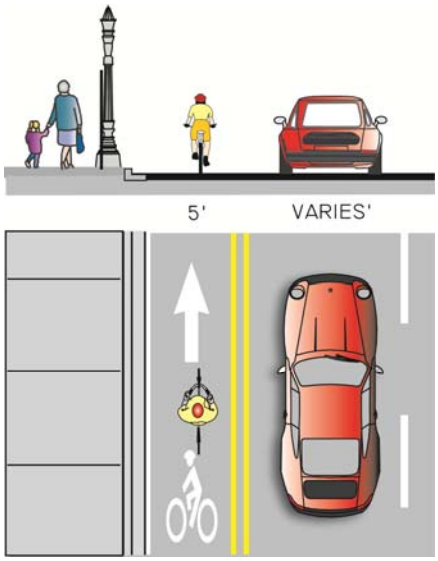
Advantages of contraflow bike lanes:

- Provides direct access and connectivity for bicycles traveling in both directions.
- Influences motorist choice of routes without limiting bicycle traffic.
- Cyclists do not have to make detours as a result of one-way traffic.

Disadvantages / potential hazards

- Parking should not be provided on the far side of the contraflow bike lane.
- Space requirements may require reallocation of roadway space from parking or travel lanes.
- The lane could be illegally used by motorists for loading or parking.
- Conversion from a two-way street requires elimination of one direction of automobile traffic.
- Public outreach should be conducted prior to implementation of this treatment.

Design Example



Recommended contraflow bike lane design.

This contraflow bike lane in Portland, OR (left) provides a key connection along a narrow one-way street.

Design Summary

- Width: 5-7
- Mark with a solid double yellow line and bike lane markings that are clearly visible.
- Consider coloration on the bike lane.

Guidance

- Wisconsin Bicycle Facility Design Handbook.
- City of Portland, OR Bikeway Design Best Practices for the 2030 Bicycle Master Plan.
- Currently used in Berkeley, CA, Olympia and Seattle, WA; Madison, WI, Cambridge, MA, San Francisco, CA, and Portland, OR.
- NACTO. Urban Bikeway Design Guide.

Shared Bicycle/Bus Lane

Discussion

The shared bus/bicycle lane should be used where width is available for a bus lane, but not a bus and bike lane. The dedicated lane attempts to reduce conflicts between bicyclists, buses, and automobiles. Various cities have experimented with different designs and there is currently no evidence of one design being more effective than the others.

Shared bike/bus lanes can be appropriate in the following applications:

On auto-congested streets, or with moderate or long bus headways.

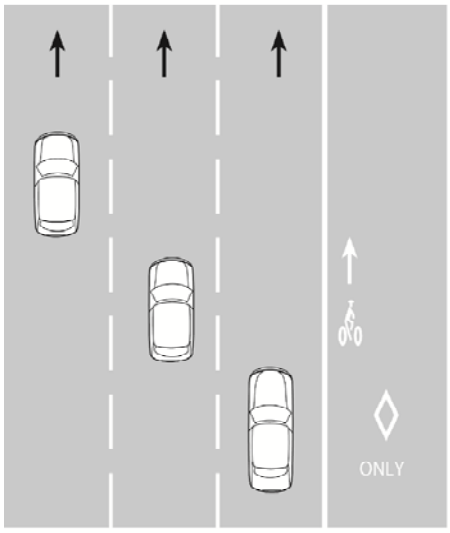
Moderate bus headways during peak hour.

No reasonable alternative route.

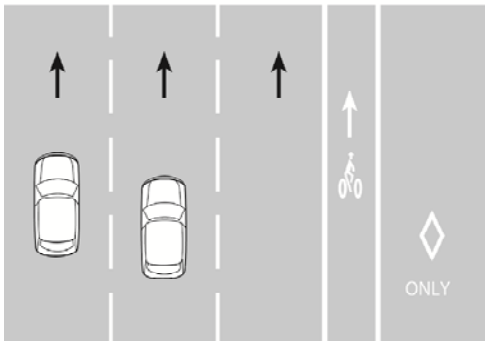
Design Summary

- Provide a standard width bike lane (minimum 4') where possible.
- Paint bicycle symbol or shared lane marking symbol to the left side of the bus lane, to allow bicyclist to pass a bus that has turned in at a stop.

Design Example



Minimum design: shared bicycle/bus lane.



Preferred design: separated bike lane and bus lane.

Bicycle Detection at Signalized Intersections

Discussion

Traffic Operations Policy Directive 09-06, issued August 27, 2009 by Caltrans modified CA MUTCD 4D.105 to require bicyclists to be detected at all traffic-actuated signals on public and private roads and driveways. If more than 50 percent of the limit line detectors need to be replaced at a signalized intersection, then the entire intersection should be upgraded so that every line has a limit line detection zone. Bicycle detection must be confirmed when a new detection system has been installed or when the detection system has been modified.

The California Policy Directive does not state which type of bicycle detection technology should be used. Two common types of detection are video and in pavement loop detectors. Where loop detectors exist, they can be calibrated to detect bicycles without significant cost. Video detection has a higher initial cost.

Design Summary

Caltrans Policy Directive 09-06 requires bicycle detection or fixed recall at all new and modified signals.

Provide bicycle detectors in a left-turn only lane where cyclists regularly make left turn movements.

Clearance Interval

The sum of the minimum green, yellow change interval, and red clearance interval should allow clearance for a 6' bicycle traveling at 14.7 ft/sec, with a start-up time of 6 seconds (see CA policy directive)

Limit Lines

The Reference Bicycle Rider must be detected with 95% accuracy within a 6 foot by 6 foot Limit Line Detection Zone.

Loop Detector

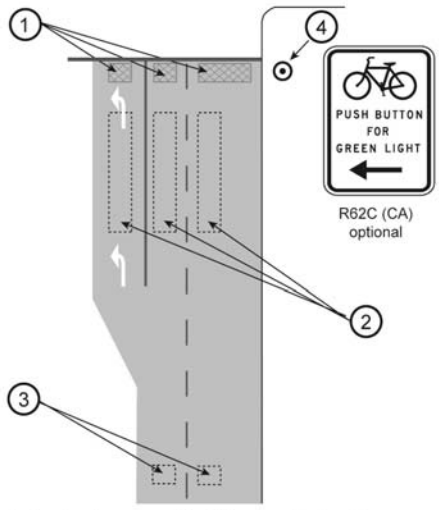
In order to minimize delay to bicyclists, it is recommended to install one loop about 100 feet from the stop bar within the bike lane, with a second loop located at the stop bar.

Details of saw cuts and winding patterns for inductive detector loop types appear on Caltrans Standard Detail ES-5B.

- NOTE: In California, Caltrans "Type C" and "Type D" quadruple loop detectors have been proven to be the most effective at detecting bicycles at signalized intersections.

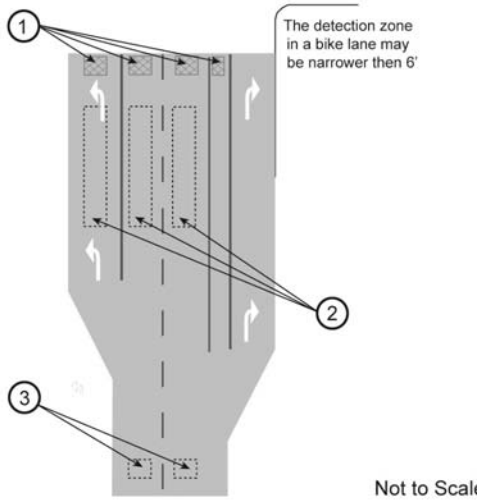
Design Example

A. Intersection with a wide right/through lane



1. Typical technology-neutral limit line detection locations. See Section 4D.105(CA).
2. Typical presence detection locations. See Section 4D.103(CA).
3. Typical advance detection locations.
4. A bicyclist pushbuttion may be used to activate a traffic signal to supplement the required limit line detection. A pushbutton should be located so it is convenient to use by bicyclists. See Section 9B.1 for bicycle regulatory signs.

B. Intersection with a Bike Lane and right-turn lane



Source: Caltrans Traffic Operations Policy Directive 09-06Video Detection – Designs not available

Bicycle Detection at Signalized Intersections

Guidance

- Caltrans Policy Directive 09-06. Provide Bicycle and Motorcycle Detection on all new and modified approaches to traffic-actuated signals in the state of California. http://www.dot.ca.gov/hq/traffops/signtech/signdel/policy/09-06.pdf
- ITE Guidance for Bicycle—Sensitive Detection and Counters: http://www.ite.org/councils/Bike-Report-Ch4.pdf

Type "C" loop detector in use in California.

Bike Lanes at Channelized Intersection With Right Turn Pocket

Discussion

The channelized intersection with right-turn pocket places a standard-width bike lane on the left side of a dedicated right turn lane. A dashed strip delineates the merging zone where automobiles cross the bike lane. This treatment includes signage advising motorists and bicyclists of proper positing within the lane.

According to the CA MUTCD and Chapter 1000, the appropriate treatment for right-turn only lanes is to place a bike lane pocket between the right-turn lane and the right-most through lane. See the sheet following for applications, where right-of-way is insufficient.

Colored bike lanes can help distinguish the bike lane in the merging area (see colored bike lane guidelines).

Advantages:

- Aids in correct positioning of cyclists at intersections with a dedicated right turn lane without adequate space for a dedicated bike lane.
- Encourages motorists to yield to bicyclists when using the right turn lane.
- Reduces motor vehicle speed within the right turn lane.

Disadvantages/potential hazards:

- May not be appropriate for high-speed arterials or intersections with long right turn lanes.
- May not be appropriate for intersections with large numbers of right-turning heavy vehicles.

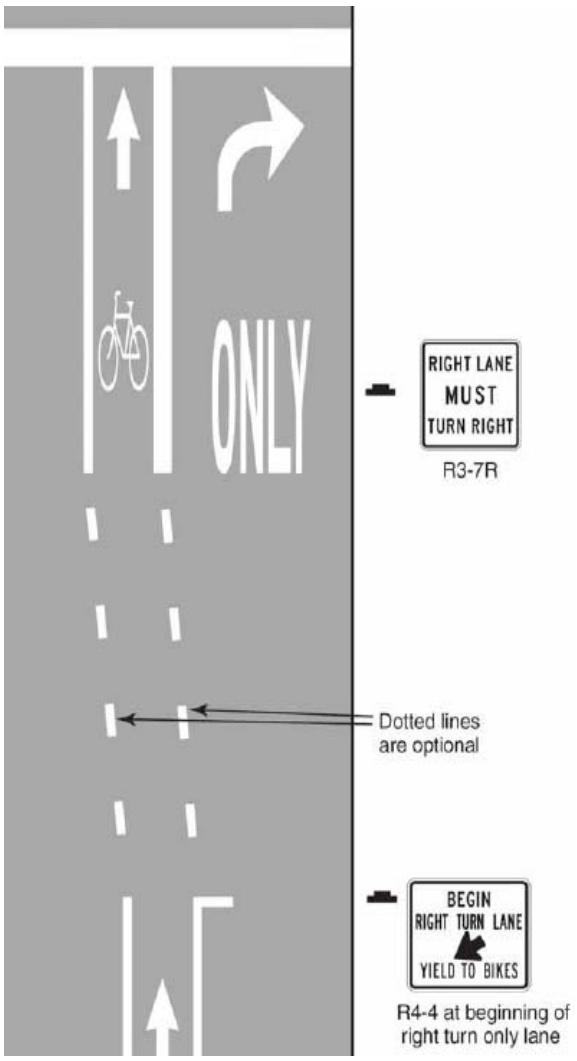
Design Summary

- Shared turn lane width – min. 12′ width.
- Bike lane pocket width – min. 4′-5′ preferred.
- Works best on streets with lower posted speeds (30 mph or less) and with low traffic volumes (10,000 ADT or less).

Guidance

- AASHTO Guide for the Development of Bicycle Facilities.
- Caltrans *Highway Design Manual* (Chapter 1000).
- *MUTCD* – California Supplement.
- NACTO. Urban Bikeway Design Guide.

Design Example



Recommended shared bike/right turn lane design.

Source: MUTCD-CA Figure 9C-4.

Continuing a bike lane straight while providing a right-turn pocket reduces bicycle/motor vehicle conflicts.

Shared Bicycle/Right Turn Lane

Discussion

This treatment is recommended at intersections lacking sufficient space to accommodate a standard bike lane and right turn lane. The shared bicycle/right turn lane places a standard-width bike lane on the left side of a dedicated right turn lane. A dashed strip delineates the space for bicyclists and motorists within the shared lane. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane. Case studies cited by the Pedestrian and Bicycle Information Center indicate that this treatment works best on streets with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less).

Advantages of Shared Bicycle/Right Turn Lanes

- Aids in correct bicycle positioning at intersections with a dedicated right turn lane without adequate space for a dedicated bike lane.
- Encourages motorists using the right turn lane to yield to bicyclists.
- Reduces motor vehicle speed within the right turn lane.

Disadvantages/Potential Hazards

- May not be appropriate for high-speed arterials or intersections with long right turn lanes.
- May not be appropriate for intersections with large percentages of right-turning heavy vehicles.

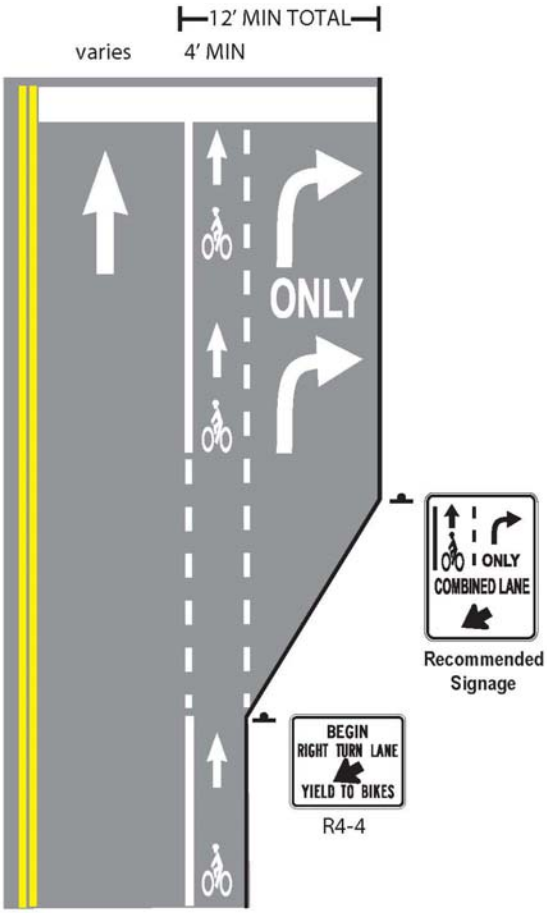
Design Summary

- Width
  - Shared turn lane – min. 12′ width
  - Bike Lane pocket – min. 4′ width. 6′preferred

Guidance

- This has been implemented in Oakland, CA.
- AASHTO Guide for the Development of Bicycle Facilities.
- NACTO. Urban Bikeway Design Guide.

Design Example



Recommended design.

Shared bicycle/right turn lanes require warning signage as well as pavement markings.

Bike Box

Discussion

A bike box is generally a right angle extension of a bike lane at the head of a signalized intersection. The bike box allows bicyclists to move to the front of the traffic queue on a red light and proceed first when that signal turns green. Motor vehicles must stop behind the white stop line at the rear of the bike box.

Bike boxes can be combined with dashed lines through the intersection for green light situations to remind right-turning motorists to be aware of bicyclists traveling straight, similar to a colored bike lane treatment. Bike boxes can be installed with striping only or with colored treatments to increase visibility. Use of coloration substantially increases costs of maintenance over uncolored (striping, bicycle symbol, and text only) treatments.

Bike boxes should be located at signalized intersections only, and right turns on red should be prohibited. Bike boxes should be used at locations that have a relatively large volume of cyclists.

On roadways without left turn pockets, the bike box also facilitates left turning movements for cyclists.

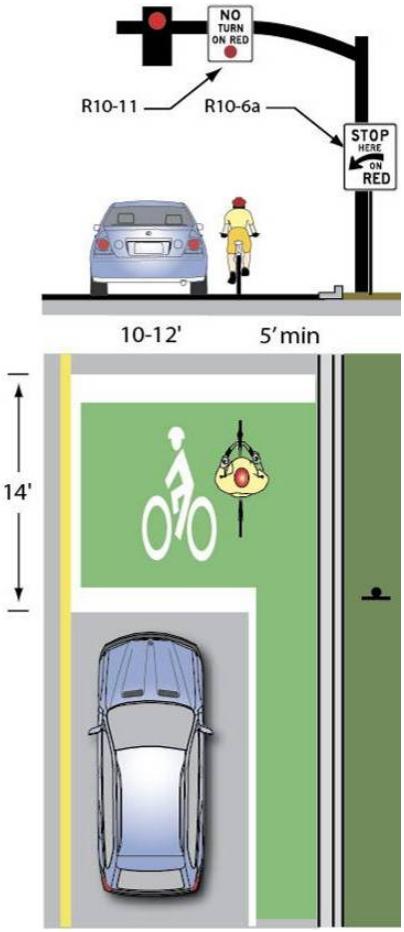
Design Summary

- Bike box dimensions: 14' deep to allow for bicycle positioning.
- Use appropriate signs as recommended by the MUTCD. Signs should prohibit 'right turn on red' and indicate where the motorist must stop.

Guidance

- FHWA has granted interim approval for use of green markings for bike lanes and cycle tracks within intersections, at conflicting points, and behind bike lane symbols and arrows (IA Memo #14).
- Evaluation of Innovative Bike-Box Application in Eugene, Oregon, Author: Hunter, W.W., 2000.
- NACTO. Urban Bikeway Design Guide.
- San Francisco, CA and Portland, OR have implemented bike boxes.

Design Example



Recommended design of a bike box.

Bike boxes have been installed at several intersections in Portland, OR

Colored Bike Lanes

Discussion

Color applied to bike lanes helps alert roadway users to the presence of bicyclists and clearly assigns right-of-way to cyclists. Motorists are expected to yield to cyclists in these areas. Some cities apply color selectively to highlight potential conflict zones, while others use it to mark all non-shared bicycle facilities in high volume traffic situations.

Color Considerations:

There are three colors commonly used in bicycle lanes: blue, green, and red. All help the bike lane stand out in merging areas. The City of Portland began using green lanes in 2008, as blue, the color used previously, is associated with ADA related signage on roadways. Green is the color recommended for use in Emeryville.

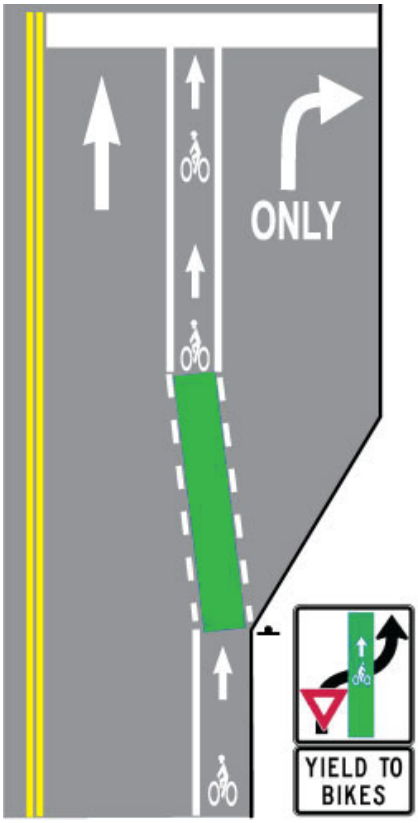
Material Options:

Colored bike lanes require additional cost to install and maintain. Techniques include:

Paint – less durable and can be slippery when wet

Colored asphalt – colored medium in asphalt during construction – most durable.

Colored and textured sheets of acrylic epoxy coating.



Recommended colored bike lane design.

Design Summary

Appropriate for heavy auto traffic streets with bike lanes; at transition points where cyclists, motorists and/or pedestrians must weave with one another; conflict areas or intersections with a record of crashes; and to emphasize bicycle space in unfamiliar or unique design treatments.

Portland, OR has used colored pavement in potential bicycle/auto conflict zones for over 10 years.

Guidance

- FHWA has granted interim approval for use of green markings for bike lanes and cycle tracks within intersections, at conflicting points, and behind bike lane symbols and arrows (IA Memo #14).
- Portland Office of Transportation (1999). Portland's Blue Bike Lanes: Improved Safety through Enhanced Visibility. Available: www.portlandonline.com/shared/cfm/image.cfm?id=58842
- NACTO. Urban Bikeway Design Guide.

Cycletracks

Discussion

Cycletracks combine the user experience of a separated path with the on-street infrastructure of a conventional bike lane. Cycletracks have different forms, but all share common elements. They are separated from vehicle traffic lanes, parking lanes and sidewalks and provide space exclusively for bicyclists. When on-street parking is available, cycletracks are located on the outside of the parking lane. Cycletracks can be either one-way or two-way, on one or both sides of a street, and are separated from vehicles and pedestrians by pavement markings or coloring, bollards, curbs/medians or a combination of these elements. See following page for additional discussion.

Design Summary

Bikeways separated from adjacent motor vehicles by a physical barrier or line of parked cars.

Separation can be achieved in multiple ways, including grade separation, mountable curb, bollards, planters and markings.

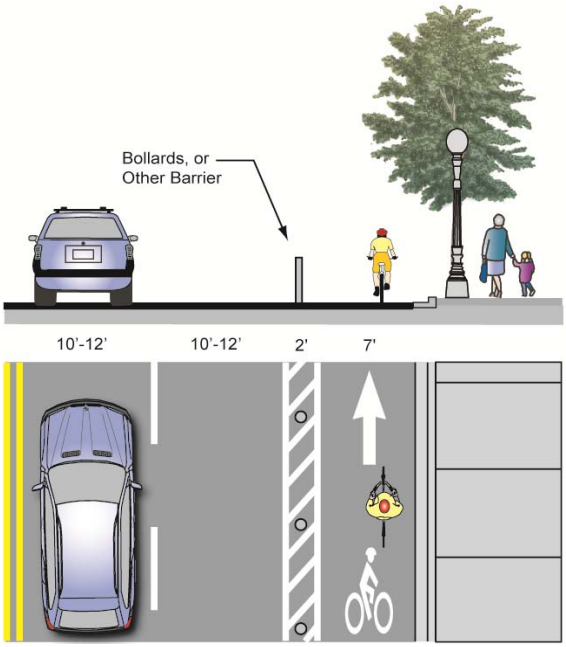
Most appropriate on wide, high-volume, high-speed roadways that are on major bike routes; and roadways with infrequent cross streets, curb cuts and long blocks.

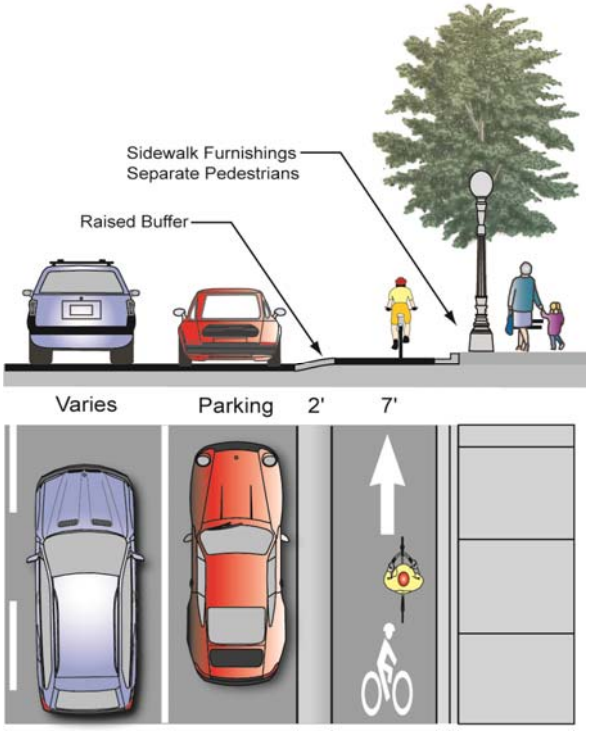
Cycletrack Width:

- 7 feet minimum for passing/obstacle avoidance
- 12 feet minimum for two-way facility

Design Example

Design Example (continued)





Guidance

This treatment is not currently present in any State or Federal design standards

Cycletracks

Additional Discussion – Cycletracks

Separation

Cycletracks can be separated by a barrier or by on-street parking. Cycletracks using barrier separation are typically at-grade. Openings in the barrier or curb are needed at driveways or other access points. The barrier should be dropped at intersections to allow vehicle crossing.

When on-street parking is present, it should separate the cycletrack from the roadway, the cycletrack should be placed with a 2-foot buffer between parking and the cycletrack to minimize the hazard of opening car doors to passing bicyclists.

Placement

Cycletracks should be placed along slower speed urban/suburban streets with long blocks and few driveway or midblock access points for vehicles. Cycletracks located on one-way streets will have fewer potential conflicts than those on two-way streets. A two-way cycletrack is desirable when there are more destinations on one side of a street or if the cycletrack will be connecting to a shared use path or other bicycle facility on one side of the street.

Cycletracks should only be constructed along corridors with adequate right-of-way. Sidewalks or other pedestrian facilities should not be narrowed to accommodate the cycletrack as pedestrians will likely walk on the cycletrack if sidewalk capacity is reduced. Visual and physical cues should be present that make it easy to understand where bicyclists and pedestrians should be moving.

Intersections

Cycletracks separate bicyclists and motor vehicles to a greater degree than bicycle lanes. This produces added comfort for bicyclists on the cycletrack, but it creates additional considerations at intersections that must be addressed. Right turning motorists conflicting with cycletrack users is the most common conflict. Both roadway users have to expand their visual scanning to see potential conflicts. To mitigate for this issue, several treatments can be applied at intersections:

Protected Phases at Signals. This treatment must have separate signal phases for bicyclists and will potentially increase delay. With this treatment, left and right turning movements are separated from conflicting through movements. The use of a bicycle signal head is required in this treatment to ensure all users know which signals to follow. Demand only bicycle signals can be implemented to reduce vehicle delay to prevent an empty signal phase from regularly occurring. With this scenario, a push button or imbedded loop within the cycletrack should be available to actuate the signal. If heavy bicyclist left turns are expected, these movements should be given its own signal phase and push button.

Advanced Signal Phases. Signalization utilizing a bicycle signal head can also be set to provide cycletrack users a green phase in advance of vehicle phases. The amount of time will depend on the width of the intersection.

