

CITY OF HALF MOON BAY

Bicycle and Pedestrian Master Plan: Design Guidelines



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CONTEXT



CONTEXT

GUIDANCE BASIS

The sections that follow serve as an inventory of pedestrian and bicycle design treatments and provide guidelines for their development to implement the Half Moon Bay Bicycle and Pedestrian Master Plan (BP Master Plan). These treatments and design guidelines are important because they represent the tools for creating a walking- and bicycle-friendly, safe, accessible community. The guidelines are not, however, a substitute for a more thorough evaluation by a professional upon implementation of facility improvements. The following standards and guidelines are referred to in this guide.

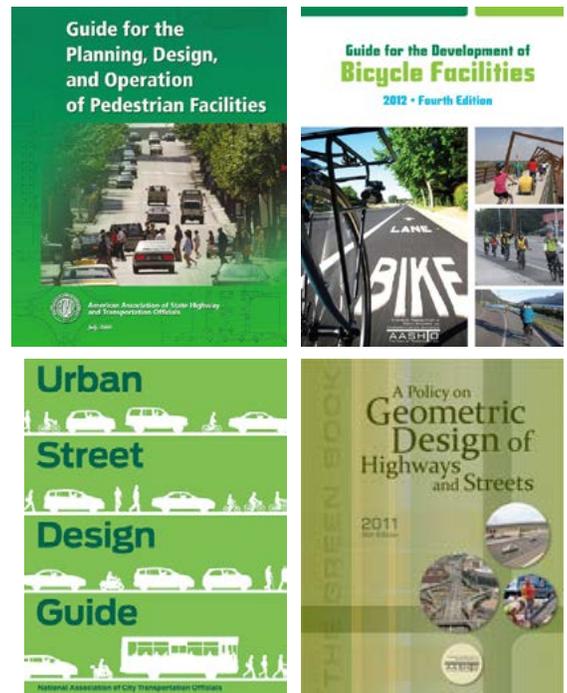
National Guidance

The American Association of State Highway and Transportation Officials (**AASHTO**) **Guide for the Planning, Design and Operation of Pedestrian Facilities (2004)** provides comprehensive guidance on planning and designing for people on foot.

Offering similar guidance for bicycle facility design, the **AASHTO Guide for the Development of Bicycle Facilities (2012)**, provides guidance on dimensions, use, and layout of specific bicycle facilities.

The National Association of City Transportation Officials' (**NACTO**) **Urban Bikeway Design Guide (2012)** and **Urban Street Design Guide (2013)** are collections of nationally recognized street design standards, and offers guidance on the current state of the practice designs.

The **AASHTO A Policy on Geometric Design of Highways and Streets (2011)** commonly referred to as the “Green Book,” contains the current design research and practices for highway and street geometric design.



Impact on Safety and Crashes

Walking and biking facilities can have a significant influence on user safety. The Federal Highway Administration’s (FHWA) **Crash Modification Factor Clearinghouse (<http://www.cmfclearinghouse.org/>)** is a web-based database of Crash Modification Factors (CMF) to help transportation engineers identify the most appropriate countermeasure for their safety needs. Where available and appropriate, CMFs or similar study results are included for each treatment.



California Guidance

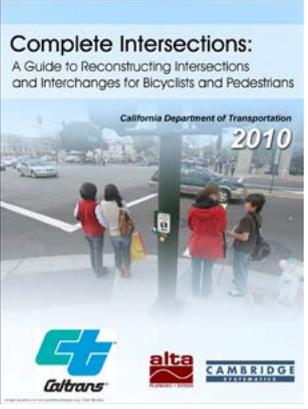
The **California Manual on Uniform Traffic Control Devices (MUTCD) (2014)** is an amended version of the FHWA MUTCD 2009 edition modified for use in California. While standards presented in the CA MUTCD substantially conform to the FHWA MUTCD, the state of California follows local practices, laws and requirements with regards to signing, striping and other traffic control devices.



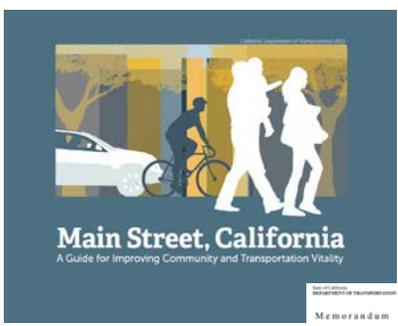
The **California Highway Design Manual (HDM) (Updated 2015)** establishes uniform policies and procedures to carry out highway design functions for the California Department of Transportation.



Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians (2010) is a reference guide that presents information and concepts related to improving conditions for bicyclists and pedestrians at major intersections and interchanges. The guide can be used to inform minor signage and striping changes to intersections, as well as major changes and designs for new intersections.



Main Street, California: A Guide for Improving Community and Transportation Vitality (2013) reflects California's current manuals and policies that improve multimodal access, livability and sustainability within the transportation system. The guide recognizes the overlapping and sometimes competing needs of main streets.



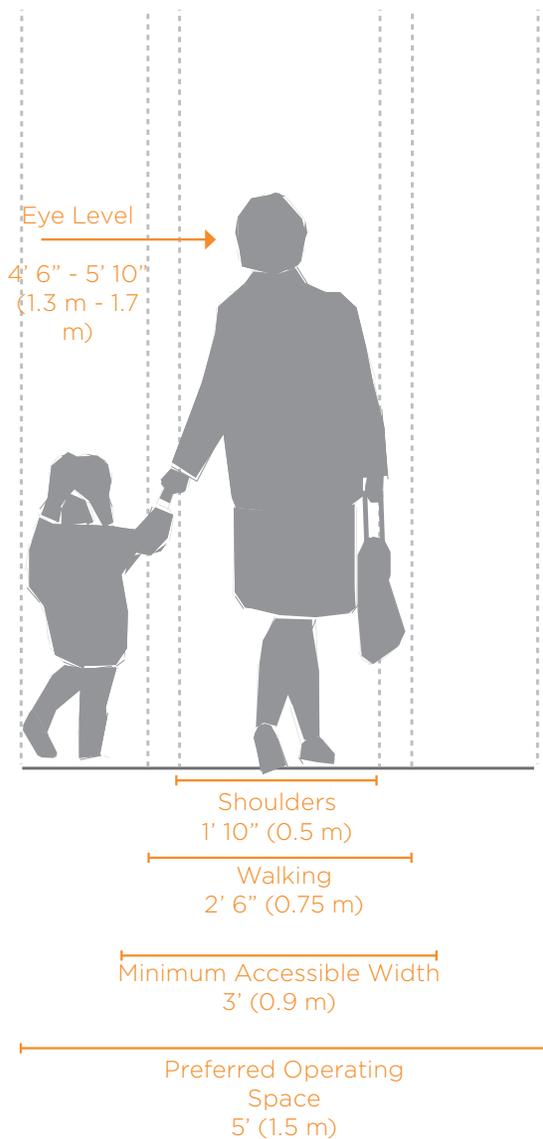
The Caltrans Memo: **Design Flexibility in Multimodal Design (2014)** encourages flexibility in highway design. The memo stated that "Publications such as the National Association of City Transportation Officials (NACTO) "Urban Street Design Guide" and "Urban Bikeway Design Guide," ... are resources that Caltrans and local entities can reference when making planning and design decisions on the State highway system and local streets and roads."



CONTEXT

DESIGN NEEDS OF PEDESTRIANS

The MUTCD recommends a normal walking speed of 3.5 feet per second when calculating the pedestrian clearance interval at traffic signals. The walking speed can drop to 3 feet per second for areas with older populations and persons with mobility impairments. While the type and degree of mobility impairment varies greatly across the population, the transportation system should accommodate these users to the greatest reasonable extent.



Pedestrian Characteristics by Age

AGE	CHARACTERISTICS
0-4	Learning to walk Requires constant adult supervision Developing peripheral vision and depth perception
5-8	Increasing independence, but still requires supervision Poor depth perception
9-13	Susceptible to "darting out" in roadways Insufficient judgment Sense of invulnerability
14-18	Improved awareness of traffic environment Insufficient judgment
19-40	Active, aware of traffic environment
41-65	Slowing of reflexes
65+	Difficulty crossing street Vision loss Difficulty hearing vehicles approaching from behind

Source: AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, Exhibit 2-1. 2004.

Types of Pedestrians

Pedestrians have a variety of characteristics and the transportation network should accommodate a variety of needs, abilities, and possible impairments. Age is one major factor that affects pedestrians' physical characteristics, walking speed, and environmental perception. Children have low eye height and walk at slower speeds than adults. They also perceive the environment differently at various stages of their cognitive development. Older adults walk more slowly and may require assistive devices for walking stability, sight, and hearing. The table below summarizes common pedestrian characteristics for various age groups.

The table below summarizes common physical and cognitive impairments, how they affect personal mobility, and recommendations for improved pedestrian-friendly design.

Disabled Pedestrian Design Considerations (AASHTO Pedestrian Guide 2004)

IMPAIRMENT	EFFECT ON MOBILITY	DESIGN SOLUTION
Physical Impairment Necessitating Wheelchair and Scooter Use	Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
	Cross-slopes cause wheelchairs to veer downhill or tip sideways.	Cross-slopes of less than two percent.
	Require wider path of travel.	Sufficient width and maneuvering space.
Physical Impairment Necessitating Walking Aid Use	Difficulty negotiating steep grades and cross slopes; decreased stability and tripping hazard.	Cross-slopes of less than two percent. Smooth, non-slippery travel surface.
	Slower walking speed and reduced endurance; reduced ability to react.	Longer pedestrian signal cycles, shorter crossing distances, median refuges, and street furniture.
Hearing Impairment	Less able to detect oncoming hazards at locations with limited sight lines (e.g. driveways, angled intersections, channelized right turn lanes) and complex intersections.	Longer pedestrian signal cycles, clear sight distances, highly visible pedestrian signals and markings.
Vision Impairment	Limited perception of path ahead and obstacles; reliance on memory; reliance on non-visual indicators (e.g. sound and texture).	Accessible text (larger print and raised text), accessible pedestrian signals (APS), guide strips and detectable warning surfaces, safety barriers, and lighting.
Cognitive Impairment	Varies greatly. Can affect ability to perceive, recognize, understand, interpret, and respond to information.	Signs with pictures, universal symbols, and colors, rather than text.

CONTEXT

PEDESTRIAN CROSSING LOCATION AND FACILITY SELECTION

The specific type of treatment at a crossing may range from a simple marked crosswalk to full traffic signals or grade separated crossings. Crosswalk lines should not be used indiscriminately, and appropriate selection of crossing treatments should be evaluated in an engineering study should be performed before a marked crosswalk is installed. The engineering study should consider the number of lanes, the presence of a median, the distance from adjacent signalized intersections, the pedestrian volumes and delays, the average daily traffic (ADT), the posted or statutory speed limit or 85th-percentile speed, the geometry of the location, the possible consolidation of multiple crossing points, the availability of street lighting, and other appropriate factors.



Midblock Crossings

Midblock crossings are an important street design element for pedestrians. They can provide a legal crossing at locations where pedestrians want to travel, and can be safer than crossings at intersections because traffic is only moving in two directions. Locations where midblock crossings should be considered include:

- Long blocks (longer than 600 ft) with destinations on both sides of the street.
- Locations with heavy pedestrian traffic, such as schools, shopping centers.
- Midblock transit stops, where transit riders must cross the street on one leg of their journey.

