San Mateo Countywide Bike and Pedestrian Plan

C/CAG
City/County Association of Governments
of San Mateo County

Appendix A: Design Toolkit

COUNTYWIDE BICYCLE AND PEDESTRIAN PLAN: TREATMENT TOOLKIT

April 2021

C/CAG
City/County Association of Governments
of San Mateo County

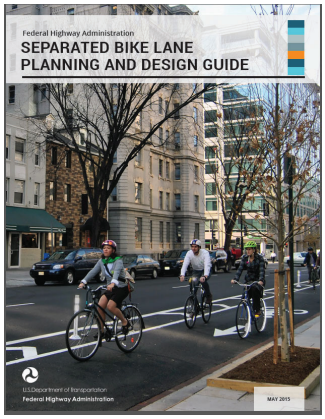
TOOLE DESIGN

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

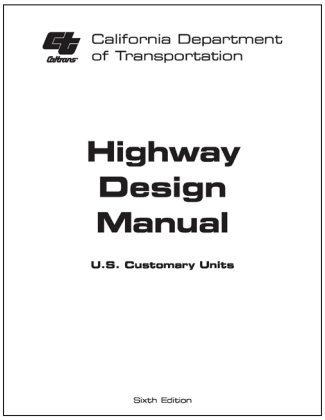
STANDARDS & RESOURCES

The facilities and amenities included in this toolkit are based on the recommendations from the following state and national standards and resources:



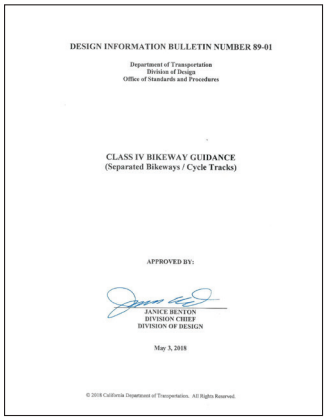
Federal Highway Administration (FHWA)

Separated Bike Lane Planning and Design Guide, 2015



California Department of Transportation (Caltrans)

Highway Design Manual, 2006

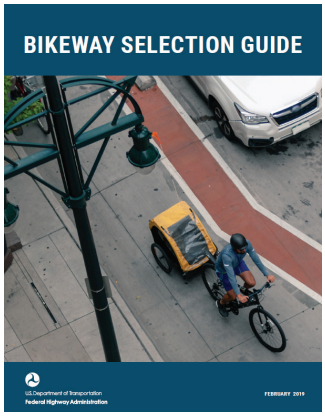


California Department of Transportation (Caltrans)

Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks), 2018

California Department of Transportation (Caltrans)

Manual on Uniform Traffic Control Devices, 2014



Federal Highway Administration (FHWA)

BIkeway Selection Guide (2019)

Massachusetts Department of Transportation (MassDOT)

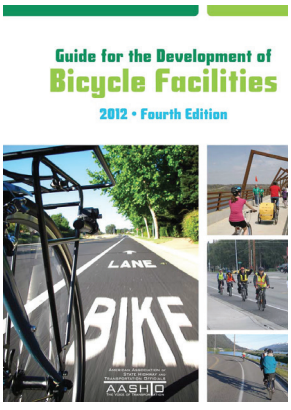
Separated Bike Lane Planning & Design Guide, 2016

National Association of City Transportation Officials (NACTO)

Urban Street Design Guide, 2013

Transit Street Design Guide, 2017

Urban Bikeway Design Guide, 2012



American Association of State Highway and Transportation Officials (AASHTO)

Guide for the Development of Bicycle Facilities, 2012

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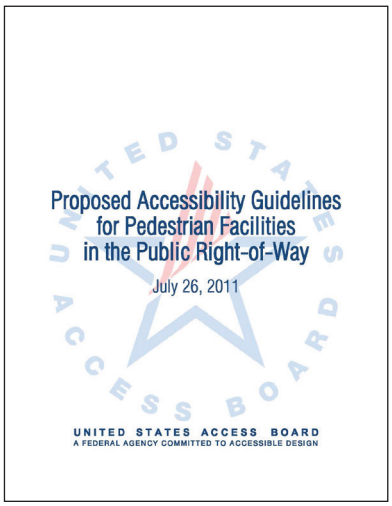
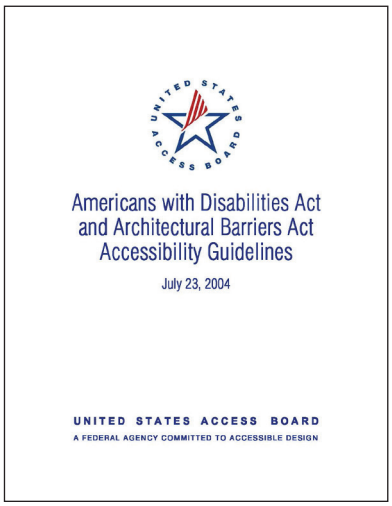


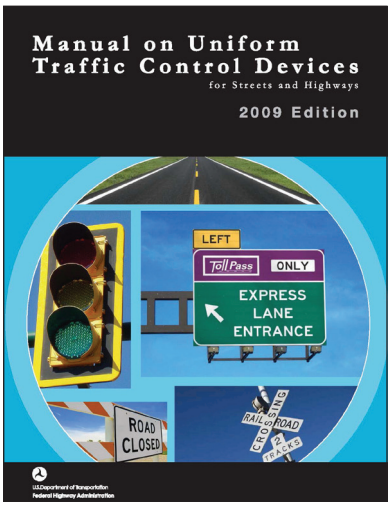
United States Access Board

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way, 2015



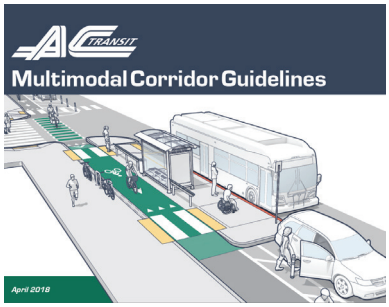
United States Access Board

Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, 2004



Federal Highway Administration (FHWA)

Manual on Uniform Traffic Control Devices, 2009

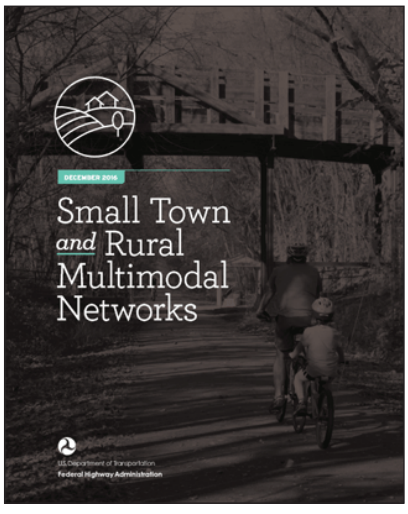


Alameda-Contra Costa Transit District

Multimodal Corridor Guidelines, 2018

Federal Highway Administration (FHWA)

Safe Transportation for Every Pedestrian, 2017



Federal Highway Administration (FHWA)

Small Town and Rural Multimodal Networks, 2016

PEDESTRIAN FACILITIES

ELEMENTS OF A STREETSCAPE

Sidewalks play a critical role in the character, function, enjoyment, and accessibility of neighborhoods, main streets, and other community destinations. In addition to providing space for pedestrians separated from motor vehicles, the space between property lines and curbs also accommodates street trees and other plantings, stormwater infrastructure, street lights, and bicycle racks. This section defines those zones and provides considerations for better activating the streetscape to enhance peoples' experiences.

ZONES

Frontage Zone:

The Frontage Zone is the area of sidewalk that immediately abuts buildings along the street. In residential areas, the Frontage Zone may be occupied by front porches, stoops, lawns, or other landscape elements that extend from the front door to the sidewalk edge. The Frontage Zone of commercial properties may include architectural features, outdoor displays, café seating, awnings, signage, etc. Frontage Zones may vary widely in width from just a few feet to several yards.

Pedestrian Zone:

Also known as the "walking zone," the Pedestrian Zone is the portion of the sidewalk space used for active travel. For it to function, it must be kept clear of any obstacles and be wide enough to comfortably accommodate expected pedestrian volumes (as anticipated by density and adjacent land use) including those using mobility assistance devices, pushing strollers, or pulling carts.

Amenity Zone:

The Amenity Zone, or "landscape zone," lies between the curb and the Pedestrian Zone. This area is occupied by fixtures such as street lights, trees, bicycle racks, parking meters, signposts, signal boxes, benches, trash and recycling receptacles, and other amenities. In commercial areas, it is typical for this zone to be hardscape pavement, pavers, or tree grates. In residential, or lower intensity areas, it is commonly a planted strip.

Frontage, Pedestrian and Amenity Zones

CONSIDERATIONS

+ Vibrant street walls with active uses adjacent to the sidewalk are particularly valuable and are essential to Main Street contexts. Where an active use adjacent to the sidewalk is not feasible, visually engaging walls should be provided adjacent to the street.

+ Outdoor dining opportunities contribute to a lively street environment and add economic value by enabling private commercial activity to spill into the public environment of the street. Sidewalk cafés are encouraged in Main Street contexts and other areas with commercial activity.

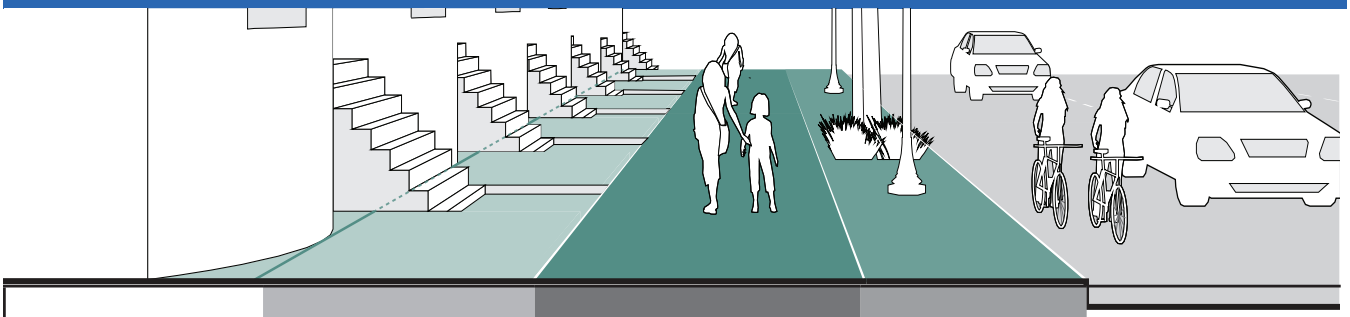
+ Planting in the public right-of-way typically occurs in the Amenity Zone; however, this is not the only place that can accommodate planting. Wherever there is an opportunity for landscape features, street or development projects should also look for opportunities to incorporate best management practices (BMPs), such as rain gardens. The preferred BMPs for use in the right-of-way are above-grade systems located within the sidewalk that treat stormwater runoff from adjacent roads and sidewalks.

+ While there are some exceptions, most street furniture installation is installed in the Amenity Zone. For example, on occasion bicycle parking may be installed in the frontage zone if it is sufficiently wide enough to accommodate it. Regardless, street furniture should not impede movement in the Pedestrian Zone.

+ Seating is most commonly located in the Amenity Zone of the street, but may also be placed in the Frontage Zone. Seating in the Amenity Zone should generally face away from the street and toward the sidewalk or be aligned perpendicular to the curb. Seating in the Frontage Zone should face the street.

SIDEWALK ZONE PREFERRED WIDTHS

The width of the various sidewalk zones will vary given the street type, the available right-of-way, scale of the adjoining buildings and the intensity and type of uses expected along a particular street segment. A balanced approach for determining the sidewalk width should consider the character of the surrounding area and the anticipated pedestrian activities. For example, is the street lined with retail that encourages window shopping or does it connect a residential neighborhood to a commercial area where pedestrians frequently need to pass one another? Does the scale of the buildings and the character of the street indicate a need for a wider sidewalk?



Street Type	Frontage Zone door swings, awnings, café seating, retail signage and displays, building projections	Pedestrian Zone zone should be clear of any and all fixed obstacles; clear space for pedestrian travel only.	Amenity Zone street lights and utility poles, street trees, bicycle racks, parking meters, transit stops, stormwater facilities, street furniture and signage	Preferred Total Width
Transit Station Areas	2 to 5 feet	6 to 15 feet	6 to 10 feet	14 to 30 feet
School Zones	2 to 6 feet	6 to 10 feet	6 to 10 feet	14 to 22 feet
Downtown/Urban Centers/Main Streets	2 to 6 feet	6 to 18 feet	6 to 10 feet	14 to 30 feet
Suburban Commercial	2 feet	6 to 8 feet	6 to 7 feet	14 to 17 feet
Suburban Areas/Residential Developments	2 feet	6 feet	5 to 7 feet	11 to 13 feet
Rural Areas	N/A	6 to 10 feet	5 to 10 feet	11 to 20 feet

CONSIDERATIONS

+ In locations with severely constrained rights-of-way, it is possible to provide a narrower Frontage Zone and Pedestrian Zone. Sidewalk width is based on local context, therefore in retrofit locations where development is not occurring and where existing building are anticipated to remain, 5-foot-wide sidewalks may be adequate.
+ Frontage Zones used for sidewalk cafés are a special condition and should generally be no less than 6 feet in width.
+ Where on-street parking is not present, the wider dimensions should be provided.
+ The provision of tree wells or landscape strip within the Amenity Zone will be based on the existing or planned character of the neighborhood.
+ Sidewalk stormwater facilities (including rain gardens) require a minimum of 7 feet of width for the Amenity Zone. The final dimensions will be established based on the context of each landscape area. Where stormwater facilities are not provided in the Amenity Zone, this area may be at the lower end of the range.

REFERENCES

NACTO. Urban Street Design Guide. 2013.

U.S. Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

ALTERNATIVE WALKWAYS

Often, traditional sidewalks are either not feasible or may be undesirable, particularly in rural communities. In these cases, people are frequently left walking on the side of the road with little to no protection from fast moving vehicles. Alternative walkways aim to provide a more comfortable space for people walking and rolling where a sidewalk may not be feasible. These walkways typically cost less money to construct and preserve the rural character of a street.

APPLICATION

- The method of separation should depend on motor vehicle speeds and volumes. For speeds below 25 mph, and volumes below 2,000 ADT, a striped edge line can be sufficient. For roadways with higher vehicle speeds and volumes, vertical elements such as wood, concrete, or asphalt curbing or flexible posts should be used to separate people walking and rolling from vehicle traffic.
- Provide traffic calming elements to slow vehicle speeds when speed and volume thresholds cannot be met.
- On streets where there are no bicycle facilities, bicyclists may be inclined to use the pedestrian walkway. Where bicyclists are expected to use the facility, provide wider walkways to accommodate people passing one another.
- Consider drainage when constructing alternative walkways to ensure pooling doesn't occur within the path of the walkway.

CONSIDERATIONS

- Alternative walkways should be a minimum of 6 feet in width, with a preferred width of 8 feet.
- Walkways should be designed to be accessible for people using mobility devices, following guidance in the ADA Accessibility Guidelines and PROWAG. Paved surfaces with accessible slopes are preferred whenever possible.
- Provide tactile warning indicators at all crossing locations to ensure that people with low or no vision can detect that they are about to enter the roadway.
- On streets with vehicle speeds below 25mph and volumes below 2,000 ADT, bicyclists should be expected to travel in the roadway with vehicles. Shared lane markings should be provided to encourage bicyclists to ride outside of the walkway area.
- Signage and pavement markings should be used to prohibit vehicles from parking in the walkway.

REFERENCES

ADA. Accessibility Guidelines. 2004.

FHWA. Manual on Uniform Traffic Control Devices. 2009.

U.S. Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

PEDESTRIAN-SCALE LIGHTING

Lighting at crosswalks and along sidewalks can help increase visibility for pedestrians and improve safety for all roadway users. Increasing or adding lighting to crosswalks, road segments, and intersections improves pedestrian and bicyclist safety by reducing crashes, increasing yielding and compliance with traffic control devices, and improving visibility.

APPLICATION

+ Pedestrian-scale lighting is lower than 20 feet and should be used alone or in combination with roadway-scale lighting in high-activity areas to encourage nighttime use.
+ Common locations for pedestrian-scale lighting include under crossings, commercial or retail areas, transit stops, and near parks and recreation centers.
+ In urbanized areas, lighting is desirable at intersections and other potential pedestrian crossing areas, particularly where a higher volume of pedestrians is expected. The selection of light post locations impacts the effectiveness of the lighting. An offset location of the luminaries may provide for better visibility or contrast.

CONSIDERATIONS

+ Use clear and consistent patterns to reinforce the direction of travel and delineate intersections.
+ Lighting can be used to illuminate sidewalks, trails, crosswalks, and approaches to intersections.
+ Lighting may either alternate on either side of a street or be arranged parallel. Parallel arrangements are more formal and common in retail activity centers.
+ Critical locations such as ramps, crosswalks, transit stops and seating areas that are used at night must be visible and lit.
+ Trees can interfere with intended lighting patterns, particularly in season of full foliage. Light and tree placement should be coordinated to provide consistent lighting year-round.

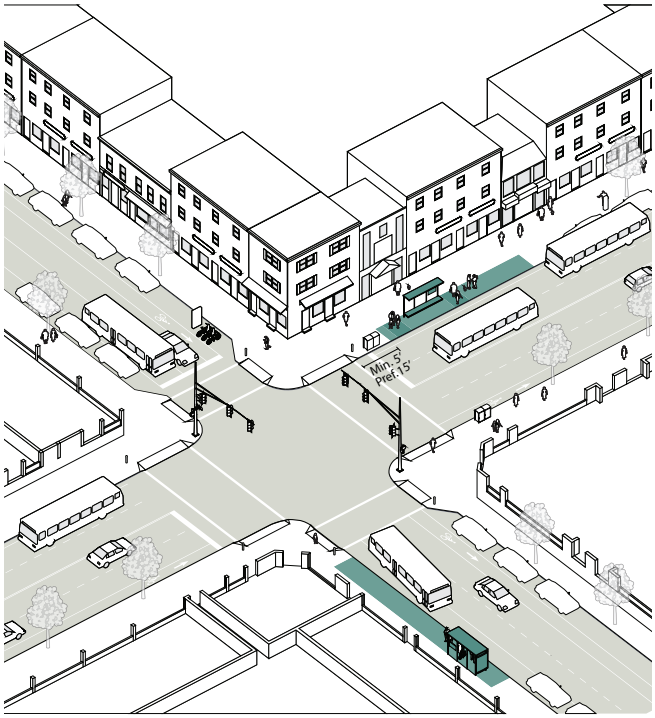
REFERENCES

Pedestrian Safety Guide and Countermeasure Selection System. 2013.