Unsignalized Treatments. At non-signalized intersections the same conflicts exist. Warning signs, special markings and the removal of on-street parking (if present) in advance of the intersection can all raise visibility and awareness for bicyclists.

Access Management. The reduction in the number of potential conflict points can also benefit a cycletrack corridor. Medians, driveway consolidations, or restricted movements reduce the potential for conflict.

Bike Path Design

Discussion

A hard surface should be used for bike paths. Concrete, while more expensive than asphalt, is the hardest of all path surfaces and lasts the longest. However, joggers and runners prefer surfaces such as asphalt or decomposed granite due to its relative "softness". While most asphalt is black, dyes (such as reddish pigments) can be added to increase the aesthetic value of the path itself.

When concrete is used the bike path should be designed and installed using the narrowest possible expansion joints to minimize the amount of 'bumping' cyclists experience on the path.

Where possible, bike paths should be designed according to ADA standards. ADA accessibility requirements for trails are exclusive to trails designed and constructed primarily for pedestrians; mountain bike and equestrian trails that also allow pedestrians, but where hiking is not the primary use, are exempt from accessibility requirements. Constructing soft surface paths may have limitations that make meeting ADA standards difficult and sometimes prohibitive. Prohibitive impacts include harm to significant cultural or natural resources, a significant change in the intended purpose of the path, requirements of construction methods that are against federal, state or local regulations, or presence of terrain characteristics that prevent compliance.

Design Summary

Width

8 feet minimum paved path width (Caltrans). AASHTO recommends a paved width of 10 feet.

A 3 to 4-foot wide native surface path may be considered alongside shared-use paths for runners.

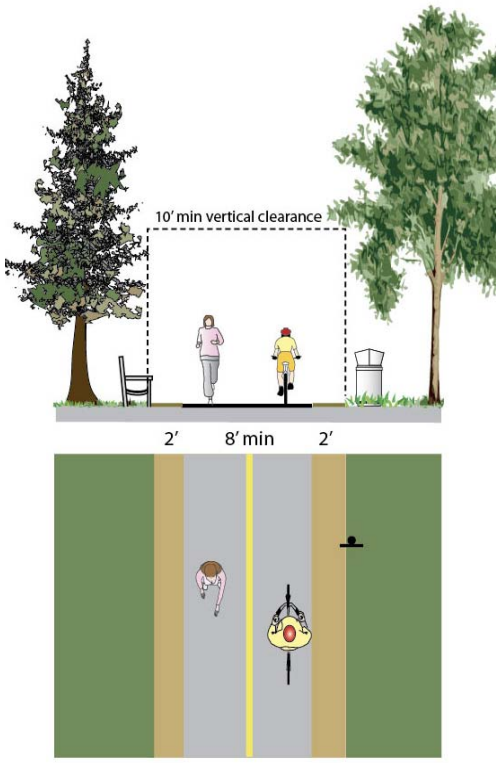
Paving

Hard, all-weather pavement surfaces are usually preferred over those of crushed aggregate, sand, clay or stabilized earth (AASHTO).

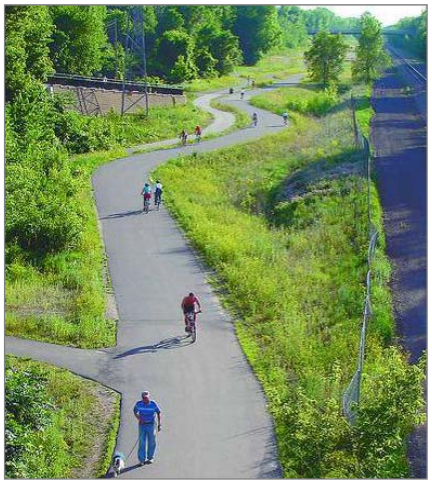
Guidance

- Caltrans Highway Design Manual Chapter 1000
- U.S. Access Board, Public Rights-of-Way Accessibility Guidelines (PROWAG).
- FHWA. Designing Sidewalks and Trails for Access.
- AASHTO Guide for the Development of Bicycle Facilities.

Design Example



Recommended bike path design.



The Cedar Lake Regional Trail in Minneapolis, MN has sufficient width to accommodate a variety of users.

Managing Multiple Users on Bike Paths

Discussion

On paths that have high bicycle and pedestrian use, conflicts can arise between faster-moving bicyclists and slower bicyclists, as well as pedestrians and other users. As this is a common problem in more urban areas, a variety of treatments have been designed to alleviate congestion and minimize conflicts.

Centerline Striping and Separation

On paths of standards widths, striping the centerline identifies which side of the path users should be on.

Physical Separation

Differing surfaces suitable to each user group foster visual separation and clarity of where each user group should be. When path corridors are constrained, the approach is often to locate the two different path surfaces side by side with no separation.

The pedestrian path should be separated from the bike path if possible. Otherwise, physical separation should be provided in the form of a small hump or other crossable barrier.

The bicycle path should be located on whichever side of the path will result in the fewest number of anticipated pedestrian crossings. For example, the bike path should not be placed adjacent to large numbers of destinations.

Bike Path Etiquette Signage

Informing path users of acceptable path etiquette is a common issue when multiple user types are anticipated. Yielding the right-of-way is a courtesy and yet a necessary part of a safe path experience involving multiple path users. Path right-of-way information should be posted at path access points and along the path. The message must be clear and easy to understand. Where appropriate, trail etiquette systems should instruct trail users to the yielding of cyclists to pedestrians and equestrians and the yielding of pedestrians to equestrians.

Design Summary

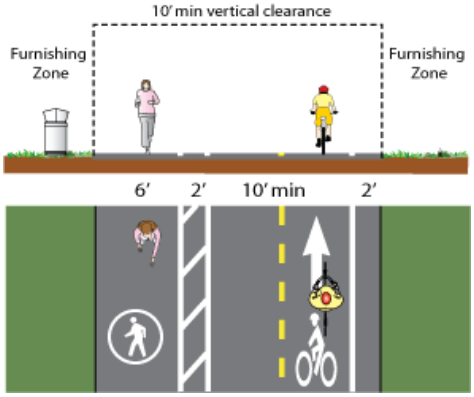
- Barrier separation – vegetated buffers or barriers, elevation changes, walls, fences, railings and bollards.
- Distance separation – differing surfaces.
- User behavior guidance signage.

Guidance

- The 2010 CA-MUTCD contains additional information about centerline striping on a path.

Design Example

Centerline striping and directional arrows encourage path users to provide space for other users to pass.



Recommended design for a separated bike path.

A commonly used bike path etiquette sign.

Path/Roadway Crossings

Discussion

While at-grade crossings create a potentially high level of conflict between path users and motorists, well-designed crossings have not historically posed a safety problem for path users. This is evidenced by the thousands of successful paths around the United States with at-grade crossings. In most cases, at-grade path crossings can be properly designed to a reasonable degree of safety and can meet existing traffic and safety standards.

Evaluation of path crossings involves analysis of vehicular and anticipated path user traffic patterns, including vehicle speeds, street width, sight distance, traffic volumes (average daily traffic and peak hour traffic), path user profile (age distribution, destinations served). Catching the attention of motorists jaded to roadway signs may require additional alerting devices such as a flashing light, roadway striping or changes in pavement texture.

An engineering study should determine whether to give pathway users or motorists the right of way at a pathway crossing. In some instances, it may be appropriate to require motorists to yield or stop for pathway users and give pathway users the right-of-way.

Design Example

An offset crossing forces pedestrians to turn and face the traffic they are about to cross.

Design Summary

At-grade path/roadway crossings generally will fit into one of four basic categories:

- Type 1: Marked/Unsignalized Unprotected crossings include path crossings of residential, collector, and sometimes major arterial streets or railroad tracks.
- Type 1+: Marked/Enhanced – Unsignalized intersections can provide additional visibility with flashing beacons and other treatments.
- Type 2: Route Users to Existing Signalized Intersection - Paths that emerge near existing intersections may be routed to these locations, provided that sufficient protection is provided at the existing intersection.
- Type 3: Signalized/Controlled - Path crossings that require signals or other control measures due to traffic volumes, speeds, and path usage.
- Type 4: Grade-separated crossings - Bridges or under-crossings provide the maximum level of safety but also generally are the most expensive and have right-of-way, maintenance, and other public safety considerations.

Guidance

- Federal Highway Administration (FHWA) Report, Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations.
- California *Highway Design Manual* Chapter 1000.
- AASHTO Guide for the Development of Bicycle Facilities.

Path/Roadway Crossings

Guidance (continued)

Summary of Path/Roadway At-Grade Crossing Recommendations[2]

	Vehicle < 9,000 ADT			Vehicle > 9,000 to 2,000 ADT			Vehicle > 12,000 to 15,000 ADT			Vehicle > 15,00 ADT		
	Speed Limit(mph)**											
Roadway Type	30	35	40	30	35	40	30	35	40	30	35	40
2 Lanes	1	1	1/1+	1	1	1/1+	1	1	1+/3	1	1/1+	1+/3
3Lanes	1	1	1/1+	1	1/1+	1/1+	1/1+	1/1+	1+/3	1/1	1+/3	1+/3
Multi-Lane (4+) w/ raised median***	1	1	1/1+	1	1/1+	1+/3	1/1+	1/1+	1+/3	1+/3	1+/3	1+/3
Multi-Lane (4 +) w/o raised median	1	1/1+	1+/3	1/1+	1/1+	1+/3	1+/3	1+/3	1+/3	1+/3	1+/3	1+/3

*General Notes: Crosswalks should not be installed at locations that could present an increased risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions), as needed, to improve the safety of the crossing. These are general recommendations; good engineering judgment should be used in individual cases for deciding which treatment to use.

For each pathway-roadway crossing, an engineering study is needed to determine the proper location. For each engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, etc. may be needed at other sites.

** Where the speed limit exceeds 40 mi/h marked crosswalks alone should not be used at unsignalized locations.

*** The raised median or crossing island must be at least 4 ft (1.2 m) wide and 6 ft (1.8 m) long to adequately serve as a refuge area for pedestrians in accordance with MUTCD and AASHTO guidelines. A two-way center turn lane is not considered a median.

1= Type 1 Crossings. Ladder-style crosswalks with appropriate signage should be used.

1/1+ = With the higher volumes and speeds, enhanced treatments should be used, including marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

1+/3 = Carefully analyze signal warrants using a combination of Warrant 2 or 5 (depending on school presence) and Equivalent Adult Unit (EAU) factoring. Make sure to project pathway usage based on future potential demand. Consider half-signals in lieu of full signals. For those intersections not meeting warrants or where engineering judgment or cost recommends against signalization, implement Type 1 enhanced crosswalk markings with marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

[2] This table is based on information contained in the U.S. Department of Transportation Federal Highway Administration Study, "Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations," February 2002.

Type 1 Path Crossings: Marked/Unsignalized

Discussion

The National MUTCD requires yield lines and "Yield Here to Pedestrians" signs at all uncontrolled crossings of a multi-lane roadway. Yield lines are not required by the CA MUTCD. The National MUTCD includes a trail crossing sign, shown to the right (W11-15 and W11-15P), which may be used where both bicyclists and pedestrians might be crossing the roadway, such as at an intersection with a shared-use path.

Currently, the crossings of the Greenway at 65th, 66th, and 67th Streets use this design.

Design Summary

Maximum traffic volumes:

- ≤9,000-12,000 Average Daily Traffic (ADT) volumes.
- Up to 15,000 ADT on two-lane roads, preferably with a median.
- Up to 12,000 ADT on four-lane roads with median.

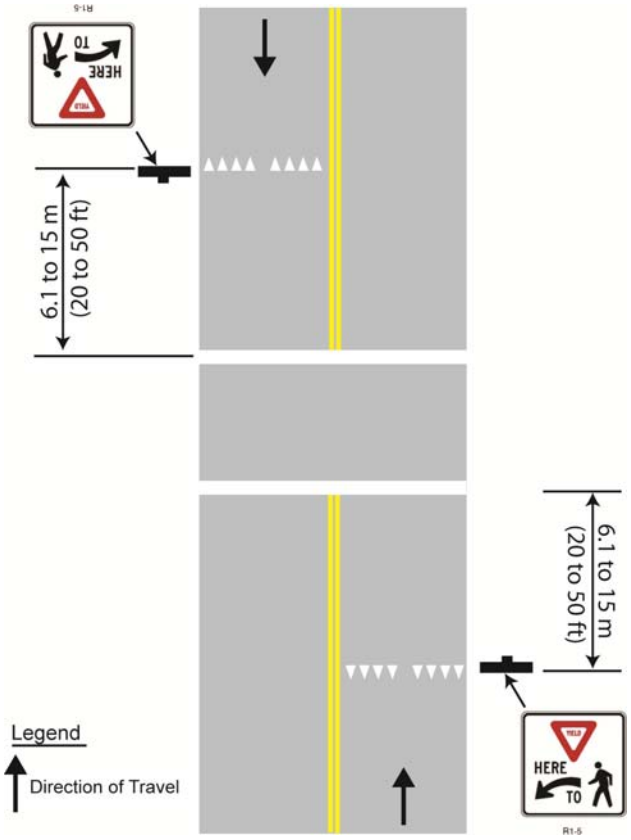
Maximum travel speed:

- 35 MPH.
- Minimum line of sight:
- 25 MPH zone: 155 feet.
- 35 MPH zone: 250 feet.
- 45 MPH zone: 360 feet.

Guidance

- California Highway Design Manual Chapter 1000
- AASHTO *Guide for the Development of Bicycle Facilities.*
- Federal Highway Administration Study, "*Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations.*"

Design Example



Recommended design from CA-MUTCD, Figure 3B-15.

Recommended signage.

Type 2 Path Crossings: Route Users to Existing Signalized Intersection

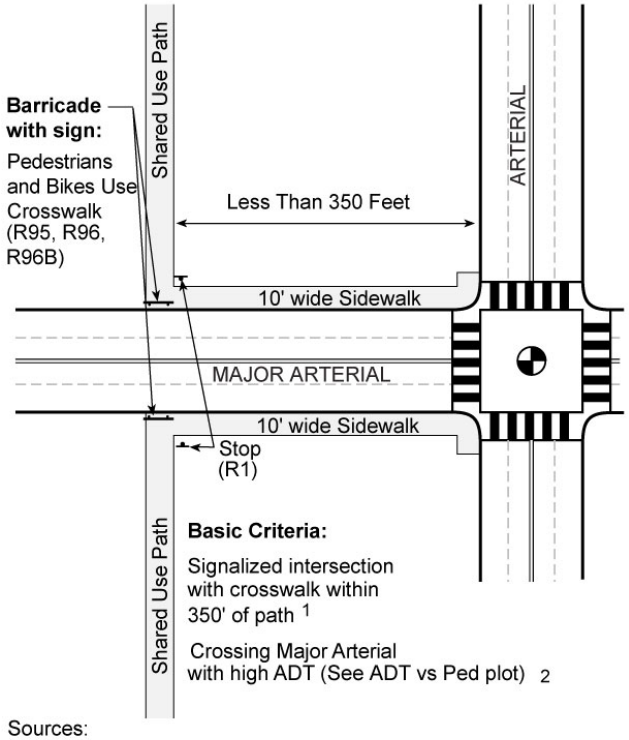
Discussion

Crossings within 350 feet of an existing signalized intersection with pedestrian crosswalks are typically diverted to the signalized intersection for safety purposes. For this option to be effective, barriers and signing may be needed to direct shared-use path users to the signalized crossings. In most cases, signal modifications would be made to add pedestrian detection and to comply with ADA.

Design Summary

- A path should cross at a signalized intersection if there is a signalized intersection within 350 feet of the path and the crossroad is crossing a major street with high average daily traffic (ADT) volumes.
- Intersection Warning (W2-1 through W2-5) signs may be used on a roadway, street, or shared-use path in advance of an intersection to indicate the presence of an intersection and the possibility of turning or entering traffic. A trail-sized stop sign (R1-1) may be placed about 5 feet before the intersection.
- Reducing the speed of the conflicting motor vehicle traffic should be considered. Options may include: transverse rumble strips approaching the trail crossing; sinusoidal speed humps[3] (compatible with slow speed snow removal operations.

Design Example



Sources:
1. California MUTCD, 2006
2. Investigation of Exposure Based Accident Areas: Crosswalks, Local Street, and Arterials, Knoblauch, 1987

Recommended at-grade crossing of a major arterial at an intersection where trail is within 350 feet of a roadway intersection

Guidance

- Caltrans *Highway Design Manual* (Chapter 1000).
- *MUTCD* – California Supplement, Part 9.
- AASHTO *Guide for the Development of Bicycle Facilities.*
- AASHTO *Policy on the Geometric Design of Highways and Streets*.
- FHWA-RD-87-038 *Investigation of Exposure-Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets, and Major Arterials.*

[3] Humps with a sinusoidal profile are similar to round-top humps but have a shallower initial rise (similar to a sine wave).

Type 3 Path Crossings: Signalized/Controlled Crossings

Discussion

Warrants from the MUTCD combined with sound engineering judgment should be considered when determining the type of traffic control device to be installed at path-roadway intersections. Traffic signals for path-roadway intersections are appropriate under certain circumstances. The MUTCD lists 11 warrants for traffic signals, and although path crossings are not addressed, bicycle traffic on the path may be functionally classified as vehicular traffic and the warrants applied accordingly.

Pedestrian volumes can also be used for warrants.

Experimental Treatment

A Toucan crossing (derived from: "two can cross") is used in higher traffic areas where pedestrians and bicyclists are crossing together.

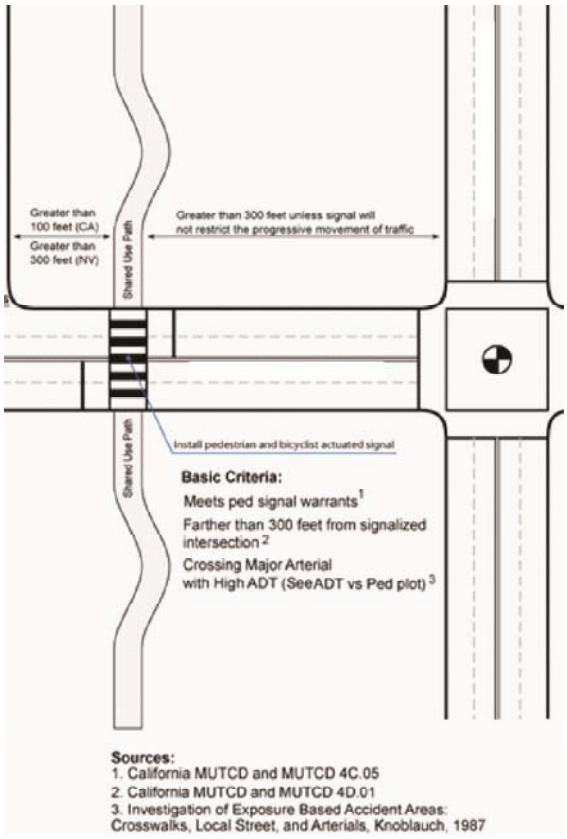
Design Summary

- Section 4C.05 in the CAMUTCD describes pedestrian volume minimum requirements (referred to as warrants) for a mid-block pedestrian-actuated signal.
- Stop lines at midblock signalized locations should be placed at least 40' in advance of the nearest signal indication.

Guidance

- MUTCD, Sections 4C.05 and 4D
- MUTCD – California Supplement, Chapters 3 and 9 and Section 4C.05 and 4D
- AASHTO Guide for the Development of Bicycle Facilities, Chapter 2

Design Example



CA-MUTCD guidance for a signalized mid-block crossing.

Toucan Crossing (This experimental treatment has not been approved for use in California).

Bicycle and Pedestrian Overcrossing Design

Discussion

Overcrossings require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an undercrossing. This results in potentially greater elevation differences and much longer ramps for bicycles and pedestrians to negotiate.

See following page for additional discussion.

Design Summary

Width

8 feet minimum, 14 feet preferred. If overcrossing has any scenic vistas additional width should be provided to allow for stopped path users. A separate 5 foot pedestrian area may be provided for facilities with high bicycle and pedestrian use.

Height

10 feet headroom on overcrossing; clearance below will vary depending on feature being crossed.

Signage & Striping

The overcrossing should have a centerline stripe even if the rest of the path does not have one.

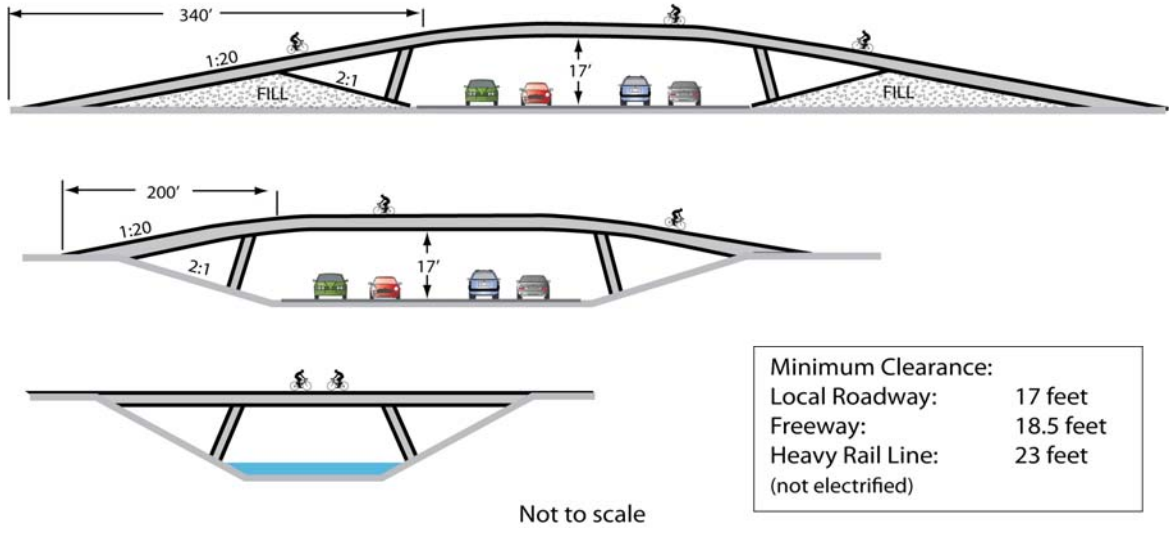
ADA Compliance

Either ramp slopes to 5% (1:20) with landings at 400 foot intervals or ramp slopes of 8.33% (1:12) with landings every 30 feet.

Guidance

- Caltrans Highway Design Manual (Chapters 200 & 1000)
- Caltrans Bridge Design Specifications
- MUTCD – California Supplement
- AASHTO Guide for the Development of Bicycle Facilities
- AASHTO Guide Specifications for Design of Pedestrian Bridges

Design Example



Additional Discussion – Grade Separated Overcrossing

Ramp Considerations:

Overcrossings for bicycles and pedestrians typically fall under the Americans with Disabilities Act (ADA), which strictly limits ramp slopes to 5% (1:20) with landings at 400 foot intervals, or 8.33% (1:12) with landings every 30 feet.

Overcrossing Use:

Overcrossings should be considered when high volumes of bicycles and pedestrians are expected along a corridor and:

- Vehicle volumes/speeds are high.
- The roadway is wide.
- An at-grade crossing is not feasible.
- Crossing is needed over a grade-separated facility such as a freeway or rail line.

Advantages of Grade Separated Overcrossing

- Improves bicycle and pedestrian safety while reducing delay for all users.
- Eliminates barriers to bicyclists and pedestrians.

Disadvantages / Potential Hazards

- If crossing is not convenient or does not serve a direct connection it may not be well utilized.
- Overcrossings require at least 17 feet of clearance to the roadway below involving up to 400 feet or greater of approach ramps at each end. Long ramps can sometimes be difficult for the disabled.
- Potential issues with vandalism, maintenance.
- High cost.

On-Street Bikeway Wayfinding Signage

Discussion

Wayfinding signs should be used in addition to white regulatory signs such as "Bike Lane" signs and yellow warning signs. Guide or wayfinding signs are generally green per the MUTCD-CA guidance, although purple is widely used in the Bay Area, and is the color recommended for continued use in Emeryville. Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the pedestrian and bicycle network
- Helping users identify the best routes to destinations.
- Helping to address misperceptions about time and distance.
- Helping overcome a "barrier to entry" for infrequent cyclists or pedestrians (e.g., "interested but concerned" cyclists).

Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Additional recommended guidelines include:

- **Place the closest destination to each sign in the top slot**. Destinations that are further away can be placed in slots two and three. This allows the nearest destination to 'fall off' the sign and subsequent destinations to move up the sign as the bicyclist approaches.
- **Use pavement markings to help reinforce routes and directional signage**. Markings, such as bicycle boulevard symbols, may be used in addition to or in place of directional signs along bike routes. Pavement markings can help cyclists navigate difficult turns and provide route reinforcement.

Design Summary

Destinations for on-street signage can include:

- On-street bikeways
- Commercial centers
- Parks and paths
- Public transit sites
- Civic/community destinations
- Hospitals
- Schools

Recommended uses for on-street signage include:

- **Confirmation signs** confirm that a cyclist is on a designated bikeway. Confirmation signs can include destinations and their associated distances, but not directional arrows.
- **Turn signs** indicate where a bikeway turns from one street onto another street. Turn signs are located on the near-side of intersections.
- **Decision signs** mark the junction of two or more bikeways. Decision signs are located on the near-side of intersections. They can include destinations and their associated directional arrows, but not distances.

Design Example

D11-1

D1-1b (L)

D1-1b (R)

D1-1c

Wayfinding signage from the MUTCD

Wayfinding that includes distance and time can aid cyclists in routefinding.

Guidance

- City of Oakland. (2009). Design Guidelines for Bicycle Wayfinding Signage.
- City of Portland (2002). Bicycle Network Signing Project.

Bicycle Parking General Guidelines

Design Summary

- Short-term parking accommodates visitors, customers, messengers and others expected to depart within two hours; requires approved standard rack, appropriate location and placement, and weather protection.
- Long-term parking accommodates employees, students, residents, commuters, and others expected to park more than two hours. This parking is to be provided in a secure, weather-protected manner and location.