Crossing Treatment Selection

PEDESTRIAN CROSSING CONTEXTUAL GUIDANCE At unsignalized locations		Local Streets 15-25 mph			Collector Streets 25-30 mph			Arterial Streets 30-45 mph						
		2 lane	3 lane	2 lane	2 lane with median refuge	3 lane	2 lane	2 lane with median refuge	3 lane	4 lane	4 lane with median refuge	5 lane	6 lane	6 lane with median refuge
1	Crosswalk Only (high visibility)	✓	✓	EJ	EJ	X	EJ	EJ	X	X	X	X	X	X
2	Crosswalk with warning signage and yield lines	EJ	✓	✓	✓	✓	EJ	EJ	EJ	X	X	X	X	X
3	Stop Sign Controlled	✓	✓	EJ	EJ	EJ	EJ	EJ	EJ	X	X	X	X	X
4	Active Warning Beacon (RRFB)	X	EJ	✓	✓	✓	✓	✓	✓	X	✓	X	X	X
5	Hybrid Beacon	X	X	EJ	EJ	EJ	EJ	✓	✓	✓	✓	✓	✓	✓
6	Full Traffic Signal	X	X	EJ	EJ	EJ	EJ	EJ	EJ	✓	✓	✓	✓	✓
7	Grade separation	X	X	EJ	EJ	EJ	X	EJ	EJ	✓	✓	✓	✓	✓

LEGEND	
Most Desirable	✓
Engineering Judgement	EJ
Not Recommended	X



CONTEXT

DESIGN NEEDS OF BICYCLISTS

The facility designer must have an understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers.

By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

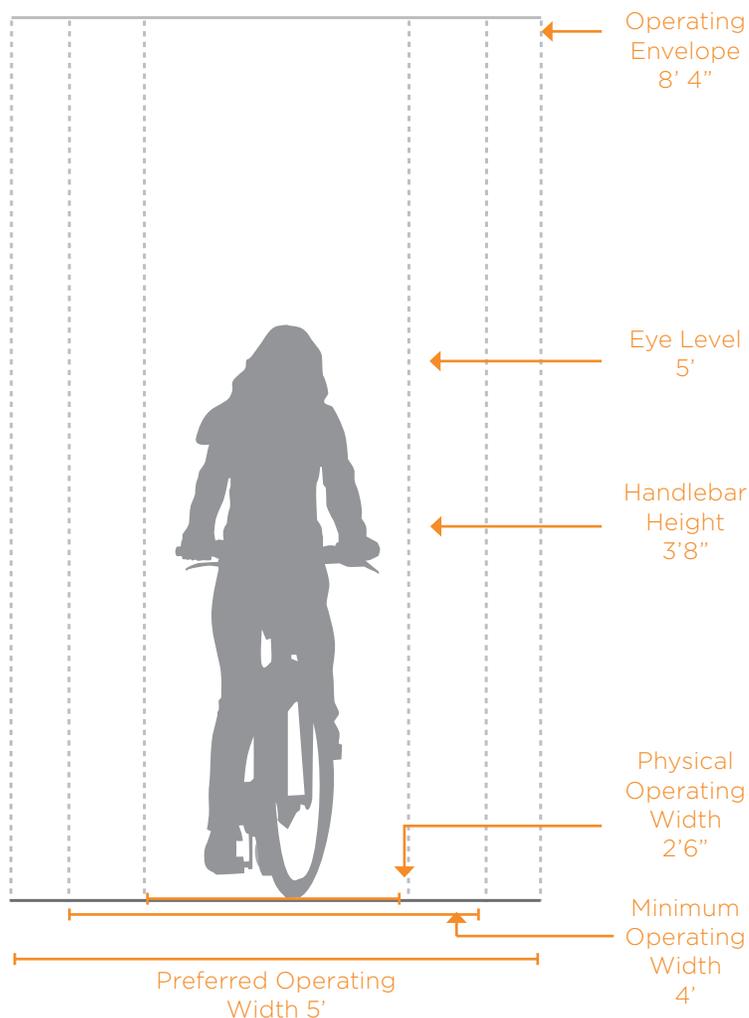
Bicycle as a Design Vehicle

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

The figure to the right illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist. Bicyclists prefer five feet or more operating width, although four feet may be minimally acceptable.

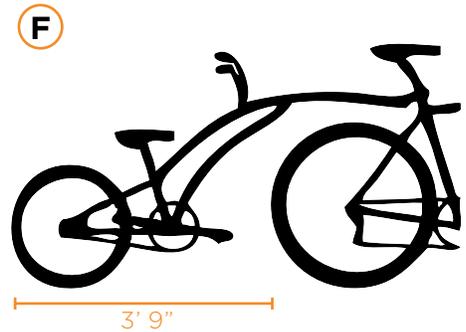
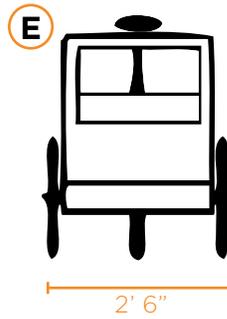
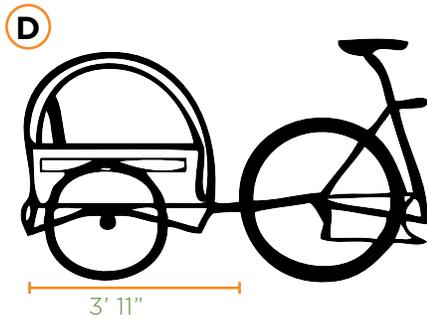
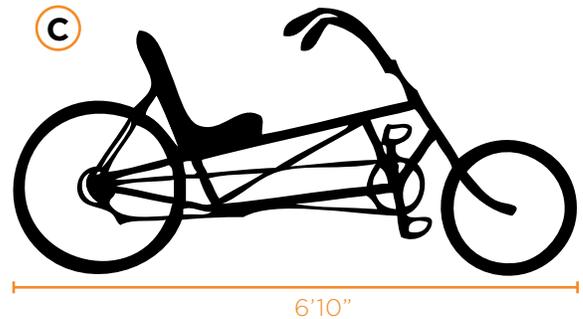
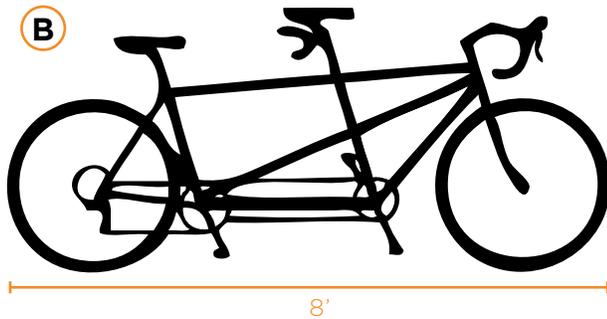
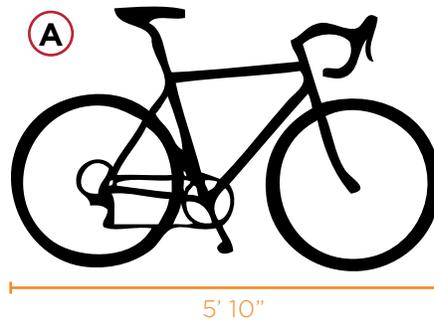
In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories. The figure to the left summarizes the typical dimensions for bicycle types.

Bicycle Rider - Typical Dimensions



Bicycle Design Vehicle - Typical Dimensions

- A: Adult Typical Bicycle
- B: Adult Tandem Bicycle
- C: Adult Recumbent Bicycle
- D: Child Trailer Length
- E: Child Trailer Width
- F: Trailer Bike Length



Source: AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition

Design Speed Expectations

The expected speed that different types of bicyclists can maintain under various conditions also influences the design of facilities such as shared use paths. The table to the right provides typical bicyclist speeds for a variety of conditions.

Bicycle as Design Vehicle - Design Speed Expectations

BICYCLE TYPE	FEATURE	TYPICAL SPEED
Upright Adult Bicyclist	Paved level surfacing	8-12 mph*
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

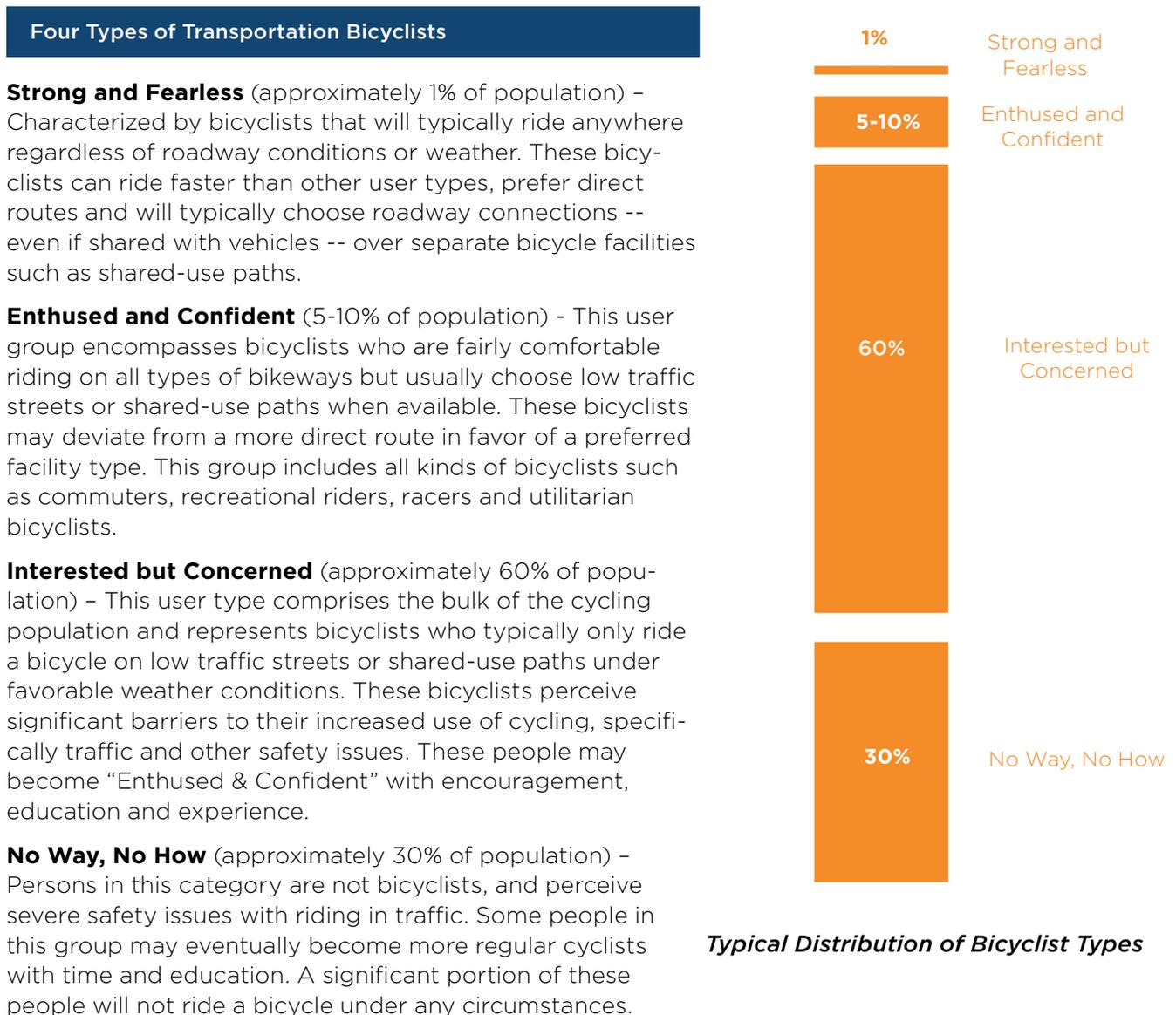
* Typical speed for casual riders per AASHTO 2013.

CONTEXT

BICYCLIST USER TYPE

The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs. Transportation) and on the level of comfort and skill of the rider (Casual vs. Experienced). An alternate research based* classification system identifies four categories to address varying attitudes towards bicycling in the US. This system is illustrated in the figure below.

* Dill, J., McNeil, N. Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential. 2012.