FHWA. Lighting Handbook. 2012.

TRANSIT STOPS

Any marked or signed location where transit vehicles stop and service passenger boarding and alighting is a transit stop. The most basic transit stops have only a pole-mounted "header" sign indicating the transit provider and route(s). High frequency routes and higher volume stops generally have more passenger amenities such as benches, shelters, traveler information, trash receptacles, bicycle parking, and other features.



APPLICATION

+ Landing zones should be provided at all doors of the transit vehicle. Buses can vary in length and will have different door configurations. Landing zones should be designed in coordination with all transit providers.

CONSIDERATIONS

+ Transit stops on urban streets are typically located at the natural curb line or on a bus bulb or transit island. Dedicated transit facilities may use medians. Transit operations, curbside uses, posted speed limits, traffic volumes, transit frequency and typical bus dwell time all influence location decisions for transit stops. See Transit Accommodations at Intersections for bus bulb design guidance.

+ Transit stops may be located on the "near-side" of an intersection before a signal or cross street, on the "far-side" after a bus has passed through an intersection, or at a mid-block location between intersections.

+ Transit stop locations are determined based on a number of factors including intersection operations, bus routing, curbside conditions, transfer points, intersection geometry and sightlines, consideration of other street users, and major generators or destinations. The location of a transit stop can affect transit travel time, passenger safety, and roadway operations.

+ Generally, transit agencies prefer far-side stops when traffic flows are heavy, where there are sight distance problems, and where buses turn left. Near-side located bus stops may be appropriate where traffic flow is lower or where transit riders can more easily transfer without crossing the street. Stops can also be placed mid-block where there are major passenger generators or where space next to an intersection is insufficient.

+ Regardless of location, all transit stops must be ADA compliant, and should be safe, convenient, well-illuminated, and clearly visible. Transit stops should be connected to the larger pedestrian network with continuous sidewalks, curb ramps, and safe pedestrian crossings. Mid-block stops should provide access to mid-block crosswalks.

+ Bus bulbs may be considered where additional pedestrian space is needed or where it is challenging for transit vehicles to reenter traffic.

+ Seating at or near transit stops can improve passenger comfort, as can shade in the form of street trees or awnings. Seating need not be a unique and dedicated element, but may include leaning rails, planters, ledges, or other street elements.

REFERENCES

AASHTO. Guide for Geometric Design of Transit Facilities on Highways and Streets. 2014.

NACTO. Urban Street Design Guide. 2013.

GREEN STORMWATER INFRASTRUCTURE

Trees, shrubs, grasses and other plantings play an important role in making streets comfortable, delightful, memorable, and sustainable. Green stormwater infrastructure refers to the use of vegetation to capture stormwater in the public right-of-way before it enters a jurisdiction's stormwater system. Stormwater features may infiltrate, retain, detain, convey and/or treat stormwater, depending on the facility and the context. Green stormwater elements should be incorporated into medians, streetscapes, and traffic calming strategies whenever possible to maximize benefits.

APPLICATION

+ Similar to street trees, green stormwater infrastructure elements have environmental and aesthetic benefits. With careful design, elements can be modified to fit within physical constraints, integrated into medians or added to the curbside buffer or frontage zones of sidewalks.
+ Green stormwater infrastructure can be designed for use along curbed and curbless streets.
+ Stormwater planters are designed to capture and absorb runoff from surrounding impervious areas including rooftops, sidewalks, plazas, parking lots and streets. They consist of structural walls and curbs which form the planter, underdrains and overflow drains connected to the storm drain system, a high draining soil mix above a gravel layer, mulch and plants.
+ Linear bioretention functions similarly to stormwater planters by receiving and filtering stormwater. Linear bioretention are built into the existing subgrade and may appear more like conventional landscaped areas when compared to stormwater planters. Linear bioretention requires more space given their larger size (relative to typical stormwater planters) and are more likely to be constrained by existing below ground utilities. Benefits include the potential to treat slightly larger drainage areas and the ability to support more plantings.

CONSIDERATIONS

+ Drainage patterns and design elements that tie into existing pipes can present significant challenges when integrating green nfrastructure into street designs. For example, medians are usually at the crown of the roadway, with water draining away from them.
+ Presence of existing underground utilities, especially the potential cost associated with reconfiguration of such utilities to accommodate the footprint of the stormwater element.
+ Impacts on maneuverability and access required for emergency vehicle response.
+ Ability to conduct routine and non-routine maintenance activities safely and effectively.
+ Cost effectiveness of stormwater benefit provided given the challenges of smaller drainage areas and limited space to provide treatment within the right-of-way.
+ Development right of adjacent properties that may be impacted by the presence of a stormwater element in the right-of-way.
+ Important considerations when selecting the right type of vegetation include sight line requirements; the type of microclimate; tolerance to drought and inundation; resistance to insects and disease; resistance to vehicular emissions; the ability to remediate pollutants; and the amount of maintenance required.
+ The San Mateo Countywide Sustainable Streets Master Plan contains more information about green storm water infrastructure and sustinable street design.

REFERENCES

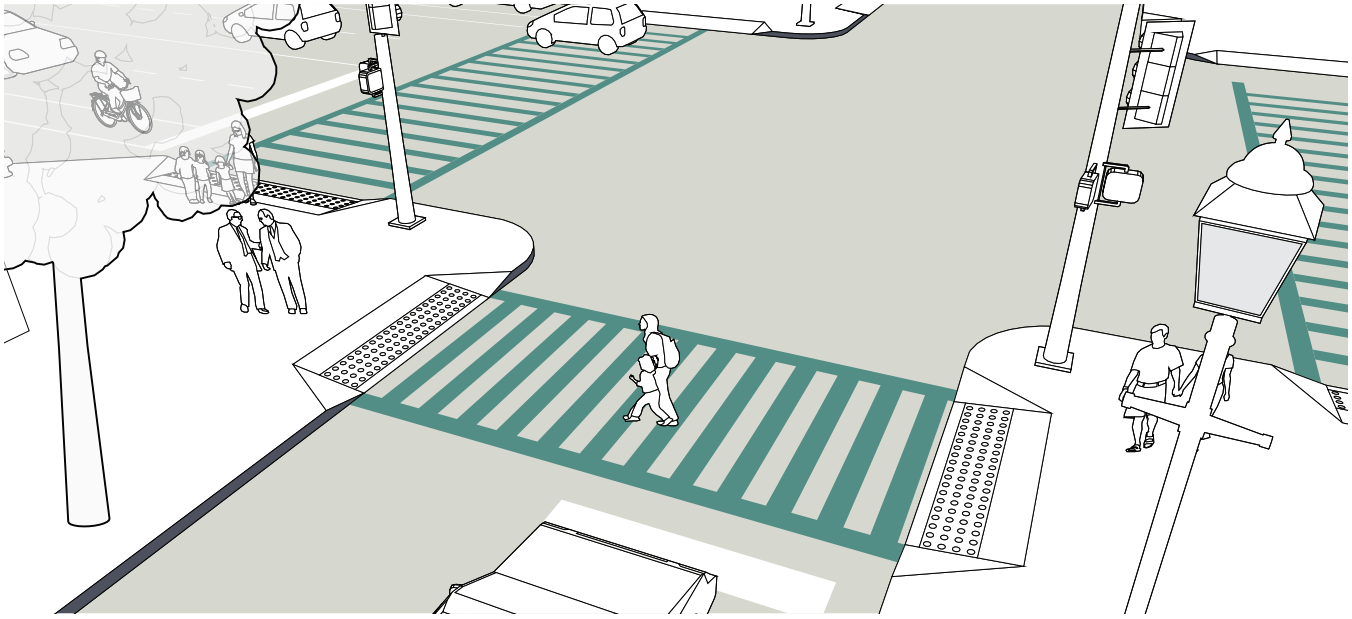
NACTO. Urban Street Stormwater Guide. 2017.

CCAG. San Mateo COuntywide Sustainable Streets Master Plan. 2021.

PEDESTRIAN INTERSECTION AND CROSSING TREATMENTS

CROSSWALK POLICY AND DESIGN

Legal crosswalks exist at all locations where sidewalks meet the roadway, regardless of whether pavement markings are present. Drivers are legally required to yield to pedestrians at intersections, even when there are no pavement markings. Providing marked crosswalks communicates to drivers that pedestrians may be present, and helps guide pedestrians to locations where they should cross the street. In addition to pavement markings, crosswalks may include signals/beacons, warning signs, and raised platforms.



APPLICATION

+ There are many different styles of marked crosswalk striping and some are more effective than others. Ladder and continental striping patterns are more visible to drivers.
+ Raised crossings can calm traffic and increase the visibility of pedestrians.

CONSIDERATIONS

+ Place marked crosswalks on all legs of signalized intersections, in school zones, and across streets with more than minimal levels of traffic.
+ Marked crosswalks should be at least 10 feet wide or the width of the approaching sidewalk if it is greater. In areas of heavy pedestrian volumes (such as Transit Station Areas, School Zones, and Main Streets), marked crosswalks can be up to 25 feet wide.
+ Stop lines at stop-controlled and signalized intersection approaches should be striped no less than 4 feet and no more than 30 feet from the edge of marked crosswalks.
+ For enhanced crossing treatments, refer to the section of this guide addressing Rectangular Rapid Flashing Beacons and HAWK Pedestrian Signals.
+ Marked crosswalks should be oriented perpendicular to streets, minimizing crossing distances and therefore limiting the time that pedestrians are exposed.

REFERENCES

ADA Accessibility Guidelines. 2004.

FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

U.S. Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines. 2005.

CURB RAMPS

The transition for pedestrians from the sidewalk to the street is provided by a curb ramp. The designs of curb ramps are critical for all pedestrians, but particularly for people with disabilities. The ADA Standards require all pedestrian crossings be accessible to people with disabilities by providing curb ramps at intersections and midblock crossings as well as other locations where pedestrians can be expected to enter the street. Curb ramps also benefit people pushing strollers, grocery carts, suitcases, or bicycles.

APPLICATION

+ At all intersections where pedestrians are permitted and expected to cross the street per ADA requirements.

CONSIDERATIONS

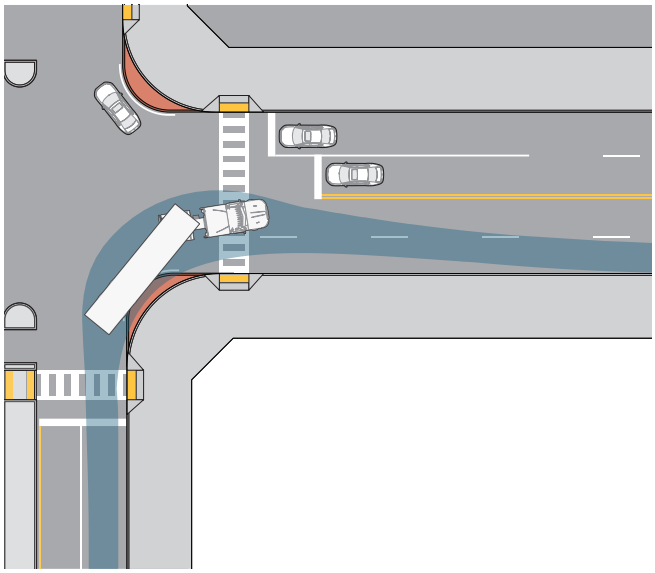
+ Furnishing zones or terraces (the space between the curb and sidewalk) of 7' of width provide just enough space at intersections for curb ramps to gain sufficient elevation to a sidewalk.
+ Separate curb ramps should be provided for each crosswalk at an intersection rather than a single ramp at a corner for both crosswalks. The separate curb ramps improve orientation for visually impaired pedestrians by directing them toward the correct crosswalk.
+ Curb ramps are required to have landings. Landings provide a level area with a cross slope of 2% or less in any direction for wheelchair users to wait, maneuver into or out of a ramp, or bypass the ramp altogether. Landings should be 5' by 5' and shall, at a minimum, be 4' by 4'.
+ Consider providing wider curb ramps in areas of high pedestrian volumes and crossing activities.
+ Flares are required when the surface adjacent to the ramp's sides is walkable, however, they are unnecessary when this space is occupied by a landscaped buffer. Excluding flares can also increase the overall capacity of a ramp in high-pedestrian areas.

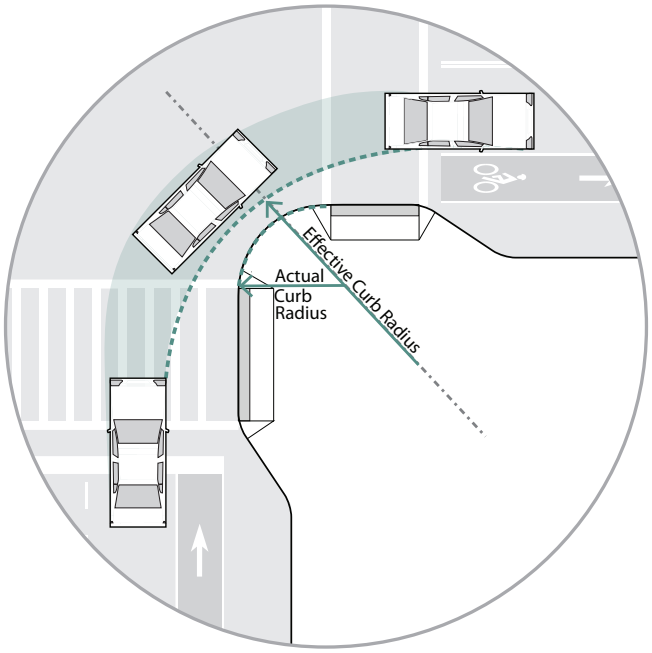
REFERENCES

U.S. Access Board. Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

CORNERS AND CURB RADII

Pedestrian safety and comfort is enhanced by smaller curb radii, which shorten crossing distances for pedestrians and reduce vehicle turning speeds. However, streets must accommodate large turning vehicles, including school buses and transit vehicles. One of the most challenging aspects of intersection design is to determine methods of accommodating large vehicles while keeping intersections as compact as possible. This requires a great deal of design flexibility and engineering judgment, as each intersection is unique in terms of the angles of the approach and departure, the number of travel lanes, the presence of a median, and a number of other features that fundamentally impact corner design.





APPLICATION

+ The design vehicle should be selected according to the types of vehicles using the intersection with considerations to relative volumes and frequencies. In most cases, the curb radii are based on a Single Unit vehicle with a 42-foot turning radius. If accommodations are needed for a larger design vehicle, a radius evaluation based on this larger vehicle would be required. Examples of typical turning templates would include a SU, WB-40, WB-50, WB-60 and WB-62.

+ Intersection design should strive for the minimum curb radius that accommodates a frequent design vehicle. The maximum curb radii are shown below.

CONSIDERATIONS

+ In some cases, it may be possible to allow a large turning vehicle to encroach on the adjacent travel lane on the departure side (on multi-lane roads) to make the turn.

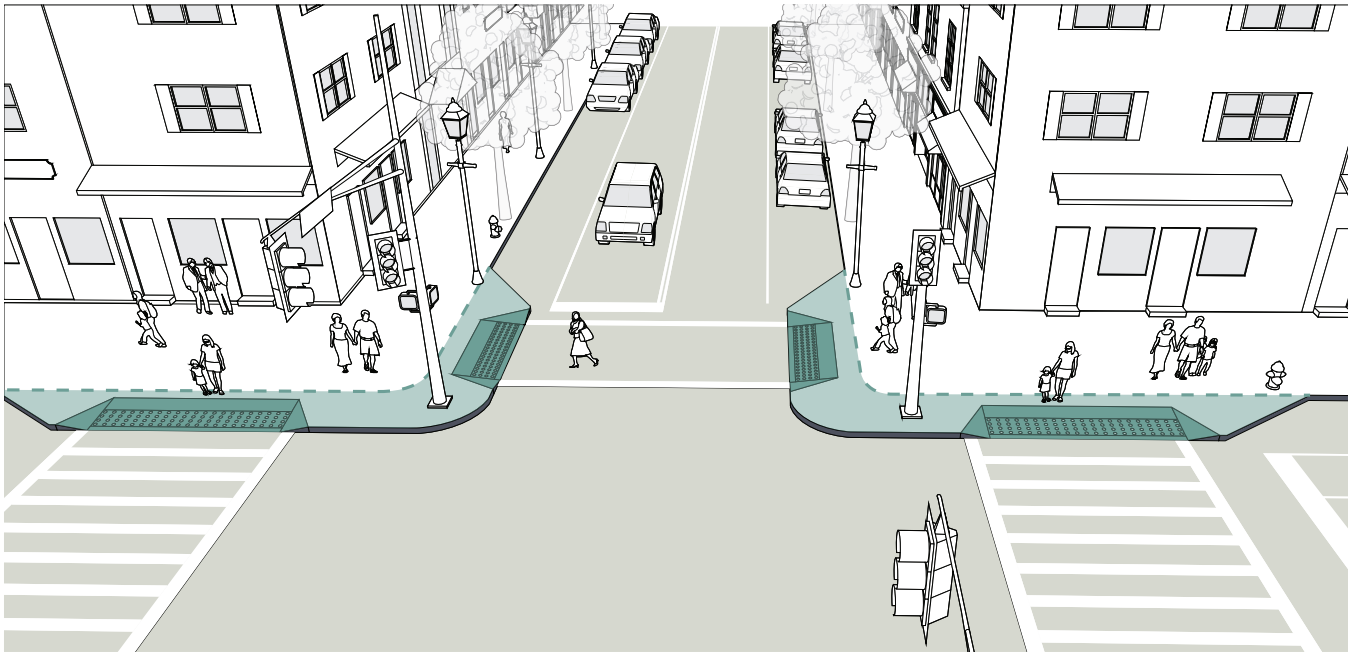
+ Mountable truck aprons deter passenger vehicles from making higher-speed turns, but accommodate the occasional large vehicle without encroachment or off-tracking into pedestrian areas. Mountable truck aprons should be visually distinct from the adjacent travel lane and sidewalk.