Discussion

Design Issue	Recommended Guidance
Minimum Rack Height	To increase visibility to pedestrians, racks should have a minimum height of 33 inches or be indicated or cordoned off by visible markers.
Signing	Where bicycle parking areas are not directly visible and obvious from the right-of-way, signs at least 12 inches square should direct them to the facility. The sign should include the name, phone number, and location of the person in charge of the facility, at a garage or a school.
Lighting	Lighting of not less than one foot-candle illumination at ground level should be provided in all bicycle parking areas.
Frequency of Racks on Streets	In popular retail areas, two or more racks should be installed on each side of each block. This does not eliminate the inclusion of requests from the public which do not fall in these areas. Areas officially designated or used as bicycle routes may warrant the consideration of more racks.
Location and Access	Access to facilities should be convenient; where access is by sidewalk or walkway, ADA-compliant curb ramps should be provided where appropriate. Parking facilities intended for employees should be located near the employee entrance, and those for customers or visitors near main public entrances. (Convenience should be balanced against the need for security if the employee entrance is not in a well traveled area). Bicycle parking should be clustered in lots not to exceed 16 spaces each. Large expanses of bicycle parking make it easier for thieves to be undetected.
Locations within Buildings	Provide bike racks within 50 feet of the entrance. Where a security guard is present, provide racks behind or within view of a security guard. The location should be outside the normal flow of pedestrian traffic.
Locations near Transit Stops	To prevent bicyclists from locking bikes to bus stop poles - which can create access problems for transit users, particularly those who are disabled - racks should be placed in close proximity to transit stops where there is a demand for short-term bike parking.
Retrofit Program	In established locations, such as schools, employment centers, and shopping areas, the City should conduct bicycle audits to assess bicycle parking availability and access, and add additional bicycle racks where necessary.

Guidance

- See Emeryville Ordinance No. 08-009 (Article 68) related to bicycle parking.
- AASHTO Guide for the Development of Bicycle Facilities.
- Caltrans *Highway Design Manual (*Chapter 1000).
- *MUTCD* - California Supplement.

Bike Racks

Discussion

Bicycle racks should be a design that is intuitive and easy to use.

A standard inverted-U style rack is recommended for San Mateo County.

Bicycle racks should be securely anchored to a surface or structure.

The rack element (part of the rack that supports the bicycle) should keep the bicycle upright by supporting the frame in two places without the bicycle frame touching the rack. The rack should allow one or both wheels to be secured.

Avoid use of multiple-capacity "wave" style racks. Users commonly misunderstand how to correctly park at wave racks, placing their bikes parallel to the rack and limiting capacity to 1 or 2 bikes.

Position racks so there is enough room between parked bicycles. Racks should be situated on 36" recommended centers (15" is the current minimum, or narrower if the space is wedge-shaped).

A five-foot aisle for bicycle maneuvering should be provided and maintained beside or between each row of bicycle racks.

Empty racks should not pose a tripping hazard for visually impaired pedestrians. Position racks out of the walkway's clear zone.

For sidewalks with heavy pedestrian traffic, at least seven feet of unobstructed right-of-way is required.

Racks should be located close to a main building entrance, in a lighted, high-visibility area protected from the elements.

Design Summary

Emeryville Ordinance No. 08-009 requires that a "bicycle parking space" be a "paved. Level, drained, lighted area for the parking of one bicycle, having a minimum width of 15 inches, a minimum length of six feet, and a minimum overhead clearance of seven feet, with access to a right of way without use of stairs.

Bicycle Parking Manufactures:

- Palmer: www.bikeparking.com
- Park-a-Bike: www.parkabike.com
- Dero: www.dero.com
- Creative Pipe: www.creativepipe.com
- Cycle Safe: www.cyclesafe.com

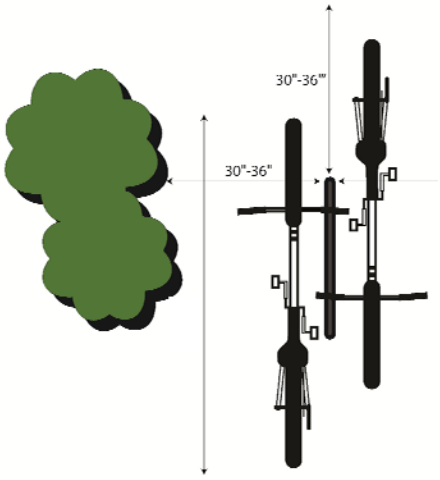
Guidance

- Association of Bicycle and Pedestrian Professionals Bicycle Parking Guidelines (2nd edition 2010)
- City of Oakland, CA Bicycle Parking Ordinance (2008)

Design Example

Standard bicycle 'staple' rack.

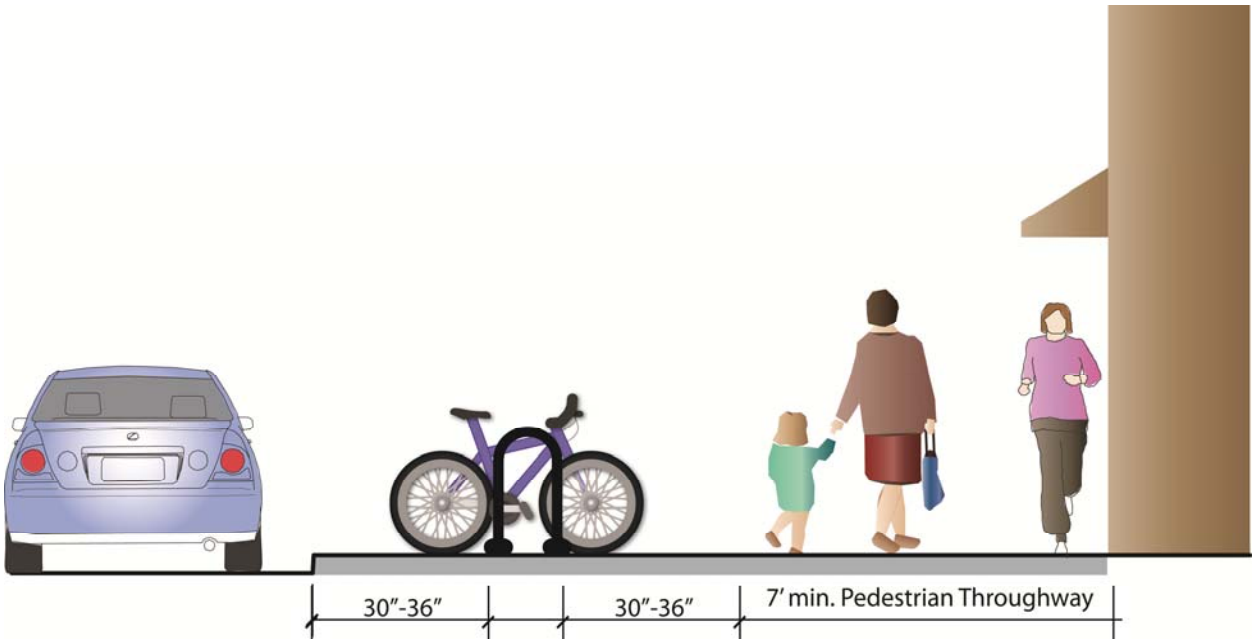
Art racks can be an attractive way of marketing the bicycle parking.



Recommended spacing for racks..

Bike Racks

Guidance (continued)



Staple rack parking configuration.

On-Street Bike Corrals

Discussion

Bicycle corrals (also known as "on-street" bicycle parking) consist of bicycle racks grouped together in a common area within the public right-of-way traditionally used for automobile parking. Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking.

Bicycle corrals move bicycles off the sidewalks, leaving more space for pedestrians, sidewalk café tables, etc. Because bicycle parking does not block sightlines (as large motor vehicles do), it may be possible to locate bicycle parking in 'no-parking' zones near intersections and crosswalks.

Bicycle corrals can be considered instead of bicycle parking on the sidewalk where:

- High pedestrian activity or narrow sidewalk width limits available space for sidewalk bike racks.
- There is a moderate to high demand for short-term bicycle parking.
- The business community is interested in sponsoring the bicycle corral.

In many communities, the installation of bicycle corrals is driven by requests from adjacent businesses, and is not a City-driven initiative. In such cases, the City does not remove motor vehicle parking unless it is explicitly requested. In other areas, the City provides the facility and business associations take responsibility for the maintenance of the facility, including sweeping. Communities can establish maintenance agreements with the requesting business.

The bicycle corral can be visually enhanced through the use of attractive planters and vegetation to act as buffers from the motor vehicle parking area as well as the use of creative demarcation elements to separate the corral for motor vehicle traffic.

Design Example

On-street bicycle parking may be installed at intersection corners or at mid-block locations.

A variety of barriers have been used to delineate on-street parking, from flexible bollards to paint.

Design Summary

- Can be used with parallel or angled automobile parking.
- Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces.
- Protect bicycles from motor vehicles with physical barriers such as curbs, bollards, or fences or through the application of other unique surface treatments as needed.
- Establish maintenance responsibility when facility is built, particularly regarding street sweeping.
- Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.
- Bicyclists should be able to access the corral from both the sidewalk and the roadway.
- Bicyclists should have an entrance width from the roadway of 5' – 6'.

Guidance

- Association of Bicycle and Pedestrian Professionals (APBP) Bicycle Parking Guide 2nd Edition

Bike Lockers

Discussion

Although bicycle lockers may be more expensive than bike racks to install, they can make the difference for commuters who are deciding whether or not to cycle. Bicycle lockers are large metal or plastic stand-alone boxes and offer the highest level of bicycle parking security available.

Some lockers allow access to two users - a partition separating the two bicycles can help ensure users feel their bike is secure. Lockers can also be stacked, reducing the footprint of the area, although that makes them more difficult to use.

Security requirements may require that locker contents be visible. Providing visibility into the locker also reduces unintended uses, such as use as homeless shelters, trash receptacles, or storage areas. Requiring that users procure a key or code to use the locker also reduces these unintended uses.

Design Example

Bike lockers at a transit station.

Traditionally, bicycle lockers have been available on a sign-up basis, whereby cyclists are given a key or a code to access a particular locker. Computerized on-demand systems allow users to check for available lockers or sign up online. Models from eLocker and CycleSafe allow keyless access to the locker with the use of a SmartCard or cell phone. With an internet connection, centralized computerized administration allows the transit agency to monitor and respond to demand for one-time use as well as reserved lockers.

Lockers available for one-time use have the advantage of serving multiple users a week. Monthly rentals, by contrast, ensure renters that their own personal locker will always be available. Bicycle lockers are most appropriate:

- Where demand is generally oriented towards long-term parking.
- At park-and-rides to help encourage multi-modal travel.
- Medium-high density employment and commercial areas and schools and colleges.
- Where additional security is required and other forms of covered storage are not possible.

Design Summary

- Place in close proximity to building entrances, or on the first level of a parking garage.
- Provide door locking mechanisms and systems.
- A flat, level site is needed; concrete surfaces preferred.
- Enclosure must be rigid.
- Transparent panels are available on some models to allow surveillance of locker contents.
- Integrated solar panels have been added to certain models for recharging electric bicycles.
- Minimum dimensions: width (opening) 2.5′; height 6′; depth 4′.
- Stackable models can double bicycle parking capacity.
- Wedge-shaped lockers are space-efficient where there is access from both sides.

Bicycle Compounds/Cages

Discussion

Bicycle compounds are fully enclosed, stand-alone bicycle parking structures. Compounds should not only have a locked gate but should also allow for the frame and both wheels to be locked to a rail, as other users also have access to the enclosure. Bicycle compounds are recommended for employment or residential bicycle parking areas, or for all-day parking at transit centers, workplaces and schools. They can be located at street level or in parking garages.

Bicycle Secure Parking Areas (SPAs) are a new concept implemented for TriMet (Portland, Oregon's transit agency). They provide high capacity, secure parking areas for 80-100 bicycles at light rail and bus transit centres. The Bicycle SPAs are semi-enclosed covered areas that are accessed by key cards and monitored by security cameras. The increased security measures provide an additional transportation option for those who may not be comfortable leaving their bicycle in an outdoor transit station exposed to weather and the threats of vandalism. They also include amenities that make the Bicycle SPA more attractive and inviting for users such as benches, bicycle repair stations, bicycle tube and maintenance item vending machines, as well as hitching posts which allow people to leave their locks at the SPA.

Design Example

Secure Parking Area (SPA) in Portland, OR use both inverted 'U' and racks that stack bicycles.

Design Summary

- See guidelines for bicycle rack placement and clear zones.
- A cage of 18' by 18' can accommodate up to 20 bicycles and uses the space of approximately two automobile parking spots.
- Improve surveillance through public lighting and video cameras.
- Bicycle compounds shall have an exterior structure consisting of metal mesh from floor to ceiling.
- In an attended parking facility, locate within 100' of an attendant or security guard or must be visible by other users of the parking facility.
- Entry doors must be steel and at least 2.5' in width, with "tamper proof" hinges. A window may be provided in the door to provide permanent visual access.
- Accommodate a maximum of 40 bicycles, or 120 if the room is compartmentalized with expanded metal mesh with lockable industrial-grade doors into enclosures containing a maximum of 40 bicycles.

Bicycle Rooms

Discussion

Bicycle rooms are locked rooms or cages which are accessible only to cyclists, and which may contain bicycle racks to provide extra security against theft. Bicycle rooms are used where there is a moderate to high demand for parking, and where cyclist who would use the bicycle parking are from a defined group, such as a group of employees. Bicycle rooms are also popular for apartment buildings, particularly smaller ones in which residents are familiar with one another.

The bicycle parking facilities shall be no further from the elevators or entrances than the closest motor vehicle parking space, and no more than 150' from an elevator or building entrance. Buildings with more than one entrance should consider providing bicycle parking close to each entrance, and particularly near entrances that are accessible through the bicycle network. Whenever possible, bicycle parking facilities should allow 24-hour secure access.

Dedicated bicycle-only secure access points shall be provided through the use of security cards, non-duplicable keys, or passcode access. The downside is that bicyclists must have a key or know a code prior to using the parking facilities, which is a barrier to incidental use.

Design Example

Bike rooms can be provided in office or apartment buildings.

Design Summary

- See guidelines for bicycle rack placement and clear zones.
- Improve surveillance through public lighting and video cameras.
- Walls should be solid and opaque from floor to ceiling.
- Install a panic button so as to provide a direct line of security in the event of an emergency.
- If the room is intended to store a large number of bicycles (more than 40 or so), it can be compartmentalized with metal mesh with lockable industrial-grade doors that form smaller enclosures, which reduces the number of people who have access to the room.

Bike Stations

Discussion

Bike depots generally refer to full-service parking facilities typically located at major transit locations that offer secure bicycle parking and other amenities. There is no universally accepted terminology to describe different types of full-service bicycle parking facilities.

The company BikeStation™, which runs several parking facilities in California and Washington, offers free parking during business hours and key-card access after-hours for members. Paying members enjoy a number of services. Services, which differ by location, may include bicycle repairs, bicycle rentals, sales and accessories, restrooms, changing rooms and showers, and access to vehicle-sharing. They can also incorporate restaurants or other services.

Design Summary

- While each depot is unique, they often provide:
  - Attended or restricted-access parking spots
  - Bicycle rentals
  - Access to public transportation
  - Commute trip-planning information

Design Example

Bike depot in Washington.

The downtown Berkeley BikeStation allows 24-hour access.

Design Review and Implementation Checklist

The purpose of a Design Review and Implementation Checklist is to ensure that bicycle needs are being considered in the planning, design, and construction of all transportation projects and new land use development. Also known as "Routine Accommodation" guidelines, these checklists can be used to ensure projects foster bicyclist safety and provide access in all roadways. Routine accommodation policies are included as part of the federal surface transportation act (SAFETEA-LU). Additionally, Caltrans Deputy Directive 64 (DD64-R1) requires the accommodation of bicyclists in all projects. In June 2006, the Metropolitan Transportation Commission (MTC) adopted regional policies to accommodate bicyclists through the Resolution No. 3765, which promotes the routine accommodation of all non-motorized travelers.

Documenting how well a project meets the City's goals to accommodate bicyclists within the transportation network is a valuable process, particularly in applying to future funding applications. The following section includes a resource to adequately consider bicycles as part of the project and land use planning process.

Design Summary for Bicyclist Accommodations

Streets

- Design "complete streets" which accommodate all bicyclists, paying special attention to vulnerable populations like children and older adults.
- Provide a continuous network of designated bikeways with appropriate facilities depending on the bicyclist demand and surrounding land uses.
- Provide bicyclist amenities, including bicycle parking and wayfinding signs where appropriate.

Uncontrolled Intersections

- Incorporate dashed lines or coloration to enhance crossings
- Consider using medians and/or traffic calming on residential streets or along bicycle boulevards

Controlled Intersections

- Provide bicycle-actuated signal detection and sufficient signal timing to accommodate bicyclists
- Design compact intersections with tight curb radii
- Place bike lanes on the right-hand side of a right turn lane
- Consider the use of bike boxes to increase the visibility of cyclists

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Appendix C. Bicycle Boulevard Treatments

Emeryville Pedestrian and Bicycle Plan

May 2012

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Introduction and Background

Bicycle boulevards are generally defined as low-volume, low-speed streets that have been optimized for bicycle travel using treatments such as traffic calming and traffic reduction, signage and pavement markings, and intersection crossing treatments. These treatments allow through-movements for bicyclists while discouraging similar through-trips by nonlocal motorized traffic. Jurisdictions throughout the country use a wide variety of strategies to determine where specific treatments are applied.

The City of Emeryville considers Bicycle Boulevards as one of the basic street "typologies" of the city's circulation system as set forth in the Circulation Element of the General Plan. Under Section 3.2 Circulation System, Bicycle Boulevards are defined as follows:

> *These are through-routes for bicycles providing continuous access and connections to the local and regional bicycle route network. Through-motor vehicle traffic is discouraged. High volumes of motor vehicle traffic are also discouraged, but may be allowed in localized areas where necessary to accommodate adjacent land uses. Local automobile, truck, and transit traffic are accommodated in the roadway, but if there are conflicts, bicycles have priority. Traffic calming techniques to slow and discourage through-automobile and truck traffic may be appropriate. Pedestrians are accommodated with ample sidewalks on both sides of the road.*

Emeryville has a partially developed bicycle boulevard network, with the main existing north-south route following Horton Street / Overland Avenue between 40th Street and 65th Street. Other existing bicycle boulevard segments include 59th Street between Horton and Doyle, and Doyle Street north of 59th Street. Proposed segments recommended for inclusion in the *Pedestrian and Bicycle Master Plan* include Stanford Avenue, Doyle Street south of 59th Street, and 45th, 47th, and 53rd Streets.

In late 2009, the Bicycle and Pedestrian Advisory Subcommittee (BPAC) forwarded a recommendation to the Transportation Committee to adopt specific vehicle speed and volume "metrics" for Emeryville's bicycle boulevard network. These would serve as thresholds that, if exceeded, would trigger traffic calming improvements in order to reduce the vehicular speeds and /or volumes. The BPAC recommended 3,000 average daily trips (ADT) and 25 mph as metrics. The recommendations of the BPAC were considered at the November 2009 Transportation Committee meeting and at the December 15, 2009 City Council meeting. Neither the Transportation Committee nor the City Council chose to take any action to approve the metrics, but instead directed staff to conduct further study of the issue.

This memorandum is intended to provide guidance to the City regarding the adoption of metrics for bicycle boulevards. It provides a summary of current bicycle boulevard standards and best practices drawn from published guidelines and case studies of other communities. Based on this summary, the memorandum then presents recommended speed, volume, and intersection delay goals for Emeryville's bicycle boulevards. Finally, it describes how closely the City's existing and proposed bicycle boulevards meet these goals, and provides recommendations for improving the City's bicycle boulevards to meet these goals. After review by the BPAC and further discussion with the City, the resulting recommendations provided here will be incorporated into the City's Pedestrian and Bicycle Plan.

1. Bicycle Boulevard Standards and Best Practices

Bicycle boulevards have been implemented in several cities throughout the country, and while no federal guidelines exist, several best practices have emerged for their development. This section summarizes standards and best practices for the development of bicycle boulevards, drawn from published materials and interviews with agency staff working to implement bicycle boulevards in communities throughout North America.

People Contacted

The following city staff were interviewed about bicycle boulevard practices and policies. Case studies from these interviews are described in the following section.

- Nathan Wilkes, Engineer, City of Austin, Texas
- Eric Anderson, Associate Planner, City of Berkeley, California
- Rafael Rius, Transportation Engineer, City of Palo Alto, California
- Roger Geller, Bicycle Coordinator, City of Portland, Oregon
- Scott Batson, Engineer, City of Portland, Oregon
- Sam Woods, Bike, Pedestrian and Neighborhood Program and Project Development Manager, City of Seattle, Washington
- Luke Korpi, Senior Civil Engineer and Neighborhood Traffic Operations Supervisor, City of Seattle, Washington
- Mike Anderson, Civil Engineer, City of Vancouver, British Columbia

Key Published Materials

The following published materials were reviewed. An annotated bibliography is provided as an appendix.

- *Guide for the Development of Bicycle Facilities.* American Association of Highway Transportation Officials (AASHTO) National Cooperative Highway Research Program, Project #15-37 (2010 proposed update).
- *Bicycle Boulevard Planning and Design Handbook.* Alta Planning + Design and Initiative for Bicycle Pedestrian Innovation. (2009).
- *BikeSafe: Bicycle Countermeasure Selection System.* U.S. Department of Transportation Federal Highway Administration (FHWA). (No date).
- *Bicycle Boulevard Design Tools and Guidelines.* City of Berkeley. (2000).
- *Policy Guidelines: "Bicycle Boulevards".* City of Napa. (2005).
- *Portland Neighborhood Greenways-Goals.* City of Portland. (2010).
- *Traffic Calming: State of the Practice.* Ewing, Reid. (1999).
- *Responding to the Challenges of Bicycle Crossings at Offset Intersections. Third Urban Street Symposium.* Hendrix, Michael. (2007).
- *Neighborhood Traffic Calming: Seattle's Traffic Circle Program.* Road Management & Engineering Journal. (1998).
- *U.S. Traffic Calming Manual.* American Planners Association (APA). (2009).

1.1. Case Studies

This section summarizes information gathered through interviews with staff at cities that have implemented bicycle boulevards. Eight staff in six communities were interviewed, representing the majority of jurisdictions currently implementing bicycle boulevard treatments.

Albuquerque, New Mexico

In 2007, the City of Albuquerque adopted a resolution for the development of bicycle boulevards. The resolution establishes the conversion of local streets to create bicycle boulevards, stating that the City will use "a package of traffic tools that transform a residential street into a 'bike expressway' that also accommodates local motor traffic." Since 2007, the City has begun implementing three bicycle boulevards by adding distinctive pavement markings and signs (Figure 1).

Street Selection

The resolution formally designates three bicycle boulevards in the city and dedicates funding to the planning and development of the boulevards. These streets were selected in conjunction with bicycle advocates.

Intersection Treatments

Albuquerque's resolution specifies that removing stop signs from the boulevard (turning onto cross-streets) and stopping traffic approaching from intersecting streets are acceptable bicycle boulevard treatments. It also allows the installation of bicycle-actuated signals or mid-block crossings at intersections with major streets. None of these treatments have been implemented at this time. Phase II of implementation will likely include turning stop signs to control minor cross streets.

Figure 1. Bicycle boulevards in Albuquerque incorporate distinctive bicycle pavement markings.

Speed Control Measures

The resolution allows removal of barriers and detours to through-bicycling, as well as other speed/volume control measures. Albuquerque signs all bicycle boulevards at an 18 mph speed limit, a treatment unique to the city. The City has not monitored the extent to which motorists comply with the speed limit, nor whether the bicyclists perceive an improved environment.

Albuquerque has a Neighborhood Traffic Management Program, which establishes that speed humps can be used where a local residential street carries more than 500 vehicles per day (vpd) traveling more than five mph over the speed limit. This program can be used to manage vehicle speeds on bicycle boulevards.

Volume Control Measures

The City defines a local residential street as having a cut-through problem if it carries more than 1,500 vpd with more than 30 percent cutting through from one major street to another. The City's bicycle boulevard resolution allows installing bike permeable street closures and mandatory turns that admit bicycles through the closure. However, the diverters that were installed have since been removed due to traffic safety concerns with the design.

- Additional information: http://www.cabq.gov/bike/documents/fsr-07-268.doc

Austin, Texas

Austin is currently developing a dual corridor bicycle boulevard on Rio Grande and Nueces Streets in the downtown area, which is scheduled for completion in spring 2011.

Street Selection

The dual corridor approach was developed from an intensive public input process and streets were selected based on public input, connections to schools, traffic impacts, motor vehicle safety, bicycle and pedestrian mobility and safety, first response routes, and motor-vehicle travel time. On Nueces Street, colored bike lanes, shared lane markings, and placemaking features will identify the street as a bicycle boulevard and enhance safety for bicyclists.

Intersection Treatments

Rio Grande Street is being developed first. The Rio Grande bicycle boulevard project incorporates four "landscaped modern roundabouts," shown in **Error! Reference source not found.**. This design would require bicyclists to take the lane to travel through the roundabout, which works best when traffic speeds are close to bicyclist speed.

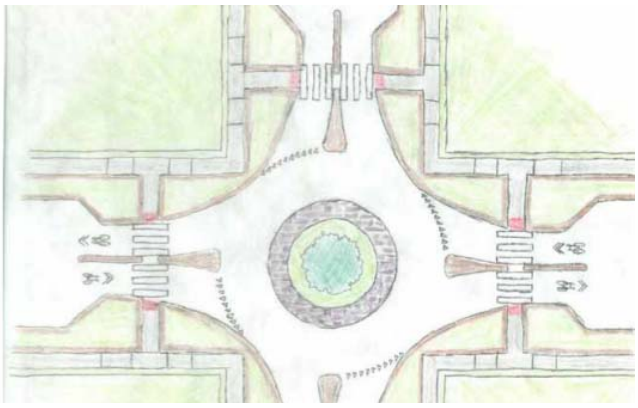


Figure 2. Landscaped modern roundabout design for downtown Austin bicycle boulevard
Source: http://www.ci.austin.tx.us/publicworks/downloads/bike_blvd_update_9_8_10.pdf

Most intersections along Nueces Street currently have four-way stops, and the proposal will remove two stop signs at each intersection. The stop signs will be "woven" so that every other pair faces the bicycle boulevard.

Speed Control Measures

The City plans to track before- and after- motor vehicle speeds, although no specific thresholds for implementing additional treatments have been set. The speed limit on Rio Grande will be reduced from 30 mph to 25 mph, and further reductions may be considered based on impacts of the traffic calming treatments. In general, traffic calming in Austin is a challenge, as the streets are not in a grid network except in the downtown area, and traffic calming treatments are limited on collector streets.

Volume Control Measures

Rio Grande Street currently has between 3,000 to 3,500 vpd and runs through a historic commercial district. No diversion is being considered at this time.