CONTEXT

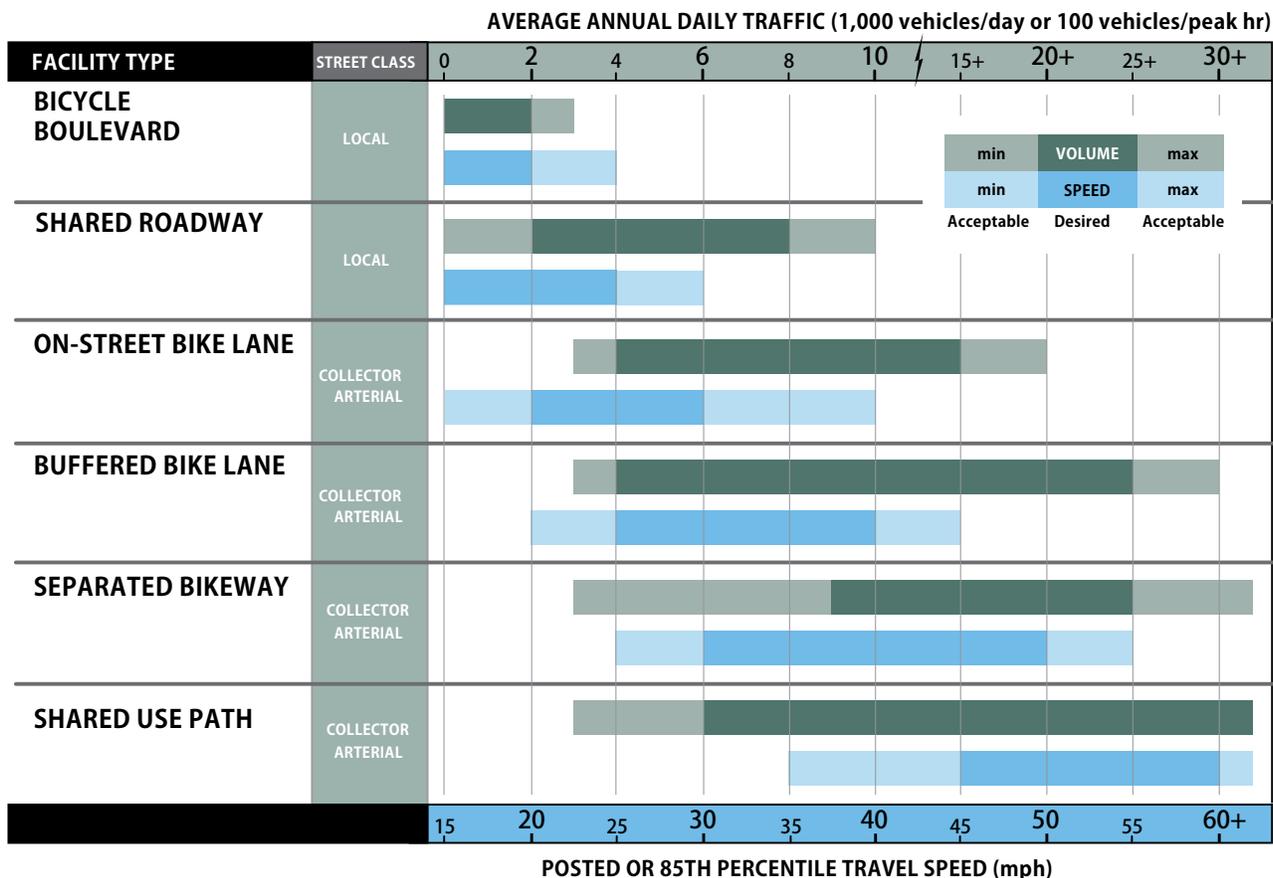
BICYCLE FACILITY SELECTION

Selecting the best bikeway facility type for a given roadway can be challenging, due to the range of factors that influence bicycle users' comfort and safety. There is a significant impact on cycling comfort when the speed differential between bicyclists and motor vehicle traffic is high and motor vehicle traffic volumes are high.

Facility Selection Table

As a starting point to identify a preferred facility, the chart below can be used to determine the recommended type of bikeway to be provided in particular roadway speed and volume situations. To use this chart, identify the appropriate daily traffic volume and travel speed on or the existing or proposed roadway, and locate the facility types indicated by those key variables.

Other factors beyond speed and volume which affect facility selection include traffic mix of automobiles and heavy vehicles, mix and volume of pedestrians, the presence of on-street parking, intersection density, surrounding land use, and roadway sight distance. These factors are not included in the facility selection chart below, but should always be considered in the facility selection and design process.



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PEDESTRIAN GUIDELINES



PEDESTRIAN GUIDELINES

PEDESTRIAN ZONES

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel separated from vehicle traffic. Providing adequate and accessible facilities can lead to increased numbers of people walking, improved safety, and the creation of social space.

Community character and the pedestrian environment vary throughout Half Moon Bay. This means that a unique, flexible approach is needed to improve the pedestrian network. Some neighborhoods do not have sidewalks and want to retain their rural character. Other areas have high pedestrian demand and should be a priority for sidewalk improvements and gap closures.

Because of these variables, pedestrian zones are created within the community, each with associated guidelines to facilitate the implementation of a complete and safe pedestrian network.

Pedestrian Priority Zones

Pedestrian Priority Zones are designated areas where high quality, connected pedestrian facilities should be provided. These areas provide pedestrian connections within downtown, to schools within Half Moon Bay, and to a majority of the senior housing facilities in the community. Projects within these zones should:

- Prioritize closing sidewalk gaps and removing obstacles
- Include wider sidewalks with pedestrian amenities
- Improve intersections and crossings

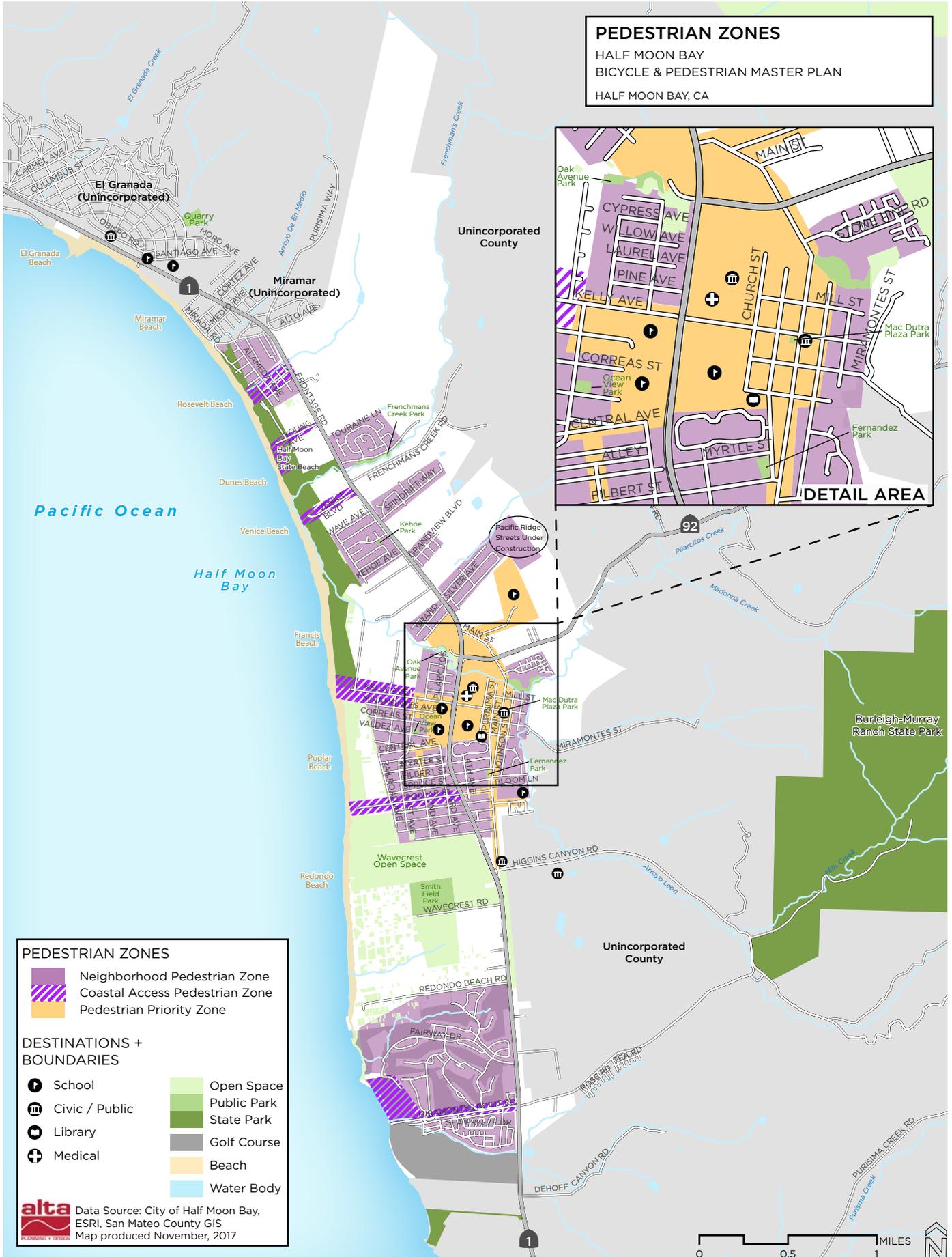
Coastal Access Zones

Coastal Access Zones are areas that provide key pedestrian connections to the Coastal Trail and to the coast. Projects in these zones should provide pedestrian accommodation that meets minimum sidewalk widths or shared use path standards. These areas should be prioritized for special studies or planning processes

Neighborhood Streets Zones

Neighborhood Streets Zones are broken down into three categories based on the unique context of the neighborhood:

- Sidewalk Zones - These include areas that currently have sidewalks, areas of new development, or key network connections within residential communities. Projects in these areas should provide sidewalks that meet minimum width requirements and improve crossings.
- Sidepath Zones - These include areas that do not currently have sidewalks, but the community desires a path or network connection. Projects in these areas should provide walkways that meet ADA standards but preserve the rural character of the neighborhood, as an alternative to concrete sidewalks, curbs, and gutters.
- Shared Zones - These include residential areas that do not currently have sidewalks, are not priority network connections, and where residents do not desire sidewalks or paths. Projects in these areas should focus on traffic calming measures to reduce vehicle speeds, and signage to increase awareness that pedestrians may be walking in the roadway.



PEDESTRIAN INFRASTRUCTURE

These guidelines are intended to inform decision-making, but are not strict standards that shall be adhered to. Within each pedestrian zone, there are guidelines for the appropriate type of pedestrian infrastructure.

Preferred Treatment

Within the pedestrian zone, infrastructure identified as a preferred treatment should be considered first and should be incorporated wherever feasible.

Optional Treatment

Optional treatments can be considered in a designated pedestrian zone. Additional context, design, engineering, or community engagement is needed to determine if the optional treatment should be pursued, but it is a possible treatment for the area.

Not Preferred, But May Be Considered

In designated pedestrian zones, these infrastructure treatments may be considered, but they are not the preferred treatment for the area.

Discouraged

In designated pedestrian zones, these infrastructure treatments are discouraged because they do not support the objectives of the pedestrian zone or do not fit the character of the area.

Pedestrian Infrastructure	Pedestrian Priority Zone	Coastal Access Zone	Neighborhood Streets		
			Sidewalk Zone	Sidepath Zone	Shared Zone
Priority Zone Sidewalks	●	○	⊘	⊘	⊘
Standard Sidewalks	○	○	●	○	⊙
Sidepaths or pedestrian lane	⊘	○	⊘	●	○
Advisory Bike Lanes/ Shared Path	⊘	○	⊘	●	○
Shared Use Streets	⊘	○	⊘	⊙	●
Traffic Calming	○	○	○	○	○
Curb Extension	○	○	○	⊙	⊘
Green Stormwater Infrastructure	○	○	○	○	○
Continental Crosswalks	●	○	○	⊙	⊙
Parallel Markings Crosswalks	⊙	○	●	●	●
Pedestrian Signals	○	○	○	⊙	⊘
Pedestrian Furniture	●	○	⊙	⊙	⊘
Pedestrian Lighting	●	○	○	⊙	⊘

●	Preferred Treatment
○	Optional treatment based on conditions
⊙	Not preferred, but may be appropriate in some circumstances
⊘	Discouraged

PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN PRIORITY SIDEWALKS

In Priority Pedestrian Zones, sidewalks should be designed to accommodate the higher pedestrian volumes expected in downtown areas, as well as amenities that improve the quality of the pedestrian experience.