REFERENCES

NACTO. Urban Streets Design Guide. 2013.

CURB EXTENSIONS

Curb extensions, also known as neckdowns, bulb-outs, or bump-outs, are created by extending the sidewalk at corners or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities. In addition to shortening crossing distances, curb extensions can be used to change the geometry of intersections resulting in smaller corner radii and slowing turning motor vehicles.



APPLICATION

+ Curb extensions should be considered only where parking is present or where motor vehicle traffic deflection is provided through other curbside uses such as bicycle share stations or parklets. They cannot be installed where the curbside lane is a vehicle travel lane.
+ Curb extensions are particularly valuable in locations with high volumes of pedestrian traffic, near schools, at unsignalized pedestrian crossings, or where there are demonstrated pedestrian safety issues.

CONSIDERATIONS

+ The turning needs of emergency and larger vehicles should be considered in curb extension design.
+ Care should be taken to maintain direct routes across intersections by aligning pedestrian desire lines on either side of the sidewalk. Curb extensions often make this possible as they provide extra space for grade transitions.
+ Consider providing a 20' long curb extension to restrict parking within 20' of an intersection to enhance visibility.
+ When curb extensions conflict with turning movements, reducing the width and/or length of the curb extension should be prioritized over elimination.
+ Emergency access is often improved through the use of curb extensions because intersections are kept clear of parked cars.
+ Curb extensions can be designed with green infrastructure to improve stormwater management. See Green Stormwater Infrastructure on Page 11 for more information.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

NACTO. Urban Street Design Guide. 2013- Curb Extensions.

PEDESTRIAN SIGNALS

Pedestrian signal heads display the three intervals of the pedestrian phase: (1) The Walk Interval, signified by the WALK indication (or the walking person symbol) alerts pedestrians to begin crossing the street. (2) The Pedestrian Change Interval, signified by the flashing DON'T WALK indication (or the flashing hand symbol and countdown display) alerts pedestrians approaching the crosswalk that they should not begin crossing the street. (3) The Don't Walk Interval, signified by a steady DON'T WALK indication (or the steady upraised hand symbol) alerts pedestrians that they should not cross the street.

CONSIDERATIONS

A primary challenge for traffic signal design is minimizing conflicts between motor vehicle and pedestrian movements. Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians. Traffic movements should be analyzed to implement WALK intervals during non-conflicting phases.

Signal design should also minimize the time that pedestrians must wait. Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (crossing against the signal) after waiting longer than 30 seconds.

Free-flowing right-turn lanes are discouraged at signalized intersections. Where they are present and unsignalized, the pedestrian signal and pushbutton should be located on the channelization ("pork chop") island and a yield or crosswalk warning sign should be placed in advance of the crosswalk.

GUIDANCE: TIMING & ACTIVATION

+ Pedestrian signals should allocate enough time for pedestrians of all abilities to safely cross the roadway. The MUTCD specifies a pedestrian walking speed of 3.5 feet per second to account for an aging population.
+ Countdown pedestrian displays inform pedestrians of the amount of time in seconds that is available to safely cross during the flashing DON'T WALK (or upraised hand) interval. All pedestrian signal heads should contain a countdown display provided with the DON'T WALK (or upraised hand) indication.
+ In areas with higher pedestrian activity, such as near transit stations, Main Streets, and school zones, push button actuators may not be appropriate. People should expect to get a pedestrian cycle at every signal phase, rather than having to push a button to call for a pedestrian phase.

GUIDANCE: ACCESSIBLE PEDESTRIAN SIGNALS (APS)

Accessible pedestrian signals and accessible detectors are devices that communicate information in non-visual formats about the pedestrian phase to pedestrians with visual and/or hearing disabilities. APS and detectors may include features such as audible tones, speech messages, detectable arrow indications and/or vibrating surfaces.

+ Pushbutton locator tones are used for locating the pedestrian pushbutton needed to actuate the WALK interval. Detectable arrows should be located on pushbuttons to point in the same direction as the crosswalk. At corners of signalized locations where two pushbuttons are present, they should be separated by at least 10 feet.
+ Audible walk indications should have the same duration as the pedestrian walk indication unless the pedestrian signal rests during the pedestrian phase, in which case the audible indication should be provided in the first seven seconds of the WALK interval.
+ For automatically-called pedestrian phases, pushbuttons can be used to activate accessible pedestrian signal features such as detectable arrow indications and/or speech messages.
+ When new pedestrian signals are installed, APS with pushbuttons are required. For existing pedestrian signals, the APS and pedestrian pushbuttons should be provided when the signal controller and software are altered, or the signal head is replaced.

REFERENCES

FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

GUIDANCE: LEADING PEDESTRIAN INTERVAL (LPI)

The Leading Pedestrian Interval initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This signal timing technique allows pedestrians to enter the intersection prior to turning vehicles, increasing visibility between all modes.

+ The LPI should be used at intersections with high volumes of pedestrians and conflicting turning vehicles and at locations with a large population of elderly or school children who tend to walk slower.
+ A lagging protected left arrow for vehicles should be provided to accommodate the LPI.
+ If an intersection has particularly high pedestrian traffic, consider lengthening the leading pedestrian interval or adding an exclusive pedestrian phase instead of a leading pedestrian interval.
+ If an intersection has such high pedestrian volumes that motorists are unable to turn across the crosswalk, the green interval for the parallel concurrent vehicle traffic can be set to extend beyond the pedestrian interval to provide turning drivers with sufficient green time to make their turns.
+ The LPI should be accompanied by an audible noise to inform visually-impaired pedestrians that it is safe to cross.
+ LPIs may be less effective when used at intersections without right-turn-on-red restrictions.

GUIDANCE: PROTECTED SIGNAL PHASING

Protected phases at intersections provide a way to separate vehicular traffic from pedestrian and/or bicyclist movements, particularly for left-turns when concurrent phasing would result in a conflict with crossing pedestrians and left-turning vehicles and right-turns when concurrent phasing would result in a conflict with through bicyclists or crossing pedestrians and right-turning vehicles.

Signal timing decisions should consider the needs of pedestrians, bicyclists, trucks, buses, and other motor vehicles.

Protected signal phasing may beappropriate at the following locations:

+ Urban areas, particularly downtown locations.
+ Intersections with a history of left- or right-hook crashes with pedestrians (or bicyclists).
+ Intersections with high volumes of pedestrians (or bicyclists) and turning vehicles.

GUIDANCE: PEDESTRIAN SCRAMBLE

An all-walk phase, also known as a "pedestrian scramble," or exclusive pedestrian phase, is a phase at signalized intersections that allows pedestrians to cross in any direction. Motorists at all approaches to the intersection are stopped while pedestrians are given the WALK signal. This treatment is particularly advantageous in situations where other intersection treatments are cost prohibitive or unable to be implemented due to insufficient right-of-way.

Applicable contexts for this treatment include:

+ Densely populated urban areas, often in downtown areas.
+ Signalized intersections with high instances of turning-vehicle–pedestrian conflicts.
+ High pedestrian volumes and either low-to-moderate vehicle volumes or high turning-vehicle volumes.

Additional implementation considerations include:

+ Typically requires longer overall signal cycle lengths which increases delay for all users.
+ Non-visual guidance should be provided for pedestrians who are visually impaired so that they know when it is an appropriate time to cross; normal auditory cues are not applicable at locations with exclusive pedestrian phases.
+ Sidewalk spaces must be sufficient to handle a queue of pedestrians waiting to cross.
+ The signal timing required for this treatment must be implemented in concert with adjacent intersections to ensure appropriate signal coordination.

RECTANGULAR RAPID FLASHING BEACONS

At some uncontrolled crossings, particularly those with four or more lanes, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds and poor pedestrian visibility combine to create conditions in which very few drivers are compelled to yield. One type of device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs combine a pedestrian crossing sign with a bright flashing beacon that is activated only when a pedestrian is present.

APPLICATION

+ RRFBs can be used when a signal is not warranted at an unsignalized crossing. They are not appropriate at intersections with signals or STOP signs.

CONSIDERATIONS

+ RRFBs are considerably less expensive to install than mast arm-mounted signals. They can also be installed with solar power panels to eliminate the need for an external power source.
+ RRFBs should be limited to locations with critical safety concerns, and should not be installed in locations with sight distance constraints that limit the driver's ability to view pedestrians on the approach to the crosswalk.
+ RRFBs should be used in conjunction with advance stop bars and signs.
+ RRFBs are usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route crossings or locations where bike facilities cross roads at mid-block locations.

REFERENCES

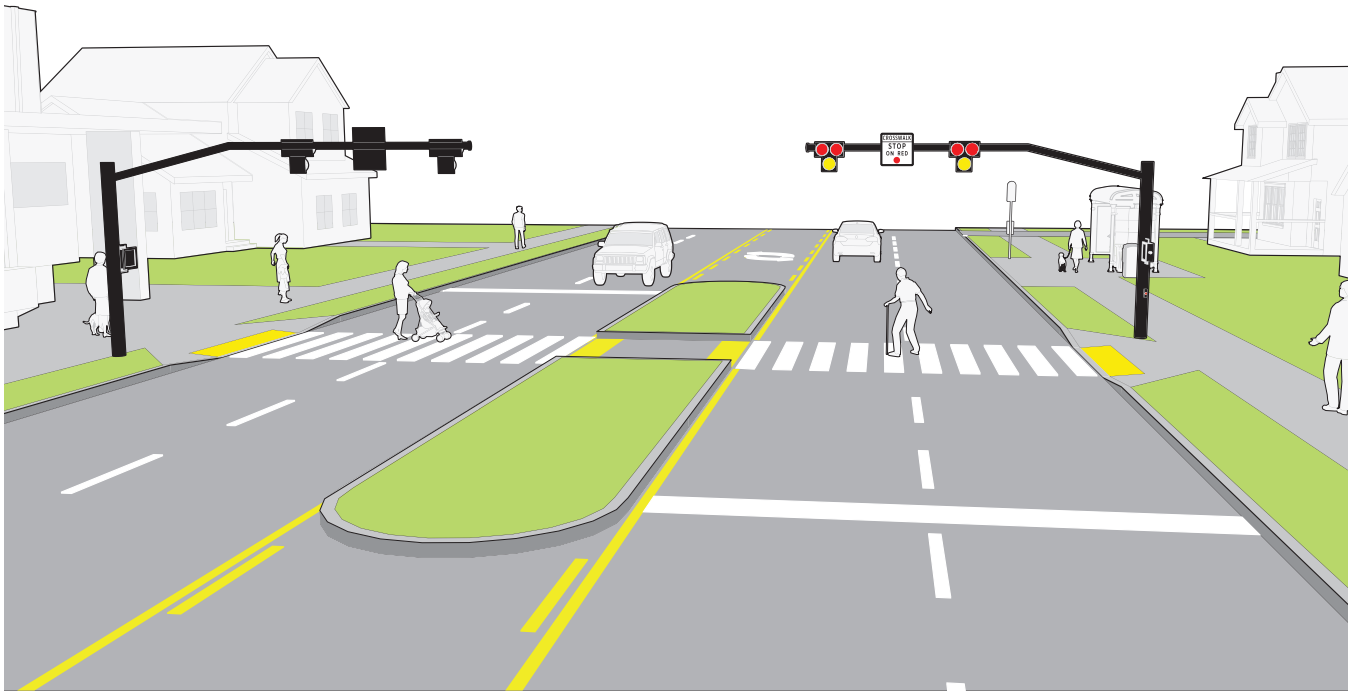
FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations. 2005.

PEDESTRIAN-ACTIVATED BEACONS

Pedestrian-activated beacons, including the High-intensity Activated Crosswalk Beacon (HAWK), are a type of hybrid signal intended to allow pedestrians and bicyclists to stop traffic to cross high-volume arterial streets. This type of signal may be used in lieu of a full signal that meets any of the traffic signal control warrants in the MUTCD. It may also be used at locations which do not meet traffic signal warrants but where assistance is needed for pedestrians or bicyclists to cross a high-volume arterial street.



APPLICATION

+ The MUTCD recommends minimum volumes of 20 pedestrians or bicyclists an hour for major arterial crossings (volumes exceeding 2,000 vehicles/hour).
+ This type of device should be considered for all arterial crossings in a bicycle network and for path crossings if other engineering measures are found inadequate to create safe crossings.

CONSIDERATIONS

+ While this type of device is intended for pedestrians, it would be beneficial to retrofit it for bicyclists as the City of Portland, Oregon has, using bicycle detection and bicycle signal heads on major cycling networks. Depending upon the detection design, the agency implementing these devices may have the option to provide different clearance intervals for bicyclists and pedestrians. The provision of bicycle signal heads would require permission to experiment from FHWA.

REFERENCES

FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Location. 2005.

SPEED TABLES AND RAISED CROSSWALKS

Vertical traffic calming treatments such as speed tables and raised crosswalks compel motorists to slow their speeds which improves safety and comfort for pedestrians and bicyclists. Raised crosswalks are created by raising the crossing to the level of the sidewalk. Raised crosswalks are speed tables, or trapezoid--shaped speed humps with a marked crosswalk across the top of the table. These treatments provide an array of benefits especially for people with mobility and visual impairments because there are no vertical transitions to navigate.

APPLICATION

+ Consider using raised crosswalks and speed tables at intersections to slow traffic turning onto the traffic-calmed street from a major street.
+ Raised crossings and speed tables are appropriate in areas of high pedestrian demand, including commercial and shopping districts, college campuses, and school zones. They should also be considered at locations where pedestrian visibility and motorist yielding have been identified as issues.
+ Raised crossings and speed tables are particularly valuable at unsignalized mid-block locations, where drivers are less likely to expect or yield to pedestrians.
+ Raised crossings can be provided along side streets of major thoroughfares to slow traffic exiting the main street.
+ Raised crossings should provide pavement markings for motorists and appropriate signage at crosswalks per the MUTCD.
+ Raised crossings an speed tables may not appropriate for high-speed roadways. Vehicle speeds, volumes, and the types of vehicles using the roadways are also factors to consider when implementing raised crossings.

CONSIDERATIONS

+ Raised crossings require detectable warnings for the visually impaired at the curb line to indicate where the roadway begins.
+ High-visibility or textured paving materials can be used to enhance the contrast between the raised crossing or intersection and the surrounding roadway.
+ Raised crossings can be used as gateway treatments to signal to drivers when there are transitions to a slower speed environment that is more pedestrian-oriented.
+ Designs should be carefully thought out to ensure proper drainage. Raised intersections can simplify drainage inlet placement by directing water away from the intersection. If the intersecting streets are sloped, catch basins should be placed on the high side of the intersection at the base of the ramp.
+ Design speeds and emergency vehicle routes must be considered when designing approach ramps.

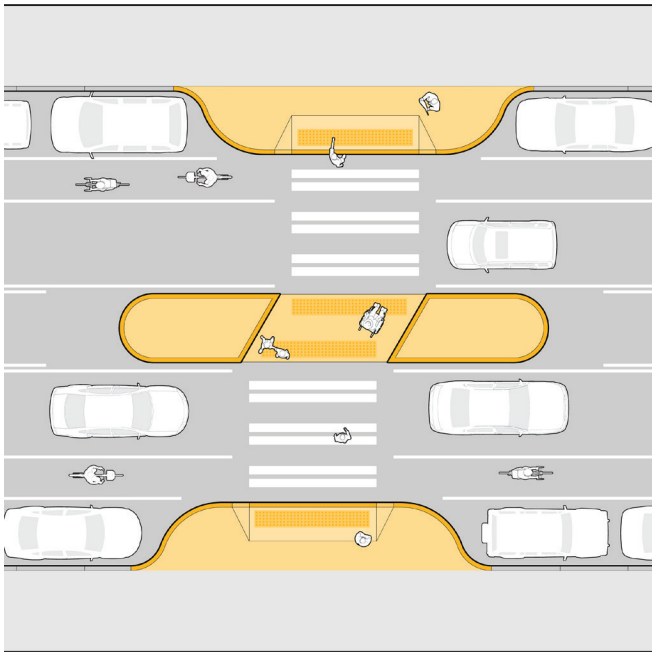
REFERENCES

NACTO. Urban Bikeway Design Guide. 2014.

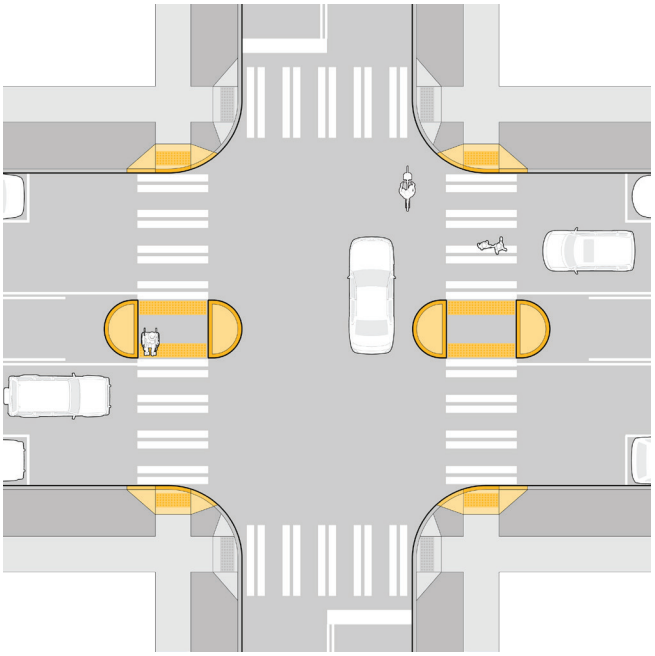
NACTO. Urban Street Design Guide. 2013.

MEDIAN REFUGES

Crossing islands are raised islands that provide a pedestrian refuge and allow multi-stage crossings of wide streets. They can be located mid-block or at intersections and along the centerline of a street, as roundabout splitter islands, or as "pork chop" islands where right-turn slip lanes are present.