- Additional information:
  - http://www.ci.austin.tx.us/publicworks/downloads/bike_blvd_update_9_8_10.pdf
  - http://www.ci.austin.tx.us/publicworks/downloads/phase_2_downtown_bicycle_boulevard_recommendation_final_report.pdf
- Contact: Annick Beaudet, Bicycle Coordinator; Nathan Wilkes, Engineer

Berkeley, California

The City of Berkeley has been developing bicycle boulevards since the Bicycle Plan was adopted in 1999. Seven bicycle boulevards are currently designated. The City is using a phased approach for developing the bicycle boulevard network. After a trial, Phase I involved installing pavement markings and signs along all designated streets. Phase II will improve arterial street crossings. Berkeley's Bicycle Boulevard Design Tools and Guidelines (2000) provides an overview of strategies used to develop bicycle boulevards, including issues addressed, typical application, implementation guidelines, design suggestions, and cost.

Street Selection

Many of the treatments used on bicycle boulevards in Berkeley were implemented as part of the Traffic Calming Program in the 1970's; bicycle boulevard alignments were chosen in part due to the presence of traffic calming. Criteria used to select streets to implement bicycle boulevard treatments on include:

- Local street or low-volume collector
- Not a transit or truck route
- Very little commercial frontage
- Within a quarter-mile of a major street or a high-traffic collector street
- Spaced between three-quarters and 1.5 miles from another bicycle boulevard (approximately the traditional spacing of major streets)
- Reasonably continuous (i.e., extends over half of the cross-section of the city)
- Few jogs with main segments at least a half-mile long
- Traffic signals at major intersections, or traffic signals are potentially feasible
- Access to major destinations
- Connections to routes in neighboring cities

Intersection Treatments

Improving crossings of arterial streets is a secondary priority for the development of bicycle boulevards in Berkeley. A contraflow bicycle lane is provided in one location to facilitate continuous bicycle travel where the corridor turns onto a one-way street. Most arterial crossings do not have specific improvements to facilitate bicycle travel.

Speed Control

Berkeley does not have a proactive program to control speeds on bicycle boulevards. The Berkeley Traffic Calming Program provides warrants for traffic calming treatments, but the process is request-based and does not apply to the development of bicycle boulevards. Bulb-outs, speed humps, and traffic circles are the primary speed control treatments used on bicycle boulevards in Berkeley. Chicanes are also used on Milvia Street.

Figure 3. Chicanes narrow travel lanes to reduce motor vehicle speeds in Berkeley.

Volume Control

Berkeley's 1990 Bicycle Master Plan cited 3,000 vpd as a threshold for a Class III bicycle route, over which a street should be considered for Class II bicycle lanes. However, the City does not designate a threshold for automobile

speeds or volumes on bicycle boulevards, as design and treatments should be sensitive to the context of the roadway. The highest volume of vehicles on a bicycle boulevard in Berkeley is approximately 1,600 vpd.[1] Volume control treatments used in Berkeley include diagonal diverters, right-turn diverters, and full diverters. As noted earlier, these treatments were installed prior to the bicycle boulevards development.

- Additional information: http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6560
- Contact: Eric Anderson, Planner

Palo Alto, California

The bicycle boulevard constructed on Bryant Street in Palo Alto in 1982 is generally considered the first bicycle boulevard in the country.

Street Selection

Palo Alto has developed bicycle boulevards on streets with existing traffic calming, pedestrian bridges and full or partial closures. The City generally considers the following features when identifying a potential bicycle boulevard:

- Low traffic volumes
- Not attractive for non-local motor vehicle traffic
- Free flow travel for bikes or reasonable ability to create right-of-way for bicycle traffic at intersections (i.e. reversing or creating two-way stop control for the crossing streets)
- Traffic control at major streets to assist crossing bicycle traffic
- Continuous streets with few jogs, and segments of a half-mile or longer

The Palo Alto BIKESAFE case study indicated that the City's goals for Bryant Street included reducing motor vehicle volumes and car-bike conflicts. The existing pedestrian-only crossing was upgraded to accommodate the anticipated levels of bicyclists, and additional improvements included two bicycle-permeable street closures, turning of most stop signs to control cross-traffic. A 1982 study found that motor vehicle volumes remained consistently less than 1,000 vpd along the corridor, despite the City having turned the stop signs to control cross-traffic, facilitating through-traffic for both drivers as well as bicyclists on the street.

Intersection Treatments

The City Bicycle Transportation Plan (2003) notes a desire to reduce the number of stop signs to minimize bicyclist delay on bicycle boulevards. On newly developed bicycle boulevards, Palo Alto is considering turning additional stop signs to control cross-traffic while facilitating free-flow movement on the bicycle boulevard and potentially converting some four-way stop-controlled intersections to two-way (controlling cross-traffic).

Speed Control

The City intends to measure speeds to track whether they increase when stop signs are turned to favor the bicycle boulevard. If speeds increase over 32 mph, the City would consider installation of speed humps, as right-of-way is generally insufficient to accommodate traffic circles. Bulb-outs will be used at intersections where pedestrian activity is high, particularly where the bicycle boulevard travels through a business district.

[1] The only exception is on Milvia Street. A bike lane is provided through the higher-volume section to provide a continuous route.

Palo Alto has specific warrants for implementation of traffic calming:[2] a neighborhood group requests the treatment, and City engineers work with the community to determine if the location is appropriate, based on a checklist of factors. Traffic calming along a bicycle boulevard is justified if it is also a designated school route and has an 85th percentile speed exceeding 32 mph. Speed humps and traffic circles are the City's most commonly used traffic calming devices. The Traffic Calming Program states that an increase of up to 25 percent of existing volume on an adjacent local street is considered acceptable on most streets.[3] However, the resulting total traffic volume on an adjacent local street must not exceed 2,500 vpd. The City would remove traffic calming treatments if they cause unacceptable delays to emergency services or other unintended results as determined by City staff.

Figure 4. A partial closure on the Bryant bicycle boulevard requires drivers to turn right while allowing bicyclists to continue straight across the cross-street.

Volume Control

Both of the principal bicycle boulevards in Palo Alto include partial diverters (Figure 4). The City is currently developing a bicycle boulevard on a street with one full closure and one partial, with bicycle and pedestrian pass-throughs on both.

- Additional information: Neighborhood Traffic Calming Program http://www.cityofpaloalto.org/knowzone/city_projects/transportation/traffic_calming.asp
- Contact: Rafael Rius, Transportation Project Engineer

Portland, Oregon

In fall 2010, the City of Portland re-branded the bicycle boulevards as "neighborhood greenways" to emphasize the benefits for pedestrians, stormwater management, and neighborhood livability. The neighborhood greenway program reaches out to inexperienced bicyclists and people who prefer to ride on quiet, local streets. Portland has an extensive toolbox of treatments and designs for use along city bikeways.[4] Treatments are selected based on traffic flow, engineering judgment, and interest of the neighborhood in traffic calming or diversion.

In December 2010, the City of Portland developed a set of draft goals for neighborhood greenways agreed upon by the City's bicycle planning staff, traffic calming staff, and City engineers. The draft goals include maximizing safety for bicyclists and pedestrians, minimizing delay for bicyclists, and minimizing negative impacts of changes to bicyclists and neighbors.

[2] Available online at: http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=6666
[3] Based on the Traffic Infusion on Residential Environments (TIRE) index, which shows that most residents do not notice an increase of 25 percent.
[4] City of Portland. (2010). Bikeway Facility Design: Survey of Best Practices. ftp://ftp02.portlandoregon.gov/PBOT/Bicycle_Plan_for_2030/Plan_Documents/Supplemental_Documents/Supplement_Appendix_D.pdf

Street Selection

The bicycle boulevard draft goals document defines project goals and performance measures for development of individual bicycle boulevards, allowing the City to track whether the design is successful at accomplishing the identified goals. Fifteen neighborhood greenway projects are currently under development, and the City has a goal of developing 15 miles of greenways per year for five years. Portland has defined specific goals and measures of success for each neighborhood greenway based on the existing conditions.

Intersection Treatments

Portland staff recognize that crossing safety at high-volume intersections is one of the keys to a successful neighborhood greenway, and the bulk of the funding for greenway projects is spent on intersection treatments. The City has used center left turn lanes, left turn pockets, short bike lanes, and a cycle track[5] to aid offset crossings. While no specific warrant exists for treatment selection, the City considers the classification of the cross street, as well as treatments recommended by National Cooperative Highway Research Program (NCHRP) Report 562, *Improving Pedestrian Safely at Unsignalized Crossings.* In addition, the City has been moving toward treatments that focus the crossing on one location, such as a two-way cycle track (Figure 5).

Figure 5. A cycle track is provided to assist with an offset crossing of a higher-order street.

Portland has used a High-Intensity Activated Crosswalk (HAWK) signal at one intersection of a bicycle boulevard at a larger street. The City has been in regular communication with the Federal Highway Administration (FHWA) regarding the signal, as well as the Cities for Cycling effort to advance the design. The City also has several pedestrian signals, which are now disallowed by the *Manual on Uniform Traffic Control Devices* (MUTCD). In general, the City prefers pedestrian signals and HAWKS over a standard signal with a diverter because standard signals always require a bicyclist to wait for the signal phase. A bicyclist is not required to activate and wait for a pedestrian signal if gaps in traffic allow the bicyclist to cross without the aid of the signal.

Speed Control Measures

One of Portland's newly established goals for bicycle boulevards is to reduce 85th percentile speeds below 25 mph (preferably 20 mph). Previously, the City required that any traffic calming be suggested and approved by residents. With the new bicycle boulevard goals, the City is the catalyst for traffic calming on bicycle boulevards, and residential approval is not required, though it is encouraged.

Figure 6. Portland has used pinch-points to narrow streets for automobiles. Source: Greg Raisman

Portland has implemented a pinchpoint design that was drawn from European designs (Figure 6). The treatment consists of

[5] A cycle track is a bicycle-only facility that is physically separated from motor vehicle and pedestrian traffic. They can be bike lanes on the inside of automobile parking, or a lane that is separated from the vehicle travel lanes with a raised curb or buffer. See the Cities for Cycling *Urban Bikeway Design Guide* (2011) for additional detail. http://nacto.org/cities-for-cycling/design-guide/cycle-tracks/

two choker islands that narrow the travel lane to a point where only one vehicle can pass at a time. The chokers are designed to allow bicyclists to pass them on the outside. The City considers it a good concept, although the first implementation was too close to an intersection and not restrictive enough (it is 16-feet curb-to-curb, which allows automobiles to pass each other).

Volume Control Measures

For any given project, the goal is to maintain volumes under 1,000 vpd and to not increase vehicular traffic over the existing conditions. Prior to the newly-established goals, the only defined threshold was that over 3,000 vpd, a City bikeway should be striped with bike lanes, while lower volumes were acceptable as a shared street (based on the 1996 Bicycle Master Plan).

However, the 1,000 vpd goal is not always possible on bicycle boulevards. Southeast Clinton Street bicycle boulevard has volumes around 2,000 to 2,400 vpd. Traffic calming along the street keeps speeds relatively low and the City is implementing the Clinton Street Bike Boulevard Enhancement Project to add distinctive signs and pavement markings to improve the visibility of the boulevard (Figure 7). The City recognizes that not all bicyclists feel comfortable riding on that roadway and targets improvements to achieve the 1,000 vpd threshold on other projects.

The City will consider traffic diversion to meet vehicle volume goals if community support exists and if treatments would not affect bus traffic. Where diversion is not possible, the City looks to solutions that add friction or force vehicles to queue in order to pass. Along short segments where neither of these is an option, the City considers a separated facility, such as a cycle track, to provide bicycle access past the difficult area.

- Additional information: http://www.neighborhoodgreenway.com/
- http://www.portlandonline.com/Transportation/index.cfm?c=50518
- Contacts: Roger Geller, Bicycle Program; Scott Batson, PE

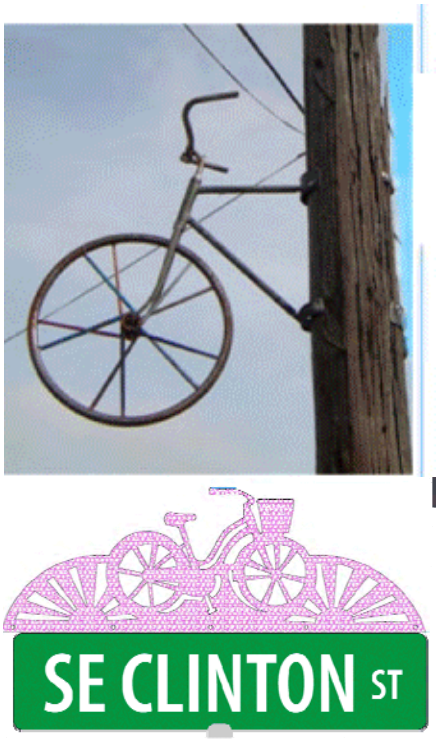


Figure 7. Design elements to improve the visibility of the Southeast Clinton Street bicycle boulevard.
Source: City of Portland

Seattle, Washington

Seattle's Traffic Calming Program pioneered mini-traffic circle devices in the 1980's and has since developed specific metrics for implementation of traffic calming treatments. The City is considering using the neighborhood greenway terminology used in Portland, incorporating green elements, storm water treatments, and pedestrian treatments in order to emphasize the benefits to users in addition to bicyclists.

Street Selection

Seattle has only recently begun planning bicycle boulevards; the 2007 bicycle master plan identified several potential locations for bicycle boulevards, but did not recommend specific designs or treatments. Several community-driven efforts are currently underway. The planned 2012 update to the Bicycle Master Plan will more clearly define neighborhood greenways.

Most of the city's bicycle boulevards were selected in part because of the presence of existing traffic calming treatments. The City is now focusing efforts on improving crossings of arterials. Arterial crossing improvements will primarily use 'bicycle signals', which allow bicyclist through-movements but require that drivers turn onto the arterial street. The treatment uses signs and pavement markings rather than physical barriers and City staff reports that compliance varies. In addition, the City considers the use of medians to control vehicular movement and provide a refuge for bicycles. The City's planned approach for developing a specific bicycle boulevard depends on the project and community.

Intersection Treatments

Most intersections of non-arterial streets in Seattle are uncontrolled, particularly where traffic circles are installed. The City has not previously installed stop controls to facilitate bicycle boulevards, but may consider doing so in the future, particularly if traffic calming is provided.

Seattle has a long history of providing traffic circles at intersections of local streets; over 1,000 traffic circles were constructed in Seattle between 1973 and the present. Studies have indicated substantial crash and injury reductions, and the City will consider a traffic circle at most non-arterial intersection as a bicycle boulevard improvement.

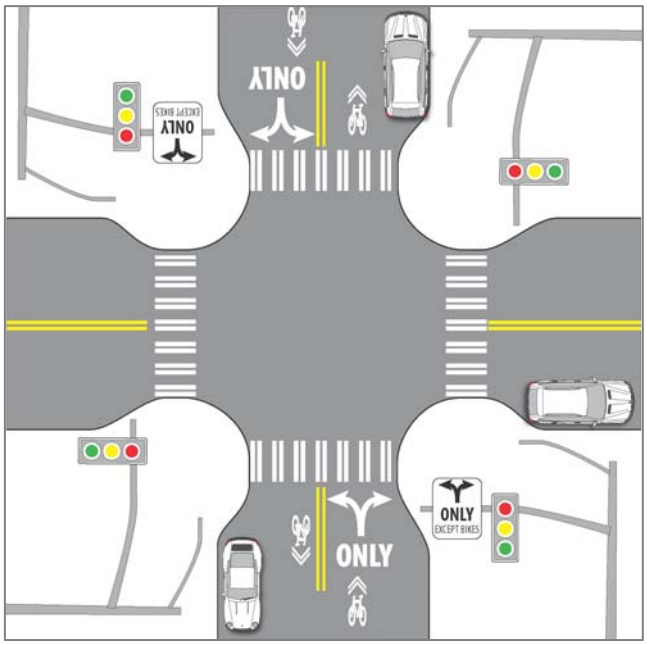


Figure 8. Example of a partial diverter signal in Seattle.

At crossings of arterial streets, Seattle has frequently used half-signals (also known as crosswalk signals), which are signals that can be actuated by bicyclists - and pedestrians as well as automobiles that control an arterial street where a non-arterial street crosses it. The City found that crash rates at half-signals are consistently equal to or lower than crash rates at full signals, and recommends installing a half-signal when traffic volumes on the cross-street are less than half of MUTCD-recommended benchmarks for a full traffic signal and when installation of a full signal might divert a substantial amount of motor vehicle traffic to the lower volume non-arterial street.

Seattle also uses signals that act as partial diverters by allowing bicyclists to travel straight through the intersection, while forcing motorists to turn either direction (Figure 8). With no physical barrier to the lower-order street, the City feels that motorist compliance with these diverters is variable. Additional police enforcement is requested as needed.

Speed Control

Seattle has not systematically looked at operational characteristics for bicycle boulevards, although the prototypical local street in Seattle carries 500 to 1,000 vpd with 85th percentile speed of 25-30 mph. The statutory speed limit is 25 mph. The City considers vehicular speeds to be a greater issue for the cycling environment than volumes. Most non-arterial streets, including designated bicycle boulevards where the 85th percentile speed is five mph over the speed limit, can be considered for traffic calming, particularly chicanes, chokers, and speed humps. Speed cushions are also used on emergency vehicle routes, and bicyclists are directed to pass between the cushions via pavement markings.

The standard for most non-arterial streets in Seattle is 25 feet wide with parking, requiring vehicles to queue to pass each other. Bicycle boulevards implemented there, and particularly on wider streets, may include corridor narrowing treatments such as chokers, or chicanes, potentially in partnership with drainage improvements such as rain gardens.

Volume Control

The City is not considering many diverters/partial closures (other than the bike signal) or closures at this time, due to the difficulty of determining impacts to adjacent streets and also planning and funding limitations.

- Seattle Bicycle Master Plan: http://www.seattle.gov/transportation/bikemaster.htm
- Additional information on traffic calming: http://www.seattle.gov/transportation/neighborhoodtraffic.htm
- Additional information at: Seattle Bike Blog, Bike boulevard coming to Wallingford http://seattlebikeblog.com/2011/01/03/bike-boulevard-coming-to-wallingford/
- Contact: Sam Woods, Bike, Pedestrian and Neighborhood Program and Project Development Manager; Luke Korpi, Senior Civil Engineer and Neighborhood Traffic Operations Supervisor

Vancouver, British Columbia

The City of Vancouver designates local street bikeways and neighborhood greenways, both of which use similar treatments to bicycle boulevards. Local street bikeways are traffic calmed to discourage through-movement of vehicles, while greenways provide bicycle, pedestrian, and green space connections within and to neighborhoods.

Street Selection

The City chooses streets to implement as local street bikeways based on streets identified in the Bike Master Plan (1999), as well as in discussions between the engineering and planning departments and the community.

Intersection Treatments

The City implemented a Stop Sign Infill Program in 2006 to assign right-of-way or traffic control to one or more approaches of all intersections to clarify user behavior.

Vancouver frequently signalizes arterial streets where they cross local street bikeways. Signal warrants for these crossings consider a five-year time horizon of pedestrian volumes. The City assumes that, within the five-year horizon, any local street bikeway will have the necessary levels of use to warrant signalization. Where intersections with larger streets are not signalized, the City limits some motor vehicle movements with median islands or with right-in/right-out splitters.

Speed Control Measures

Typical traffic calming used in Vancouver includes traffic circles and speed humps, both of which are commonly used on local street bikeways. Residents can request traffic calming through the City's Livable Neighborhood Program.

Volume Control Measures

Treatments for local street bikeways are selected to discourage movement of motor vehicles depending on existing volumes; if the existing conditions have low volumes, the City would use non-diversionary traffic calming and aim to not increase motor vehicle traffic. The City is conducting an ongoing monitoring program (using both automatic and manual counts) to anticipate motor vehicle and bicycle volumes on local street bikeways in the future.

On some of the older local street bikeways, complaints spurred the City to conduct counts that found over 3,000 vpd. The City responded by blocking some intersections, reducing average daily traffic to 1,000 vpd (Figure 9).

- Additional information: http://vancouver.ca/engsvcs/streets/greenways/neighbourhood/
- Contact: Mike Anderson, City Engineer

1.2. Summary of Best Practices Review

As demonstrated through the range of experiences and techniques used to develop bicycle boulevards in different jurisdictions, there are no strict standards or warrants for use of bicycle boulevard treatments. Commonalities that emerge among the jurisdictions include:

- Bicycle boulevards are low-speed, low-volume streets that encourage use by bicyclists.
- Distinctive signs and pavement markings are essential components of designating a bicycle boulevard.
- Most municipalities are looking into improving crossings of arterial streets and applying traffic calming and diversion techniques to improve the bicycling environment.
- Public input is a key component of identifying streets and treatments for bicycle boulevards.

However, the jurisdictions differed in terms of street selection, intersection treatments, speed control measures, and volume control measures.

Street Selection

Most municipalities identified bicycle boulevards through the City's bicycle master plan process. All municipalities considered local streets with existing traffic calming, closures, or signalized crossings of major streets. Streets that improve connectivity to key destinations, provide a direct route for bicyclists, or where residents have expressed a desire for traffic calming are also good candidates. Austin's bicycle boulevard was selected in part by connectivity to downtown and into the bicycle network, important due to the City's limited number of local through-streets. Seattle and Vancouver considered bicycle boulevard treatments in neighborhoods where residents requested traffic calming.

Figure 9. Partial closure in Vancouver, B.C.

Most bicycle boulevards are located on residential streets, although Austin, Berkeley, and Portland all have boulevards along commercial streets.

The City of Emeryville's 2010 General Plan includes bicycle boulevards as a street typology, and identifies bicycle boulevards along Horton/Overland, Doyle Street, 66th Street, 65th Street, 59th Street, 53rd Street, and 47th Street. During the development of the Pedestrian and Bicycle Master Plan, these routes were evaluated and refined.

Intersection Treatments

Major Street Crossings

Quality of treatments at major street crossings can significantly affect a bicyclist's choice to use a bicycle boulevard or not. If the delay for a bicyclist to cross a major street is considerably longer than the delay for crossing at an adjacent street, some bicyclists are less likely to use the bicycle boulevard.

Seattle and Austin have prioritized improving bicycle boulevard crossings of arterial streets when establishing a bicycle boulevard, while other jurisdictions such as Portland and Berkeley began with signs and pavement markings, and are more recently focusing on improving major street intersections. Common treatments include curb extensions, crosswalks, median islands, and signals. Treatment selection is based on engineering judgment as well as manuals, primarily the MUTCD and NCHRP Report #562 (2006). Several jurisdictions use pedestrian half-signals, which are not allowed under the MUTCD. Others use or are considering implementing HAWK signals.

Minor Street Crossings

Municipalities differ significantly on use of stop control on bicycle boulevard intersections with other local streets. CAMUTCD Section 2B.05 Stop Application specifies the places where a stop sign can be used where two streets with relatively equal traffic volumes and/or characteristics intersect. Some municipalities, including Portland and Vancouver, stop control one direction of every intersection with a minor street. Most of Seattle's minor street intersections are not stop-controlled, and if a traffic circle is installed at an intersection with stop signs, they are removed.

Many municipalities turn stop signs or remove four-way stop-controlled intersections to give right-of-way to the bicycle boulevard, reducing the delay for bicyclists on the bicycle boulevard.

Speed Control Measures

Speeds are critical to the bicycling environment because of the likelihood of injury resulting from a crash, as well as turning, passing, and other potential conflicts between motor vehicles and bicyclists.

Automobile speed has a significant impact on the likelihood a fatality will result from a crash (see Figure 10).

Roads selected for bicycle boulevards tend to have maximum motor vehicle speeds of 25 mph, although some communities such as Albuquerque are reducing speeds through traffic calming or posting reduced speed

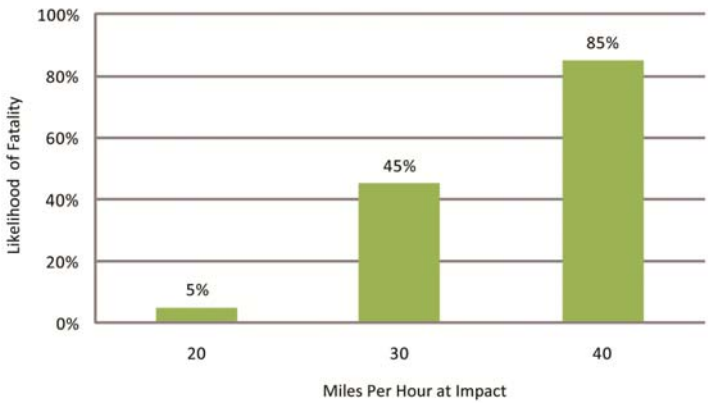


Figure 10. Likelihood of pedestrian fatality resulting from crash based on automobile speed.
Source: U.K. Department of Transport

limits. Table 1 summarizes guidance for speeds on bicycle boulevards from the communities interviewed and key resources.

In general, a speed differential between motor vehicles and bicyclists of 15 mph or less is desirable to reduce turning conflicts and the number of passing events; the San Francisco Bicycle Plan recommends re-designing a street for maximum speed of 15 mph unless volumes are low.

Table 1. Posted Speeds and Speed Thresholds

Source	Posted Speed	Speed Threshold/Goal
Albuquerque, New Mexico	18	None specified
Austin, Texas	25	85th percentile 25 mph or less
Berkeley, California	25	None specified
Palo Alto, California	25	85th percentile 32 mph or less
Portland, Oregon	25	85th percentile25 mph or less; 15-20 mph preferred
Seattle, Washington	25	85th % speeds <5mph over posted
Vancouver, British Columbia	25	None specified
AASHTO *Guide for the Development of Bicycle Facilities*	25	None specified

Volume Control Measures

Motor vehicle traffic volumes affect the comfort of a bicyclist, particularly for roadways with shared travel lanes, such as bicycle boulevards. Higher vehicle volumes are less comfortable and mean more potential conflicts. To illustrate, on a 25 mph street with 1,000 vpd, during peak hour a cyclist traveling at 12 mph would be passed by a car traveling in the same direction about every two minutes.[6] By comparison, at 3,000 vpd, a bicyclist would be passed by a car every 46 seconds, and at 5,000 vpd, a bicyclist would be passed by a car every 28 seconds.