PARKING LANE/ ENHANCEMENT ZONE	FURNISHING ZONE (OPTIONAL)	PEDESTRIAN THROUGH ZONE	FRONTAGE ZONE
<p>The parking lane can act as a flexible space to further buffer the sidewalk from moving traffic. Curb extensions and bike corrals may occupy this space where appropriate.</p> <p>In the edge zone there should be a 6-inch-wide curb.</p>	<p>This zone should be 2-6 feet wide.</p> <p>The furnishing zone buffers pedestrians from the adjacent roadway, and is also the area where elements such as street trees, signal poles, signs, and other street furniture are properly located.</p> <p>Space constraints may preclude providing this pace in some locations.</p>	<p>This zone should be 6-12 feet wide.</p> <p>The through zone is the area intended for pedestrian travel. This zone should be entirely free of permanent and temporary objects.</p> <p>Wide through zones are needed in downtown areas or where pedestrian flows are high.</p> <p>In constrained conditions, a minimum through zone of 6 feet should be maintained, with other zones narrowed to meet needs.</p>	<p>This zone should be 2.5-10 feet wide.</p> <p>The Frontage Zone allows pedestrians a comfortable “shy” distance from the building fronts. It provides opportunities for window shopping, to place signs, planters, or chairs.</p> <p>Not applicable if adjacent to a landscaped space.</p>

Typical Application

- Sidewalks should be provided on both sides of streets in Pedestrian Priority Zones
- All gaps in the sidewalk network within the Pedestrian Priority Zone should be prioritized.

Design Features

- It is important to provide adequate width along a sidewalk corridor. A pedestrian through zone width of six feet enables two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably.
- Appropriate placement of street trees in the furnishing zone (minimum width 4 feet) helps buffer pedestrians from the travel lane and increases facility comfort.

Further Considerations

- The Americans with Disabilities Act requires a 3 foot clear width in the pedestrian zone plus 5 foot passing areas every 200 feet. Wider sidewalks are recommended for Pedestrian Priority Zones.
- Providing a 6 foot clear width across the full corridor for all new sidewalks (and up to 12 feet in downtown and pedestrian-priority areas) meets requirements for passing and maneuverability.
- Existing deficient-width sidewalks should be retrofitted to meet citywide standards.
- The number and width of driveways should be minimized in Pedestrian Priority Zones. Sidewalks should be kept level (no sloping) at driveways.

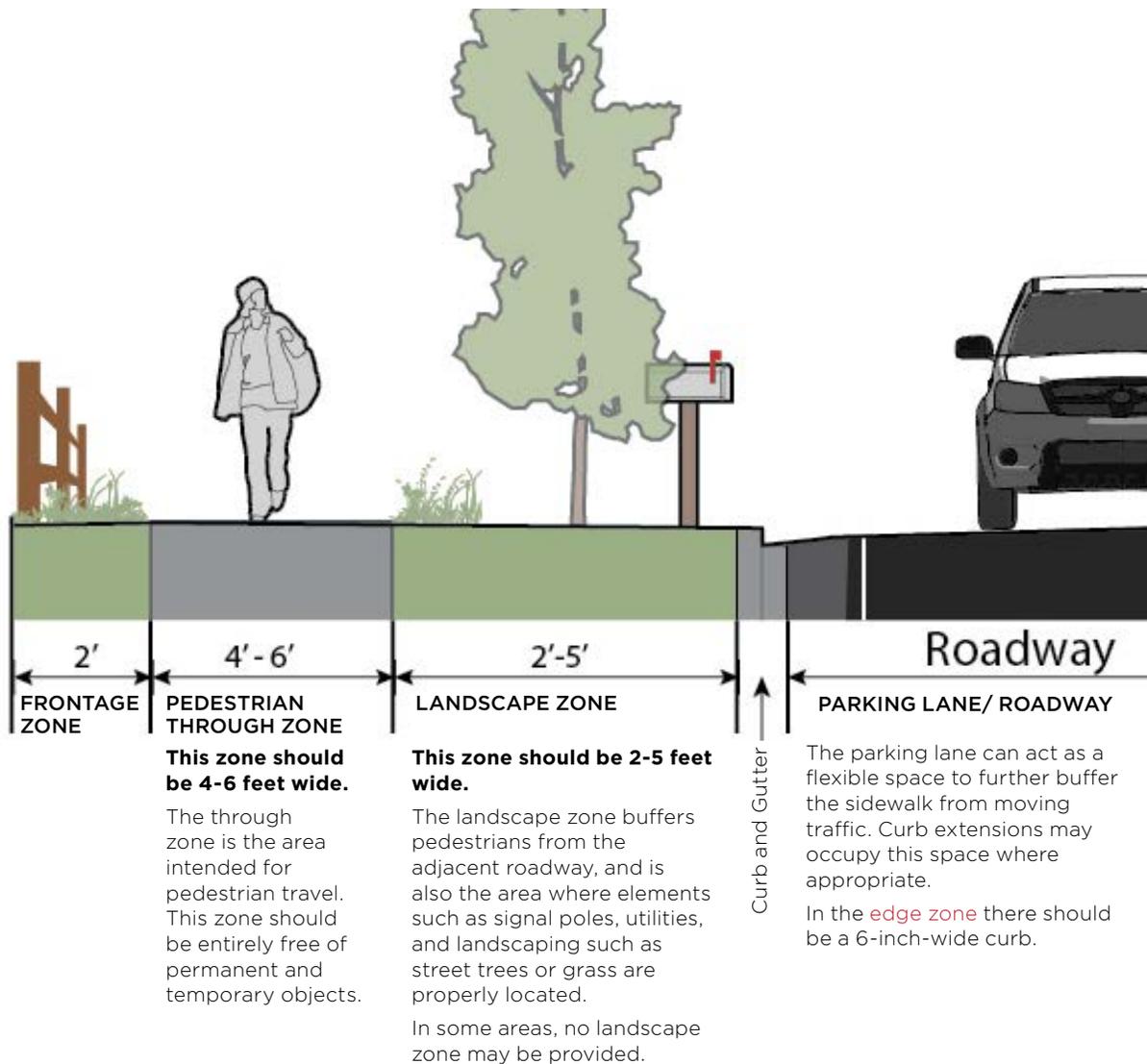
Construction Costs

The cost of building sidewalks vary based on the location, type of material, the scale, and whether it is part of a broader street construction project. A five-foot concrete sidewalk is approximately \$32 per linear foot on average, with the additional cost of new curbs and drainage likely to be substantially higher.

PEDESTRIAN INFRASTRUCTURE

STANDARD SIDEWALKS

Standard sidewalks are appropriate for Coastal Access Zones and Neighborhood Zones. In Neighborhood Zones, pedestrian demand is generally somewhat lower and surrounding land uses are residential. As a result, sidewalks and landscaped zones may be narrower than appropriate for Pedestrian Priority Zones. In many cases Coastal Access Zones occur within neighborhoods where limited space must be balanced with high pedestrian demand during beach season. The Standard Sidewalks guidelines ensure adequate width for pedestrians and a landscape zone to create a comfortable pedestrian environment.



Typical Application

- Sidewalks should be provided on both sides of streets.
- When retrofitting gaps in the sidewalk network, locations near transit stops, schools, parks, public buildings, and other areas with high concentrations of pedestrians should be the highest priority.

Design Features

- It is important to provide adequate width along a sidewalk corridor. A pedestrian through zone width of six feet enables two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably.
- The landscape zone helps buffer pedestrians from the travel lane and increases facility comfort.

Further Considerations

- The Americans with Disabilities Act requires a 3 foot clear width in the pedestrian zone plus 5 foot passing areas every 200 feet. Wider sidewalks are recommended for Pedestrian Priority Zones.
- The clear width may be reduced to a minimum of 32 inches for short, constrained segments of up to 24 inches long, provided that constrained segments are separated by regular clear width segments that are a minimum of 48 inches long and 36 inches wide.
- Providing a 4-6 foot clear width for all new sidewalks will provide adequate maneuverability standards for neighborhood streets.
- Existing deficient-width sidewalks are to be retrofitted to meet citywide standards.

Construction Costs

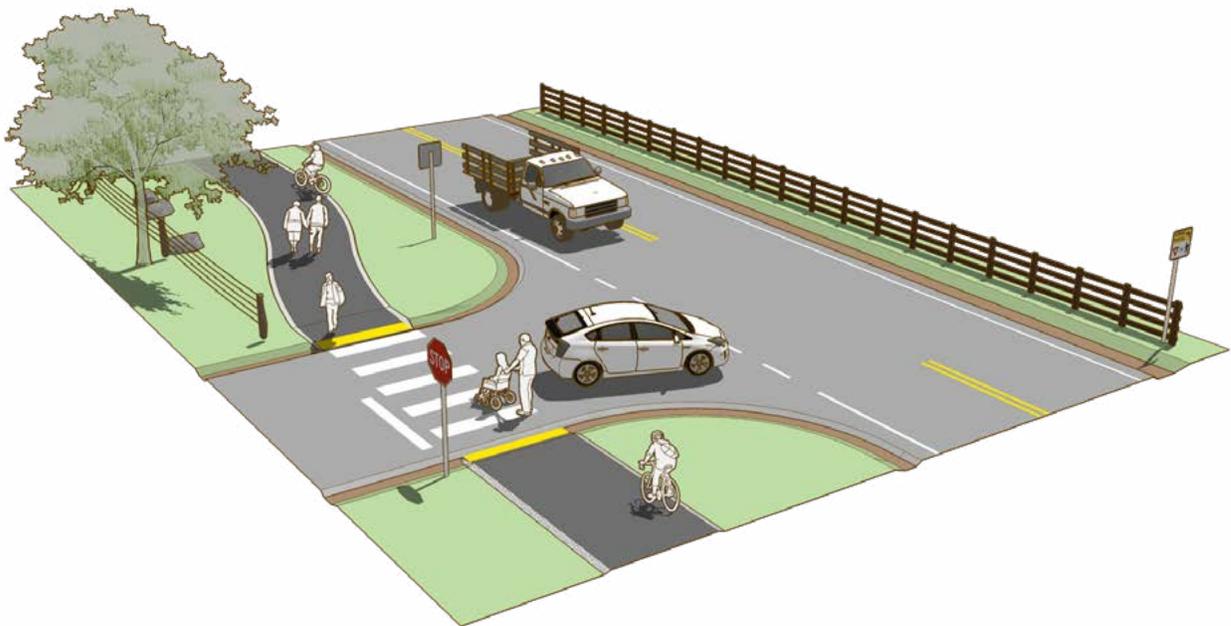
The cost of building sidewalks vary based on the location, type of material, the scale, and whether it is part of a broader street construction project. A five-foot concrete sidewalk is approximately \$32 per linear foot on average, with the additional cost of new curbs and drainage likely to be substantially higher.

PEDESTRIAN INFRASTRUCTURE

SIDEPATH

FROM THE FHWA SMALL TOWN AND RURAL DESIGN GUIDE

A sidepath is a bidirectional shared use or pedestrian only path located immediately adjacent and parallel to a roadway. Sidepaths can offer a high-quality experience for users of all ages and abilities as compared to on-roadway facilities in heavy traffic environments, allow for reduced roadway crossing distances, and maintain rural and small town community character.

**Typical Application**

Sidepaths are used on roadways without sidewalk, curb, and gutter, but where additional separation from traffic is desired.

Design Considerations

- Sidepath width impacts user comfort and path capacity. As user volumes or the mix of modes increases, additional path width is necessary to maintain comfort and functionality.
- Minimum recommended pathway width is 6 ft (2 m). In low-volume and constrained situations, the absolute minimum width is 4 ft (1.2 m), and the path should be marked for pedestrians only.
- Provide a minimum of 2 ft (0.6 m) clearance to any sign posts or vertical elements.



Sidepath in Seattle with Green Stormwater Infrastructure integrated.



Sidepath with gravel separation.

Design Considerations (continued)

- Separation from the roadway should be informed by the speed and configuration of the adjacent roadway and by available right-of-way.
- Separation narrower than 5 ft is not recommended, although may be accommodated with the use of a physical barrier between the sidepath and the roadway.

Further Considerations

- Green Stormwater Infrastructure can be incorporated in the buffer area between the path and the roadway in the form of rain gardens or bioswales. These features can both help manage stormwater and beautify the buffer.

PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN LANE

FROM THE FHWA SMALL TOWN AND RURAL DESIGN GUIDE

A pedestrian lane is an interim or temporary pedestrian facility that may be appropriate on roads with low to moderate speeds and volumes. A pedestrian lane is a designated space on the roadway for exclusive use of pedestrians. The lane may be on one or both sides of the roadway and can fill gaps between important destinations. In Half Moon Bay, these lanes may be used in Coastal Access Zones or in Neighborhood Street Zones to connect key destinations.

**Typical Application**

A pedestrian lane may be considered to operate similarly to a sidewalk.

Sufficient space to provide a pedestrian lane may already exist or may be created through configuration changes, including removing or consolidating on-street parking, or narrowing of travel lanes. Implementing pedestrian lanes may share some strategies with the implementation of bike lanes. For more information on potential implementation strategies, refer to the FHWA Resurfacing Guide 2016.

Design Considerations

Pedestrian lanes should be designed to support and promote side-by-side walking within the lane. Because of the lack of physical separation, additional width beyond this should be included for added comfort.

- 8 ft (2.4 m) width is preferred
- 5 ft (1.5 m) width is the minimum to allow for side-by-side walking and maneuverability by users of mobility devices.



Pedestrian lane near Detroit, OR. Photo: City of Detroit, OR



At-grade concrete sidewalk separated by curb stops. Photo Credit: City of Seattle

Design Considerations (continued)

Pedestrian lanes are intended for use by pedestrians and must meet accessibility guidelines for a pedestrian access route. This includes:

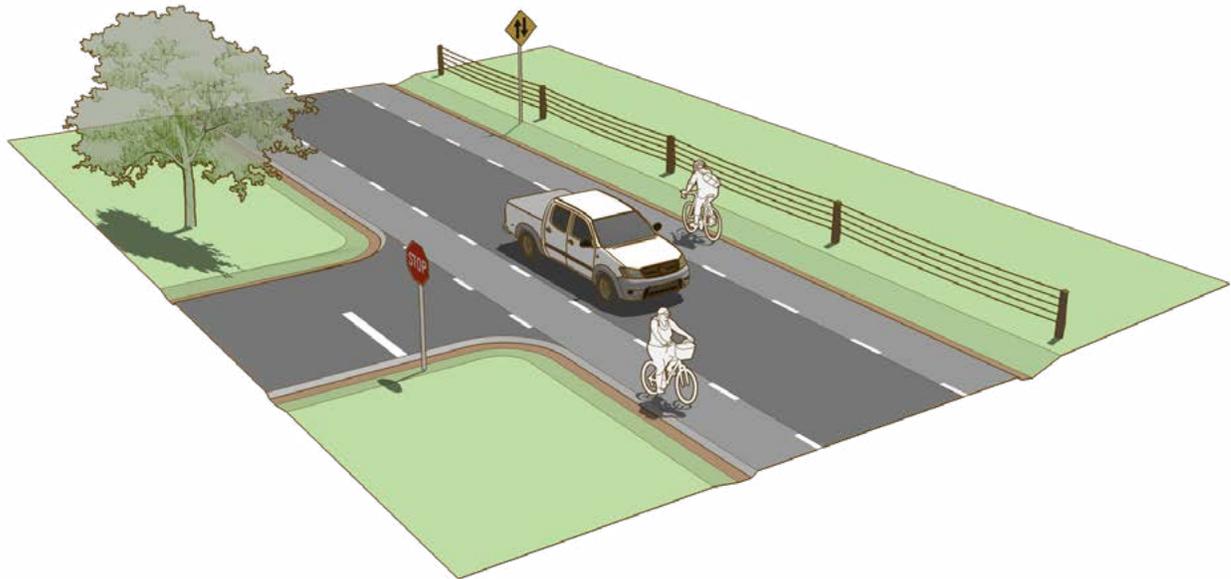
- The grade of pedestrian lanes shall not exceed the general grade established for the adjacent street or highway.
- The cross slope of pedestrian lanes shall be 2 percent maximum.
- The surface of pedestrian lanes shall be firm, stable, and slip resistant.

PEDESTRIAN INFRASTRUCTURE

ADVISORY SHOULDER

FROM THE FHWA SMALL TOWN AND RURAL DESIGN GUIDE

Advisory shoulders create usable shoulders for bicyclists and pedestrians on a roadway that is otherwise too narrow to accommodate them. The shoulder is delineated by pavement marking and optional pavement color. Motorists may only enter the shoulder when no bicyclists are present and must overtake these users with caution due to potential oncoming traffic.



Typical Application

Advisory shoulders are used on roadways that are too narrow to accommodate bike lanes or sidewalks or where the community desires a more rural character.

Advisory shoulders are most appropriate on streets with low to moderate volumes and moderate speed motor vehicles. These would not be appropriate on roadways with speeds over 35 miles per hour. In Half Moon Bay, this treatment may be appropriate on local roads that are too narrow for sidewalks or side paths.

Design Considerations

- An approved Request to Experiment is required to implement Advisory Shoulders, called “dashed bicycle lanes” in the FHWA experimentation process. For more information on the experimentation process, visit <http://mutcd.fhwa.dot.gov>
- The preferred width for an advisory shoulder is 6 ft (2.0 m). The minimum width is 4 ft (1.2 m) when no curb and gutter is present.



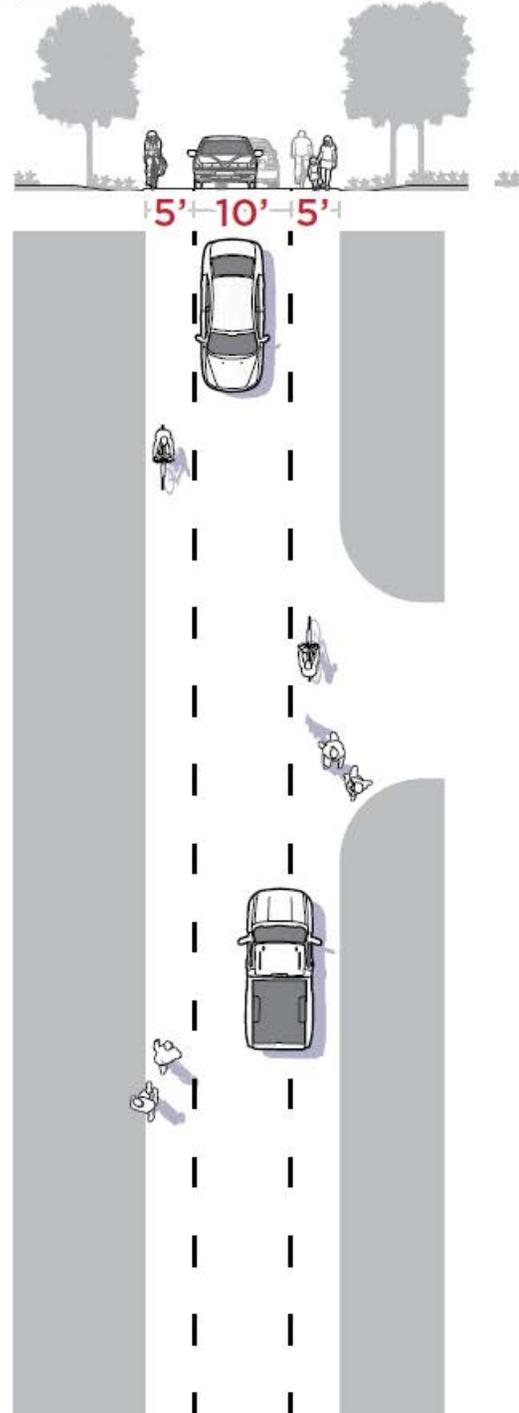
Advisory shoulder in Hanover, NH. Photo: Western Transportation Institute.

Design Considerations (Continued)

- Consider using contrasting paving materials between the advisory shoulder and center travel lane to differentiate the advisory shoulder from the center two-way travel lane in order to minimize unnecessary encroachment and reduce regular straddling of the advisory shoulder striping.
- Preferred two-way center travel lane width is 135-16 ft (4.1-4.9 m) although may function with widths of 10-18 ft (3.0-5.5 m).
- Advisory shoulder designs work best on road segments without frequent stop or signal controlled intersections that require vehicles to stop within the roadway. The visual definition of the advisory shoulder should be maintained through all driveways and street crossings, and provide a conventional shoulder at controlled intersections.
- Incorporate traffic calming and speed reduction strategies to encourage vehicles to stay in the center lane
- For additional information, visit <http://ruraldesignguide.com/mixed-traffic/advisory-shoulder>

DIMENSIONS

Length: 1255 ft



Example of advisory shoulder in Hanover, NH.

PEDESTRIAN INFRASTRUCTURE

SHARED USE STREET

A shared use street, or yield roadway, is designed to serve pedestrians, bicyclists, and motor vehicle traffic in the same slow speed travel area. Shared Use Streets serve bidirectional motor vehicle traffic without lane markings in the roadway travel area. Shared Use Streets are appropriate in the Neighborhood Street Zone, in areas that do not currently have sidewalks, have a community that would like to maintain a rural character, and experience low volumes of traffic. In some circumstances they may also be appropriate in Coastal Access Zones.

**Typical Application**

Shared Use Streets are appropriate on streets that currently do not have sidewalks, serve primarily local traffic, do not serve through-traffic, or do not provide a critical network connection. The community wishes to retain a more rural character.

Design features and signage promote slow traffic to create a low stress environment.

Design Features

- The paved two-way travel lane should be narrow to encourage slow travel speeds and require courtesy yielding when vehicles traveling in opposite directions meet, preferably less than 20 feet wide.
- Total traveled way width may vary from 12 ft (3.6 m) to 20 ft (6.0 m)
- If the roadway is wider than 20 feet, consider traffic calming features to narrow the roadway and slow traffic.
- When width is 15 ft or narrower, follow guidance for AASHTO Low Volume Roads 2001. Pull-out areas should also be provided every 200-300 ft to allow for infrequent passing between motor vehicles.

Design Features (continued)

- Parking may be located on the paved roadway surface or on gravel or soil shoulders outside of the paved roadway. The parking lane may also serve as a pull-out area while yielding.
- Do not mark a center line within the travel area. The single two-way lane introduces helpful traffic friction and ambiguity, contributing to a slow speed operating environment.
- Trees may be planted within the roadside area at regular intervals to visually and physically narrow the corridor, add to the aesthetic environment, and encourage slow speeds.
- Use signs to warn road users of the special characteristics of the street and to prevent through-traffic

Further Considerations

- Green Stormwater Infrastructure can be incorporated at intervals in the roadside/ parking area in the form of rain gardens or bioswales. These features can both help manage stormwater and help narrow the roadway and calm traffic.
- Shared Use Roads must meet accessibility guidelines for walkways.



Many streets in Half Moon Bay already operate as a shared use street, such as Poplar St above.