Mid-block Crossing Island with Curb Extensions



Intersection Crossing Islands (Left Turns Prohibited)

APPLICATION

+ Medians can provide a place of refuge for pedestrians, allowing them to cross one direction of traffic at a time.
+ On a local road with relatively low traffic speeds and volumes, placing a raised median or crossing island might be done for aesthetic considerations or special pedestrian crossing characteristics and volumes.
+ On a collector road with moderate-to-high traffic speeds and volumes, or on multi-lane roadways, a raised median or crossing island installation should be strongly considered.
+ Should a midblock crossing be provided along a multilane arterial, a raised median or crossing island and supplementary traffic control devices are desirable.

CONSIDERATIONS

+ There are two primary types of crossing islands. The first type provides a cut-through of the island, keeping pedestrians at street-grade. The second type ramps pedestrians up above street grade and may present challenges to constructing accessible curb ramps unless they are more than 17 feet wide (accommodating for ramp width and landing area).
+ Crossing islands should be considered where crossing distances are greater than 50 feet. For long distances, islands can allow multi-stage crossings, which in turn allow shorter signal phases.
+ Crossing islands can be coupled with other traffic calming features, such as partial diverters and curb extensions at mid-block and intersection locations.
+ At mid-block crossings where width is available, islands should be designed with a stagger, or in a "Z" pattern, encouraging pedestrians within the median to face oncoming traffic before crossing.
+ Medians can be designed to include green infrastructure to improve stormwater management. See Green Stormwater Infrastructure on Page 11 for more information.

REFERENCES

NACTO. Urban Street Design Guide. 2013.

Manual on Uniform Traffic Control Devices. 2009.

RAISED MEDIANS OR HARDENED CENTERLINES

Raised medians or hardened centerlines are roadway design treatments designed to provide access management and to separate opposing directions of motor vehicle travel at intersections and midblock locations. They can be extended across an intersection or a driveway, creating a continuous median to provide access management restricting motorist turning or crossing movements.

APPLICATION

+ Where used as an access management strategy, they can simplify and improve safety for pedestrians and bicyclists by eliminating motorist left turns. When used at intersections and the hardened centerline or median extends up to or beyond crosswalks, they reduce left-turning motorist speeds.
+ Intersection or midblock crossing locations.
+ Locations where it is desired to restrict left-turning motorists to improve safety, such as those where left-turning motorists do not sufficiently yield, turn too fast, or cut across centerlines.

CONSIDERATIONS

+ Must be at least 6 feet in width to provide pedestrian refuge or 8 feet to provide bicyclists refuge.
+ Crossing islands greater than 6 or 8 feet in width and wider crossings should be considered where pedestrian or bicycle volumes are higher.
+ Landscaping should not obstruct visibility between pedestrians and approaching motorists.
+ Crossings must be fully accessible by means of ramps or cut-throughs, with detectable warnings.
+ Fences, railings, and curbs can orient pedestrians to face the direction of oncoming traffic.
+ If installing at midblock locations, consider accompanying this treatment with an active warning beacon.
+ Hardened centerlines can be created with temporary curbing with flexible delineators located on the centerline of a roadway.
+ Hardened centerlines may extend past the crosswalk to slow left-turning vehicles; however, vertical elements should not be located within the crosswalk.
+ Raised medians may take up space that can be better used for wider sidewalks, bicycle lanes, landscaped buffer strips, or on-street parking.

REFERENCES

NACTO. Urban Street Design Guide. 2013.

SCHOOL-SPECIFIC TREATMENTS

All treatments presented in this toolkit can be installed near schools to improve safety and comfort for people walking and bicycling. In addition, Caltrans allows jurisdictions to install a suite of additional treatments in school zones to further enhance safety for children.

R1-6

CONSIDERATIONS

Children walking may require more time to cross the street and be more difficult for motorists to see compared to the average person walking. As such, many schools and local jurisdiction staff implement treatments to slow motor vehicle speeds, reduce crossing distances, extend pedestrian signal lengths, and increase visibility of people walking. Common treatments installed near schools include:

- Leading pedestrian intervals
- Median refuges
- High-visibility crosswalk markings and advance yield/stop lines
- Curb extensions
- Speed tables and raised crossings
- Pedestrian crossing signs
- Rectangular Rapid Flashing Beacons

In addition, Caltrans allows jurisdictions to install the treatments listed below in school zones:

- Yellow “Slow School Xing” pavement markings
- Yellow crosswalk markings may be used at marked crosswalks with 600 feet of a school building or campus.
- Standard school zone speed limits are set at 25 mph. Engineering and traffic studies can be conducted to reduce speed limits to 15 or 20 mph in school zones.
- Overhead flashing beacons and pedestrian crossing signs with school children may be used at unsignalized school crossings.
- In-street pedestrian signs (also called paddle signs) may include school children symbol at school crossings.

REFERENCES

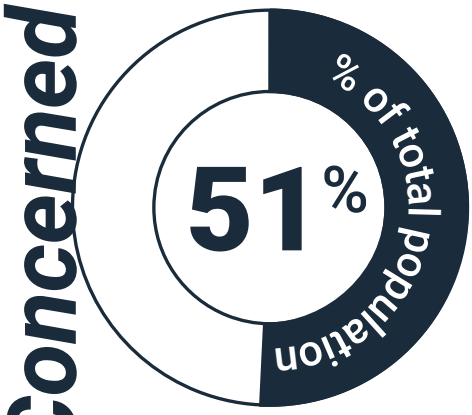
Caltrans. California Manual on Uniform Traffic Control Devices. 2012.

BICYCLE FACILITIES

POTENTIAL BICYCLE USERS

The figure below illustrates a typical range of cyclists. Estimates show the greatest percentage of the population—approximately 51%—fall into the "Interested but Concerned" category. The "Interested but Concerned" are most comfortable cycling separated from motorized vehicles. On the other end of the spectrum, roughly 4% of the population is "Strong and Fearless", comfortable sharing the road with motorized vehicles. In the middle, approximately 5% are "Enthusiastic and Confident", comfortable cycling for short distances with motorized vehicles. The remaining portion of the population falls under the category of "Non-Bicyclists", uncomfortable bicycling in any condition, have no interest in bicycling, or are physically unable to bicycle. See pages 28-29 to determine which facility types best serve the different types of cyclists.

Interested but Concerned



Who are they? A mother and daughter who enjoy Saturday rides to the park along the Alamo Creek Bike Path that runs near their house. Concern over crossing a busy road prevents them from riding together to elementary school during the week.

Who are they? A 45-year-old father of two who was just diagnosed with pre-diabetes. His doctor encouraged him to be more active, so he's been thinking about commuting to work by bike. As a motorist, he feels uncomfortable passing bicyclists, so he isn't sure he'd feel comfortable as a bicyclist sharing the road with cars.

Who are they? A worker who just started a new job at Kaiser Permenente. He enjoys riding as long as he stays on quiet streets or the sidewalk. He'd like to be able to ride to more destinations, but he's uncomfortable crossing busy roads and intersections along the way.

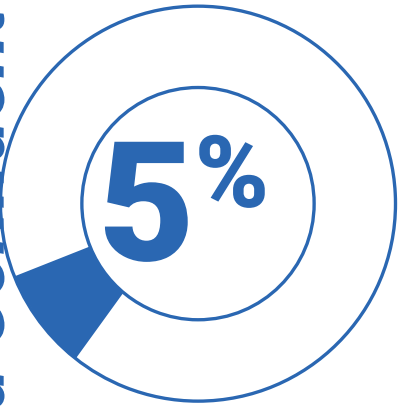
LOWER STRESS TOLERANCE

REFERENCES

- Speed thresholds based on Level of Traffic Stress. "Interested but Concerned" riders are sensitive to increases in volume or speed. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

POTENTIAL BICYCLE USERS

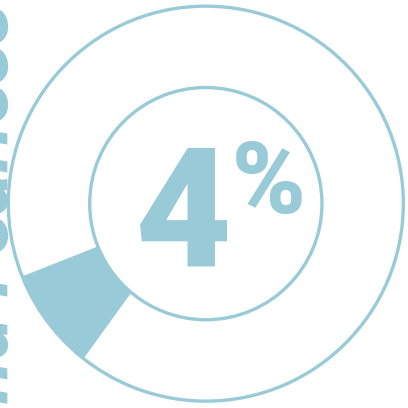
Enthusiastic and Confident



Who are they? A woman who rides her bike downtown every morning to run errands. She prefers to ride on neighborhood streets, but doesn't mind riding the last few blocks on a busy street since there's a bike lane.

Who are they? A lower-income resident who rides a bicycle to save money for other household expenses. He's comfortable riding on Tabor Avenue because it has bike lanes.

Strong and Fearless



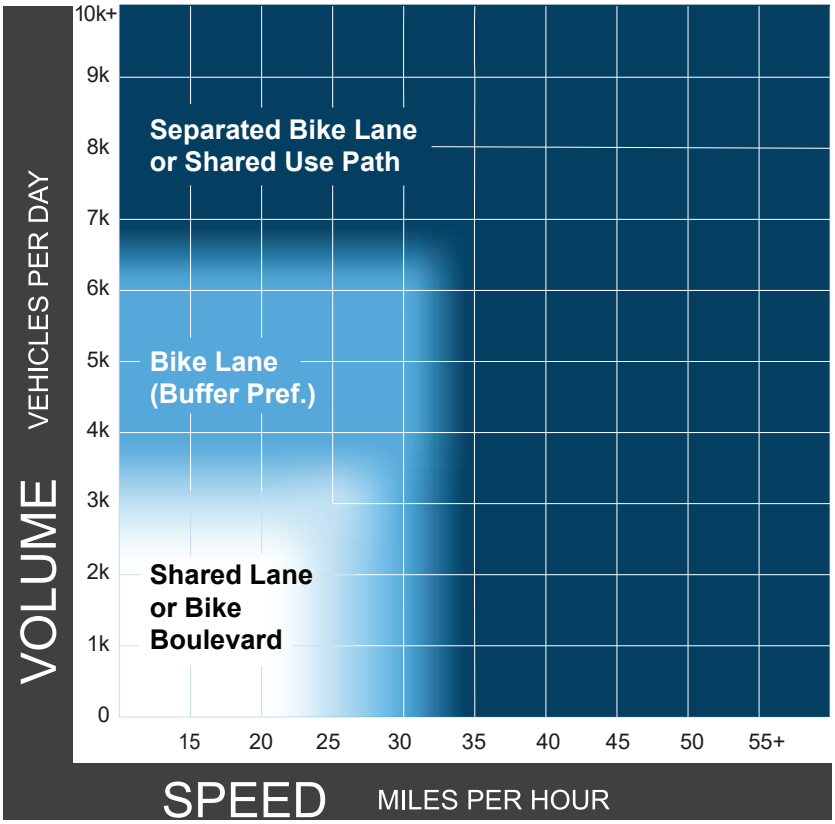
Who are they? A recent College of San Mateo grad who can't wait to hit the road this weekend for a 100-mile ride on his brand new road bike. He helped pay his way through college as a bike messenger, and loves the rush that he gets from racing.

HIGHER STRESS TOLERANCE

BICYCLE FACILITY SELECTION

Designing for Interested but Concerned and Enthusiastic and Confident Bicyclists

"Interested but Concerned" bicyclists prefer physical separation as traffic volumes and speeds increase. The bikeway facility selection chart below identifies bikeway facilities that improve the operating environment for this bicyclist type at different roadway speeds and traffic volumes. The "enthusiastic and confident" bicyclist will also prefer bikeway treatments noted in this chart. If a community's goal is to increase bicycling, it is appropriate to select facility types based on this chart.



Source: AASHTO Guide for the Development of Bicycle Facilities, 5th Edition (expected publication 2019).

* To determine whether to provide a shared-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

FACILITY DETAILS:

- Physically separated facility:
  - Separated bike lane or shared-use path, separated from traffic by parking, posts, curb, etc.
  - For two-way facility: 10 to 12 ft preferred, 8 ft minimum
- Bike lane: 5 to 7 ft
- Buffered bike lane: 8 to 9 ft total

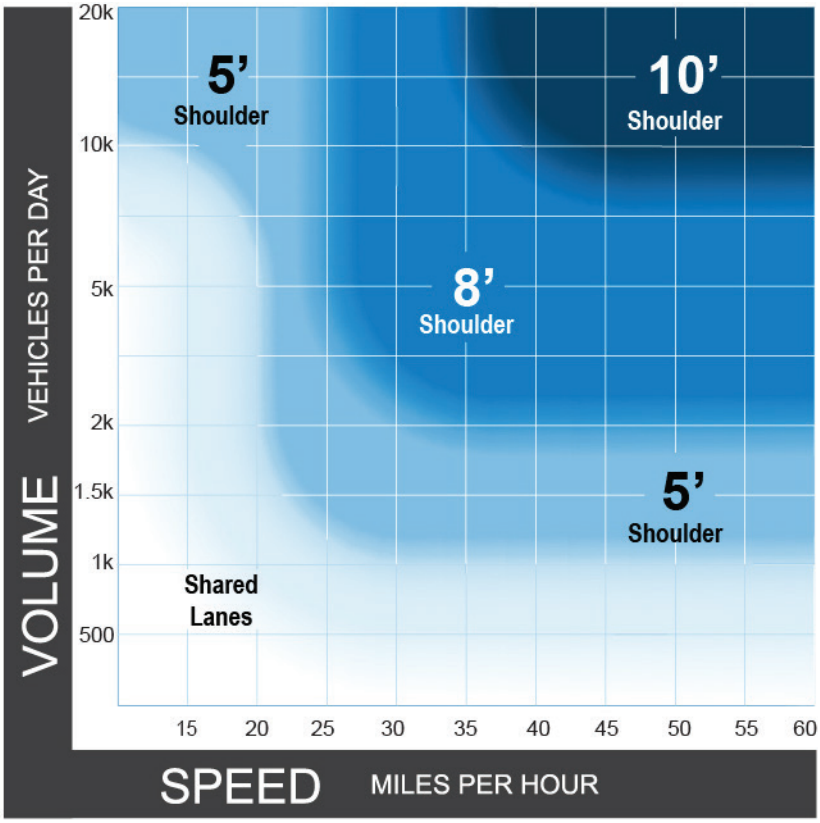
CHART REFERENCES

- Transitions are based on a shift in the 2010 Highway Capacity Manual (HCM 2010) bike Level of Service (LOS) from A to B (assuming no parking, 12 ft outside travel lane, 6 ft bike lane, 8 ft buffered bike lane). This roughly translates to a C to D transition with on-street parking (8 ft parking lane).
- Speed thresholds based on Level of Traffic Stress. "Interested but Concerned" riders are sensitive to increases in volume or speed. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

BICYCLE FACILITY SELECTION

Shoulder Widths for Rural Roadways

When selecting a minimum shoulder width to accommodate bicyclists, the decision should be based on traffic volumes and posted speeds in the rural context. For the purposes of determining the appropriate shoulder width, it is assumed that posted speeds are approximately the same as operating speeds. If operating speeds differ from posted speeds, then operating speed should be used instead of posted speed.



Notes

1 *This chart assumes the project involves reconstruction or retrofit in constrained conditions. For new construction, follow recommended shoulder widths in the AASHTO Green Book.*

2 *A separated shared use pathway is a suitable alternative to providing paved shoulders.*

3 *Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.*

4 *If the percentage of heavy vehicles is greater than 10%, consider providing a wider shoulder or a separated pathway.*

CHART REFERENCES

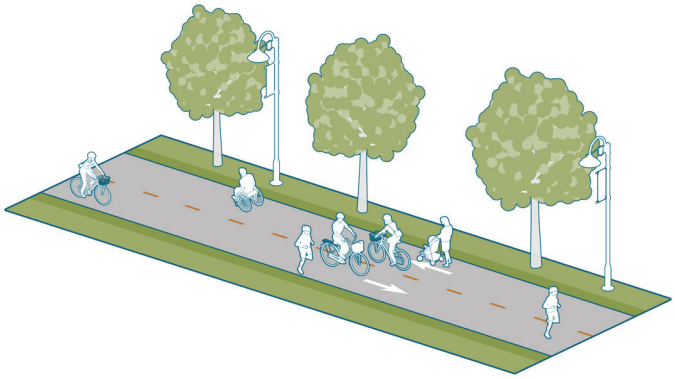
- Transitions are based on a shift in the 2010 Highway Capacity Manual (HCM 2010) bike Level of Service (LOS) from A to B (assuming no parking, 12 ft outside travel lane, 6 ft bike lane, 8 ft buffered bike lane). This roughly translates to a C to D transition with on-street parking (8 ft parking lane).
- Speed thresholds based on Level of Traffic Stress. "Interested but Concerned" riders are sensitive to increases in volume or speed. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

BICYCLE FACILITY OVERVIEW

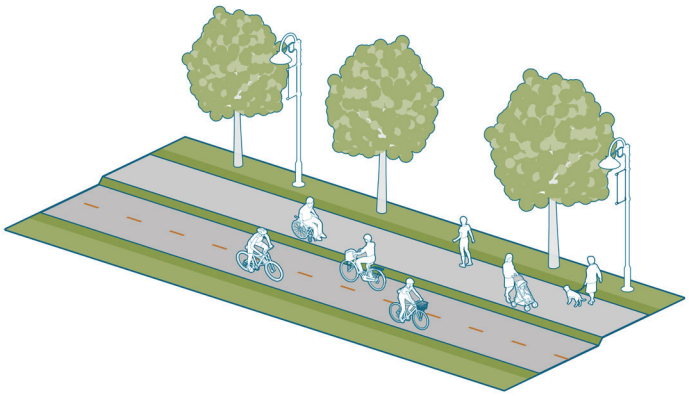
MULTI-USE PATHS (CLASS I)

A multi-use path is a two-way facility physically separated from motor vehicle traffic used by bicyclists, pedestrians, and other non-motorized users. Multi-use paths are often located in an independent alignment, such as a greenbelt or abandoned railroad. However, they are also regularly constructed along roadways; often bicyclists and pedestrians will have increased interactions with motor vehicles at driveways and intersections on these paths.