Table 2. Traffic Volume Guidelines

Source	Volume Threshold
Albuquerque, New Mexico	500+ vpd threshold for speed humps; 1,500 for diversion
Austin, Texas	None
Berkeley, California	None
Palo Alto, California	None
Portland, Oregon	1,000 vpd goal, depends on street
Seattle, Washington	None
Vancouver, British Columbia	< 3,000 vpd
AASHTO *Guide for the Development of Bicycle Facilities*	generally < 3,000 vpd

There is a wide variation in vehicle volume goals for bicycle boulevards considered by different jurisdictions, shown in Table 2. Goals range from 1,000 to 3,000, with the majority of jurisdictions lacking a volume goal. No jurisdiction has a specific set threshold that triggers implementation of volume control treatments. Instead, the decision to implement volume control treatments is based on the context of the bicycle boulevard, and engineering judgment plays heavily in the decision.

[6] At peak hour, assuming peak hour is 10 percent of vpd, the street is two-way with traffic volumes split evenly between each direction, and cars are evenly spaced along the street .

The majority of cities interviewed have a traffic calming program that is separate from bicycle boulevard implementation programs. Portland has modified the traffic calming program to permit traffic calming to be installed on a bicycle boulevard at the City's discretion, rather than just as a response to community request.

Impacts to Neighboring Streets

Some cities consider how traffic calming and/or diversion can affect traffic on adjacent streets; in Palo Alto, an increase of up to 25 percent of existing volume (under 2,500 vpd) is generally considered acceptable.[7] The Traffic Calming Program manual estimates that traffic calming treatments such as a series of speed humps can be expected to divert 10 to 20 percent of traffic onto other routes, while full and partial street closures result in a 50 to 90 percent diversion.

Portland's Neighborhood Traffic Management Program's has defined an 'impact threshold curve' to evaluate what impacts are acceptable to neighboring streets. The City's standard impact curve is expressed in terms of total traffic volume. The parameters allow for an increase of up to 150 vpd on any street, while an increase of over 400 vpd on a local street is unacceptable, and the the resulting traffic volume on any local street should not exceed 3,000 vpd.[8]

Impacts to Emergency Response Vehicles

Jurisdictions consider traffic calming impacts to emergency vehicle routes in one or more of the following ways:

- Treatments on emergency response routes must be approved by emergency response officials. (Seattle)
- A limited set of emergency-vehicle-friendly traffic calming techniques are allowed. (Portland, Vancouver)

Examples of emergency-vehicle-friendly traffic calming techniques include 22-foot speed tables in lieu of speed humps, laterally offset speed tables (also called split humps), speed lumps (which have a gap that emergency vehicles' wheels can fit through), and other treatments.

The Palo Alto Traffic Calming Program Manual notes that emergency "vehicles are particularly susceptible to the vertical displacement of speed humps because of the weight and length of fire trucks, and the delicate instruments and patients in paramedic vans and ambulances." Emergency vehicles must reduce speeds more than a passenger car would to travel over a speed hump. The manual also states that intersection treatments have less of an impact on emergency vehicles than corridor treatments, as the vehicles already slow for intersections. Emeryville's emergency vehicle response time goals are an average of five minutes or less.[9]

It is estimated that a ladder truck may be delayed up to ten seconds at a speed hump and an ambulance may be delayed up to five seconds.[10]

[7] Based on the Traffic Infusion on Residential Environments (TIRE) index, which shows that most residents do not notice an increase of 25 percent.
[8] http://www.portlandonline.com/transportation/index.cfm?&a=85375&c=35934
[9] City of Emeryville Website. Accessed March 15, 2011. http://www.ci.emeryville.ca.us/index.aspx?NID=359
[10] Ewing, Reid. (1999). p.142 Traffic Calming: State of the Practice. http://www.ite.org/traffic/tcsop/Chapter7.pdf

Other Lessons Learned

Experience in several communities indicates that it is important to record where automobile speed measurements are taken in relation to the traffic calming or diversion treatment and replicate for before and after trials. In addition, traffic calming and diversion measures can be implemented on a trial basis to gauge residents' support prior to finalizing the design. Temporary speed humps, tables, and lumps are available, and temporary closures can be created with construction barrels or planters. However, the temporary measures can diminish residents' opinions due to unappealing design.

2. Recommended Bicycle Boulevard Policies and Treatments for Emeryville

This section recommends policies for bicycle boulevard development in Emeryville. None of the case study cities have strict policies that require specific action if bicycle boulevard goals are not met. Similarly, because of the variety of conditions and importance of context-sensitive design, Emeryville's policies are meant to serve as guidelines, rather than standards. If a bicycle boulevard goal is not met, the City should consider treatments that will allow the bicycle boulevard to meet goals, or if goals cannot be met, should consider a different type of bicycle facility.

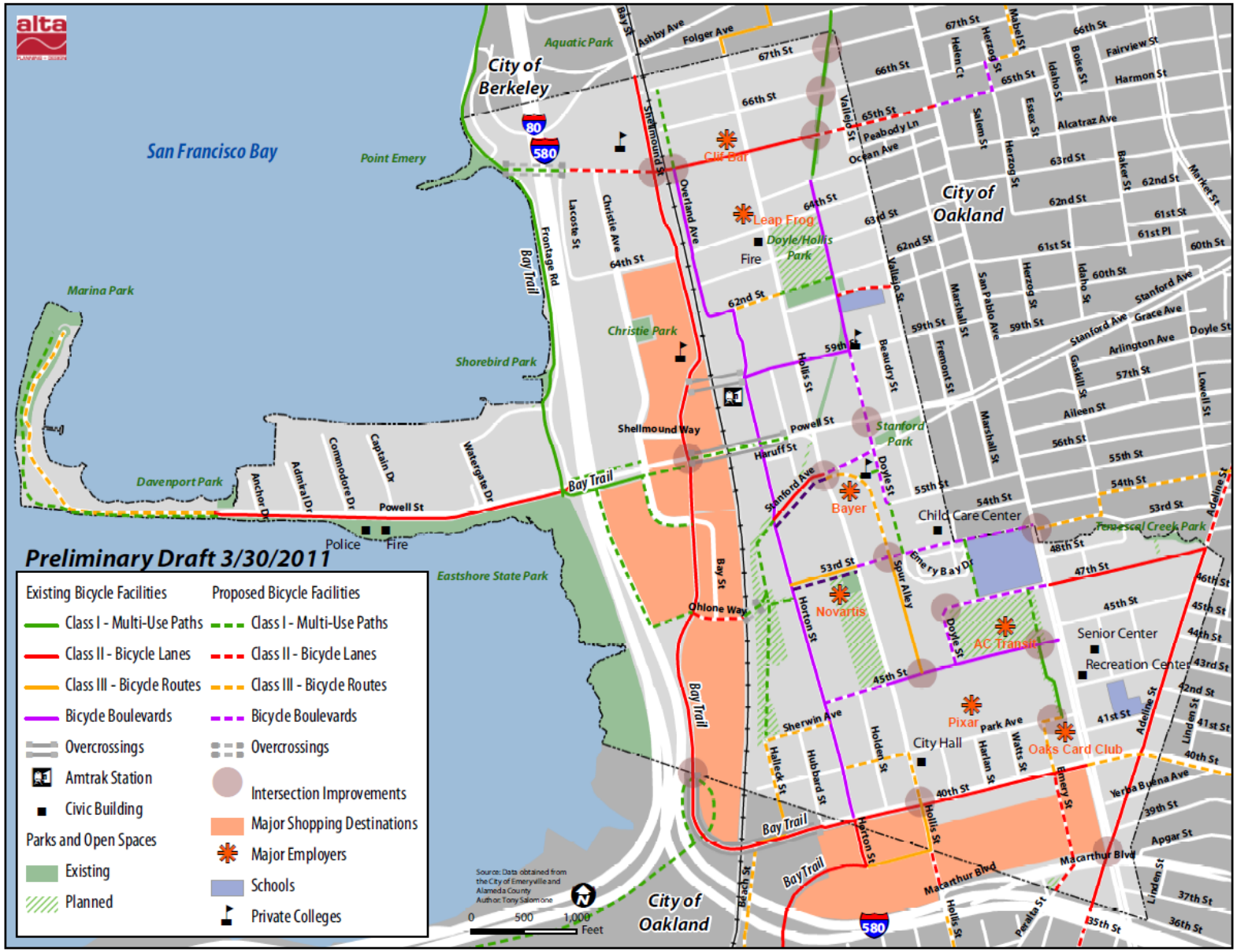
This section first identifies Emeryville's existing and proposed bicycle boulevards. It then presents three goals for bicycle boulevards addressing speeds, volumes, and intersection delay.

2.1. Street Selection

Emeryville's General Plan and the 1999 Pedestrian and Bicycle Plan identify bicycle boulevards based on existing traffic conditions and proximity to key destinations, including schools and parks. *Memorandum #4. Recommended Pedestrian and Bicycle Infrastructure Projects* further refined this list. Table 3 lists the bicycle boulevards recommended in the memorandum. Note that bicycle boulevards on 66th Street and 59th Street are not recommended for inclusion in the Pedestrian and Bicycle Master Plan. See also Map 1.

Table 3. Emeryville's Bicycle Boulevards

Street	Extents	Notes
45th Street	Horton Street to Doyle Street	Included in General Plan.
47th Street/Doyle Street	45th Street to San Pablo Avenue	New bicycle boulevard. Designated as Class II/III in General Plan.
53rd Street	Horton Street to San Pablo Avenue	Included in General Plan.
Doyle Street	Ocean Avenue to 55th Street	Included in General Plan.
Horton Street/Overland Avenue	66th Street to 40th Street	Included in General Plan.
Stanford Avenue	Horton Street to Doyle Street	Included in General Plan.
66th Street	Shellmound Street to City Limits.	Modified from General Plan. Not recommended as a bikeway in the Pedestrian and Bicycle Master Plan.
59th Street	Horton Street to Doyle Street	Modified from General Plan. Changed eastern extent from City Limits to Doyle Street.
55th Street	Doyle Street to City Limits.	Modified from General Plan. Not recommended as a bikeway in the Pedestrian and Bicycle Master Plan.



Map 1. Recommended Bikeway Network

Going forward, this list should be revisited in conjunction with future updates to the Pedestrian Bicycle Master Plan or as community feedback requires to determine whether conditions on the selected streets are still appropriate for bicycle boulevards, and to verify whether the treatment level for the street is still appropriate.

2.2. Bicycle Boulevard Goals and Metrics

This section outlines recommended bicycle boulevard goals and metrics for Emeryville based on the best practices resources surveyed. The bicycle boulevard goals address metrics for motor vehicle speeds, motor vehicle volumes, and major intersection delay, described below.

Speed Goals

Streets developed as bicycle boulevards should have posted speeds of 20 mph or less, with 85th percentile speeds at 22 mph or less. If the street has relatively high volumes (over 3,000 vpd) 85th percentile speeds should be further reduced below 22 mph where feasible.

Rationale

Higher vehicular speeds increase the frequency of automobiles passing bicyclists and increase the severity of crashes that occur. Cyclists generally travel at approximately 12 mph, and maintaining vehicular speeds at a speed closer to bicyclists' speeds greatly improves bicyclists' comfort on a street. Slower vehicular speeds also improve drivers' ability to see and react to bicyclists and minimize conflicts at driveways and other turning locations.

Motor Vehicle Volume Goals

Traffic volumes on bicycle boulevards east of Hollis Street should be below 1,500 vpd. West of Hollis Street, traffic volumes should be below 3,000. Higher volumes can be permitted for short segments with additional treatments.

Rationale

Volumes of motor vehicles determine the frequency of passing events; at 1,000 vpd cars pass a bicyclist approximately every two minutes, while at 3,000 vpd passing events occur every 46 seconds. The rate of automobiles passing a cyclist indicates the number of potential conflicts and affects the comfort of the bicycling environment.

Bicycle boulevards with volumes higher than 3,000 vpd are not recommended, although a segment of a bicycle boulevard may accommodate more traffic for a short distance if necessary to complete the corridor. Providing additional separation with a bike lane, raised bike lane, cycle track, or other treatment is recommended where traffic calming or diversion cannot reduce volumes below this threshold.

Major Intersection Goals

Minimize bicyclist delay and maximize safety at intersections and major crossings.

Rationale

Collisions and delay are the two major considerations of bicycle boulevard crossings of major streets (transit streets and connector streets). Bicycle boulevards intersect the following major streets: Hollis Street, San

Pablo Avenue, 65th Street, Powell Street, Park Avenue, 40th Street. Emeryville should develop a warrant for facilitating bicyclist crossings at major streets based on bicyclist delay, rather than bicyclist volumes.

Where there is a history of bicycle-related crashes along a bicycle boulevard, the City should determine the causes of the crashes and consider treatments to mitigate the problem. The National Cooperative Highway Research Program (NCHRP) Report # 562 *Improving Pedestrian Safety at Unsignalized Crossings* (2006) the MUTCD, and FHWA-RD-04-100 *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations* can be used to determine which treatments are appropriate to aid bicyclists crossing the major street. Treatments may include but are not limited to bicycle detection, warning signage, flashing beacons, in-pavement lights, median refuges, curb extensions, or signalization.

2.3. Monitoring

The metrics used to monitor these goals (motor vehicle speeds and volumes and bicyclist delay) should be measured regularly to determine whether additional treatments are necessary to bring the street to the target goal. For example, fifteen years of data at 45th Street and Horton Street show that traffic volumes are slowly rising. Emeryville should collect this data and evaluate each bicycle boulevard in the case of any of the following:

- Development occurs that is projected to increase motor vehicle volumes on the bicycle boulevard
- The Bicycle and Pedestrian Plan is updated
- Substantial community concern is brought to the City

2.4. Bicycle Boulevard Treatment Selection

This section identifies five levels of treatment for bicycle boulevards. The appropriate treatment level is dependent on how well the bicycle boulevard meets the above speed, volume and delay goals. If one treatment does not address out-of-compliance bicycle boulevards, the next treatment level should be used. This phased approach promotes implementation of the least amount of treatment to achieve the desired outcome. Table 4 shows the hierarchy of application levels.

The minimum standard to designate a street as a bicycle boulevard, Level 1 treatments consist of "Bicycle Boulevard" or other identification signs and pavement markings. The second level includes these items, plus wayfinding signage and treatments to major street crossings. All bicycle boulevards in Emeryville should meet Level 2 treatments at a minimum.

Traffic calming and diversion treatments (Levels 3, 4, and 5) should be implemented on bicycle boulevards as necessary when the street exceeds the target vehicular speed and volume thresholds. If an analysis shows that the bicycle boulevard does not meet the thresholds, the City should consider applications for the next treatment level.

Note that while traffic calming treatments primarily affect motor vehicle speeds, they also reduce volumes, as drivers avoid slower streets. Speed humps can lead to a 20 percent reduction in vehicular speeds, while chicanes, traffic circles, and other narrowing can reduce vehicle volumes by 10 percent.[11]

[11] Berkeley Bicycle Boulevard Design Tools and Guidelines.

Table 4 : Application of bicycle boulevard treatment levels

Treatment Level	Signs	Pavement Markings	Intersection Treatments	Traffic Calming	Traffic Diversion
Level 1 Basic Bicycle Boulevard	• identification	• shared lane markings			
Level 2 Enhanced Bicycle Boulevard	• identification • wayfinding	• shared lane markings • directional markings for bicyclists	• crossing improvements at major streets (high-visibility crosswalks, median islands, HAWK and standard signals)		
Level 3 Limited Traffic Calming	• identification • wayfinding	• shared lane markings • directional markings for bicyclists	• crossing improvements at major streets (high-visibility crosswalks, median islands, HAWK and standard signals) • improve visibility of bicyclists (forward stop bars, bicycle crosswalks)	• vertical speed control (speed humps/ cushions/ tables) • horizontal speed control (chicanes, traffic circles, curb extensions)	
Level 4 Significant Traffic Calming	• identification • wayfinding	• shared lane markings • directional markings for bicyclists	• crossing improvements at major streets (high-visibility crosswalks, median islands, HAWK and standard signals) • improve visibility of bicyclists (forward stop bars, bicycle crosswalks)	• vertical speed control (speed humps/ cushions/ tables) • horizontal speed control (chicanes, traffic circles, curb extensions) • narrowings (chokers, neckdowns, pinchpoints, center island narrowing)	
Level 5 Traffic Diversion	• identification • wayfinding	• shared lane markings • directional markings for bicyclists	• crossing improvements at major streets (high-visibility crosswalks, median islands, HAWK and standard signals) • improve visibility of bicyclists (forward stop bars, bicycle crosswalks)	• vertical speed control (speed humps/ cushions/ tables) • horizontal speed control (chicanes, traffic circles, curb extensions) • narrowings (chokers, neckdowns, pinchpoints, center island narrowing)	• full and partial closures, diagonal diverters

Level 1. Basic Bicycle Boulevard

Signs and pavement markings represent the least physically intensive treatments and should be included in all bicycle boulevard treatments. Emeryville's pavement stencils and purple bicycle boulevard signs provide a strong visual identity for the street and designate the corridor as a bicycle route. This is the minimum treatment for a street to be considered a bicycle boulevard.

Level 2. Enhanced Bicycle Boulevards

Wayfinding signs and directional pavement markings improve the experience of a bicycle boulevard and passively market the facility. Intersection treatments that reduce delay can be a major determinant of whether a bicyclist uses the bicycle boulevard rather than a parallel street. Emeryville should build all bicycle boulevards to a Level 2 minimum standard.

Level 3. Limited Traffic Calming

If speeds and volumes on a bicycle boulevard rise above the City's goals, Level 3 treatments should be implemented. Traffic calming should be considered on bicycle boulevards that have 85th percentile speeds greater than 22 mph. Limited traffic calming can also reduce volumes 10 to 20 percent.

Specific treatments depend on public input, whether the street is a transit street, vehicular speeds, and lane widths. Where on-street parking is important, minimize loss of parking by using vertical speed control where appropriate, minimizing impacts to bicycle travel where possible.

Level 4. Significant Traffic Calming

If treatments indicated in Level 3 do not reduce speeds and volumes below the City's goals, Level 4 treatments should be implemented. On bicycle boulevards east of Hollis Street where automobile speeds and volumes are identified issues, neck-downs can reduce speeds significantly, as drivers must slow and wait for one car to pass the treatment at a time. This treatment is not recommended on bicycle boulevards west of Hollis due to limited effectiveness because of low traffic volumes.

Treatments shall not significantly hinder emergency vehicle access or bus routes and the Emeryville Fire Department, AC Transit, or Emery Go-Round should be consulted in the design, as appropriate. Neck-downs shall be designed to permit a 20 foot clear access for emergency vehicles.

Level 5. Traffic Diversion

If treatments indicated in Level 4 do not reduce speeds and volumes below the City's goals, Level 5 treatments should be implemented. Where a bicycle boulevard has high traffic volumes, particularly cut-through traffic, diversion should be considered to substantially reduce volumes on the road. Diversion should only be implemented after a thorough traffic analysis and public outreach process, and traffic conditions should be evaluated after six months to determine whether neighboring streets were negatively impacted.

Alternatively, a treatment can be implemented based on engineering judgment and monitored to determine impacts to neighboring streets. Based on the *Traffic Infusion on Residential Environments* (TIRE) index, an increase of up to 25 percent of existing volume on an adjacent local street is generally acceptable.

3. Recommended Design Treatments for Emeryville's Bicycle Boulevards

This section provides existing conditions and general recommendations for Emeryville's existing and proposed bicycle boulevards, based on automobile speeds and volumes, number and location of crashes, and other factors. Table 4 summarizes existing conditions and proposed treatments for all bicycle boulevards.

All bicycle boulevards in the City need some level of treatment to be brought up to Level 2: Enhanced Bicycle Boulevard Design treatments. Sections of several bicycle boulevards are also designated as transit streets in the City's General Plan. Treatments on these streets should allow for wider travel lanes, limit horizontal traffic calming treatments, and depending on bus volumes, should consider separation of bicyclists and motor vehicles.

The primary emergency response routes used by the Emeryville Fire apparatus include the following:

- Hollis Street (entire length)
- San Pablo Avenue (entire length)
- Powell Street (from tip of peninsula to San Pablo Avenue)
- Park Avenue (Hollis Street to San Pablo Avenue)
- 40th Street (entire length, including overcrossing)
- Christie Avenue (Shellmound Street to 65th Street)
- Shellmound Way (entire length)
- Shellmound Street (Ashby/I-80 off-ramp/Aquatic Park to 40th Street)

Secondary access routes include 45th Street between Horton Street and San Pablo Avenue, 53rd Street between Horton Street and San Pablo Avenue, and Horton Street/Overland Avenue.

At this time, all of Emeryville's bicycle boulevards with vehicle volume data except Horton/Overland meet vehicle volume goals. Vehicle volumes at 45th Street, 47th Street, and Stanford Avenue, and vehicle speeds and intersection delay on all bicycle boulevards should be measured to determine if additional treatments are necessary.

More extensive treatments are required along Horton/Overland to meet the proposed bicycle boulevard goals. Section 4.1 provides detailed recommendations for Horton/Overland. Prior to installation of any diverters a traffic study will be needed to determine the effects.

Table 4. Existing Conditions of Existing and Proposed Bicycle Boulevards

Bicycle Boulevard	Existing Conditions	Recommended Treatments
45th Street Horton Street to Doyle Street	VPD: n/a Speed: n/a Major Intersections: Hollis Street (4-way stop), San Pablo Avenue (signal) Crash History: None, but San Pablo Avenue & 45th Street has 7 collisions Two-lane road with parallel parking on both sides. No bicycle facilities signed or striped. Identified as Green Street in General Plan.	• Measure speeds and traffic volumes. • Install bicycle boulevard signage and pavement markings to bring up to Level 2 Treatments. • Consider speed lumps (similar to a speed hump with a gap that allows vehicles with a wider wheel bed to pass unencumbered) if measured speeds are higher than 20 mph. • If Spur Alley bicycle route is implemented, improve crossing with high visibility crosswalks and consider raised intersection.
47th Street/Doyle Street 45th Street to San Pablo Avenue	VPD: n/a Speed: n/a Major Intersections: San Pablo Avenue (signal) Crash History: none Two-lane road with diagonal parking. No bicycle facilities signed or striped. Poorly defined roadway and access point at 47th and Doyle intersection. Identified as Green Street in General Plan.	• Measure speeds and traffic volumes. • Define 47th/Doyle intersection by articulating corner with curb, gutter and sidewalk. Reconfigure existing parking area. Maintain minimum of 20-ft street width for emergency access • Improvements on Doyle Street must consider parking needs for planned Emeryville Center for Community Life.
53rd Street Horton Street to San Pablo Avenue	VPD: Hollis Street: 1,009 Adeline Street: 515 San Pablo Ave: 880 Speed: n/a Major Intersections: Horton Street (signal), Hollis Street (signal), San Pablo Avenue (signal) Crash History: none Signed as bicycle route between Horton Street and Hollis Street. Speed bumps between Boyer Street and San Pablo Avenue. 53rd Street/ San Pablo Avenue intersection is skewed. Identified as Green Street in General Plan. Connects to planned bicycle route in Oakland. Coordinate with the Emeryville Center for Community Life (ECCL) development.	• Measure speeds. • Install bicycle boulevard signage and pavement markings to bring up to Level 2 Treatments. • Consider green street treatments such as narrowing street and removing parking to provide bioswales or to daylight Temescal creek. • At Spur Alley intersection, install high-visibility crosswalks and consider raised intersection. • At San Pablo Avenue, add bicycle pocket or narrow 53rd Street to one lane in either direction with shared lane marking. Adjust signal timing to provide enough time for bicyclists to cross San Pablo Avenue.

Table 4. Existing Conditions of Existing and Proposed Bicycle Boulevards

Bicycle Boulevard	Existing Conditions	Recommended Treatments
Doyle Street Ocean Avenue to 55th Street	VPD: 59th Street: 665 Powell Street: 504 Speed: n/a Major Intersections: Powell Street (Doyle stop-controlled) Crash History: Stanford Avenue (4-way stop) none **Between Ocean Avenue and 59th Street:** Bicycle boulevard signage and stencils installed. Traffic calming includes curb extensions and roadway narrowing. Stop signs turned to favor bicycle boulevard traffic. **Between 59th Street and 55th Street:** No signage, pavement stencils or traffic calming. Powell Street intersection difficult to cross.	• Measure speeds. • Install wayfinding signage. • Add HAWK signal or full signal at Powell Street. • Install bicycle boulevard signage and pavement markings south of 59th Street to bring up to Level 2 Treatments.
Horton Street/Overland Avenue 66th Street to 40th Street	VPD: Between the following streets: Park Ave & 40th Street: 3,177 Stanford Ave & 53rd St: 4,859 59th St & Powell St: 3,742 64th St and 65th St: 1,808 Speed: n/a Major Intersections: 65th Street (signal) 40th Street (signal) Crash History: At 59th Street: 2-3 crashes At Powell Street: 1 crash At 40th Street: 2 crashes High collision location Entire route signed as bicycle boulevard. Bicycle boulevard pavement markings north of 62nd Street and south of 53rd Street. Bike lanes striped on Horton Street from 62nd to 53rd Street. Section from 59th Street to Stanford Avenue identified as Green Street and Transit Street in General Plan.	• Measure speeds • Consider diversion at 62nd Street, Stanford Avenue, 45th Street, and 40th Street. Diversion to be installed on a temporary trial basis first, with final decision after evaluation and potential traffic analysis. • Reconfigure roadway between 62nd Street and Stanford Avenue to prevent loading/parking in bicycle lanes. Alternative 1: buffered bike lanes. Alternative 2: Remove bike lanes and create shared roadway with chicanes to reduce traffic speeds and allow for vehicle loading. Alternative 3: Remove bike lanes and provide shared roadway with parking/loading on one side. • North of 62nd Street and south of Stanford Avenue, consider speed cushions, tables, split lumps, curb extensions, median islands and permanent speed feedback signs to reduce vehicle speeds. • Improve bicycle detection at 40th Street and 65th Street. • See Section 4.1 for details
Stanford Avenue Horton Street to Doyle Street	VPD: n/a Speed: n/a Major Intersections: Hollis Street (signal) Crash History: none	• Measure speeds and volumes • Install bicycle boulevard signage to bring up to Level 2 Treatments.