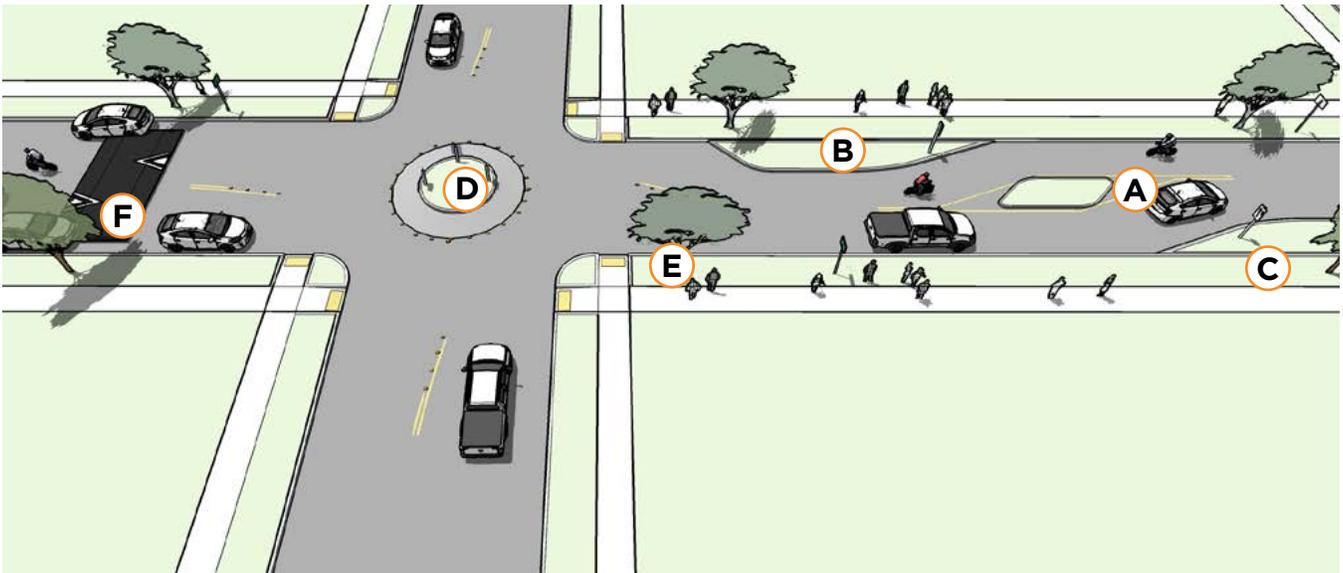
Yield street in Manzanita, OR. Photo: Alta Planning + Design.

PEDESTRIAN INFRASTRUCTURE

TRAFFIC CALMING

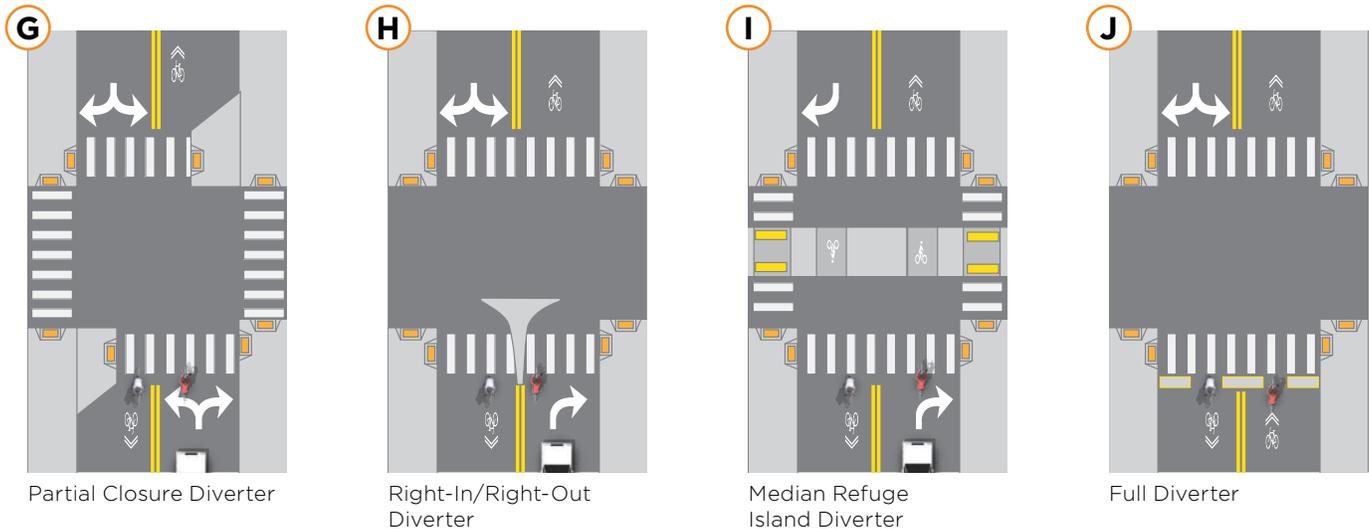
Traffic calming may include elements intended to reduce the speeds of motor vehicle traffic to be closer to bicycling and walking speeds, or may include design elements that restrict certain movements for motorized travel to discourage the use of shared roadways for through travel by automobiles.

Traffic calming treatments can cause drivers to slow down by constricting the roadway space or by requiring careful maneuvering. Such measures may reduce the design speed of a street, and can be used in conjunction with reduced speed limits to reinforce the expectation of lowered speeds. They can also lower vehicle volumes by physically or operationally reconfiguring corridors and intersections along the route.

Traffic Calming Treatments to Reduce Motor Vehicle Speeds**Typical Application**

- Shared roadways should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 20 mph (25 mph maximum). Roadways with average speeds above this limit should be considered for traffic calming measures.
- Maintain a minimum clear width of 14 feet with a constricted length of at least 20 feet in the direction of travel.
- Bring traffic volumes down to 1,500 cars per day (4,000 cars per day maximum). Roadways with daily volumes above this limit should be considered for traffic calming measures.

Traffic Calming Treatments to Reduce Motor Vehicle Volumes



Design Features (Speed Reduction)

- A** Median islands create pinch point for traffic in the center of the roadway and offers shorter crossing distances for pedestrians when used in tandem with a marked crossing.
- B** Chicanes slow drivers by requiring vehicles to shift laterally through narrowed lanes and which avoids uninterrupted sightlines.
- C** Pinch points, chokers, or curb extensions restrict motorists from operating at high speeds on local streets by visually narrowing the roadway.
- D** Neighborhood traffic circles reduce speed of traffic at intersections by requiring motorists to move cautiously through conflict points.
- E** Street trees narrow a driver's visual field and creates a consistent rhythm and canopy along the street, which provides a unified character and facilitates place recognition.
- F** Speed humps slow drivers through vertical deflection. To minimize impacts to bicycles, use a sinusoidal profile and leave a gap along curb so that bicyclists may bypass the hump when appropriate. Speed cushions operate in a similar fashion to speed humps, but allow for unimpeded travel by emergency vehicles.

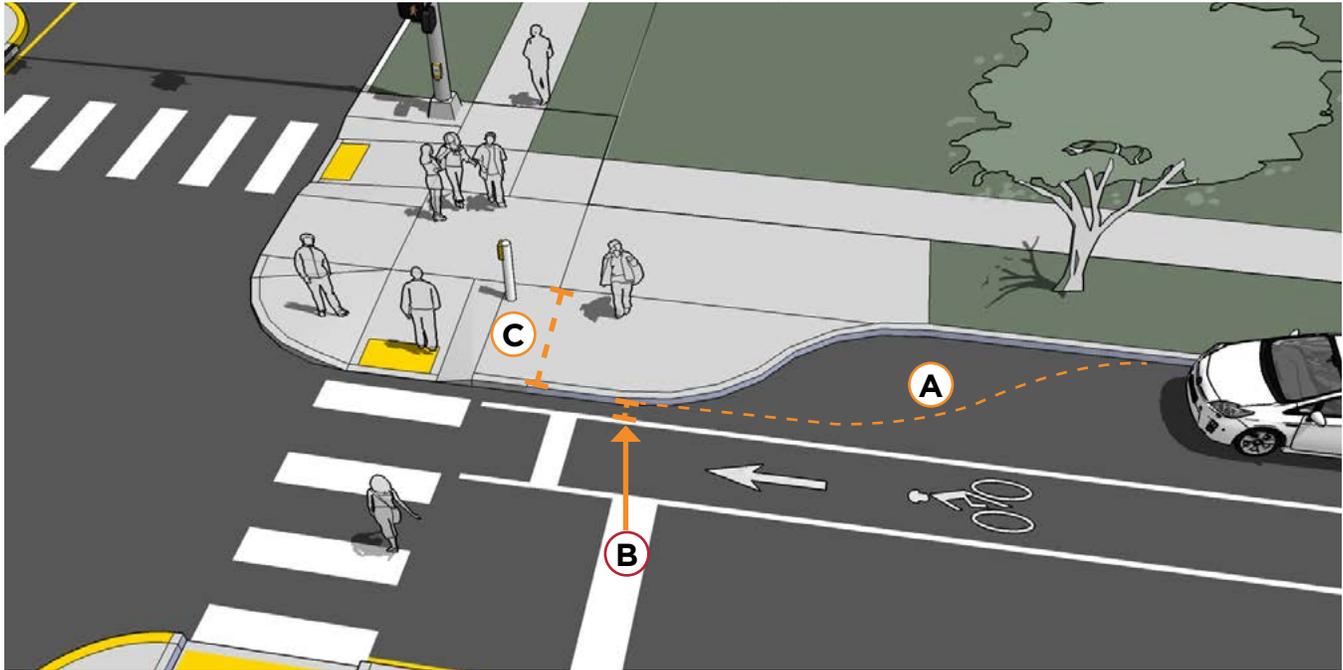
Design Features (Volume Reduction)

- G** Partial closure diverters allows bicyclists to proceed straight across the intersection but forces motorists to turn left or right. All turns from the major street onto the bikeway are prohibited. Can incorporate curb extensions with stormwater management features and/or a mountable island.
- H** Right-in/right-out diverters force motorists to turn right while bicyclists can continue straight through the intersection. The island can provide a through bike lane or bicycle access to reduce conflicts with right-turning vehicles. Left turns from the major street onto the bikeway are prohibited, while right turns are still allowed.
- I** Median refuge island diverters restrict through and left-turn vehicle movements along the bikeway while providing refuge for bicyclists to cross one direction of traffic at a time. This treatment prohibits left turns from the major street onto the bikeway, while right turns are still allowed.
- J** Full diverters block all motor vehicles from continuing on a neighborhood bikeway, while bicyclists can continue unrestricted. Full closures can be constructed to be permeable to emergency vehicles.

PEDESTRIAN INFRASTRUCTURE

CURB EXTENSIONS

Curb extensions minimize pedestrian exposure during crossing by shortening crossing distance and giving pedestrians a better chance to see and be seen before committing to crossing.



Typical Application

- Within parking lanes appropriate for any crosswalk where it is desirable to shorten the crossing distance and there is a parking lane adjacent to the curb.
- May be possible within non-travel areas on roadways with excess space.
- Particularly helpful at midblock crossing locations.
- Curb extensions should not impede bicycle travel in the absence of a bike lane.

Design Features

- A** For purposes of efficient street sweeping, the minimum radius for the reverse curves of the transition is 10 ft and the two radii should be balanced to be nearly equal.
- B** When a bike lane is present, the curb extensions should terminate one foot short of the parking lane to maximize bicyclist safety.
- C** Reduces pedestrian crossing distance by 6-8 ft.
 - Planted curb extensions may be designed as a bioswale for stormwater management.



Example of a curb extension with a rain garden.



Example of a midblock curb extension.

Further Considerations

- Green Stormwater Infrastructure can be incorporated in the buffer area between the path and the roadway in the form of rain gardens or bioswales. These features can both help manage stormwater and beautify the buffer.

Construction Costs

The cost of a curb extension can range from \$2,000 to \$20,000 depending on the design and site condition, with the typical cost approximately \$12,000. Green/vegetated curb extensions cost between \$10,000 to \$40,000.

PEDESTRIAN INFRASTRUCTURE

GREEN STORMWATER INFRASTRUCTURE

Green infrastructure treats and slows runoff from impervious surface areas, such as roadways, sidewalks, and buildings. Sustainable stormwater strategies may include bioretention swales, rain gardens, tree box filters, and pervious pavements (pervious concrete, asphalt and pavers). Bioswales are natural landscape elements that manage water runoff from a paved surface, reducing the risks of erosion, flooding, or sedimentation of local streams and creeks, which can threaten natural habitats. Plants in the swale trap pollutants and silt from entering a storm drainage channel, either natural or man-made.

**Typical Application**

- Install in areas that are prone to flooding to improve drainage and reduce costs compared to installing traditional gutter and drainage systems.
- Use green infrastructure to provide an ecological and aesthetic enhancement of traditional traffic speed and volume control measures, such as along a bicycle boulevard corridor.
- Bioswales and rain gardens are appropriate at curb extensions and along planting strips.
- Street trees and plantings can be placed in medians, chicanes, and other locations.
- Pervious pavers can be used along sidewalks, street furniture zones, parking lanes, gutter strips, or entire roadways. They are not likely to provide traffic calming benefit on bicycle boulevards.