Path width should be determined based on three main characteristics: the number of users, the types of users, and the differences in their speeds. For example, a path that is used by higher-speed bicyclists and children walking to school may experience conflicts due to their difference in speeds. Another example would be when the path is shared by multiple user types such as roller bladers, skateboarders, or dogs on leashes. By widening the path to provide space to accommodate passing movements, conflicts can be reduced.



Multi-use path with combined pedestrian and bicycle traffic



Bike path with adjacent pedestrian path

APPLICATION

+ Many people express a strong preference for the separation between bicycle and motor vehicle traffic provided by paths when compared to on-street bikeways. Multi-use paths may be desirable along high-volume or high-speed roadways, where accommodating the targeted type of bicyclist within the roadway in a safe and comfortable way is impractical. However, multi-use paths may present increased conflicts between path users and motor vehicles at intersections and driveway crossings. Conflicts can be reduced by minimizing the number of driveway and street crossings present along a path and otherwise providing high-visibility crossing treatments.

CONSIDERATIONS

+ Typical paths shall be 12 feet wide with 3 foot shoulders on each side, allowing allows users to pass one another with minimal conflict.
+ Path clearances are an important element in designing paths and reducing user conflicts. Vertical objects close to the path edge can endanger users and reduce the comfortable usable width of the path. Vertical objects should be set back at least two feet from the edge of the path. Path shoulders may reduce conflicts by providing space for users who step off the path to rest, allowing users to pass one another, or providing space for viewpoints.
+ A path may benefit from the separation of users by user speed, type, or direction. When separating users, consider the path width and paving material preferred by each user.
+ When accommodating moderate to high volumes of horseback riders, it is recommended to provide a separated unpaved bridle path. Six feet of clearance and separation is recommended between the multi-use path and the bridle path. Elevation change between the multi-use path and the bridle path can also be considered.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

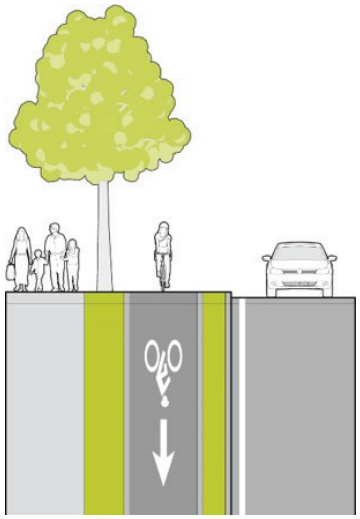
FHWA. Achieving Multimodal Networks. 2016.

FHWA. Shared-Use Path Level of Service Calculator. 2006.

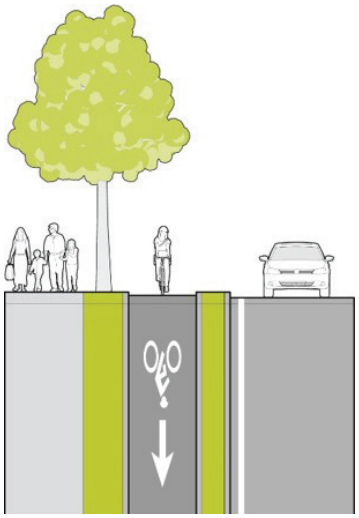
FHWA. Manual on Uniform Traffic Control Devices. 2009.

SEPARATED BICYCLE LANES (CLASS IV)

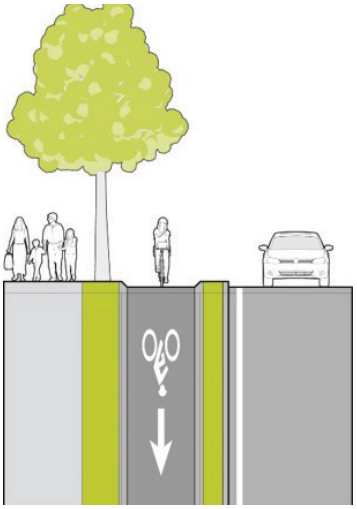
Buffered bike lanes are created by painting or otherwise creating a flush buffer zone between a bike lane and the adjacent travel lane. While buffers are typically used between bike lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bike lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles.



One-way sidewalk-level separated bike lane



One-way intermediate-level separated bike lane



One-way street-level separated bike lane

APPLICATION

Separated bike lanes can generally be considered on any road with one or more of the following characteristics:

+ Traffic lanes: 3 lanes or greater.
+ Posted speed limit: 30 mph or more.
+ Traffic: 6,000 vehicles per day or greater.
+ On-Street parking turnover: frequent.
+ Bike lane obstruction: likely to be frequent.
+ Streets that are designated as truck or bus routes.

Separated bike lanes are preferred over multi-use paths in higher density areas, commercial and mixed-use development, and near major transit stations or locations where pedestrian volumes are anticipated to exceed 200 people per hour on a shared use path.

CONSIDERATIONS

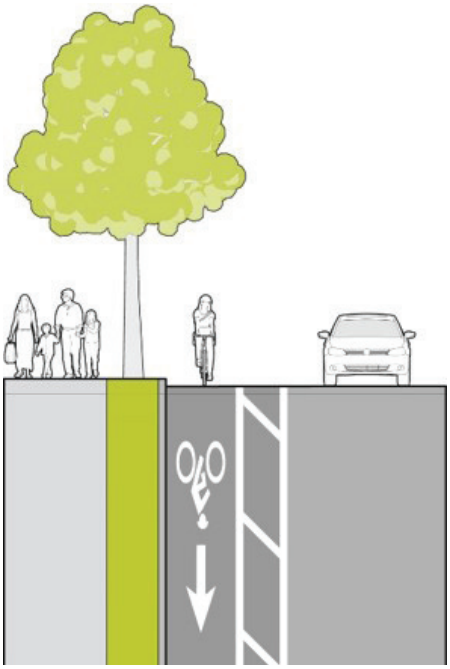
+ Separated bike lanes are more attractive to a wider range of bicyclists than striped bikeways on higher volume and higher speed roads. They eliminate the risk of a bicyclist being hit by an opening car door and prevent motor vehicles from driving, stopping or waiting in the bikeway. They also provide greater comfort to pedestrians by separating them from bicyclists operating at higher speeds.
+ Choice of one- or two-way facility should be based on connectivity, bicyclist desire lines, roadway configuration, and potential intersection conflicts. Generally, one-way facilities are preferred.

REFERENCES

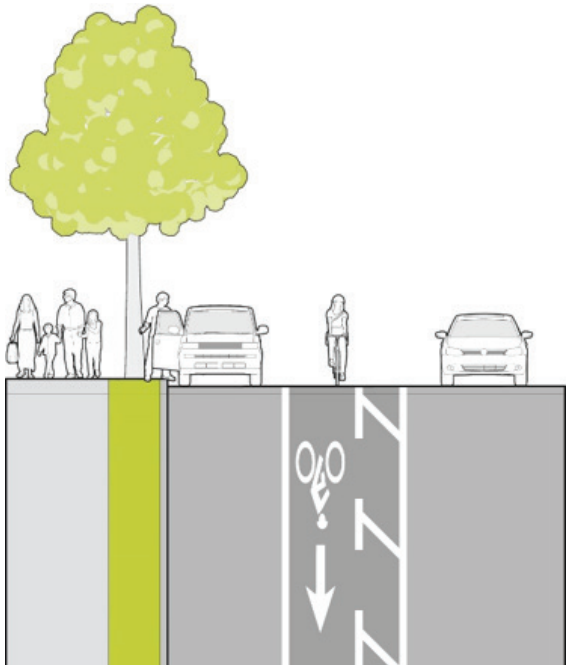
Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2018.
Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2015.
FHWA. Separated Bike Lane Planning and Design Guide. 2015.
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.
NACTO. Urban Bikeway Design Guide. 2nd Edition.

BUFFERED BICYCLE LANES (CLASS II)

Buffered bike lanes are created by painting or otherwise creating a flush buffer zone between a bike lane and the adjacent travel lane. While buffers are typically used between bike lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bike lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles.



Buffered bike lane adjacent to a curb



Buffered bike lane adjacent to parking

APPLICATION

+ Can be used on one-way or two-way streets. Preferable to a conventional bike lane when used as a contra-flow bike lane on one-way streets.
+ Wider bike lanes or buffered bike lanes are preferable at locations with high parking turnover, roadways with greater than 5 percent heavy vehicles, and on roadways with speed limits 30 mph or higher or traffic volumes over 6,000 vehicles per day.

CONSIDERATIONS

+ Typically installed by reallocating existing street space.
+ Consider placing buffer next to parking lane where there is commercial or metered parking.
+ Where there is 7 feet of roadway width available for a bicycle lane, a buffered bike lane should be installed instead of a conventional bike lane.
+ Buffered bike lanes allow bicyclists to ride side by side or to pass slower moving bicyclists.
+ Preferable to a conventional bike lanes when used as a contra-flow bike lane on one-way streets.
+ Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

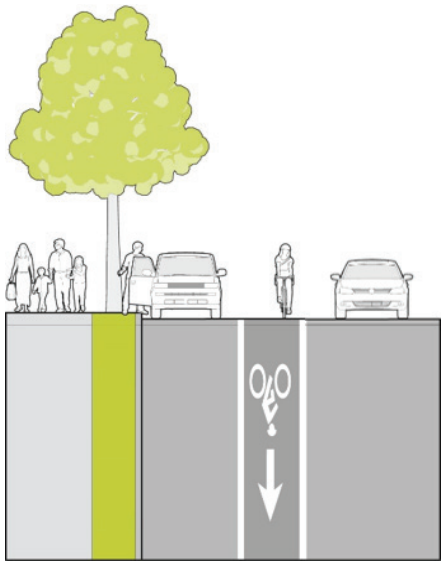
NACTO. Urban Bikeway Design Guide. 2nd Edition.

Portland State University, Center for Transportation Studies. Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT. 2011.

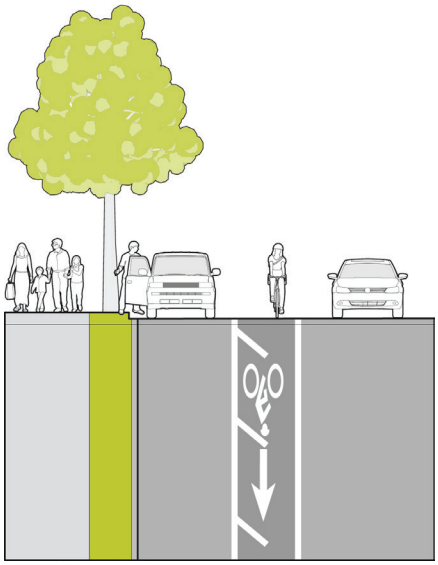
BICYCLE LANES (CLASS II)

Bike lanes provide an exclusive space for bicyclists in the roadway. Bike lanes are established through the use of lines and symbols on the roadway surface. Bike lanes are for one-way travel and are normally provided in both directions on two-way streets or on one side of a one-way street. Bicyclists are not required to remain in a bike lane when traveling on a street and may leave the bike lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements.

Bike lane adjacent to a curb



Bike lane adjacent to parking



Bike lane with door zone marking

APPLICATION

+ Typically installed by reallocating existing street space.
+ Can be used on one-way or two-way streets.
+ Contra-flow bike lanes may be used to allow two-way bicycle travel on streets designated for one-way travel for motorists to improve bicycle network connectivity.
+ Place bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume is less than 6,000 vehicles per day.
+ Bike lanes can be placed on the left side of one-way streets and some median-divided streets, and may actually be preferrable on streets with heavy right-turn volumes, onstreet parking, frequent bus service, and/or high volumes of left-turning bicyclists.

CONSIDERATIONS

+ Consider placing bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day.
+ Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.
+ Wider bike lanes or buffered bike lanes are preferable at locations with high parking turnover.
+ Bike lanes may only be used temporarily by vehicles accessing parking spaces and entering and exiting driveways and alleys. Stopping, standing and parking in bike lanes is prohibited.

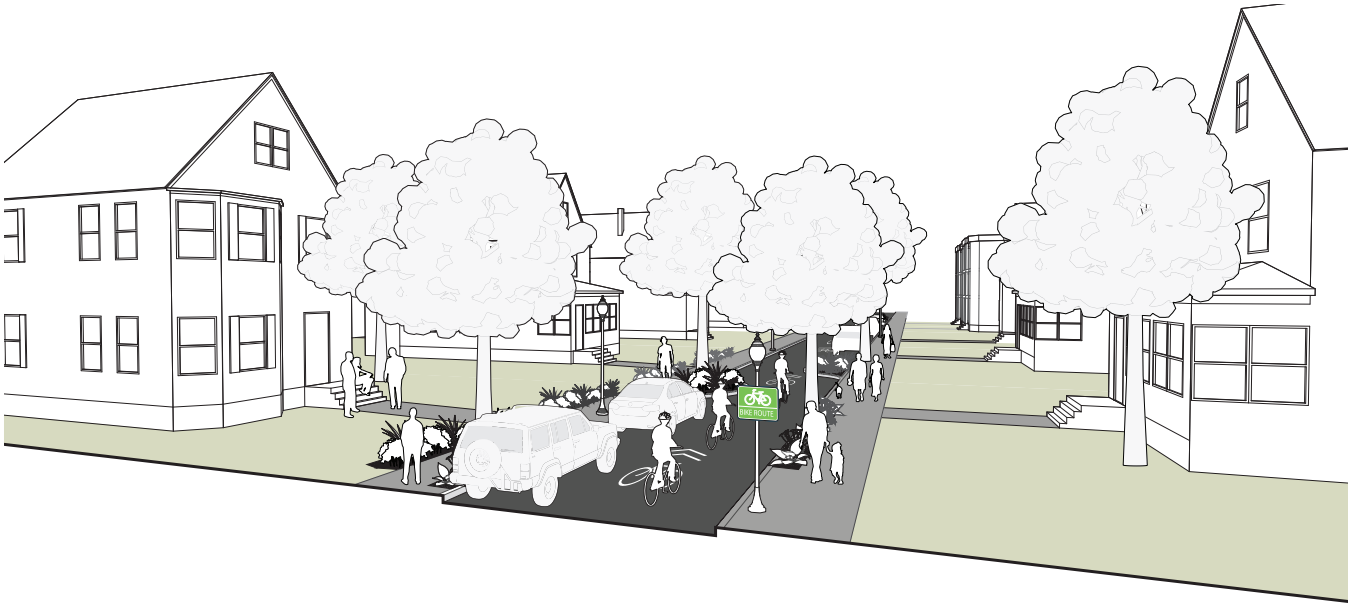
REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

BICYCLE BOULEVARDS (CLASS III)

Bicycle boulevards are applied on quiet streets, often through residential neighborhoods. These treatments are designed to prioritize bicycle through-travel, while calming motor vehicle traffic and maintaining relatively low motor vehicle volumes. Treatments vary depending on context, but often include elements of traffic calming, including traffic diverters, speed attenuators such as speed humps or chicanes, pavement markings, and signs. Bicycle boulevards are also known as neighborhood greenways, neighborhood bikeways, among other locally-preferred terms.



APPLICATION

Bicycle boulevards can generally be considered on any road with one or more of the following characteristics:

+ Maximum Average Daily Traffic (ADT): 3,000
+ Preferred ADT: up to 1,000
+ Target speeds for motor vehicle traffic are typically around 20 mph; there should be a maximum < 15 mph speed differential between bicyclists and vehicles.
+ Where these traffic characteristics are not already present, traffic calming and traffic diversion measures should be implemented to reach these desired thresholds.

CONSIDERATIONS

+ Many cities already have signed bike routes along neighborhood streets that provide an alternative to traveling on high-volume, high-speed arterials. Applying bicycle boulevard treatments to these routes makes them more suitable for bicyclists of all abilities and can reduce crashes.
+ Stop signs or traffic signals should be placed along the bicycle boulevard in a way that prioritizes the bicycle movement, minimizing stops and delays for bicyclists whenever possible.
+ Communities should begin by implementing bicycle boulevard treatments on one pilot corridor to measure the impacts and gain community support. The pilot program should include before-and-after crash studies, motor vehicle counts, and bicyclist counts on both the bicycle boulevard and parallel streets. Findings from the pilot program can be used to justify bicycle boulevard treatments on other neighborhood streets.
+ Additional treatments for major street crossings may be needed, such as median refuge islands, rectangular rapid flashing beacons, bicycle signals, and HAWK or half signals.

REFERENCES

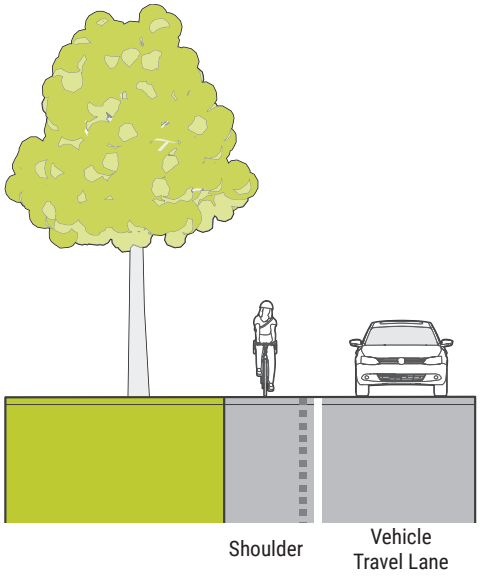
AASHTO. Guide for the Development of Bicycle Facilities. 2012.

FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Bikeway Design Guide. 2012.

RURAL BICYCLE ROUTES (CLASS III)

In many cases, rural routes should provide shoulders to accommodate bicyclists. Shoulders are portions of the roadway that accommodate stopped or parked vehicles, emergency use, bicycles, motor scooters and pedestrians where sidewalks do not exist. This type of facility is applicable in rural areas where dedicated bikeways either will not fit on the street or would not be appropriate given the surrounding context.



APPLICATION

- Shoulder width should be at least 4 feet if the roadway is curbless and there are no vertical obstructions. If curbs or vertical obstructions are present, shoulder width should be 5 feet minimum exclusive of the gutter if present.
- Shoulders should be wider on roads with high levels of bicycle traffic to accommodate bicyclist passing and facilitate side-by-side bicycling.
- When posted speed limits or 85th percentile speeds exceed 50 mph and/or if heavy vehicles frequently use the road, shoulders should exceed minimum widths to enhance bicyclist comfort.
- The width of a shoulder with rumble strips should be measured from the rightmost side of the rumble strip. Periodic gaps should be provided to allow bicyclists to move across the strip pattern.
- Edge line rumble strips can provide additional bicyclist space on paved shoulders.