Table 4. Existing Conditions of Existing and Proposed Bicycle Boulevards

Bicycle Boulevard	Existing Conditions	Recommended Treatments
	Bike lanes striped between Hollis Street and Horton Street. No bicycle boulevard signage. Bicyclists are not detected in bike lanes at Hollis Street. Section between Horton Street and Hollis Street identified as a Transit Street in General Plan.	• Extend bicycle lanes to Doyle Street. Will likely require removal of on-street parking. • Install bicycle detection in bicycle lane at Hollis Street.
59th Street Horton Street to Doyle Street	VPD: Horton Street: 467 Hollis Street: 1,374 Doyle Street: 370 Speed: n/a Major Intersections: Hollis Street (signal) Crash History: At Horton Street: 2 crashes Bicycle boulevard pavement stencils east of Hollis Street. Bicycle lanes west of Hollis Street. Diagonal parking between Hollis Street and Doyle Street. Identified as Green Street in General Plan. Section between Horton Street and Hollis Street identified as a Transit Street in General Plan.	• Measure speeds. • Install bicycle detection at Hollis Street. • Install bicycle boulevard signage to bring up to Level 2 Treatments.

3.1. Horton/Overland Treatments

The Horton/Overland bicycle boulevard provides a continuous north-south connection through most of Emeryville, and is a very important bicycle connection, providing access to the Transit Center, the future South Bayfront Bridge, and to Mandela Parkway/Bay Trail in Oakland. The entire bicycle boulevard is currently signed. Bicyclists share the road with motorists north of 62nd Street and south of 53rd Street. Bike lanes are striped between 62nd Street and 53rd Street.

Twenty-four hour traffic counts conducted in fall 2010 show that sections of the bicycle boulevard exceed the 3,000 vehicles per day goal. Within a 24-hour weekday period 3,177 motorists were counted between Park Avenue and 40th Street, 4,859 motorists were counted between Stanford Avenue and 53rd Street, and 3,742 motorists were counted between 59th Street and Powell Street. Volumes along the bicycle boulevard are expected to increase with the construction of Emery Station West. The entrance for the transit center will be located on Horton Street at 59th Street, and the entrance to the garage that will serve the facility will be located along Horton Street just south of 62nd Street.

Delivery drivers and other motorists commonly park on the bicycle lanes on Horton Street between 62nd Street and Powell Street. Bicyclists have noted that it is difficult to merge with traffic to travel around parked vehicles.

Recommended Treatments

The following treatments are recommended along the Horton/Overland bicycle boulevard. Figure 11 summarizes these treatments.

- **Consider new diverters at 62nd Street, Stanford Avenue, and 45th Street. Enhance the existing signed diversion at 40th Street.** Diverters should be implemented on a trial basis first, with final decision after evaluation. Diverters at these streets may reduce traffic volumes along much of

Horton/Overland. However, these diverters are not likely to mitigate traffic volumes associated with the development of Emery Station West. See Figures 12 through 14 for illustrations of the diverters at 62nd Street, Stanford Avenue and 45th Street. The 40th Street diversion would be enhanced by installing bollards on the north leg, preventing motorists from traveling north across 40th. The left turn lane for eastbound traffic on 40th would be replaced with a raised median with pedestrian refuge. Signs currently prohibit vehicle through traffic northbound on Horton Street. Landscaping on all diverters should be maintained and kept to a level allowing visibility of intersecting and oncoming traffic.

- **Reconfigure roadway between 62nd Street and Stanford Avenue to prevent loading/parking in bicycle lanes**. Four alternatives are presented.
    - **Alternative 1** would buffer the existing bicycle lanes with a one-foot striped buffer. The vehicle travel lanes would be reduced to 22 feet, and the centerline would be removed. This treatment is low cost. See Figure 15.
    - **Alternative** 2: Remove bike lanes and create shared roadway with chicanes to reduce traffic speeds and allow for vehicle loading. Raised chicanes would serve to reduce vehicle speeds, and provide a location for official vehicle loading. Bicyclists would ride in the travel lane with motorists. Due to the volumes of motorists on Horton Street, this alternative may not provide a comfortable bicycling environment. See Figure 16.
    - **Alternative 3**: Remove bike lanes and create shared roadway with parking/loading zone on one side. The vehicle travel lanes would be reduced to 23 feet, and the centerline would be removed. Due to the volumes of motorists on Horton Street, this alternative may not provide a comfortable bicycling environment. See Figure 17.
- **North of 62nd Street and south of Stanford Avenue, reduce vehicle speeds**, if a speed survey indicates the need. Treatments such as speed bumps or cushions and permanent speed feedback signs can reduce vehicle speeds and are relatively low-cost.
- **At Horton and 40th Street, install video detection and stripe a bicycle lane between right and left turn lanes** to allow bicyclists to continue through. This should be installed in conjunction with the bollards at 40th Street.
- **At Overland and65th Street, adjust signal phasing and install bicycle detection.** Move signage directing bicyclists to Overland Avenue further east to provide advance notice of the turn. Stencil shared lane markings in the right turn lane to indicate to motorists that bicyclists may be using the lane.

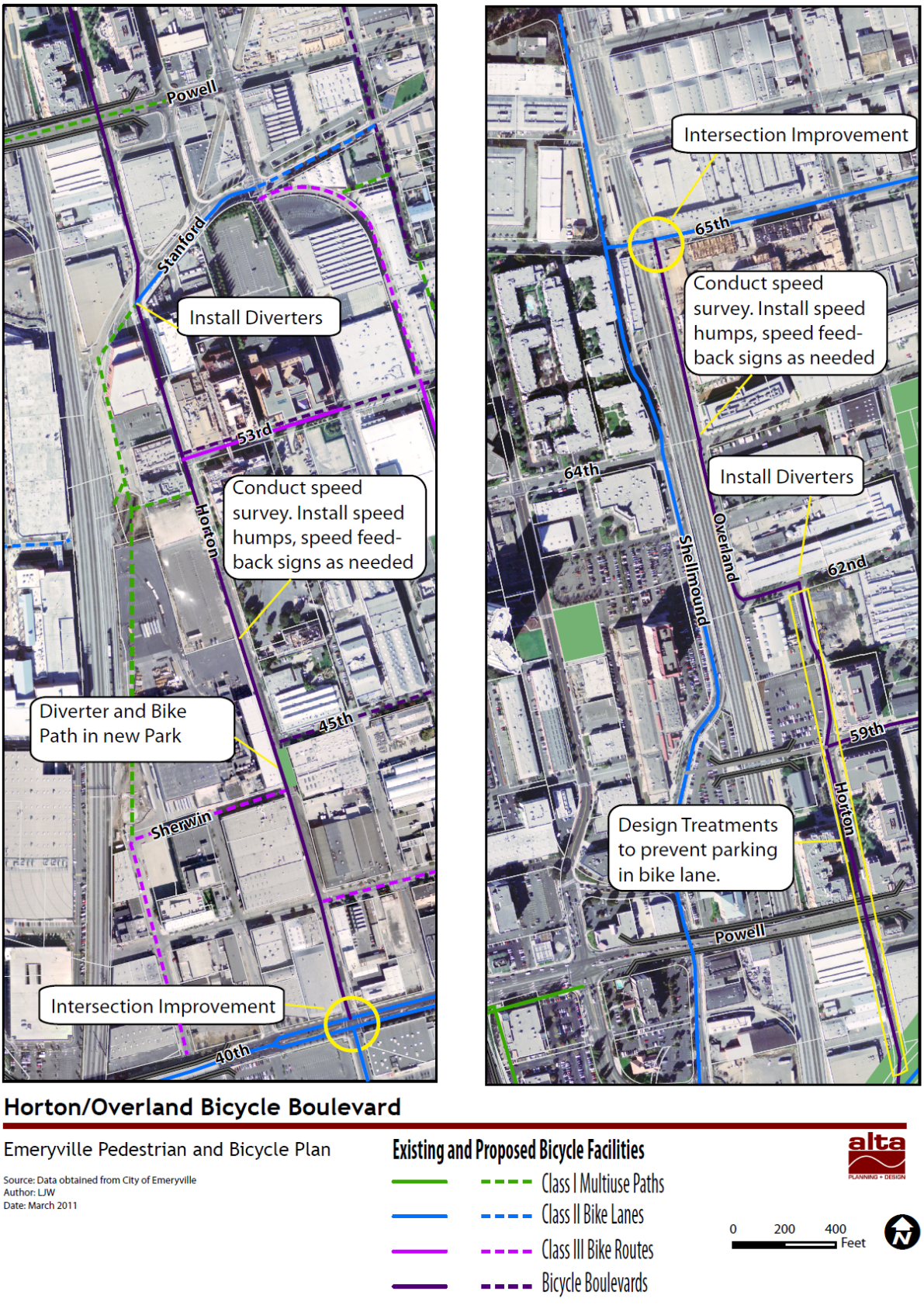


Figure 11: Recommended Treatments for Horton/Overland Bicycle Boulevard

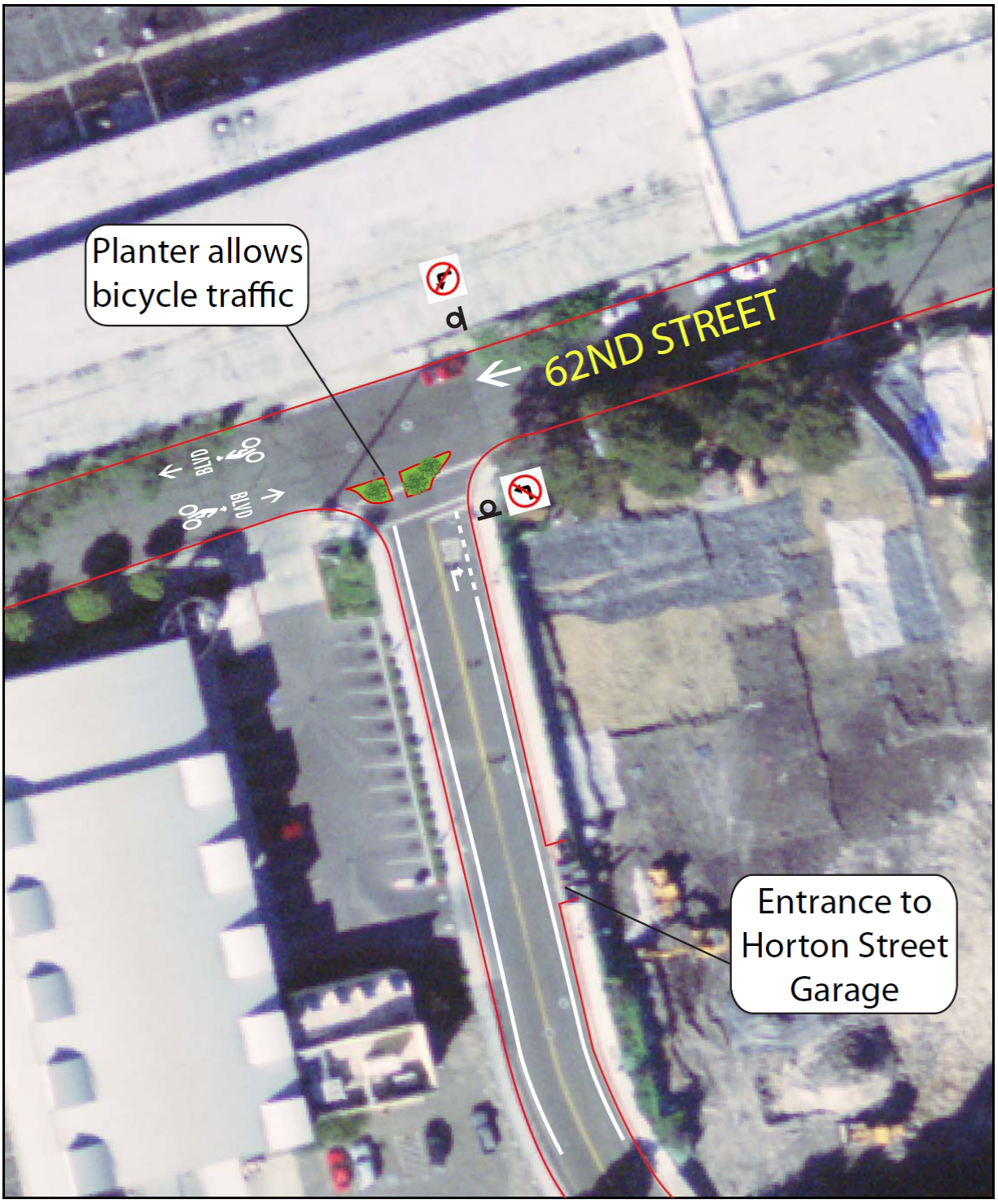


Figure 12: Diverter at Horton Street and 62nd Street

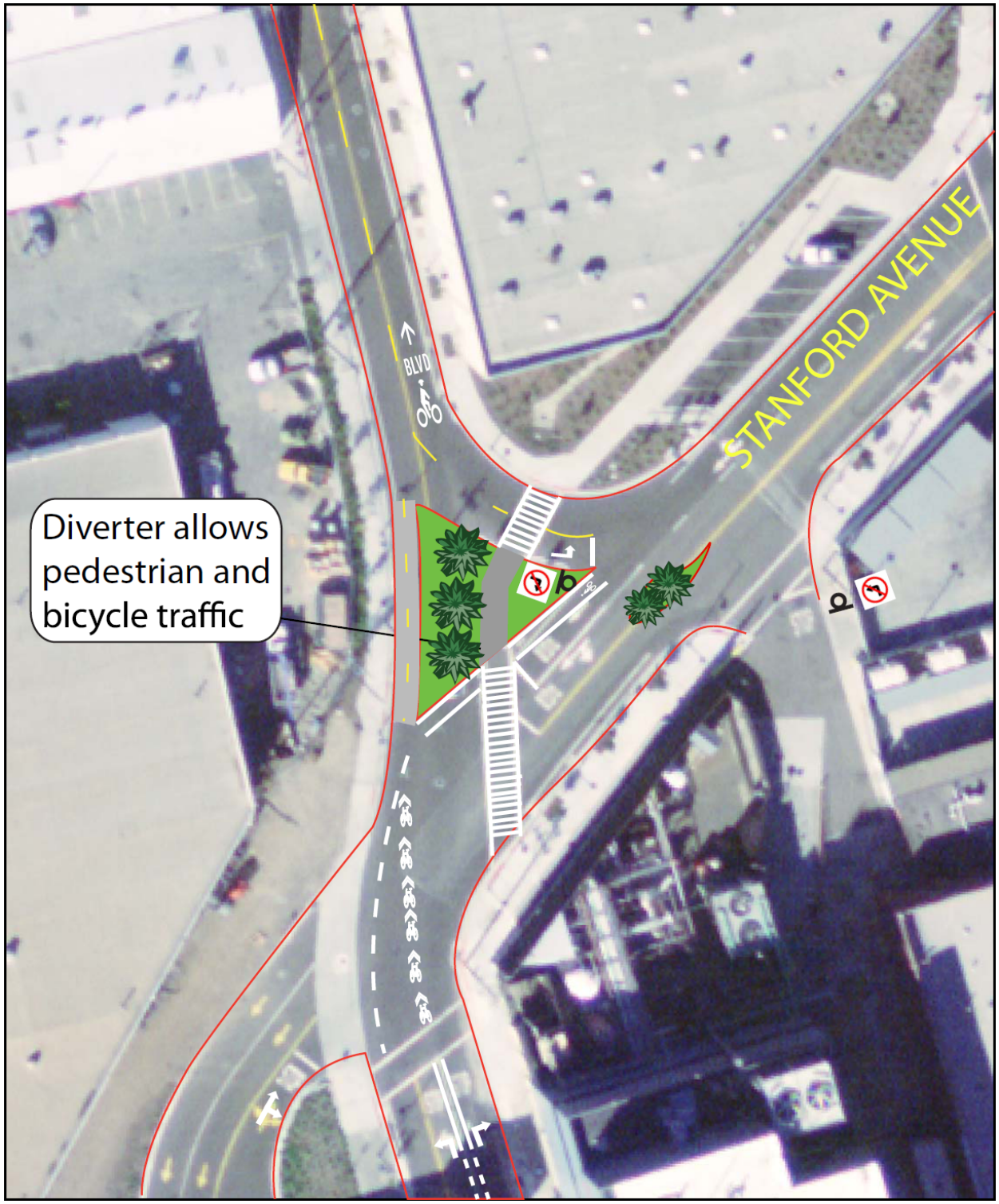


Figure 13: Diverter at Horton Street and Stanford Avenue

Figure 14: Diverter and Park at Horton Street between 45th Street and Sherwin Avenue

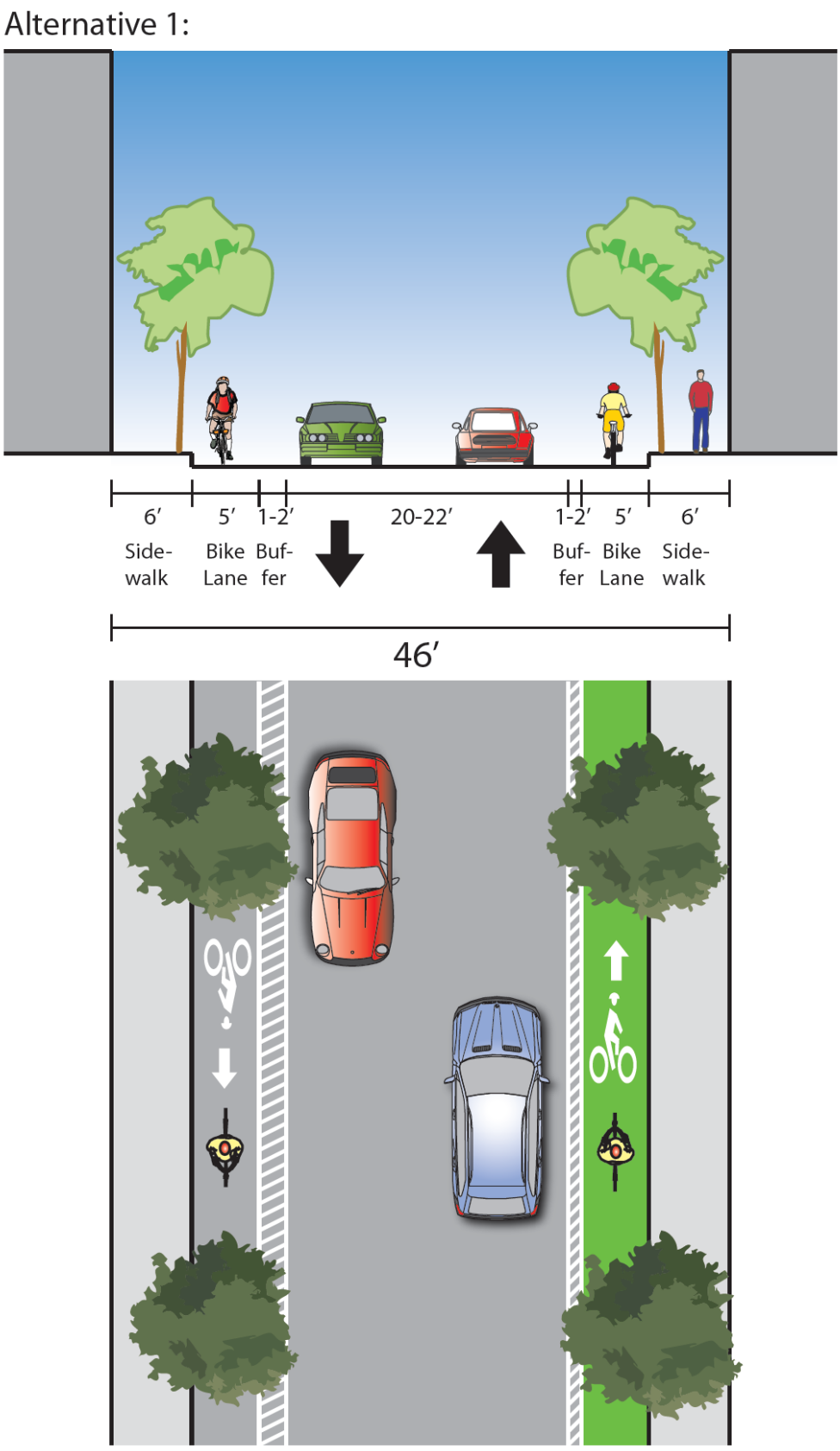


Figure 15: 62nd Street to Stanford Avenue, Alternative 1, Buffered Bicycle Lanes
Note: graphic shows options for more visible separation by widening the buffer (left) or applying coloration (right)

Alternative 2:

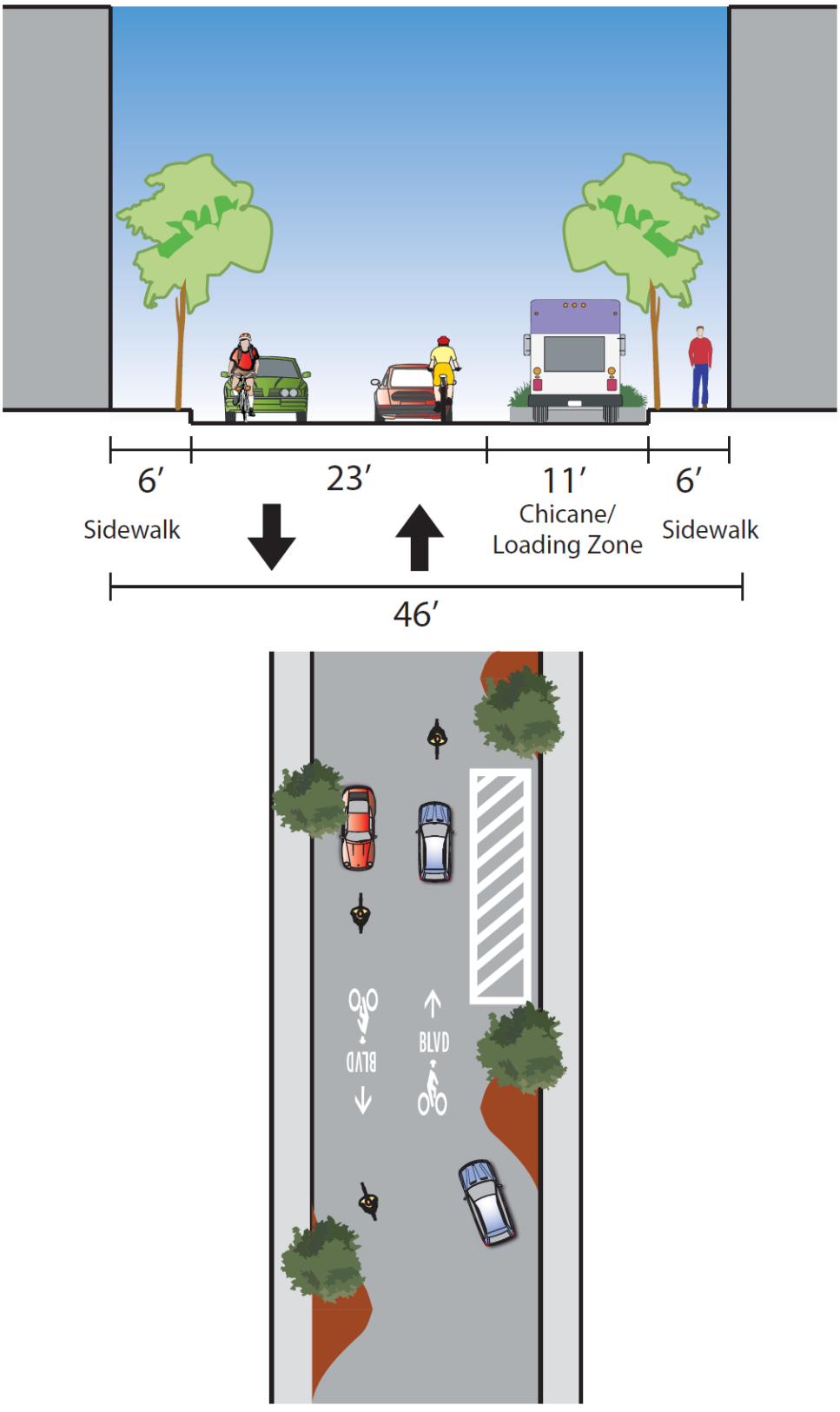


Figure 16: 62nd Street to Stanford Avenue, Alternative 2, Shared Roadway with Chicanes

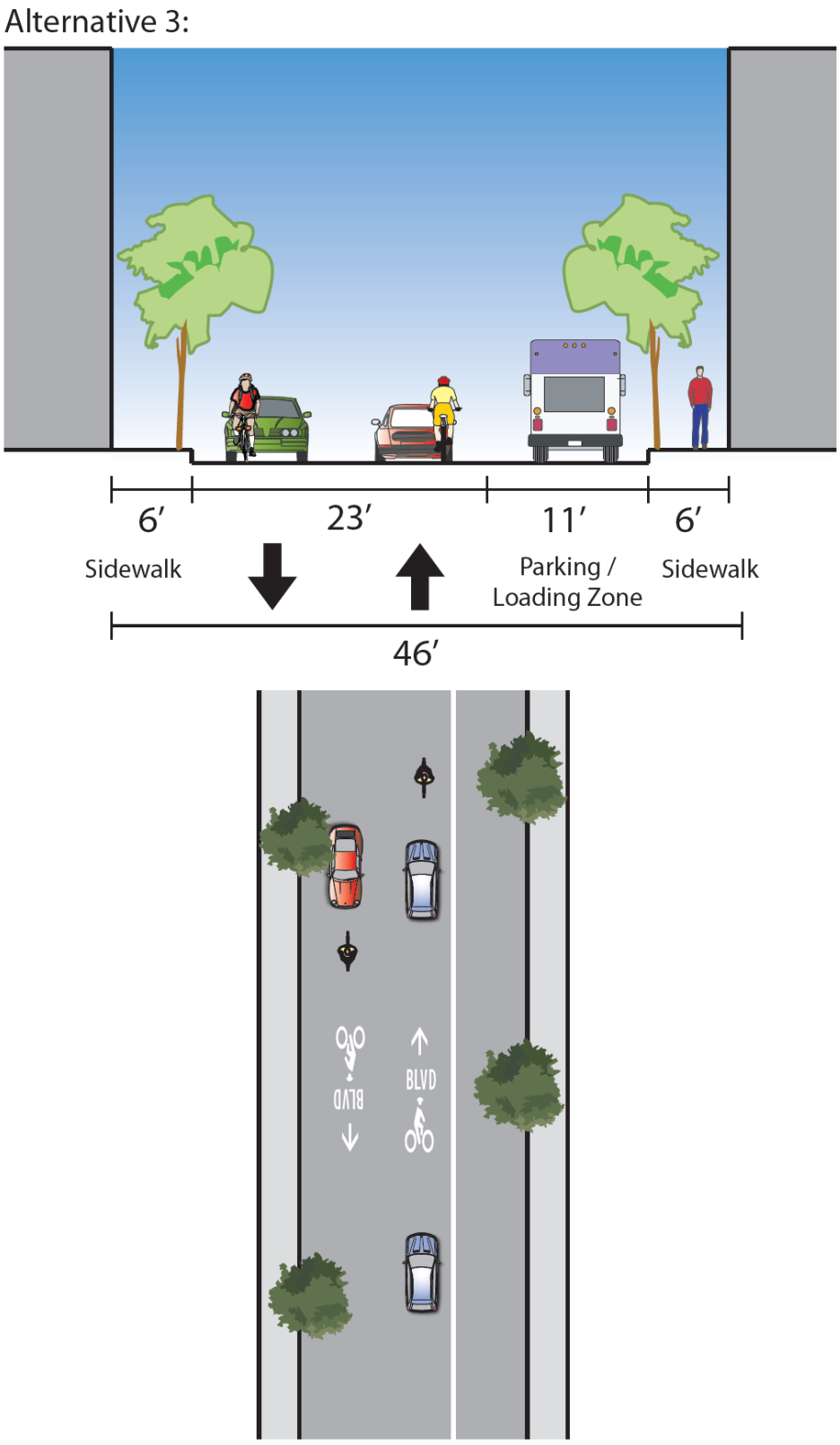


Figure 17: 62nd Street to Stanford Avenue, Alternative 3, Shared Roadway with Parking/Loading Zone

4. Glossary

85th percentile speed	The speed which 85 percent of traffic travels below and 15 percent travels above; this higher-than-average speed is often used to set speed limits.
Average daily traffic (ADT)	The number of vehicles per day on a roadway during a typical 24-hour period.
Bicycle boulevard	A street segment, or series of contiguous street segments, that have been modified to accommodate through bicycle traffic but discourage through motor vehicle traffic.
Cut-through traffic	Traffic using minor roadways, usually residential streets, as shortcuts to avoid congestion on major streets.
Speed control measures	Traffic calming measures that use deflection of vehicle travel paths to moderate speeds. Examples include speed humps and tables, raised intersections, traffic circles, chicanes, chokers, and others.
Speed lump or cushion	Called speed lumps in the United States, speed cushions are a treatment developed in Europe that is similar to a speed hump with a gap that allows vehicles with a wider wheel bed to pass unencumbered.
Traffic calming	Traffic calming involves changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut-through volumes, in the interest of street safety, livability, and other public purposes. (Institute of Transportation Engineers).
Vehicles per day (vpd)	The measure of average daily traffic on a roadway during a 24-hour period.
Volume control measures:	Traffic calming measures that use barriers to preclude one or more movements along a street or at an intersection. Examples include full, half, and diagonal street closures, median barriers, and right-in, right-out islands.