Design Features**Bioswales**

Bioswales are shallow depressions with vegetation designed to capture, treat, and infiltrate stormwater runoff by reducing velocity and purifying the water while recharging the underlying groundwater table.

To meet the minimum criteria for infiltration rates, bioswales are designed to pass 5-10 inches of rain water per hour. The overflow/bypass drain system should be approximately 6 inches above the soil surface to manage heavier rainfall.

Bioswales have a typical side slope of 4:1 (maximum 3:1) to allow water to move along the surface and settles out sediments and pollutants.

Ground cover can be used to discourage pedestrian trampling.

Green Infrastructure



Green infrastructure such as bioswales and rain gardens helps manage stormwater while improving the aesthetic appearance of pedestrian and bicycle facilities.

Design Features (continued)

Drainage

The edge of the swale should be flush with the grade to accommodate sheetflow runoff, with a minimum 2-inch drop between the street grade and the finished grade of the facility. Where there are curbs, cut-outs at least 18 inches wide should be provided intermittently (3-15 feet apart) to allow runoff to enter and be treated. Low curbs, barriers, and/or hardy vegetative

Pervious Pavement

In areas where landscaping such as swales are less desired or feasible, pervious pavement can also effectively capture and treat stormwater runoff.

The desired storage volume and intended drain time is determined by the depth of the pervious layer, void space, and the infiltration rate of underlying soils. An underdrain system must be used to treat overflow, or drain excess runoff to the municipal sewer system, and allow the facility to drain within 48 hours.

Engineering judgment and surrounding street context should be used when selecting the permeable surface, whether it is pavers, concrete or asphalt. Some decorative pavers may be more appropriate for bicycle and/or pedestrians areas due to the potential for shifting under heavy loads.

Crash Reduction

To the extent that any associated traffic calming reduces the likelihood of crashes, green infrastructure can have a positive impact on roadway safety.

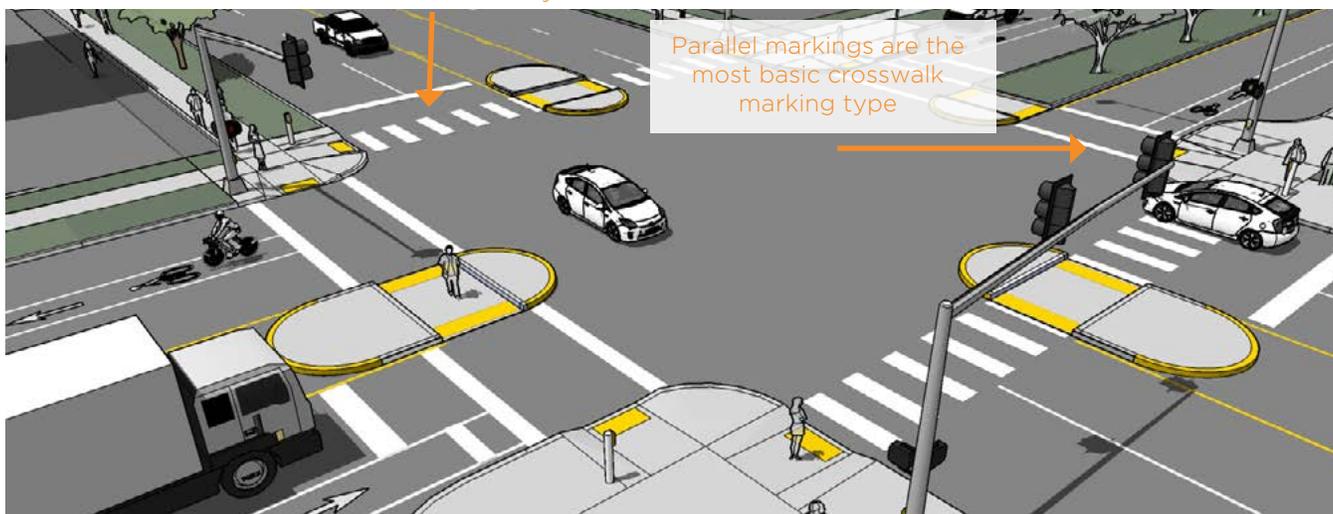
PEDESTRIAN INFRASTRUCTURE

MARKED CROSSWALKS

A marked crosswalk signals to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Generally, continental markings should be used in the Pedestrian Priority Zone, within 500 feet of a school, or in areas where additional visibility is desired. Parallel markings are generally appropriate in the Neighborhood Street Zones. At mid-block locations, crosswalks can be marked where there is a demand for crossing and there are no nearby marked crosswalks.

Continental markings provide additional visibility

Parallel markings are the most basic crosswalk marking type



Typical Application

All crosswalks should be marked at signalized intersections. At unsignalized intersections, crosswalks may be marked under the following conditions:

- At a complex intersection, to orient pedestrians in finding their way across and to help make vehicles aware of pedestrians.
- At an offset intersection, to show pedestrians the shortest route across traffic with the least exposure to vehicular traffic and traffic conflicts.
- At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.
- At an intersection that serves a walking route to a school or senior center, or within downtown Half Moon Bay.

Design Features

- The crosswalk should be located to align as closely as possible with the through pedestrian zone of the sidewalk corridor
- The landing at the top of a ramp shall be at least 4 feet long and at least the same width as the ramp itself.
- The ramp shall slope no more than 8.33%, with a maximum cross slope of 2.0%.
- If the ramp runs directly into a crosswalk, the landing at the bottom will be in the roadway.
- If the ramp lands on a dropped landing within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 5'-0" long and at least as wide as the ramp itself.

Marked Crosswalks



Marked crosswalks are used to raise driver awareness of pedestrian and pathway crossings and help direct users to preferred crossing locations.

Further Considerations

Continental crosswalk markings should be used at crossings with high pedestrian use or where vulnerable pedestrians are expected, including: school crossings, across arterial streets for pedestrian-only signals, at mid-block crosswalks, and at intersections where there is expected high pedestrian use and the crossing is not controlled by signals or stop signs. High-visibility crosswalks are not appropriate for all locations. See intersection signalization for a discussion of enhancing pedestrian crossings.

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority. Thermoplastic markings offer increased durability than conventional paint.

At midblock locations, additional design features may be desired to increase visibility and motorist yielding. Beacons actuated by pedestrians can alert motorists to a crossing. Raised crosswalks can reduce vehicle speeds while also improving visibility of pedestrians, especially where high volumes of children are expected to cross.

Crash Reduction

At an unsignalized four-leg intersection with no marked crosswalks and stop control for the minor street, installing markings to facilitate crossing of a major street reduced crash likelihood by 65% (CMF ID: 3019). The number of travel lanes for the major street ranged from two to eight.

Construction Costs

Marked crosswalks range from approximately \$100 to 2,100 each, or around \$800 on average. High-visibility crosswalks, such as Continental-style crossings, can range from \$600 to \$5,700 each, or around \$2,500 on average.

PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN SIGNAL STRATEGIES

Enhancements may be made to signalized intersections to reduce pedestrian-vehicle conflicts and increase user comfort and usability.

**Considerations**

Pedestrian-vehicle conflicts can occur when drivers performing turning movements across the crosswalk do not see or yield to pedestrians who have the right-of-way. Pedestrians may also arrive at an intersection late, or may not have any indication of how much time they have to safely cross the intersection. Signal enhancements should be considered at locations with a history of crash risk, long crossing distances, or large volumes of turning traffic.

Adequate pedestrian crossing time is a critical element of the walking environment at signalized intersections. The length of a signal phase with parallel pedestrian movements should provide sufficient time for a pedestrian to safely cross the adjacent street. The MUTCD recommends a walking speed of 3.5 ft per second. At crossings where older pedestrians or pedestrians with disabilities are expected, crossing speeds as low as 3 ft per second should be assumed.

Design Features

- Countdown signals should be used at all new and rehabbed signalized intersections.
- Leading Pedestrian Intervals (LPI) give pedestrians a head start into the intersection, which can reduce right turn and permissive left turn vehicle and pedestrian conflicts.
- An exclusive pedestrian phase (known as Pedestrian Scramble or Barnes Dance), stops all traffic and gives pedestrians the right-of-way in all directions (including diagonally). This is most appropriate in locations with very high pedestrian volumes.
- Audible pedestrian signals make signals accessible by individuals with visual disabilities by providing audible tones or verbal messages to convey when it is appropriate to walk, when they must wait, and feedback when the signal has been actuated via pushbutton.

PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN SIGNAL ACTUATION

Pedestrian signals can be actuated either manually using a pedestrian push button, passively using automated detection equipment, or automatically during each signal cycle using pedestrian recall.

**Typical Application**

- Manual activation of pedestrian signals is performed with a pedestrian push button. This requires the pedestrian to locate and press the pushbutton to actuate the pedestrian signal phase. The decision to install pushbuttons, should take into account pedestrian accessibility needs and pedestrian volumes.
- Passive detection uses a variety of automated detection equipment, including microwave and infrared detectors, to automatically detect the presence of pedestrians. This can provide the convenience of automatic recall with the traffic flow benefits of pushbutton actuation.
- Automatic pedestrian recall provides a pedestrian walk phase during every cycle. This makes pedestrian crossings predictable, minimizes unnecessary pedestrian delay, and does not create uncertainty over whether a pedestrian has been detected.

Design Features

The minimum walk interval time is 7 seconds. The walk and pedestrian clearance times can be adjusted to account for the elderly, wheelchair users, and visually-disabled people who typically need more time to cross. The walk time can be calculated based on a slower walking speed, 2.8 fps - 3.0 fps, and/or a longer crossing distance from pushbutton-to-far curbside (or pushbutton-to-pushbutton), instead of curb-to-curb.

A pushbutton outfitted with a pilot or indicator light and/or audible/vibrotactile feedback acknowledges that the pedestrian call has been placed, reassuring the pedestrian that they have been detected.

Pedestrian push buttons can be configured to provide additional crossing time when they arrive at the crossing during the flashing don't walk interval. The CAMUTCD requires signage indicating the walk time extension at or adjacent to the push button (R10-32P).

PEDESTRIAN INFRASTRUCTURE

BEACONS

Beacons enhance uncontrolled crosswalks through flashing lights and other devices that call attention to pedestrians crossing the roadway. Beacons may be actuated by pedestrians wishing to cross at a crosswalk, or may flash on a continuous basis to warn motorists of potential pedestrian activity at the location.

Standard beacons use a round yellow light that flashes at regular intervals. Over time, motorists have become complacent with this type of beacon, resulting in lower yielding rates. New beacon designs incorporate high-visibility elements that increase compliance.

PEDESTRIAN HYBRID BEACON

Sometimes called a “HAWK” signal, pedestrian hybrid beacons use yellow warning and red stop lights similar to a traffic signal. After pedestrian actuation, the yellow light will flash and then turn solid to warn motorists to slow for a queued pedestrian phase. A solid red light follows, requiring motorists to come to a full stop, and a pedestrian WALK phase is triggered. When the crossing phase has expired, the beacon flashes red and then goes dark.



PEDESTRIAN SIGNS WITH LEDS

Pedestrian crosswalk signs can be enhanced with perimeter LED lights that are activated by a pedestrian push-button. When actuated, the LED lights flash to alert motorists to a pedestrian crossing.



Design Considerations

- Beacons must be placed at least 100 ft from the nearest controlled intersection.
- Beacons are not required to meet warrants for a traffic signal, but implementation should consider vehicle volumes, street and lane widths, and traffic gaps in conjunction with pedestrian volumes, walking speeds, and delay.
- Pedestrian actuation is preferred to continuous flashing, as it reduces motorist complacency with the beacon and increases yielding compliance.