CONSIDERATIONS

For roads that are unable to provide consistent and standard size bikeable shoulders in both directions, prioritize:

- The uphill direction on hilly roads to reduce conflicts between slow-moving bicyclists and fast-moving motor vehicles.
- The inside of a horizontal curve and/or the downgrade of a vertical curve where sight distance is restricted.

- Paved shoulders should be considered on roadways popular with recreational bicyclists that have significant motor vehicle traffic during periods when recreational bicycling is known to occur.
- Bicyclists will not use a shoulder if it is covered in gravel, glass and other road debris, so regular street sweeping is important.
- In rural areas, paved shoulders can also provide space for pedestrians on roadways without sidewalks. In situations where a shoulder is intended for pedestrian use, it must meet Americans with Disabilities Act requirements to the maximum extent possible

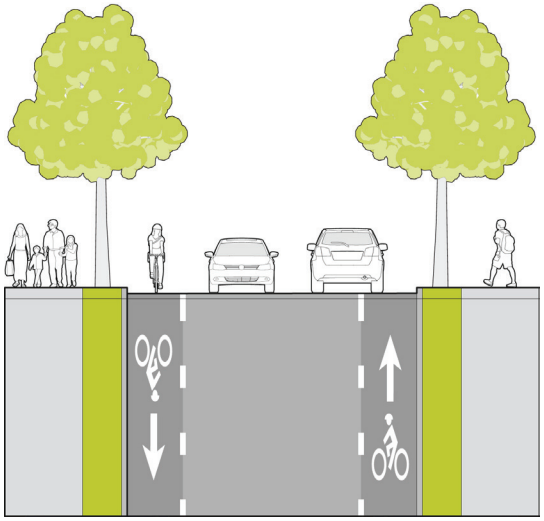
REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

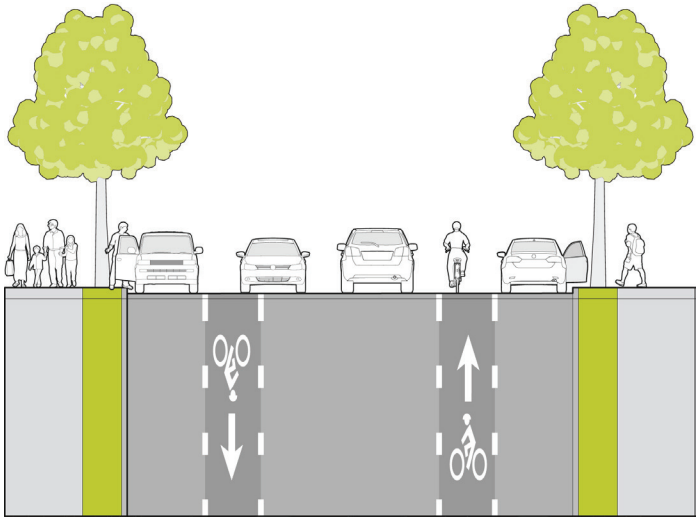
FHWA. Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

ADVISORY BIKE LANES (CLASS III)

Advisory bicycle lanes (ABLs) are used to create narrow streets where bicyclists are provided priority movement and motorists are compelled to yield to bicyclists as well as drivers approaching in the opposing direction. ABLs use dotted lane lines, allowing motorists to enter them to yield and are designed using dimensions based on conventional bicycle lanes. ABLs are reserved for use on low-volume, low-speed streets.



Advisory bike lane without parking



Advisory bike lane with parking

APPLICATION

Advisory bike lanes can generally be considered on any road with one or more of the following characteristics:

+ Traffic lanes: 2 lanes or less
+ Posted speed limit: 25 mph or less
+ Traffic: 3,000 vehicles per day or less
+ On-street parking turnover: infrequent

CONSIDERATIONS

+ Treatment requires FHWA permission to experiment.
+ For use on streets too narrow for bike lanes and normal width travel lanes.
+ To reduce motorist speeds, and to encourage yielding, the unmarked space between the two advisory bike lanes should be no wider than 18 feet.
+ This treatment should only be used on streets with >60% continuous daytime parking occupancy.
+ Where parking occupancy is continuously <50%, it is preferable to consolidate it to one side of the street or remove it.
+ A Two-Way Traffic warning sign (W6-3) may increase motorists understanding of the intended two-way operation of the street.

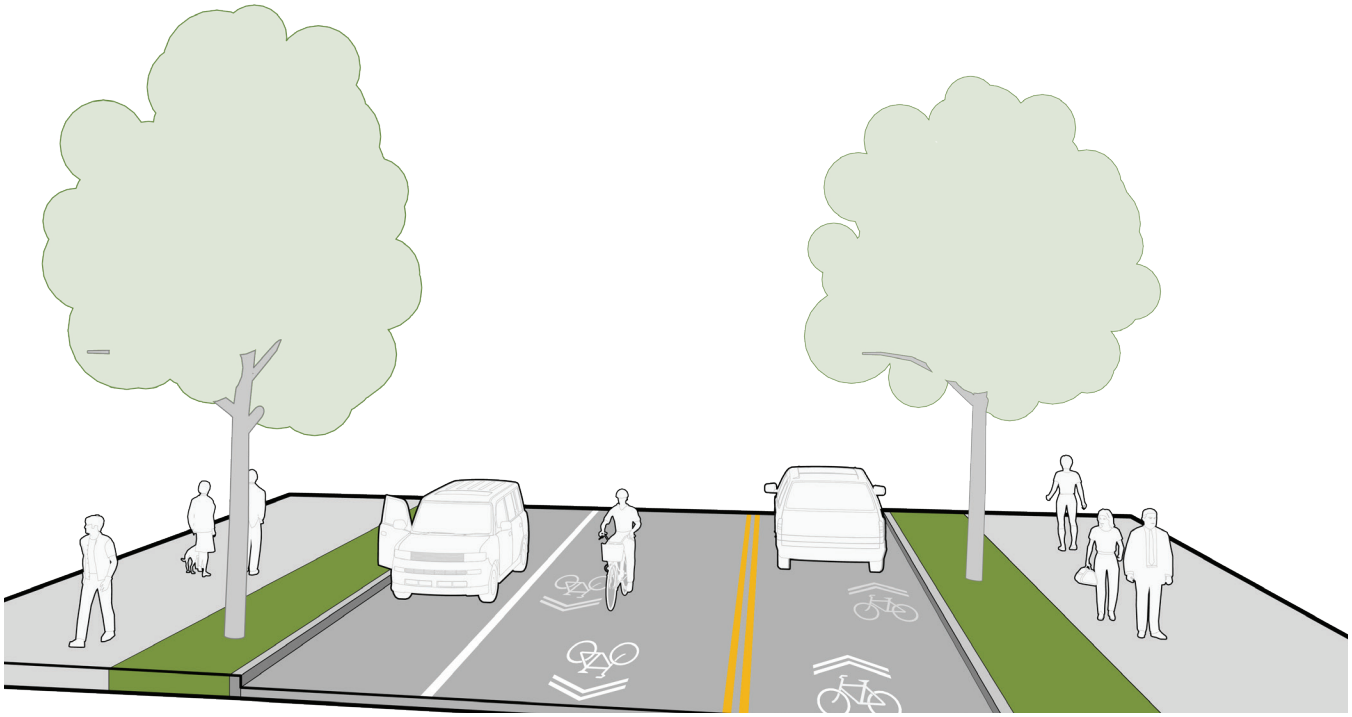
REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/dashed_bike_lanes.cfm

SHARED LANE MARKINGS

Shared lane markings (or "sharrows") are pavement markings that denote shared bicycle and motor vehicle travel lanes. The markings are two chevrons positioned above a bicycle symbol, placed where the bicyclist is anticipated to operate. In general, this is a design solution that should only be used in locations with low traffic speeds and volumes as part of a signed route or bicycle boulevard. Shared lane markings are sometimes used as a temporary solution on constrained, higher-traffic streets (up to 10,000 vehicles per day) until additional right-of-way can be acquired, but should not be considered a permanent solution in these contexts.



APPLICATION

+ Typically used on local, collector, or minor arterial streets with low traffic volumes. Commonly used on bicycle boulevards to reinforce the priority for bicyclists.
+ Typically feasible within existing right-of-way and pavement width even in constrained situations that preclude dedicated facilities.
+ May be used as interim treatments to fill gaps between bike lanes or other dedicated facilities for short segments where there are space constraints.
+ May be used for downhill bicycle travel in conjunction with climbing lanes intended for uphill travel.
+ Typically supplemented by signs, especially Bikes May Use Full Lane (R4-11).

CONSIDERATIONS

+ Intended for use only on streets with posted speed limits of up to 25 mph and traffic volumes of less than 4,000 vehicles per day. Maximum posted speed of street: 35 mph.
+ May be used as a temporary solution on constrained streets with up to 10,000 vehicles per day until a more appropriate bikeway facility can be implemented. Maximum posted speed of street: 35 mph.
+ Intended for use on lanes up to 14 feet wide (up to 13 feet preferred). For lanes 15 feet wide or greater, stripe a 4-foot bike lane instead of using shared lane markings.
+ The marking's centerline must be at least 4 feet from curb or edge of pavement where parking is prohibited.
+ The marking's centerline must be at least 11 feet from curb where parking is permitted, so that it is outside the door zone of parked vehicles.
+ For narrow lanes (11 feet or less), it may be desirable to center shared lane markings along the centerline of the outside travel lane.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

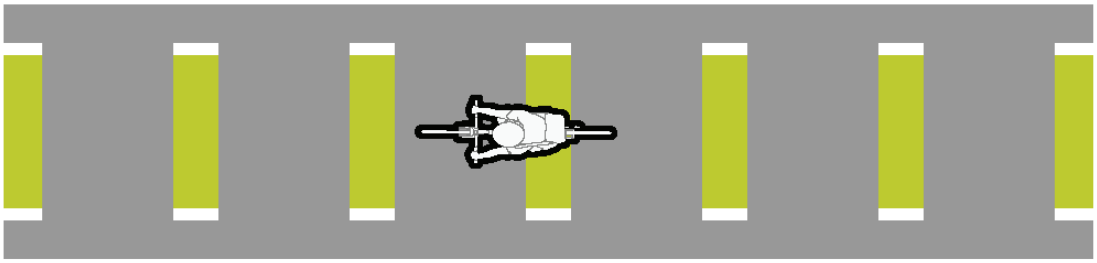
NACTO. Urban Bikeway Design Guide. 2014.

Caltrans. Manual on Uniform Traffic Control Devices. 2012.

BICYCLE INTERSECTION DESIGN & SPOT TREATMENTS

CONFLICT AREA MARKINGS

Intersection pavement markings are designed to improve visibility, alert all roadway users of expected behaviors, and to reduce conflicts with turning vehicles. They may be used with any Class II or Class IV bike lane across driveways, through intersections, or in separated bike lane mixing zones.



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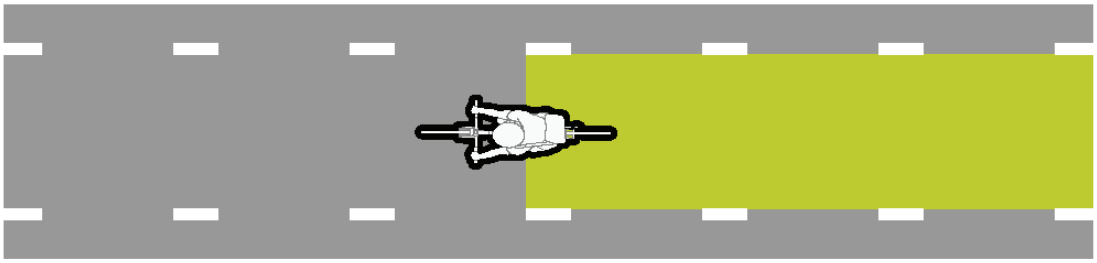
Dash



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Conflict Areas

APPLICATION

+ A variety of pavement marking symbols can enhance intersection treatments to guide bicyclists and warn of potential conflicts.
+ Green pavement markings may be applied in a solid or dashed pattern within a dashed bicycle lane to indicate conflict areas and where merging maneuvers are permitted, such as across intersections, driveways, and at STOP or YIELD-controlled cross-streets.
+ Dashed lane lines may be sufficient for guiding bicyclists through intersections; however, consider providing enhanced markings with green pavement and/or symbols at complex intersections or at intersections with documented conflicts and safety concerns.

CONSIDERATIONS

+ Symbol placement within intersections should consider vehicle wheel paths to minimize maintenance.
+ Driveways with higher volumes may require additional pavement markings and signage.
+ Consideration should be given to using intersection pavement markings as spot treatments or standard intersection treatments. A corridor wide treatment can maintain consistency; however, spot treatments can be used to highlight conflict locations.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities. 2012.

Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2018.

FHWA Memorandum – Interim Approval for Optional Use of Green Colored Pavement for Bike Lane. 2011.

FHWA. Separated Bike Lane Guide.

Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Bikeway Design Guide. 2012.

BIKE BOXES

A bike box provides dedicated space between the crosswalk and vehicle stop line where bicyclists can wait during the red light at signalized intersections. The bike box allows a bicyclist to take a position in front of motor vehicles at the intersection, which improves visibility and motorist awareness, and allows bicyclists to "claim the lane" if desired. Bike boxes aid bicyclists in making left turning maneuvers at the intersection, and provide more queuing space for multiple bicyclists than that provided by a typical bike lane.

APPLICATION

+ Applicable wherever a bike route requires a left turn at a signalized intersection or there is a desire for bicyclists to enter and clear the intersection ahead of vehicle traffic.

CONSIDERATIONS

+ In locations with high volumes of turning movements by bicyclists, a bike box should be used to allow bicyclists to shift towards the desired side of the travel way. Depending on the position of the bike lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.

+ In locations where motor vehicles can continue straight or cross through a right-side bike lane while turning right, the bike box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning vehicle. When a bike box is implemented in front of a vehicle lane that previously allowed right turns on red, the right turn on red movement must be restricted using signage and enforcement once a bike box is installed.

+ A bicycle box should only extend across one travel lane. Bicycle boxes should not be used to facilitate bicycle left turns. A two-stage turn queue box is the preferred method of accommodating left turns."

REFERENCES

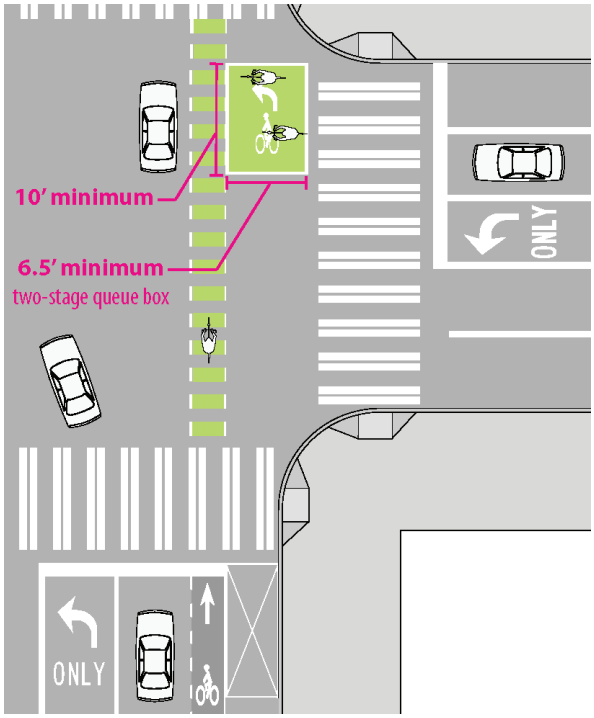
FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning & Design Guide. 2016.

NACTO. Urban Bikeway Design Guide - Bike Boxes. 2012.

TWO-STAGE TURN QUEUE BOXES

The two-stage turn box designates a space for bicyclists to wait while performing a two-stage turn across a street at a location outside the path of traffic. Two-stage turn queue boxes may be used with any type of bicycle facility. A two-stage turn queue box should be considered where separated bike lanes are continued up to an intersection and a protected intersection is not provided.



APPLICATION

+ Two stage turn boxes are applicable at locations where a left turn movement is expected by bicyclists. These are preferred where a bicyclist would have to cross over more than one lane of traffic to make a left turn or in-street rail tracks (e.g. streetcar).

CONSIDERATIONS

+ This treatment has been granted interim approval by FHWA and Caltrans.
+ Two-stage turn box dimensions will vary based on the street operating conditions, the presence or absence of a parking lane, traffic volumes and speeds, and available street space. The turn box may be placed in a variety of locations including in front of the pedestrian crossing (the crosswalk location may need to be adjusted), in a 'jug-handle' configuration within a sidewalk, or at the tail end of a parking lane or a median island.
+ A minimum width of 10 feet is recommended for the box.
+ A minimum depth of 6.5 feet is recommended for the box.
+ Dashed bike lane extension markings may be used to indicate the path of travel across the intersection.

REFERENCES

FHWA. Bicycle Facilities and the Manual on Uniform Traffic Control Devices - Two-Stage Turn Box. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MIXING ZONES

A mixing zone requires turning motorists to merge across a separated bike lane at a defined location in advance of an intersection. Unlike a standard bike lane, where a motorist can merge across at any point, a mixing zone design limits bicyclists' exposure to motor vehicles by defining a limited merge area for the turning motorist. Mixing zones are compatible only with one-way separated bike lanes.

APPLICATION

+ Protected intersections are preferable to mixing zones. Mixing zones are generally appropriate as an interim solution or in situations where severe right-of-way constraints make it infeasible to provide a protected intersection.
+ Mixing zones are only appropriate on street segments with one-way separated bike lanes. They are not appropriate for two-way separated bike lanes due to the contra-flow bicycle movement.
+ This type of conflict marking is not commonly used in California.