5. Annotated Bibliography

This section briefly summarizes the key published materials that provide specific guidance for development of bicycle boulevards.

American Association of Highway Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities

The proposed update to the 1999 *Guide to the Development of Bicycle Facilities* (expected 2011) includes the bicycle boulevard as a recognized bicycle facility. The Guide defines a bicycle boulevard as, "a local street or series of contiguous street segments that have been modified to function as a through street for bicyclists while discouraging through automobile travel." It recommends bicycle boulevards where the speed differential between motorists and bicyclists is typically 15 mph or less, generally with posted speed of 25 mph or less. The Guide also states that bicycle boulevards should generally have an ADT of less than 3,000 vehicles per day.

Recommendations for bicycle boulevard design elements include:

- Traffic diverters
- Priority assignment of two-way stop-controlled intersections that favors the bicycle boulevard
- Neighborhood traffic circles and mini-roundabouts at minor intersections
- Other traffic-calming features where deemed appropriate
- Wayfinding signs to guide bicyclists
- Shared lane markings to alert drivers to the path bicyclists need to take on a shared roadway
- Crossing improvements where the boulevard crosses major streets, including traffic signals/crossing beacons with bicycle-sensitive loop detectors or push-buttons, median refuges, and curb extensions

The Guide does not provide any specific metrics for applying these treatments, although the section on bicycles and traffic calming provides an overview of the range of traffic calming treatments that are beneficial to the bicycling environment.

Alta Planning + Design and IBPI Fundamentals of Bicycle Boulevard Planning and Design

Published in July 2009, this collaboration between Alta Planning + Design and Portland State University's Initiative for Bicycle and Pedestrian Innovation (IBPI) is an overview of bicycle boulevard planning and design elements. The resource provides guidance for bicycle boulevard implementation, including corridor selection, public process, and other considerations. The design elements were grouped into: signage, prioritizing travel on bicycle boulevards, intersection treatments, traffic calming, and traffic reduction, and the document provides general guidance and cost estimates for each treatment.

- Resource available at: http://www.altaplanning.com/bike+blvd+guidebook.aspx

Bicycle Countermeasure Selection System (BIKESAFE)

Sponsored by the U.S. Department of Transportation Federal Highway Administration (FHWA), the BIKESAFE website is a compendium of measures used to improve safety and mobility for bicycling. The website provides a description and analysis of factors contributing to bicycle crashes and a description of treatments and countermeasures to address these crashes. The website also includes case studies.

- Resource available at: http://www.bicyclinginfo.org/bikesafe/

City of Berkeley Bicycle Boulevard Design Tools and Guidelines

Published in April 2000, the City of Berkeley's Bicycle Boulevard Design Tools and Guidelines reports on the Early Design Phase of implementing bicycle boulevard improvements defined in the 1999 Berkeley Bicycle Plan. The document defines the purpose, goals and objectives of developing bicycle boulevards in Berkeley. It provides a summary of the process used to identify streets for bicycle boulevard treatments. The document outlines existing conditions on streets designated as bicycle boulevards, as well as concerns and solutions suggested by the public.

The document also provides an overview of strategies used to develop bicycle boulevards, including issues addressed, typical application, implementation guidelines, design suggestions, and cost. The document also reviews the impacts of traffic calming devices, discussing ITE's *Traffic Calming: State of the Practice* (1999) report, although it does not specifically state thresholds or metrics such as average daily traffic for implementing traffic calming or diversion measures.

- Resource available at: http://www.ci.berkeley.ca.us/contentdisplay.aspx?id=6652

City of Napa Policy Guidelines: "Bicycle Boulevards"

The City of Napa, California adopted policy guidelines for implementation of bicycle boulevards in 2005. The goal was to, "to develop and maintain a safe integrated bicycle route network for residents and visitors, connecting key destinations to neighborhoods, neighborhoods to each other, and the City of Napa to the county." The guidelines outline characteristics of roads where bicycle boulevards could be implemented, including the requirement that, "Potential candidate streets include local streets or low-volume collector streets with less than 5,000 vpd." Lane widths should be Napa's typical 12-foot width, but narrowing lanes is appropriate for low volume streets (approximately 2,500 vpd or less) that are not designated emergency response routes. On-street parking can only be removed if a safety enhancement is required. Traffic calming is allowable, based on Public Work's *Citywide Guidelines for Traffic Calming and Neighborhood Traffic Management* manual.

- Resource available at: http://www.cityofnapa.org/images/publicworks/Traffic/TACpolicies/tac_10.pdf

Traffic Calming: State of the Practice

This widely used manual on traffic calming was published in 1999 by the Institute of Transportation Engineers (ITE). While this manual does not address bicycle boulevards, many of the treatments discussed can be applied to bicycle boulevards. The manual includes a brief history of traffic calming, a toolbox of measures, consideration of engineering and aesthetic issues, impacts, legal authority and liability, warrants, and effectiveness of various traffic calming treatments. The manual defines traffic calming measures, including: speed humps/tables, raised intersections, traffic circles, chicanes, chokers, and lateral shifts (all speed control measures); and street closures, diverters, median barriers, and other elements that restrict motor vehicle movements (all volume control measures).

The report analyzes impacts of traffic calming treatments using the following measures:

- 85th percentile speeds
- Daily traffic volumes
- Number of crashes
- Ease of street crossings for bicyclists/pedestrians
- Safer bicycle operation

The manual summarizes impacts to average speeds, volumes, and numbers of crashes for typical traffic calming measures. The manual found that volume control measures lead to significant reductions in annual collision frequency, although this was primarily attributed to reducing the vehicular volumes.

Table 4 provides a summary of the impacts of traffic calming and diversion techniques as well as considerations for emergency vehicle response routes.

Table 4. Recommended Treatment Matrix

Treatment	Average Speed After Installation	Impacts to Motor Vehicle Volumes	Allowed on Emergency Response Routes
Speed Hump	27.3 mph (12′ humps) 25.6 mph (14′ humps)	20 percent reduction	No
Speed Table/ Raised Crosswalk (22′)	29.2 mph	12 percent reduction	Yes
Speed Lump	27.0 mph	12 percent reduction	Yes
Raised Intersection	34.3 mph	12 percent reduction	Yes
Chicane	32.3 mph	10 percent reduction	Yes
Mini Traffic Circle	30.3 mph	5 percent reduction	No
Curb Extension	32.3 mph	10 percent reduction	Yes
Neckdown	32.3 mph	10 percent reduction	Yes
Pinchpoint	28.6 mph	10 percent reduction	Yes
Center Island Narrowing	32.3 mph	10 percent reduction	Yes
Full Closure	N/A mph	44 percent reduction	No
Partial Closure/ Choker Entrance	26.3 mph	42 percent reduction	Yes, with mountable curb or removable bollards
Diagonal Diverter	27.9 mph	35 percent reduction	Yes
Median Island/Diverter	32.3	10 percent reduction	Yes

Source: Ewing, *Traffic Calming: State of the Practice*

- Resource available at: http://www.ite.org/traffic/tcstate.asp#tcsop

Responding to the Challenges of Bicycle Crossings at Offset Intersections.

This resource was written by an engineer at the Seattle Department of Transportation for the Third Urban Street Symposium in 2007. The report identifies solutions to offset bikeway crossings, which are a typical challenge for bicycle boulevard design. The report evaluates three existing facilities, finding high compliance with a side path and signalized crossing treatment in Tucson, AZ and a striped left turn in Portland, OR (91 percent compliance). By contrast, a left turn pocket in Seattle, WA had only 60 percent compliance.

The report also makes recommendations for additional treatments, including: a median left turn lane (allows two-way protected left turns); a right bicycle lane and refuge area (bicycle lane on the main street with a 'jug handle' waiting area for bicyclists to cross); and a median bicycle path (full median island with two-way bicycle path).

The report notes the lack of federal guidelines or warrants for providing bicycle crossings at offset intersections. It recommends considering volume of traffic including turning volumes, the speed limit or 85th percentile speed of the main street, and the make-up of the bicyclists using the crossing.

- Resource available at: http://www.urbanstreet.info/3rd_symp_proceedings/Responding%20to%20the%20Challenges.pdf

Neighborhood Traffic Calming: Seattle's Traffic Circle Program

Published in 1998 in the Road Management & Engineering Journal, this article outlines the Neighborhood Traffic Control Program (NTCP), in particular the use of traffic circles for traffic calming. Over 600 traffic circles were constructed in Seattle between 1973 and 1998. The article summarizes the process for determining a location for a traffic circle. Traffic circles are designed to allow a single unit fire truck (45-foot turning radius) to pass, and they include a two-foot mountable curb to facilitate emergency vehicle access. An analysis of crashes between 1991 and 1994 found a 94 percent reduction in crashes (11 crashes after construction, compared to 187 prior), as well as a substantial reduction in injuries. The analysis concludes that, "The significant reduction in accidents attributable to traffic circles demonstrates that they pay for themselves many times over in reduced accident costs in just the first year." They did not find that traffic circles reduce traffic volumes.

- Resource available at: http://www.usroads.com/journals/rmej/9801/rm980102.htm

U.S. Traffic Calming Manual, APA (2009)

Written by Reid Ewing and Steven J. Brow, this recently published manual updates the material developed in Ewing's 1999 *Traffic Calming: State of the Practice*. The Manual defines traffic calming as:

> Traffic calming involves changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut-through volumes, in the interest of street safety, livability, and other public purposes.

The manual contains updated information from a survey of 20 jurisdictions considered leaders in traffic calming practices as well as relevant literature and online resources. It provides an overview of a model traffic calming process, including recommendations for selecting treatments using different methodologies. The toolbox section describes key design features, considerations, and impacts of traffic calming and diversion devices. Each section includes a brief description of impacts to bicycle and pedestrian traffic, as well as recommendations for mitigating potential safety concerns.

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6. Bicycle Boulevard Treatments

Bicycle Boulevard Signs

Design Summary

- Signs identify routes to both bicyclists and motorists, provide destination and distance information, and warn users about changes in road conditions as needed.
- Signs should be consistent in content, design, and intent throughout the region; colors reserved by the Manual on Uniform Traffic Devices (MUTCD) for regulatory and warning road signs (red, yellow, orange, etc.) are not recommended. Green and purple are commonly used.
- Signs "brand" the bicycle boulevard network, fostering familiarity among bicyclists and motorists with traffic conditions expected on these facilities. Unlike other marketing efforts, signs passively advertise the bicycle boulevard 24 hours a day.

Identification signs indicate that a street is a bicycle boulevard.

Street signs can be modified to indicate that the street is a bicycle boulevard.

Treatments

Identification Signs

Also known as 'confirmation' signs, identification signs remind bicyclists and motorists that they are on a bicycle boulevard. Identification signs typically include a bicycle logo or bicycle boulevard branding. The use of modified street signs such as in Berkeley, CA and Vancouver, B.C. is an effective way to provide identification of the route without introducing a new sign.

Wayfinding Signs

Wayfinding signs provide direction, distance and/or estimated travel time to destinations including commercial districts, transit hubs, schools and universities, and other bikeways. Wayfinding signs are placed where multiple routes intersect and at key bicyclist decision points. Wayfinding signs displaying destinations, distances and "riding time" can dispel common misperceptions about time and distance while increasing users' comfort and accessibility to the boulevard network.

Oakland's wayfinding signs provide distance.

Warning signs

Warning signs advise motorists to "share the road" and "watch for bicyclists" as well as warning about pedestrian crossings, and traffic calming. Warning signs should also be placed on major streets approaching bicycle boulevards to alert motorists of bicyclist crossings. See Manual on Uniform Traffic Control Devices (MUTCD) for guidance on use of warning signs.

Warning signs inform motorists to expect bicyclists.

Bicycle Boulevard Pavement Markings

Design Summary

- Pavement markings identify the roadway as a bicycle boulevard for bicyclists and drivers and provide wayfinding and traffic guidance.
- Markings encourage proper positioning in the roadway.

Treatments

Shared lane markings can also provide directional support for bicyclists.

Bicycle boulevard marking in Berkeley, CA.

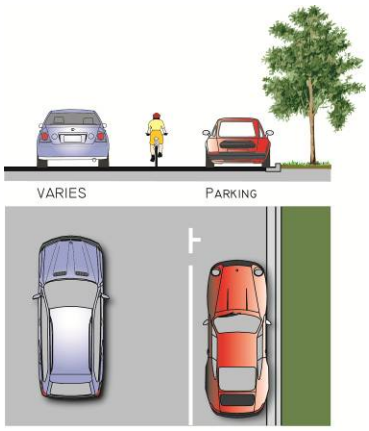
Directional Pavement Markings

Directional pavement markings (also known as "breadcrumbs") lead bicyclists along a bicycle boulevard and reinforce the notion that they are on a designated route. Markings can take a variety of forms, such as small (12-24 inches) bicycle symbols placed every 600-800 feet along a linear corridor or large (6-foot by 30-foot) markings.

When a bicycle boulevard follows several streets (with multiple turns at intersections), additional markings accompanied by directional arrows may be provided to guide bicyclists through turns. On streets with narrow lanes where an automobile cannot pass a bicyclist within one lane of traffic, place stencils in the center of the travel lane. Emeryville recommends that there be a minimum of two shared lane markings on each block, one at each end, and otherwise located at an interval of 200 linear feet. Bicycle boulevard markings should also include a minimum of two, one on each end of the block and every 600 linear feet.

On-Street Parking Delineation

Delineating on-street parking spaces with paint or other materials clearly indicates where a vehicle should be parked, and can discourage motorists from parking their vehicles too far into the adjacent travel lane. This helps bicyclists by maintaining a wide enough space to safely share a travel lane with moving vehicles.



Example of on-street parking delineation.

Centerline Striping Removal

Motorists have an easier time passing bicyclists on roads without centerline stripes for the majority of the block length. If there is too much oncoming traffic for a motorist to cross the centerline to pass a bicyclist, is likely that there is too much traffic for the subject street to be a successful bicycle boulevard. In addition, not striping the centerline reduces maintenance costs. This treatment may increase speeds, and additional treatments such as traffic circles should be used in conjunction with this treatment.

Minor Unsignalized Intersections

Design Summary

- To encourage use of the bikeways and improve bicyclists' safety, reduce bicycle travel time by eliminating unnecessary stops and improving intersection crossings.

Treatments

Stop Sign on Cross-Street

Ideally, the majority of intersections along a bicycle boulevard should have cross traffic stop-controlled or signalized. Where stop signs are facing every other block, turning signs along the bikeway to stop the cross traffic should be considered to maximize through-bicycle connectivity and momentum. Stop signs increase bicycling time and energy expenditure due to frequent starting and stopping, leading to non-compliance by bicyclists and motorists, and/or use of other routes. If several stop signs are turned along a corridor, speeds should be monitored, and traffic-calming treatments used to reduce excessive vehicle speeds on the bicycle boulevard. Bicycle boulevards should have fewer stops or delays than local streets; a typical bicycle trip of 30 minutes is increased to 40 minutes if there is a STOP sign at every block.[12]

Stop signs effectively minimize conflicts along bicycle boulevards.

High-Visibility Crosswalks

Crosswalks may be marked to improve visibility, particularly near activity centers with large amounts of pedestrian activity such as schools or commercial areas. Crosswalks are often combined with curb extensions, allowing bicyclists to move further into the road before making the crossing.

High-visibility crosswalks increase visibility of bicyclists crossing a street on a bicycle boulevard.

Bicycle Forward Stop Bar

A second stop bar for bicyclists placed closer to the centerline of the cross street than the drivers' stop bar increases the visibility of bicyclists waiting to cross a street. This treatment is typically used with other crossing treatments (i.e. curb extension) to encourage bicyclists to take full advantage of crossing design and to encourage cyclists to come to a full stop at the intersection. They are appropriate at unsignalized crossings where fewer than 25 percent of motorists make a right turn movement.

Bicycle forward stop bars encourage bicyclists to wait where they are more visible.

[12] *Berkeley Bicycle Boulevard Design Tools and Guidelines*

Minor Unsignalized Intersections

Contraflow Bike Lanes

Allowing bicyclists to travel against the flow of traffic on a one-way street can improve connectivity on the bicycle boulevard network. Contraflow bike lanes are installed on left side of the street facing one-way traffic. The contraflow lane is generally separated from the motor vehicle lane with a double-yellow line, although a physical barrier or colored pavement can be used.

Intersection treatments such as signs and pavement markings should warn drivers to expect bicyclists in the reverse direction. This treatment may require modifications to existing traffic signals to allow bicyclists to activate signal from "wrong" direction.

This contraflow lane in Portland, OR provides a short cut-through for bicyclists following a bicycle boulevard.

Offset Intersections

Design Summary

- Provide turning lanes or pockets at offset intersection, providing bicyclists with a refuge to make a two-step turn.
- Bike turn pockets: five feet wide, with a total of 11-feet required for both turn pockets and center striping.

Treatments

Offset intersections can be challenging for bicyclists, who need to briefly travel along the busier cross street in order to continue along the boulevard.

Bicycle Left-Turn Lane

A bicycle left-turn lane can be painted where a bicycle boulevard crosses a street that has sufficient gaps in traffic to allow a bicyclist to cross one direction without a long wait. The bicyclist crosses one lane into the center of the cross street, and has a protected space to wait for a gap in the other direction.

The bike turn pockets should be at least four feet wide, with a total of 11 feet for both turn pockets and center striping.

Bike Lanes on the Cross Street

To assist with a bicycle boulevard jog to the left, a short segment of bike lane can be provided along the cross street. Crossing treatments appropriate to the level of street should be provided on both sides, so that bicyclists heading either direction on the bicycle boulevard can cross and ride in the lane on the appropriate side of the street; otherwise, wrong-way riding is likely to occur.

Bicycle Sidepath/Cycle Track

On particularly busy streets, a two-way or two one-way separated path can be provided on one side of the roadway. Bicyclists enter the sidepath from the bicycle boulevard and ride to a signalized intersection, where they cross, then continue along the bicycle boulevard. While more comfortable for users, this treatment is expensive and requires sufficient right-of-way.

Example of a bicycle left-turn lane.

Short bike lanes protect a left-turn jog.

Photo: City of Portland

Bicycle side path in Tucson, AZ.

Photo: Tom Thivener

A two-way cycle track on one side of the street provides a short connection.

Major Unsignalized Intersections

Design Summary

- Bicycle signals may be appropriate for use where high levels of bicycle traffic on a minor street cross a major street. Instructional and regulatory signage should be included with installation.

Treatments

Crossbikes

Crossbikes can be provided adjacent to the standard crosswalk marking or independently. Painted markings such as bicycle stencils or color treatment (including pattered surfacing) can accompany crossbikes to indicate to all users that bicyclists may use the crossing.

Medians/Refuge Islands

At uncontrolled intersections of bicycle boulevards and major streets, an island can be provided to allow bicyclists to cross one direction of traffic at a time when gaps in traffic allow. The bicycle crossing island should be at least 8' wide (measured perpendicular to the centerline of the major road) to be used as the bike refuge area.

Narrower medians can accommodate bikes if the holding area is at an angle to the major roadway, which allows stopped bicyclists to face oncoming motorists. Railings can also be provided so bicyclists do not have to put their feet down, thus making it quicker to start again. Crossing islands can be placed in the middle of the intersection, prohibiting left and thru vehicle movements.

Pedestrian Hybrid Beacon

Also known as HAWK signals, pedestrian hybrid beacons can be used where a full traffic signal is otherwise unwarranted by volumes or gaps. Pedestrian hybrid beacons are installed to aid crossings where drivers do not tend to stop. The beacon signal consists of a traffic signal head with a red-yellow-red lens. The unit is off until activated, then:

- The signal flashes yellow to warn approaching drivers.
- A solid yellow advises drivers to prepare to stop.
- The signal changes to a solid red, and a WALK indicator is shown.

Bicycle signals can be actuated with bicycle sensitive loop detectors, video detection, or push buttons. HAWKS have not been approved for use in California, but are incorporated into the 2010 Federal MUTCD.

Crossbike in Berkeley, California.

Medians on bicycle boulevards should provide space for a bicyclist to wait.

Pedestrian hybrid signals for bicyclists should be clearly marked to minimize confusion.

Traffic Calming: Vertical Speed Control Measures

Design Summary

- Slopes should not exceed 1:10 or be less steep than 1:25. The *U.S. Traffic Calming Manual* recommends side slopes on tapers to be no greater than 1:6 to reduce the risk of bicyclists losing their balance. The vertical lip should be no more than a quarter-inch high.

Treatments

Split Speed Tables

Speed tables can be divided between lanes of traffic such that there is a longitudinal gap between them, which emergency vehicles can pass through. This treatment was designed and tested in Portland, Oregon.

Speed Lumps/ Cushions

Speed lumps are rounded or flat-topped raised areas across the road that include wheel cutouts to allow large vehicles to pass unaffected while acting as speed humps to passenger cars. They are increasingly used along emergency vehicle routes and recommended in the *U.S. Traffic Calming Manual*. Experience in La Habra, CA recommends a configuration of three lumps with a six-foot-wide center lump to minimize emergency vehicle delay. Wheel gaps should be one or two feet wide.

Speed Tables/Raised Crosswalk

Speed tables are longer than speed humps and flat-topped. The 22-foot table with a vertical rise of three inches high and 10-foot plateau is the most common. Because a speed table cannot be straddled by a truck, it decreases the risk of bottoming out. A raised crosswalk is a speed table that is marked and signed for pedestrian crossing. It extends fully across the street and can be loner and higher than a typical speed table.

Speed Humps

Speed humps are rounded raised areas requiring approaching vehicles (automobiles and bicyclists) to reduce speed. Emergency vehicle response times should be considered where speed humps are used. Some bicyclists find speed humps uncomfortable or challenging, and speed humps can be designed to leave gaps in the center or three to four feet by the curb for bicyclists and drainage. Ewing (1999) found that that speeds increase about 0.5 to 1.0 mph for every 100 feet of separation for hump spacing up to 1,000 feet.

Raised Intersection

A speed table across the entire intersection, a raised intersection is generally three inches shorter than a standard curb height. ADA standards for curb ramps and tactile warnings should be used to accommodate pedestrians. Raised intersections are expensive, and drainage issues can arise.

Speed humps are a common traffic calming treatment.

Raised crosswalks calm traffic while improving the pedestrian environment.

Speed lumps or cushions are divided to allow emergency vehicles to pass unaffected.

Raised intersections are expensive but attractive features.

Traffic Calming: Horizontal Speed Control Measures

Design Summary

- Traffic calming treatments reduce vehicle speeds to the point where they generally match bicyclists' operating speeds, enabling motorists and bicyclists to safely co-exist on the same facility.
- Typical designs end bike lanes 70 to 100 feet in advance of slow points, allowing bicyclists to merge with motor vehicle traffic.
- In locations with high bicycle and/or motor vehicle volumes, provide five- to six-foot bypass lanes that are separated from motor vehicle lanes.

Chicanes require all vehicles to reduce their speeds to maneuver around the obstacle.

Treatments

Chicanes

Chicanes are a series of raised or delineated curb extensions, edge islands, or parking bays on alternating sides of a street forming an S-shaped curb, which reduce vehicle speeds by requiring drivers to shift laterally through narrowed travel lanes. (Edge islands leave a gap by the curb to improve drainage). European designs recommend shifts of least one lane width, deflection angles of at least 45 degrees, and islands to prevent drivers from traveling straight.[13]

Traffic circles require both drivers and bicyclists to reduce speeds.

Mini Traffic Circles

Mini traffic circles are raised or delineated islands placed at intersections that reduce vehicle speeds by narrowing turning radii and narrowing the travel lane. They can be used to replace four-way stops with yield controls, although they are typically not signed as such. Mini traffic circles can also include a paved apron to accommodate the turning radii of larger vehicles like fire trucks or school buses. Larger circles should include splitter islands at the approaches. Left turns in front of the islands may be allowed to accommodate larger trucks at small intersections.

Curb bulb-outs improve visibility of pedestrians at the intersection.