CONSIDERATIONS

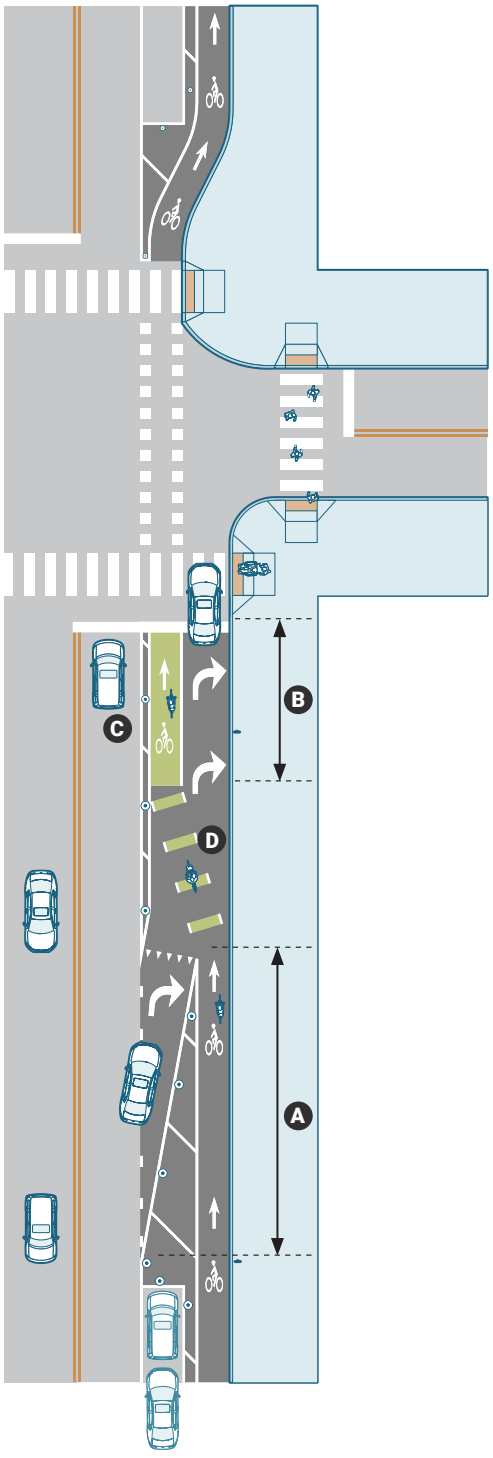
Ⓐ Locate merge points where the entering speeds of motor vehicles will be 20 mph or less by (a) minimizing the length of the merge area and (b) locating the merge point as close as practical to the intersection.

Ⓑ Minimize the storage length of the turn lane

Ⓒ Provide a buffer and physical separation (e.g. flexible delineator posts) from the adjacent through lane after the merge area, if feasible.

Ⓓ Highlight the conflict area with green surface coloring and dashed bike lane markings, as necessary, or shared lane markings placed on a green box.

+ Provide a BEGIN RIGHT (or LEFT) TURN LANE YIELD TO BIKES sign (R4-4) at the start of the merge area.
+ Restrict parking within the merge area
+ At locations where raised separated bike lanes approach the intersection, the bike lane should transition to street elevation at the point where parking terminates.
+ Where posted speeds are 35 mph or higher, or at locations where it is necessary to provide storage for queued vehicles, it may be necessary to provide a deceleration/storage lane in advance of the merge



REFERENCES

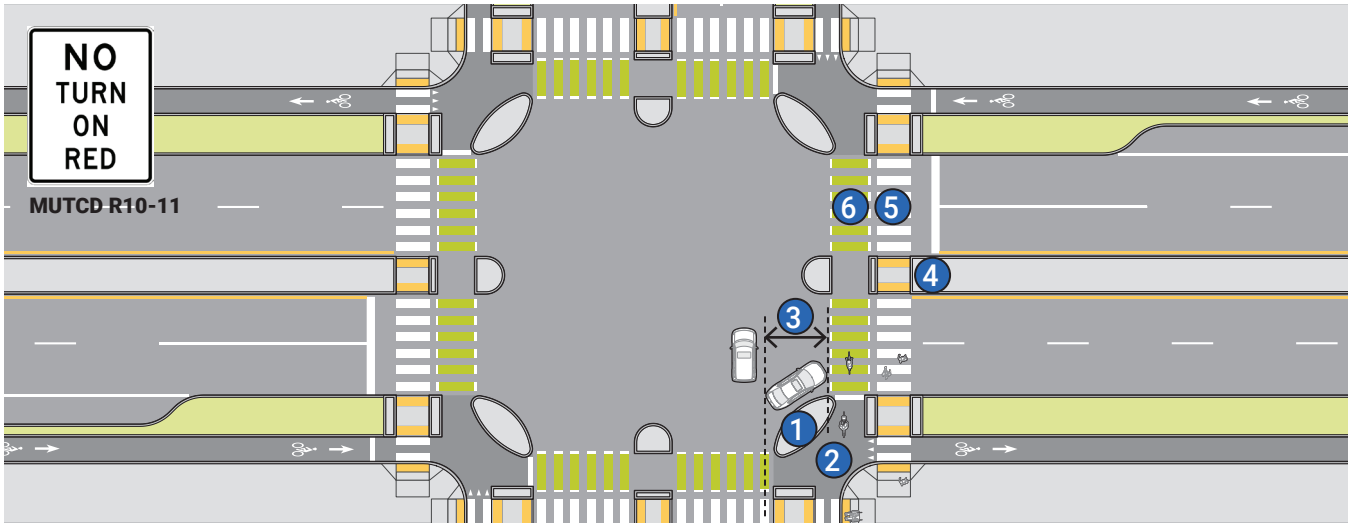
FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

NACTO. Urban Bikeway Design Guide. 2012.

PROTECTED INTERSECTIONS

Protected intersections are a type of intersection design that improves safety by reducing the speed of turning traffic, improving sight lines, and designating space for all road suers. Protected intersections reduce conflict points between motorists and bicyclists.



APPLICATION

+ Ideal at all signalized intersections with sufficient space to accommodate the design., especially along separated bicycle lanes.
+ Protected intersections should minimize bicyclist exposure to motor vehicles. This can be accomplished by:
  + Creating space for a motorists to yield to bicyclists and pedestrians. Research has found crash reduction benefits at locations where bicycle crossings are set back from the motorist travel way by a distance of 6 to 20 feet, creating space for turning motorists to yield. At locations where the street buffer is <6 feet midblock, additional dedication from developments may be necessary at intersections to create a ≥6 foot setback.
  + Minimizing the turning speed of motor vehicles through the use of small curb radii (<20 feet) along the corner refuge island. Where larger radii are required to accommodate oversized vehicles, such as buses and trucks, provide mountable aprons to maintain the smaller curb radii for most vehicles.
  + Providing a No Turn On Red sign where turning motorists are likely to block crosswalks, or where protected signal phasing is provided.

CONSIDERATIONS

1. Corner refuge island size may vary. The curb radius along the path of motor vehicle travel should minimize turning motorist speeds to 15 mph or less.
2. The forward bicycle queuing area should allow at least one bicyclist to wait without obstructing crossing bicyclists or pedestrians.
3. The motorist yield zone should be 6 feet in length minimum, up to a typical car length (16.5 feet), to create space for a turning motorist to yield to a through moving bicyclist.
4. A pedestrian crossing island should be a minimum of 6 feet in width to minimize pedestrian crossing distances of the street.
5. Marked pedestrian crosswalks should be provided across all bike lane crossings.
6. Bicycle crossings should be separate from pedestrian crossings. They can be supplemented with green pavement to improve contrast.

REFERENCES

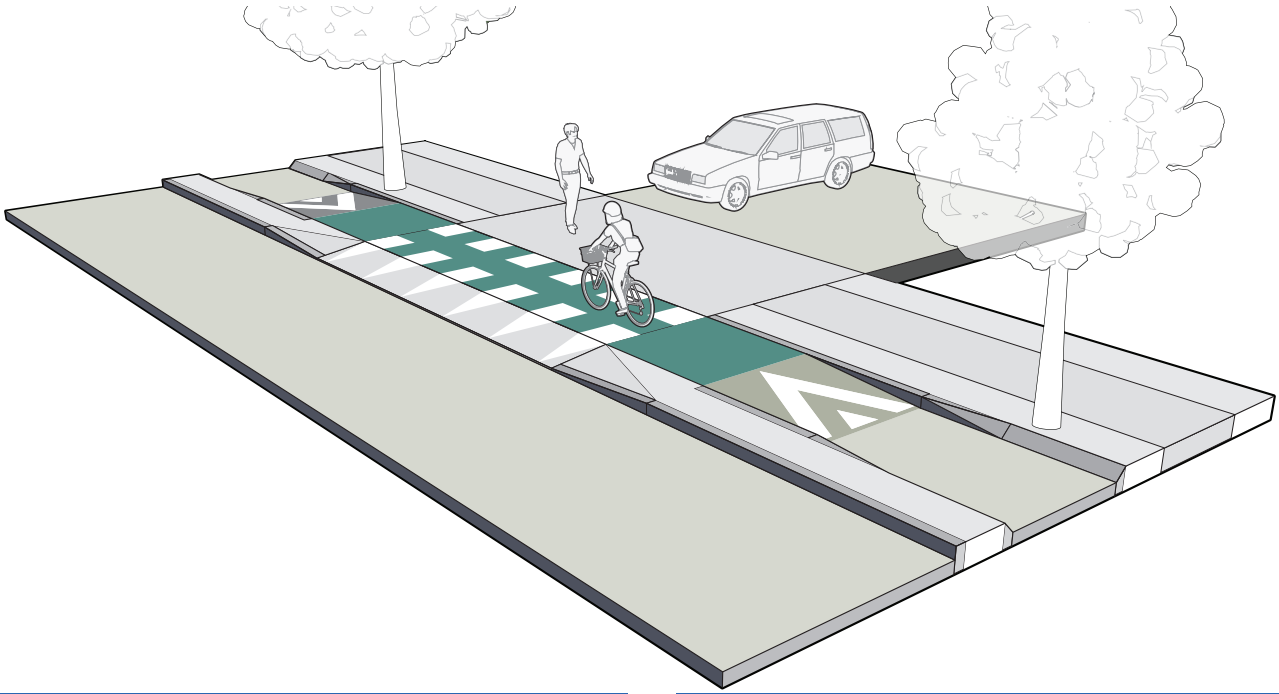
FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

NACTO. Urban Bikeway Design Guide. 2012.

SEPARATED BIKE LANES AT DRIVEWAYS

Most bicycle facilities will need to cross streets, driveways, or alleys at multiple locations along a corridor. At these locations, the crossings should be designed to 1) delineate a preferred path for people bicycling through the intersection and 2) to encourage driver yielding behavior, where applicable. Bicycle crossings may be supplemented with green pavement, yield lines, and/or regulatory signs.



APPLICATION

+ Whenever a bicycle lane intersects with a high traffic driveway special treatment should be taken to reduce conflict.

CONSIDERATIONS

+ Supplemental yield lines, also known as shark's teeth, can be used to indicate priority for people bicycling and may be used in advance of unsignalized crossings at driveways, at signalized intersections where motorists may turn across a bicycle crossing during a concurrent phase, and in advance of bicycle crossings in roundabouts.
+ Raised bicycle crossings promote driver yielding behavior by slowing their speed before the crossing and increasing visibility of people bicycling.
+ Bicycle crossings should be a minimum of 6 feet wide for one-way travel and 10 feet wide for two-way travel, as measured from the outer edge of the elephant's feet. Bicycle lane symbol markings should be avoided in bicycle crossings. Directional arrows are preferred within two-way bicycle crossings. Two-way crossings should be indicated with warning signage for drivers entering and exiting the driveway.
+ Dashed green pavement may be used in the bicycle crossing to increase the visibility of the crossing where permitted conflicts occur. Green color may be desirable at crossings where concurrent vehicle crossing movements are allowed and where sightlines are constrained, or where motor vehicle turning speeds exceed 10 mph.

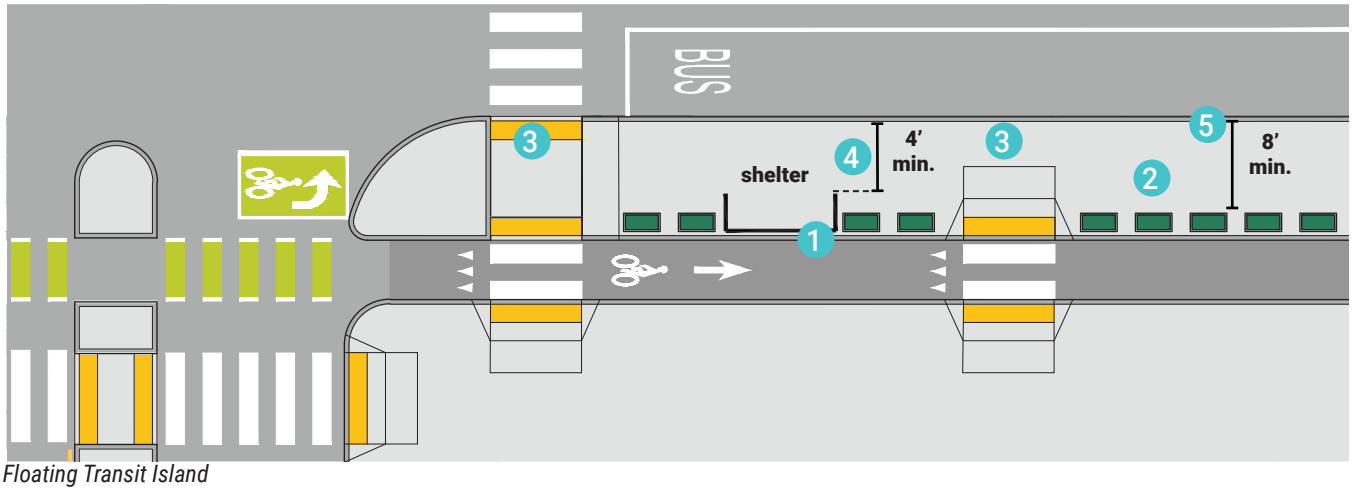
REFERENCES

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning & Design Guide. 2016.

BUS STOPS AND BIKE LANES

Conventional curbside bus stops along streets with sameside bike lanes can create conflicts between bicyclists and buses. Floating transit islands are sidewalk-level platforms built between the bikeway and the roadway travel lane. These facilities reduce conflicts between bicyclists traveling in conventional bike lanes and buses that must pull into conventional bike lanes to load and unload passengers. Where feasible, separated bike lanes should be located behind bus stops to eliminate conflicts between bicyclists and buses. This treatment is compatible with near-side, far-side and mid-block bus stop locations.



Floating Transit Island

CONSIDERATIONS

Curbside bus stops

+ At approaches to curbside bus stops, bike lanes can have solid or dashed lines and green pavement can be used to identify potential conflict areas between buses and bicyclists.
+ Curbside bus stops with interrupted bike lanes require less space than floating bus stops, but provide less separation between buses and bicyclists. Curbside stops should only be considered at locations with lower boarding/alighting levels and/or on streets with lower bicycle volumes.

Floating transit islands

+ The space between the bike lane and the sidewalk must have a detectable edge so pedestrians with vision disabilities can distinguish between the two. The bike lane may be located at street-level, intermediate-level, or sidewalk-level. The bike lane elevation can affect the treatment used and can itself be a treatment for creating the detectible edge. The following design treatments can help provide this tactile cue:
  + Street furniture or other vertical objects.
  + A curb.
  + Curb height changes.
  + Continuous low landscaping.
  + A directional indicator (in accordance with International Standard 23599) installed linearly along the sidewalk adjacent to the edge.
+ Consider bus queuing and bus length to determine island length and pedestrian crossing placement.
+ Ensure visibility between bicyclists and pedestrians for safety.
+ Consider raised pedestrian crossings between the floating transit island and the sidewalk to prioritize pedestrians.

APPLICATION

1. Provide a buffer of 6”-12” between the bus shelter and the bike lane. This buffer is narrower than the shy distance normally used for vertical surfaces (2’), but this is acceptable for short distances in constrained spaces.
2. Channelizing railings, planters or other treatments can be used to help direct people to the crossing location(s).
3. Multiple pedestrian crossings are recommended, but not required.
4. Provide a minimum 4-foot-wide walkway between the curb and the transit shelter.
5. Minimum 8-feet of clear width at the location where the bus doors will open to accommodate persons in wheelchairs.

REFERENCES

MassDOT. Separated Bike Lane Planning & Design Guide. 2016.

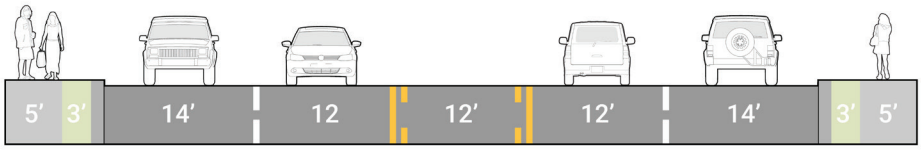
Alameda-Contra Costa Transit District. Multimodal Corridor Guidelines. 2018.

ADDITIONAL CONSIDERATIONS

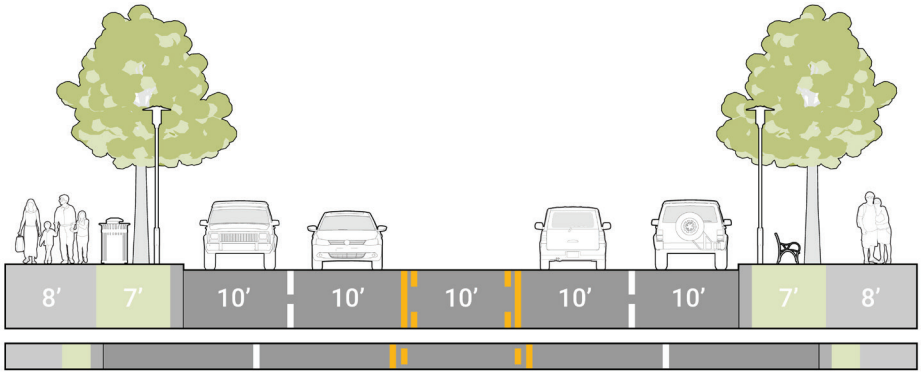
LANE NARROWING

Lane narrowing can improve comfort and safety for vulnerable road users. Narrowing lanes creates space that can be reallocated to other modes, in the form of wider sidewalks, bike lanes, and buffers between cyclists, pedestrians and motor vehicles. Space can also be dedicated to plantings and amenity zones, and reduces crossing distances at intersections.