Curb Bulb-Outs/Curb Extensions

Curb bulbouts extend the sidewalk or curb face into the parking lane at an intersection, visually narrowing the roadway. The curb extensions should only extend across the parking lane and should not obstruct bicyclists' path of travel or the travel lane. Curb extensions can increase the amount of space available for street furniture and trees or act as stormwater management features.

[13] Ewing, Reid. (1999). Traffic Calming: State of the Practice.

Traffic Calming: Narrowings

Design Summary

- Narrowings reduce the travel lane such that drivers must stop to allow one vehicle to pass from a single direction at a time.

Treatments

Choker

Similarly, to chicanes, chokers are curb extensions or edge islands placed midblock requiring drivers to reduce speeds to pass each other. This treatment narrows the travel lane to a maximum of 20 feet, with a constricted length of 20 feet in the direction of travel. European versions of this treatment often narrow the lane to considerably less than 20 feet clear width.

Neckdown

Neckdowns are narrowings at an intersection created by curb extensions on either side of the intersection. They are often combined with parking bays on side streets off commercial main streets. Curb radii should allow trucks to pass without having to pass the centerline, or incorporate mountable curbs if an alternate truck route is not available.

Pinchpoint

In a pinchpoint, bicyclists travel on the outside of the islands, reducing potential conflicts with motor vehicles. Pinchpoints encourage bicyclists to ride on the side of the road, then merge back into traffic, potentially reducing bicyclists comfort levels.

Center Island Narrowing

A short median island causes a small amount of deflection without blocking driveway access. Standard size is six feet wide and 20 feet long. A diverging taper can be used to deflect traffic to the right.

Pinchpoints allow bicyclists to avoid conflicts with motor vehicles in the narrow passageway.
Source: Greg Raisman
Utrecht, The Netherlands

Alternative pinchpoint design with speed hump in Skandinavia.

A neckdown in Eugene, OR narrows the travel lane at an intersection.

Traffic Diversion

Design Summary

- Traffic diversion treatments maintain through-bicycle and pedestrian travel on a street while physically restricting through-vehicle traffic.
- Traffic diversion is most effective when higher-order streets can sufficiently accommodate the diverted traffic.
- Bike lanes through diverters should be five or six feet in width, to allow trailers to pass while discouraging passenger car use.

Treatments

Full Closure

Raised features turn vehicle traffic while permitting through-bicycle travel. The treatment creates a "T" that does not affect vehicular traffic on the cross street but prevents driving along the bicycle boulevard. Full closures can be permeable to emergency vehicles with the use of removable bollards or mountable curbs (maximum of six inches high).

Partial Closure/Choker Entrance

Partial closures are intersection bulbouts or islands that allow full bicycle passage while restricting vehicle access to one side only. Motorists on the bicycle boulevard must turn onto the cross street while bicyclists may continue forward along a short contra-flow bike lane past the closure. These devices can permit some vehicle turning movements from a cross street onto the bicycle boulevard while restricting other movements.

Diagonal Diverter

Diverters can be placed diagonally across a four-way intersection, requiring all motor vehicle traffic to turn.

Median Island/Diverter

A median island can block automobiles from crossing a road while allowing bicyclists to pass through short gaps. Median island diverters can be narrow extruded curbs or wider islands with landscaping. The median can also provide a bike-only left-turn pocket permitting bicyclists to make left turns while restricting vehicle left turns.

Supplemental Treatment: Bike Boxes

Right-turn conflicts between bicyclists and motorists may occur at intersections at signals where traffic is diverted and forced to turn, while bicyclists continue through the intersections. Bike boxes increase bicyclist visibility to drivers by providing a space for bicyclists to wait at signalized intersections.

Choker entrances prevent vehicular traffic from turning from a main street.

Non-motorized only diverters deter motorists from driving on the street.

Median diverters include pass-throughs for bicyclists.

This bike-only left-turn pocket prevents motor vehicles from turning.

Appendix D. Bicycle Transportation Account Compliance

Emeryville Pedestrian and Bicycle Plan

May 2012

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D.1.Bicycle Transportation Account Compliance

Caltrans Bicycle Transportation Account (BTA) is a significant source of funding for bicycle facility construction. To become eligible for such funding, a jurisdiction must adopt a bicycle plan that meets certain BTA requirements.

Table D-1 is provided for the convenience of Caltrans staff, to outline the elements within the Emeryville *Pedestrian and Bicycle Plan* (Plan) that comply with the Bicycle Transportation Account (BTA) requirements. It lists the name and location of elements within the Plan that meet Caltrans BTA requirements. In cases where the BTA requirement is not applicable, that is noted below. See also the Action Plan in **Chapter 8**, which outlines specific steps the city will take to implement the Plan.

Table D-1: BTA Compliance

BTA 891.2	Required Plan Elements	Compliant Elements in Plan	Page
(a)	The estimated number of existing bicycle commuters in the plan area and the estimated increase in the number of bicycle commuters resulting from implementation of the plan.		
	Existing Bicycle Commuters	Existing Conditions and Needs Analysis	3-12
	Estimated Increase in Bicycle Commuters	Demand Projection	D-3
(b)	A map and description of existing and proposed land use and settlement patterns which shall include, but not be limited to, locations of residential neighborhoods, schools, shopping centers, public buildings, and major employment centers.		
	Map and description of existing land use and settlement patterns	Land Use Map	D-4
	Map and description of proposed land use and settlement patterns	Land Use Map	D-4
(c)	A map and description of existing and proposed bikeways.		
	Map of existing bikeways	Existing Conditions and Needs Analysis	3-11
	Description of existing bikeways	Existing Conditions and Needs Analysis	3-7
	Map of proposed bikeways	Site-Specific Projects	7-12
	Description of proposed bikeways	Site Specific Projects	7-13
(d)	A map and description of existing and proposed end-of-trip bicycle parking facilities. These shall include, but not be limited to, parking at schools, shopping centers, public buildings, and major employment centers.		
	Map and description of existing end-of trip bicycle parking facilities	Citywide Improvements	5-6
	Map and description of proposed end-of-trip bicycle parking facilities	Citywide Improvements, Resources for the Design of Bicycle Facilities, Bicycle Parking Map	5-7, B-36, D-5

BTA 891.2	Required Plan Elements	Compliant Elements in Plan	Page
(e)	A map and description of existing and proposed bicycle transport and parking facilities for connections with and use of other transportation modes. These shall include, but not be limited to, parking facilities at transit stops, rail and transit terminals, ferry docks and landings, park and ride lots, and provisions for transporting bicyclists and bicycles on transit or rail vehicles or ferry vessels.		
	Map and description of existing bicycle facilities for connections with other modes	Site Specific Projects (proposed) Existing Conditions and Needs Analysis (existing)	7-2, 7-12, 3-1
	Parking facilities at transit stops and terminals	Bicycle Parking Map	D-5
	Provisions for bicycles on transit vehicles	Existing Conditions and Needs Analysis	3-16
(f)	A map and description of existing and proposed facilities for changing and storing clothes and equipment. These shall include, but not be limited to, locker, restroom, and shower facilities near bicycle parking facilities.		
	Map and description of existing end-of-trip facilities	City does not have this information.	
	Map and description of proposed end-of-trip facilities	Action Steps for policy 3.5	8-19
(g)	A description of bicycle safety and education programs conducted in the area included within the plan, efforts by the law enforcement agency having primary traffic law enforcement responsibility in the area to enforce provisions of the Vehicle Code pertaining to bicycle operation, and compile existing data on the resulting effect on accidents involving bicyclists.		
	Description of bicycle safety and education programs	Existing Conditions and Needs Analysis	3-22
	Effect of programs on accidents involving cyclists	Unknown	
(h)	A description of the extent of citizen and community involvement in development of the plan.		
	Description of public involvement in developing the plan	Existing Conditions and Needs Analysis	3-23
(i)	A description of how the bicycle transportation plan has been coordinated and is consistent with other local or regional transportation, air quality, or energy conservation plans, including, but no limited to, programs that provide incentives for bicycle commuting.		
	Description of coordination and consistency with other local and regional plans	Vision Goals and Policies, Consistency with General Plan	2-1, E-1
	Programs that provide incentives for bicycle commuting	Existing Conditions and Needs Analysis	3-22
(j)	A description of the projects proposed in the plan and a listing of their priorities for implementation.		
	Description of proposed projects	Site-Specific Projects	7-13
	Priority list of proposed projects	Site-Specific Projects	7-13
(k)	A description of past expenditures for bicycle facilities and future financial needs for projects that improve safety and convenience for bicycle commuters in the plan area.		
	Description of past expenditures	Funding and Implementation	8-3
	Estimated future financial needs	Funding and Implementation	8-2

D.2.Projected Increase in Bicycle Commuters

The projects identified in this plan would likely increase the number of additional bicycle commuters. Dill and Carr (2003), found that each additional mile of bike lanes in a city per square mile could be expected to increase the percentage of workers bicycling by 1 percent.[1] Emeryville's land area is 1.25 square miles, and the Plan calls for an additional 3.72 miles of bike boulevards, bike lanes, and bike paths, so the estimated mode share for commuters, college students, and children biking to school is increased by 3 percent.

Data	Present	Projected	Source and Assumptions
Commute Statistics			
Study Area Population	10,080	12000	Census 2010, Projections from General Plan
Employed Population	5,776	6900	Projection from General Plan
Bike-to-work mode share	1.13%	4.13%	2005-2009 ACS*
Bike-to-work commuters	65	285	2005-2009 ACS
Work-at-home mode share	8.10%	8.10%	2005-2009 ACS
Work-at-home commuters	47	56	Assumes 10% of population makes at least one bicycle trip
Estimated number of people who use transit	1052	1257	2005-2009 U.S. Census American Community Survey
Bike-to-transit mode share	1%	4%	Estimated 1% of boardings, BART Station Profile Report*
Transit bicycle commuters	11	50	Estimated 1% of boardings, BART Station Profile Report
School children, ages 6-14	322	383	2005-2009 ACS
School children bicycling mode share	2%	5%	National Average 2%*
School children bike commuters	6	19	School children population multiplied by children bike mode share
College students in study area	465	554	2005-2009 U.S. Census American Community Survey
Estimated college bicycling mode share	5%	8%	National Biking and Walking Study, FHWA*
College bike commuters	23	44	College population multiplied by mode share
Total number of bike commuters	152	455	Total of bike-to-work, transit, school, college, and utilitarian commuters
Total daily bicycling trips *(taken by residents)*	305	909	Total bicycle commuters, two legs of round trip

**Projection based on adding 3.72 miles of protected facilities to a 1.2-square mile city.*

D.3. Additional Maps

[1] http://nexus.umn.edu/Courses/pa8202/Dill.pdf

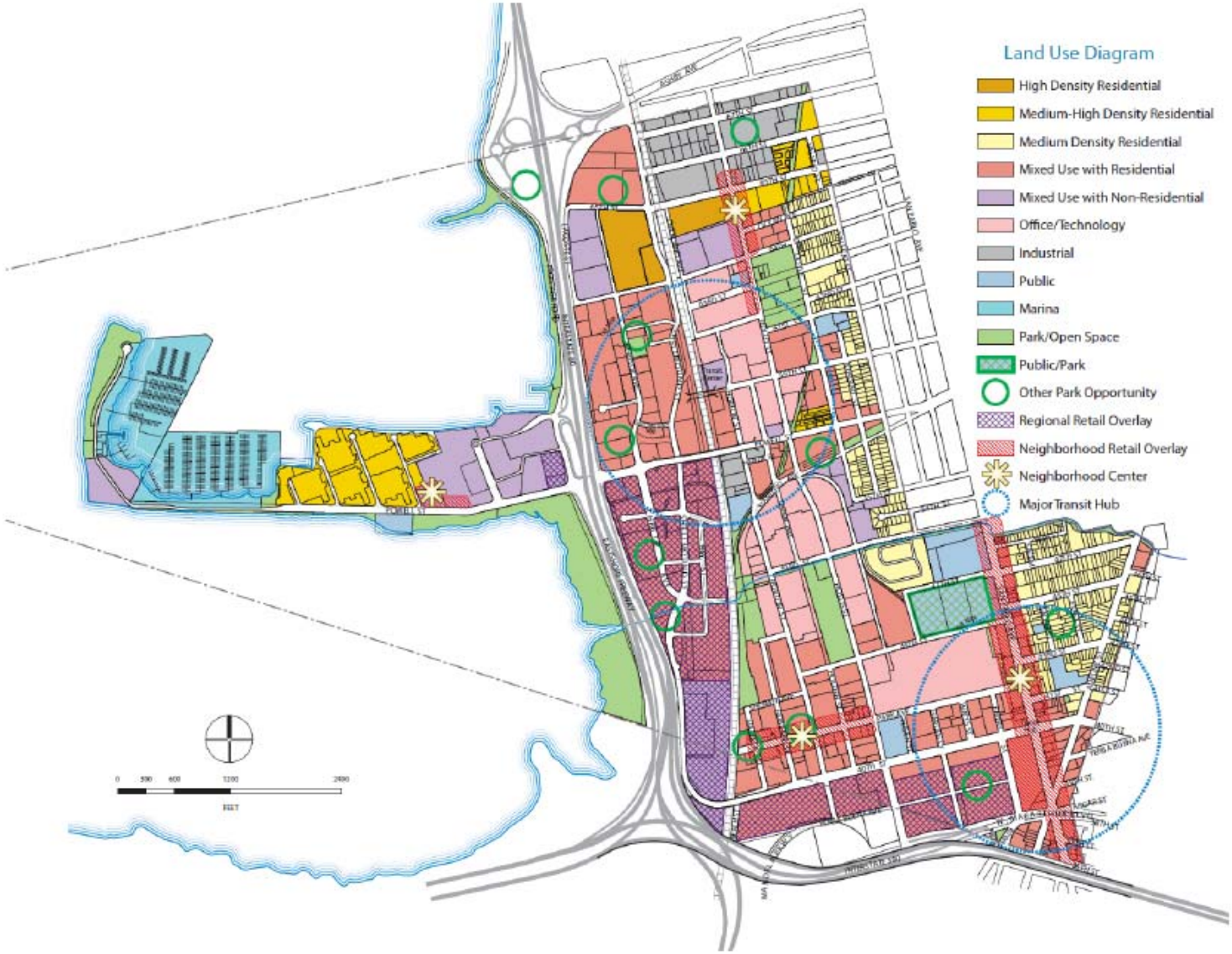

Figure D-1: 2010 General Plan Land Use Map

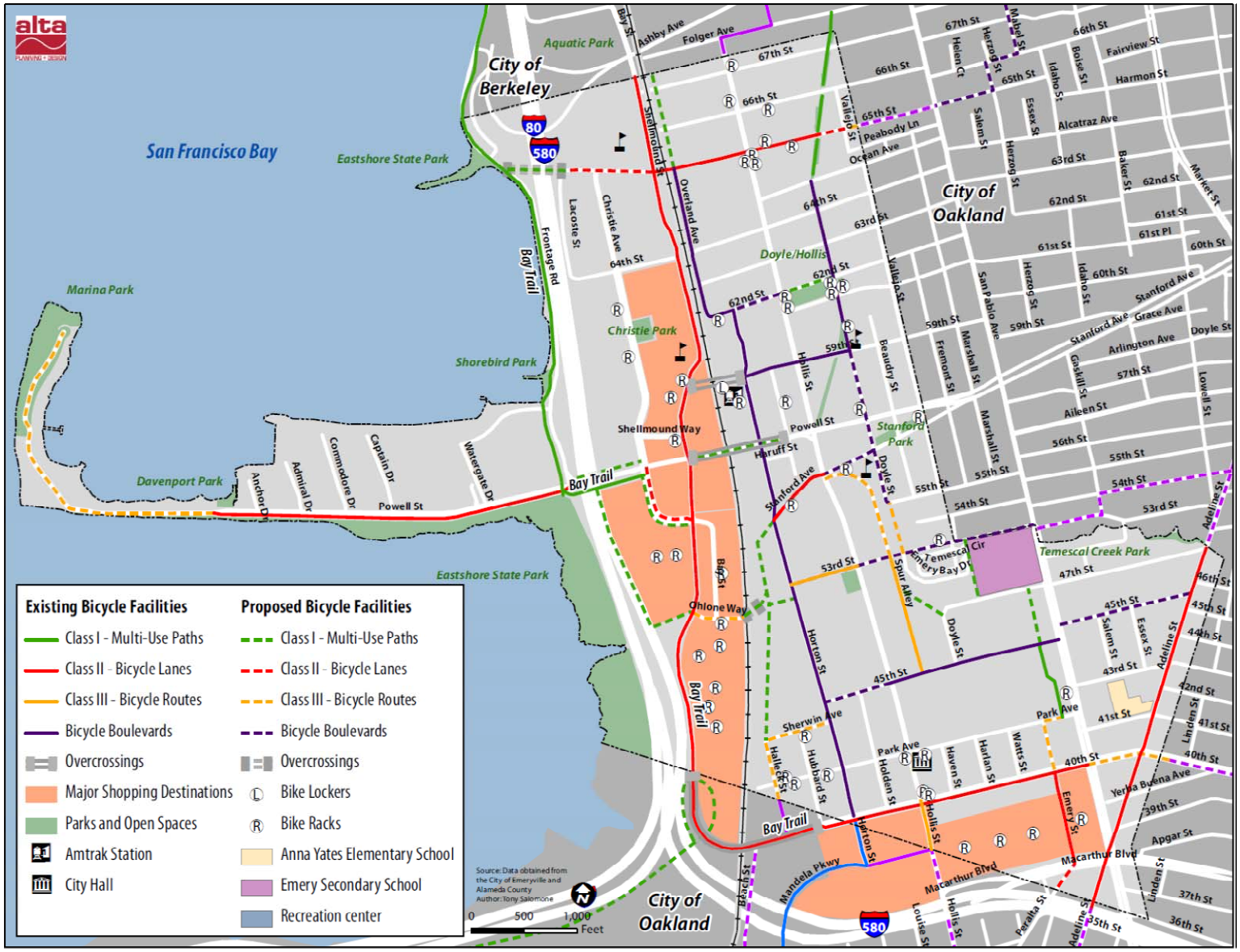

Figure D-2: Bicycle Parking Map

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Appendix E. Consistency with the General Plan

Emeryville Pedestrian and Bicycle Plan

May 2012

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Consistency with the General Plan

Many of the recommendations included in the *Pedestrian and Bicycle Plan* are drawn from the *Emeryville General Plan* that was adopted in 2009 and amended in 2010. Some pedestrian or bikeway projects identified in the *General Plan* have not been included in this Plan or have been modified. A summary of these changes and the rationale for each are provided in **Table E-1**.

Upon adoption of this Plan, the *General Plan* will need to be amended to maintain consistency between the plans.

Table E-1. Projects Identified by the *General Plan* either Modified or No Longer Recommended for Inclusion

Name	Extents	Change	Rationale
I-80 Bike and Pedestrian Path – North Segment	Powell Street - Lacoste Street	Removed	Once Powell Street improvements and 65th Street Bridge over I-80/I-580 are constructed, the need for this project is lessened.
Lacoste Street	65th Street to 64th Street	Removed	Same as above
North-South Powell Bike/Ped Bridge	East of I-80	Removed	Same as above
Ex'pressions Path	Ex'pressions campus	Changed classification from multi-use path to pedestrian path.	Duplicative of 65th Street and Shellmound Street. No clear right-of-way through campus.
66th Street Bicycle Boulevard	Shellmound Street to East City Limits	Removed	Becomes less critical once Ex'pressions multi-use path is changed to pedestrian-only path.
47th St connector to Hollis Street	From Doyle and 47th Streets to Hollis Street	Removed	Proposed alignment would require acquisition or easements and cost would outweigh benefits of project.
59th Street Bicycle Boulevard	East of Doyle Street	Removed.	East of Doyle Street, 59th Street crosses San Pablo Avenue at an offset intersection, and does not connect to a bike facility in Oakland.
55th Street Bicycle Boulevard	East of Doyle	Removed	Same as above
65th Street Bicycle Boulevard	Christie Avenue to Lacoste Street	Changed classification from bicycle boulevard to bike lanes	Continues on existing bike lanes on 65th Street to Vallejo Street and transitions to Class III until the Oakland border.
47th Street/Doyle Street Class II/III	Joseph Emery Park Path to 45th Street	Removed	Sufficient nearby bicycle connections.
47th Street	Adeline Street to San Pablo Avenue	Removed.	Bicycle boulevard recommended on 45th Street.

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Appendix F. Status of the 1998 Plan

Emeryville Pedestrian and Bicycle Plan

May 2012

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Status of the 1998 Plan

Changes to Bikeway Network since 1998 Bicycle and Pedestrian Plan

Emeryville's bicycle network was laid out in the City's 1998 Bicycle and Pedestrian Plan. The City has constructed many of the bikeways identified in that plan, though some bikeways have been constructed as a different type of bikeway than indicated in the plan. The City's General Plan, adopted in 2009, incorporates the bicycle network identified in the 1998 plan, with some additions and modifications.

The status of bikeways proposed in the 1998 Bicycle and Pedestrian Plan are summarized in the following tables:

- **Table 1** lists bikeways proposed in the 1998 Bicycle and Pedestrian Plan that were not included in the City's 2009 General Plan. These bikeways are no longer being pursued by the City.
- **Table 2** lists bike lanes proposed in the 1998 Bicycle and Pedestrian Plan that were constructed as a different class.
- **Table 3** lists bikeways that were not in the 1998 Bicycle and Pedestrian Plan, but were added to the General Plan.
- **Table 4** lists the status of bikeways from the 1998 Bicycle and Pedestrian Plan that were included in the General Plan but are not yet completed.

Table 1:Bikeways Proposed in the 1998 Bicycle and Pedestrian Plan that Were Not Included in General Plan

Bikeways Not Included in 2009 General Plan			
Type/Classification Identified in 1998 Plan	**Description**	**Status**	**Notes**
Class I Path	from 1-80 to Police Station south of Powell Street	Included as pedestrian-only trail in General Plan	
Class II Bike Lanes	67th Street from Shellmound Street to Oakland border	Not included in plan as bikeway.	Long term, bike lanes possible when uses change; General Plan kept industrial
Class III Bike Route	36th Street from Peralta Street to San Pablo Avenue	Not included in plan, as it lies entirely in Oakland.	36th Street is a one-way street

Table 2: Bikeways Identified in 1998 Bicycle and Pedestrian Plan That Have Been Constructed as a Different Class

Bikeways Constructed as Different Class			
Type/Classification Identified in 1998 Plan	**Description**	**Status**	**Notes**
Class II Bike Lanes	Horton Street from 53rd Street to 40th Street	Constructed as bike boulevard with no bike lanes	Street too narrow for parking and bike lanes

Bikeways Constructed as Different Class			
Class II Bike Lanes	Emery Street from Park Avenue to 45th Street	Constructed as Class I path	Emery Street vacated as part of Pixar development. New path constructed.
Class II Bike Lanes	Overland Avenue from 64th Street to 65th Street	Constructed as bike boulevard with no bike lanes	Street built too narrow for lanes
Class III Bike Route	Overland Avenue from 62nd Street to 64th Street	Constructed as bike boulevard	

Table 3: New Bikeways Included in the 2009 General Plan

Class	Alignment	Extents	Notes
Class I Path	To Bay Bridge East Span	From south IKEA entrance at Shellmound Way to Bay Bridge East Span	
Class I Path	Parallel to and east of I-80	From south of Christie/Shellmound Intersection to Lacoste/64th Intersection	
Ped-Bike Bridge	Over Powell Street east of I-80		
On-street	Lacoste Street	From 64th to 65th	
Ped-Bike Bridge	Over I-80 just south of Ashby	From 65th Street to Bay Trail/Frontage Road	Design finalized
Bicycle Boulevard	65th Street	From Lacoste Street to Christie Avenue	
Class I Path	Through Ex'pression College	From Christie/65th intersection to Shellmound/66th intersection	
Bicycle Boulevard	66th Street	From Shellmound Street to Oakland	
On-street	65th Street	From Greenway to Oakland	Requires coordination with Oakland, San Pablo signal, Oliver Lofts
Class I Path	Parallel to and west of San Pablo Avenue	53rd to 47th	
Class I Path		47th to Spur Alley and 47th to Hollis	
Class I Path	Parallel to and west of San Pablo Avenue	Park Avenue to 47th Street	Section between Park Avenue and 45th Street under construction
On Street	Adeline Street	40th Street to Oakland	
Bicycle Boulevard	53rd Street	From Horton Street to San Pablo Avenue	General Plan extended 53rd bikeway to San Pablo Ave
On-street	Sherwin Ave/Halleck St/Beach St	From Horton Street to end of Beach	

Class	Alignment	Extents	Notes
On Street	Hollis Street	40th Street to Oakland	

** General plan does not differentiate between Class II Bike Lanes and Class III Bike Routes. This table uses the generic term on-street bikeway to indicate Class II or III.*

Table 4: Status of Bikeways Proposed in 1998 Bicycle and Pedestrian Plan

Included in General Plan but Not Yet Completed			
Type/Classification Identified in 1998 Plan	**Description**	**Status**	**Notes**
Ped-Bike Bridge	South Bayfront Bridge: Ped-bike bridge over railroad tracks from Horton Street to Bay Street at 53rd Street	Designed	
Class I Path	From Horton Street to South Bayfront Bridge	Designed	Alignment modified for General Plan. Horton Landing Park will include bike path connection to South Bayfront Bridge
Class II Bike Lanes	Overland 65th to 67th	Street not built with development	GP designates a Class I path as a replacement
Class III Bike Route	59th from Doyle to Vallejo	Proposed	GP designates as bike boulevard
Class III Bike Route	Emery-Peralta from Park to Oakland	Proposed	
Class III Bike Route	Doyle-47th from 45th to San Pablo	Proposed	
Class III Bike Route	Doyle from 59th to 55th	Proposed	General Plan designates as bike boulevard
Ped-Bike Route	53rd to 55th path	Proposed	May not be feasible
Ped-Bike Route	Spur Alley from Hollis/Stanford to 53rd	Proposed	Need to acquire easement
Wider Bus-Bike Lane	40th from San Pablo to Oakland	Proposed	Working with Oakland and BART
Class II Bike Lanes	45th from Horton to just west of San Pablo Avenue	Street too narrow for parking and bike lanes	General Plan designates as bike boulevard, extends to San Pablo Ave
Class I Path	Through parking lot from Amtrak bridge to Shellmound	Preliminary plans for Marketplace PUD include "dismount and walk" bike path.	Not yet constructed.
Class I Path	From Horton Street to Amtrak bridge	Approved plans for Emery Station West do not include path to bridge.	Not yet constructed.
Class III Route	Spur Alley from 53rd to Hollis		

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