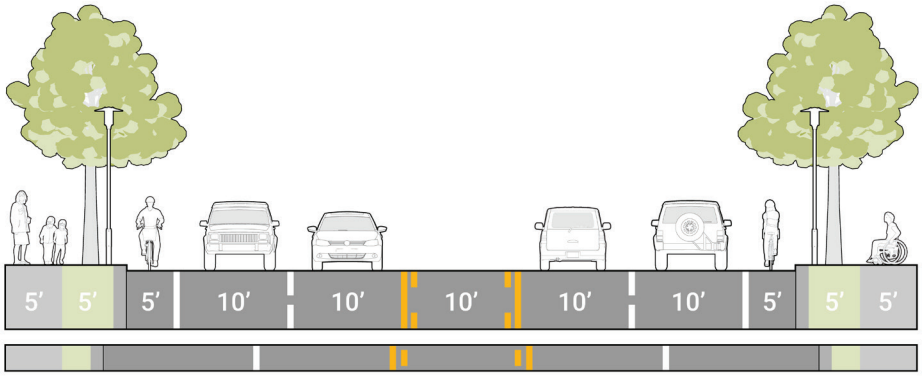
Roadway before narrowing



Narrowing motor vehicle lanes to increase sidewalk and amenity zones



Narrowing motor vehicle lanes to increase amenity zone and add bicycle lanes



APPLICATION

+ Motor vehicle travel lanes as narrow as 10 feet are allowed in low-speed environments (45 mph or less) according to the AASHTO Green Book.
+ 10-foot travel lanes are not recommended on 4-lane undivided arterial roadways, but may be considered where speeds are 30 mph or less and truck use is low.

CONSIDERATIONS

+ Narrowing existing motor vehicle lanes may result in enough space to create separated bicycle lanes, widened sidewalks and buffers, or a combination of on-street bike lanes and enhancements to the pedestrian corridor.
+ Narrower lanes can contribute to lower operating speeds along the roadway, which may be appropriate in dense, walkable corridors.

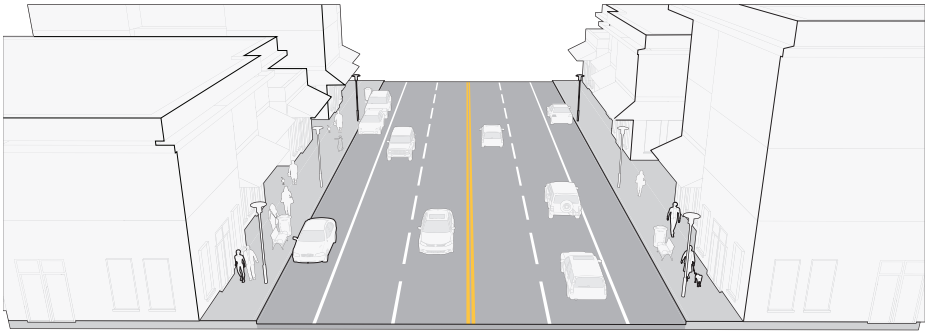
REFERENCES

AASHTO. Green Book. 2011.

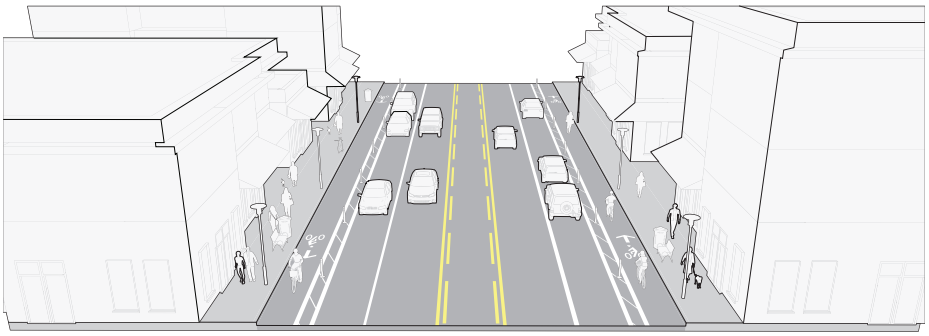
FHWA. Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

LANE RECONFIGURATION

Road diets are the reconfiguration of one or more travel lanes to calm traffic and provide space for bicycle lanes, turn lanes, streetscapes, wider sidewalks, and other purposes. Four- to three-lane conversions are the most common road diet, however, there are numerous types (e.g., three- to two-lanes, or five- to three-lanes).



Typical 4-lane road with on-street parking



Three-lane road diet (with center two-way left-turn lane), with on-street parking and separated bicycle lanes

APPLICATION

+ Lane reconfiguration is a great tool for reducing collisions and injuries, improving pedestrian crossings and providing designated space for bicyclists. Road diets improve safety as they reduce conflict points and lead to fewer and less severe collisions.

CONSIDERATIONS

+ Four-lane streets with volumes less than 15,000 vehicles per day are generally good candidates for four- to three-lane conversions.
+ Four-lane streets with volumes between 15,000 to 20,000 vehicles per day may be good candidates for four- to three-lane conversions. A traffic analysis is needed to determine feasibility.
+ Six-lane streets with volumes less than 35,000 vehicles per day may be good candidates for six- to five-lane (including two-way center turn lane) conversions. A traffic analysis is needed to determine feasibility.

REFERENCES

Dr. Ata M. Kahn, P.E., ITE Journal, Washington, D.C.

FHWA. Road Diet Guide. 2014.

NACTO. Urban Street Design Guide .2013.

MAINTENANCE OF MULTI-USE PATHS

Once constructed, shared use paths require regular maintenance to ensure a safe and usable experience for the life of the path system.

CONSIDERATIONS

+ The width of the path should allow maintenance vehicles to travel along the path and provide areas where they may turn around.
+ The pavement section should also provide enough stability to prevent substantial wear and cracking with regular maintenance vehicle traffic. Typically, 6-inch thick concrete or asphalt provides stability to withstand maintenance traffic.
+ Regular sweeping, trash removal, and snow plowing of shared use paths enhance the user experience and minimize opportunities for conflict or injury.
+ Provide surface repairs such as crack repair, concrete stone replacement, and/or joint sealing as soon as the issue is identified. These problems grow worse over time and can continue to provide opportunity for conflict or injury.
+ Cut back vegetation that is encroaching on shared use paths. Cut back tree roots and/or install root barriers where appropriate.
+ Cut back vegetation that is encroaching on signage along the path systems.
+ Inspect signs and markings regularly, replacing and repairing them as soon as possible. Consider upgrading old signs or markings with newer materials, if available.
+ Ensure drainage swales and structures are kept free of silt and debris and are functioning appropriately.
+ For any construction project that may impact an existing shared use path, an appropriate detour and signage plan should be proposed by the contractor to ensure continuous and safe service of the shared use paths.
+ Check, repair, and maintain all lights and lighting systems, particularly underpass lighting.
+ Natural surface paths may need regrading, weeding, or the repair of ruts.

MAINTENANCE OF SEPARATED BIKE LANES

Separated bike lanes require routine maintenance to ensure they provide safe bicycling conditions. Because of their location on the edge of the roadway, separated bike lanes are more likely to accumulate debris in all seasons. During the freeze/thaw cycles of the winter months, separated bike lanes are particularly susceptible to icing. As bicyclists are typically inhibited from exiting separated bike lanes, they may have no opportunity to avoid obstacles such as debris, obstructions, slippery surfaces, and pavement damage and defects.

CONSIDERATIONS

A separated bike lane should be maintained in a similar manner as the adjacent roadway, regardless of whether the separated bike lane is at street level or sidewalk level. Maintenance of separated bike lanes is therefore the responsibility of the public or private agency that is responsible for maintaining the adjacent roadway. This practice may contrast with responsibility for maintaining the adjacent sidewalk, which in some cases will be that of the abutting landowner.

Generally, separated bike lane widths of 8 feet or more are compatible with smaller sweepers and plows, but responsible parties may have larger and incompatible maintenance fleets. Narrower sweepers and plows (approximately 4 feet to 5 feet minimum operating width) may be required to clear one-way separated bike lanes.

Trash Collection

Where separated bike lanes are introduced, the general public, public works staff and contractors should be trained to place garbage bins in the street buffer zone to avoid obstructing the bike lane. Sidewalk buffers may be used to store bins where street buffers are too narrow. Special consideration may be required in separated bike lane design for access to large dumpsters which require the use of automated arms. This may require spot restrictions of on-street parking or curb cuts to dumpster storage in order to accommodate access.

Sweeping and Debris Removal

For street-level separated bike lanes without raised medians, debris can collect in the street buffer area between vertical objects and can migrate into the bike lane if not routinely collected. Landscaped areas, including green stormwater infrastructure, can also collect debris and require regular attention. Fine debris can settle into permeable pavement and inhibit surface infiltration unless vacuumed on a routine basis. At a minimum, permeable pavement should be vacuumed several times per year, depending on material type.

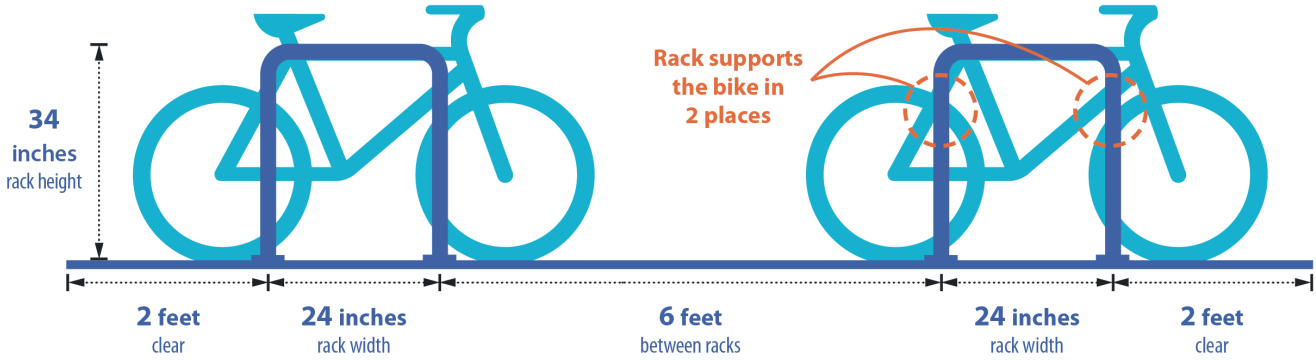
REFERENCES

NACTO. Urban Street Design Guide. 2013.

MassDOT. Separated Bicycle Lane Planning & Design. 2015.

SHORT-TERM BICYCLE PARKING

Bicycle parking enhances the effectiveness of bicycle networks by providing locations for the secure storage of bicycles during a trip. Bicycle parking enables bicyclists to secure their bicycles while patronizing businesses, recreating, and going to work. Bicycle parking requires far less space than automobile parking-- in fact, 10 bicycles can typically park in the area needed for a single car.

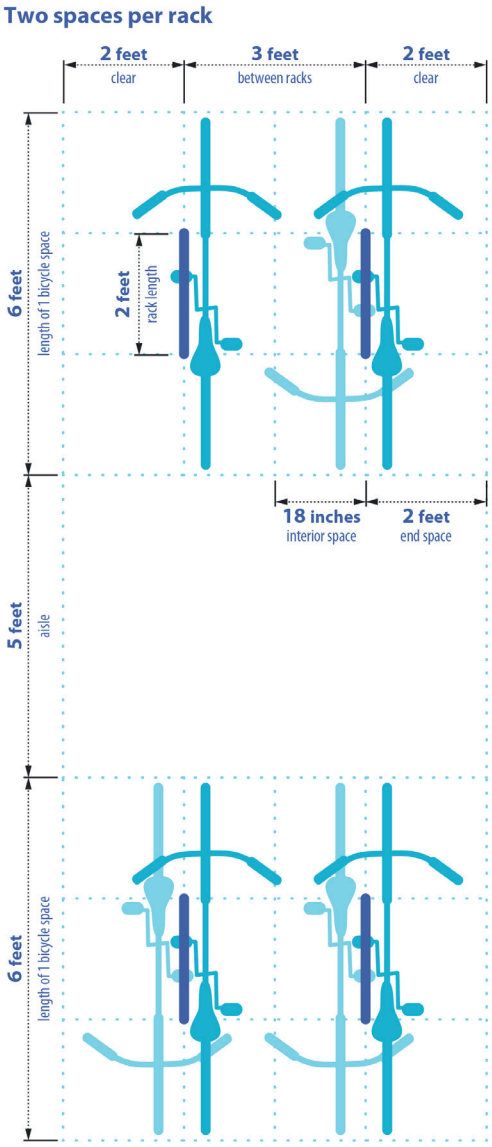


APPLICATION

+ Bicycle parking consists of a rack that supports the bicycle upright and provides a secure place for locking. Bicycle racks should be permanently affixed to a paved surface. Movable bicycle racks are only appropriate for temporary use, such as at major community gatherings.

CONSIDERATIONS

+ Bicycle parking facility should not obstruct pedestrian traffic or interfering with the use of the pedestrian areas.
+ Each parked bicycle should be accessible without moving another bicycle.
+ On-street bicycle parking is intended for short term use.
+ Multiple types of racks exist, but all should adhere to guidance pictured above regarding providing two points of contact for bike frame to prevent bikes from falling.



REFERENCES

FHWA. Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

LONG-TERM BICYCLE PARKING

Long-term bicycle parking is intended to provide sheltered and secure bicycle storage for residents, employees and long-term visitors who are leaving their bicycles in a residential or commercial building for several hours or longer and therefore need their bicycles to be protected from vandalism, theft and the elements.

APPLICATION

Lockers should be:

+ Clearly marked as a long-term bicycle parking space.
+ Located no lower than the first complete parking level below grade, and no higher than the first complete parking level above grade.
+ Available and accessible to all building tenants during the buildings hours of operation and at all times for residents in residential contexts.
+ Located in a well-lit, visible location near the main entrance or elevators.
+ Separated from vehicle parking by a barrier that minimizes the possibility of a parked bicycle being hit by a car.
+ Securely anchored.
+ Well-maintained and well lit.

CONSIDERATIONS

A bicycle locker is a secure, locked box that stores a single bicycle and provides:

+ Highly secure bicycle storage in an enclosed box.
+ Direct or indirect access to the street or sidewalk depending on whether it is located in a parking garage or at street level.
+ Varying amount of conflict with automobiles depending on whether it is located in a parking garage or at street level.
+ Long-term bicycle parking can also be provided indoors. This can be located within businesses or offered as a locked public facility, accessible with the same key card technology as bicycle lockers.

REFERENCES

Manual on Uniform Traffic Control Devices. 2009.

NACTO. Urban Street Design Guide. 2013.

WALK AUDITS

Walk audits (also called road safety audits) are a tool that transportation practitioners use to collect information about street conditions and identify opportunities to improve roadway safety for people walking and bicycling. Walk audits are an on-the-ground review of infrastructure and user behaviors. Audits are conducted to gather more detailed information on infrastructure design and deficiencies that may be impacting traffic safety. Audits are also a great opportunity to engage stakeholders from the area and get their insights on issues impacting pedestrian and bicyclist safety.

APPLICATION

A few reasons to conduct a walk audit include:

- Document existing conditions to assess how walkable or bikeable a route is
- Identify barriers to walking and bicycling
- Determine issues that can be fixed
- Engage community members, local agency staff, or elected officials in discussions about roadway safety at a specific location.

CONSIDERATIONS

- There are numerous checklists available that can be used to structure and conduct walk audits.
- The choice of whether a walk audit focuses on walking and bicycling conditions at the same time or separately may depend on what the known issues are, time constraints, or who is participating in the audit.
- A walk audit can occur as part of a bigger plan to assess overall walkability, or it can be a one-time event to understand or express concerns about a specific area, such as walking routes near schools.

REFERENCES

U.C. Berkeley. A Technical Guide for Conducting Pedestrian Safety Assessment for California Communities. 2013.

FHWA. Pedestrian Road Safety Audit Guidelines and Prompt Lists. 2014.

WAYFINDING

Wayfinding is a highly visible way to improve bicycling in an area because it helps identify the best routes to destinations, helps people overcome a barrier of not knowing where to ride, and reminds motorists to anticipate the presence of bicyclists. A wayfinding system typically combines signage and pavement markings to guide bicyclists along preferred routes to destinations across the community, county, or region. The routes may or may not be numbered, named, or color-coded. Signs may also indicate distances or travel time to destinations. Similar wayfinding systems can be devised for pedestrian travel.

Bicycle Boulevard sign in Berkeley, CA

Bike Wayfinding sign in Fort Collins, CO

D11-1

D1-3c

CONSIDERATIONS

A bicycle wayfinding protocol should coordinate with bicycle route maps and provide three general forms of guidance:

- Decision assemblies, which consist of Bike Route identification and optional destination fingerboards, placed at decision points where routes intersect or on the approaches to a designated bike route.
- Decision signs, which consist of Bike Route panels and arrow plaques, placed where a designated bike route turns from one street to another.
- Confirmation assemblies, which consist of Bike Route panels and optional destination fingerboards, placed on the far side of intersections to confirm route choice and the distance (and optionally, time) to destinations.

Sign design can be customized to add distinct community branding, but the clarity and accuracy of the information must be the top priority.

- Basic bicycle route signs consist of a MUTCD-style "Bike Route" sign (D11-1 shown above) placed every half mile on a major bike route and on the approach to major bike routes at decision points. Unique numbered routes can be designated and can incorporate a route name or agency logos.
- Bike route signs can be supplemented with "fingerboard" panels showing destinations, directions, and distances (MUTCD D1 series).
- Place directional signs on the near side of intersections and confirmation signs on the far side of intersections.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2014.

Caltrans. Manual on Uniform Traffic Control Devices. 2012.

TOOLE
DESIGN