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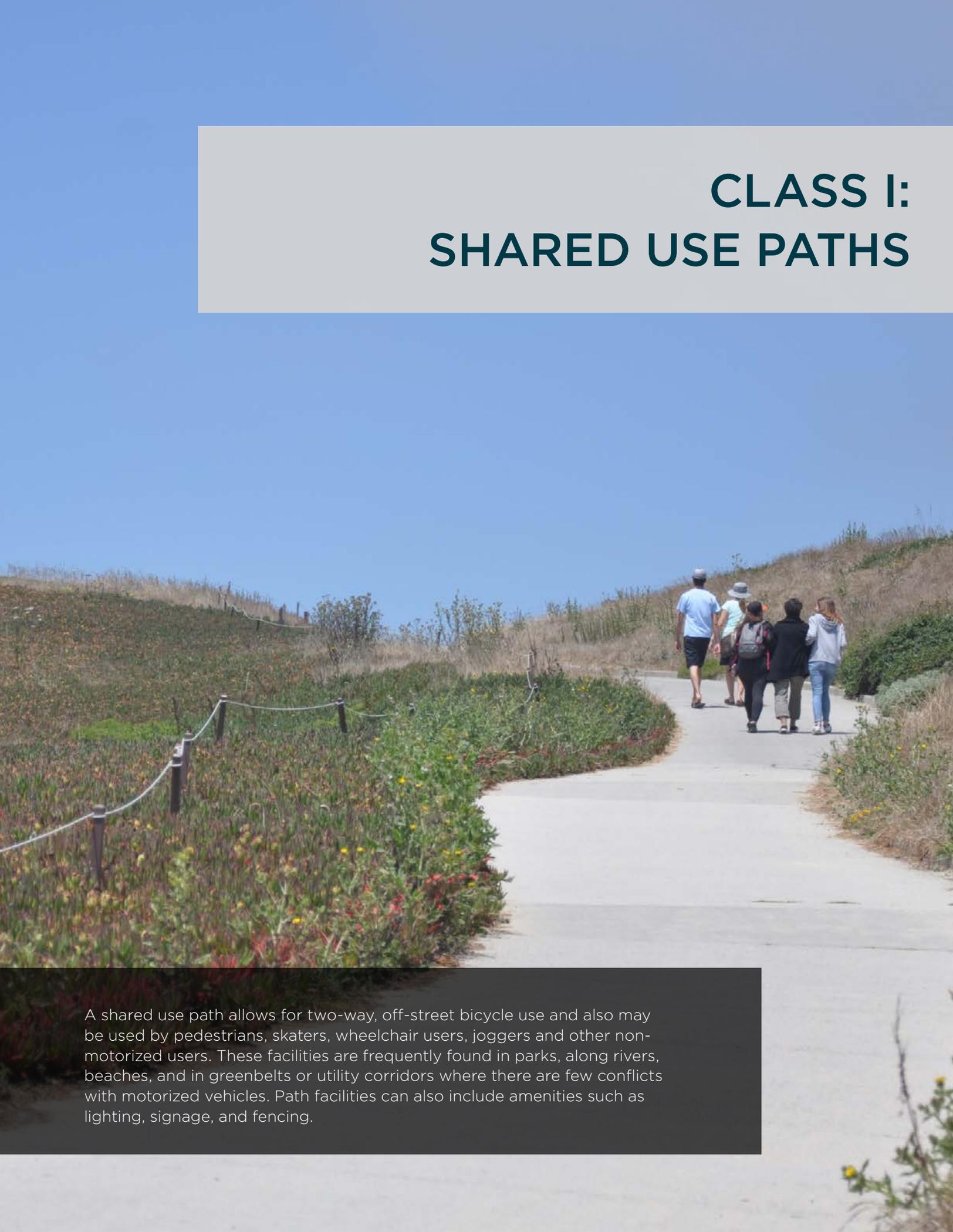


BICYCLE GUIDELINES

Bicycle facilities cover a wide range of width, separation from traffic, and treatments at intersections. Well-designed bicycle facilities should support bicyclists of varying ages and abilities in addition to meeting local neighborhood contexts.

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CLASS I: SHARED USE PATHS



A shared use path allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles. Path facilities can also include amenities such as lighting, signage, and fencing.

SHARED USE PATHS

SHARED USE PATHS

A shared use path can provide a desirable facility, particularly for recreation, and users of all skill levels preferring separation from traffic. Bicycle paths should generally provide directional travel opportunities not provided by existing roadways.

**Typical Application**

- Commonly established in natural greenway corridors, utility corridors, or along abandoned rail corridors.
- May be established as short accessways through neighborhoods or to connect to cul-de-sacs.
- May be established along roadways as an alternative to on-street riding. This configuration is called a sidepath.

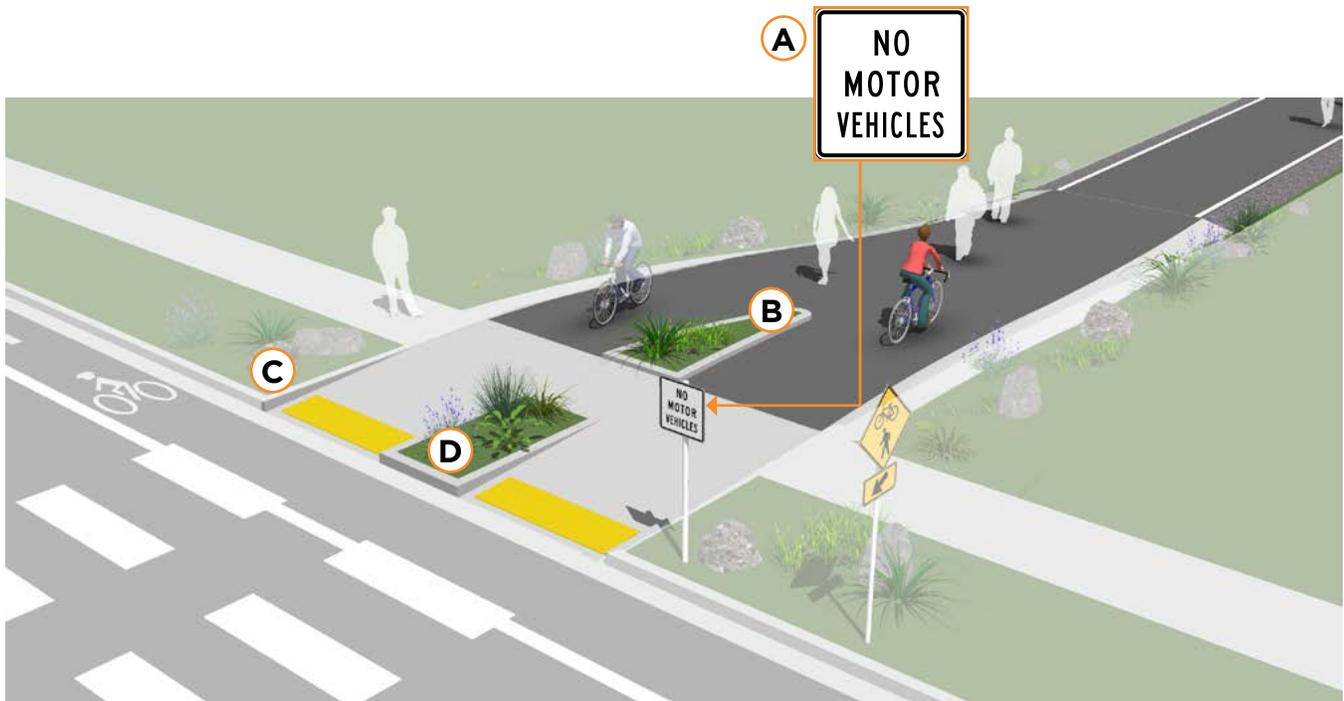
Design Features

- **A** Recommended 10' width to accommodate moderate usage (14' preferred for heavy use). Minimum 8' width for low traffic situations only.
 - Minimum 2' shoulder width on both sides of the path, with an additional foot of lateral clearance as required by the MUTCD for the installation of signage or other furnishings.
 - Recommended 10' clearance to overhead obstructions (8' minimum).
 - When striping is required, use a 4" dashed yellow centerline stripe with 4" solid white edge lines. Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.

SHARED USE PATHS

BOLLARD ALTERNATIVES

Bollards are physical barriers designed to restrict motor vehicle access to the multi-use path. Unfortunately, physical barriers are often ineffective at preventing access, and create obstacles to legitimate trail users. Alternative design strategies use signage, landscaping and curb cut design to reduce the likelihood of motor vehicle access.

**Typical Application**

- Bollards or other barriers should not be used unless there is a documented history of unauthorized intrusion by motor vehicles.
- If unauthorized use persists, assess whether the problems posed by unauthorized access exceed the risks and issues posed by bollards and other barriers.

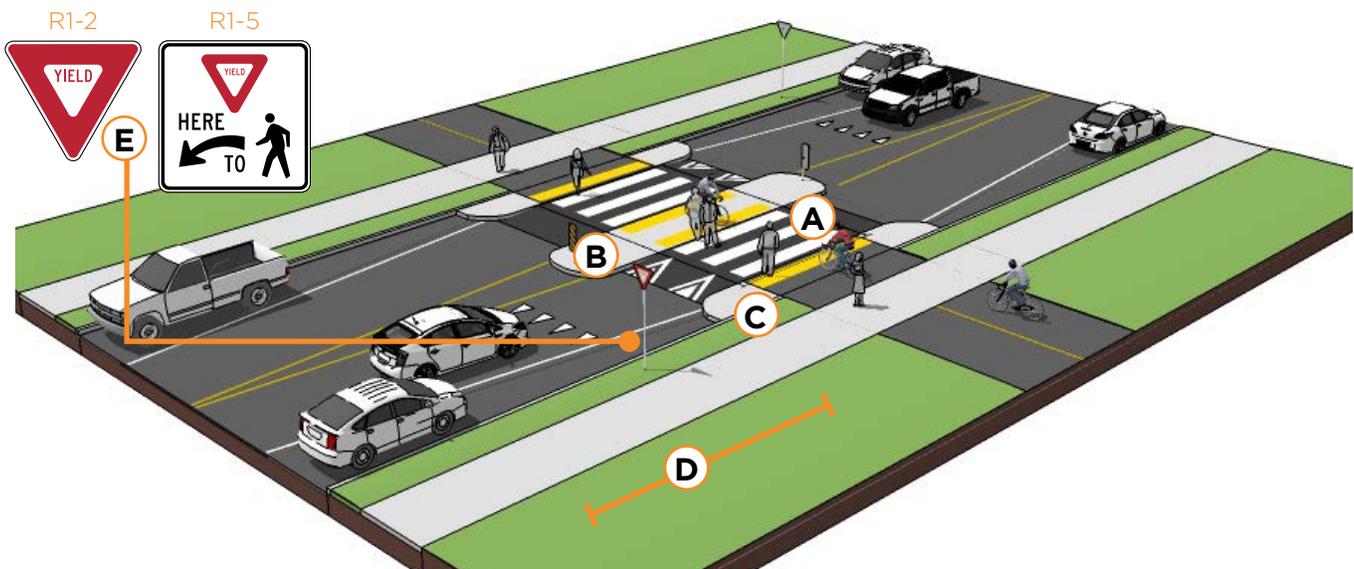
Design Features

- A** “No Motor Vehicles” signage (MUTCD R5-3) may be used to reinforce access rules.
- B** At intersections, split the path tread into two sections separated by low landscaping.
- C** Vertical curb cuts should be used to discourage motor vehicle access.
- D** Low landscaping preserves visibility and emergency access.

SHARED USE PATHS

RAISED PATH CROSSINGS

The California Vehicle Code requires that motorists yield right-of-way to pedestrians within crosswalks. This requirement for motorists to yield is not explicitly extended to bicyclists, and the rights and responsibilities for bicyclists within crosswalks is ambiguous. Where shared-use paths intersect with minor streets, design solutions such as raised crossings help resolve this ambiguity where possible by giving people on bicycles priority within the crossing.



Typical Application

- Where highly utilized shared-use paths cross minor streets.
- Where safety and comfort of path users at crossings is prioritized over vehicular traffic.

Design Features

- A** Raised crossing creates vertical deflection that slows drivers and prepares them to yield to path users, while high-visibility crosswalk markings establish a legal crosswalk away from intersections.
- B** Median refuge island creates horizontal deflection to draw driver attention to changed conditions at the crossing.
- C** Bulbouts shorten crossing distance and position users in a visible location.
- D** Parking should be prohibited 20 feet in advance of the crosswalk.
- E** Path priority signing (MUTCD R1-5 or R1-2) and stop or yield markings are placed 20 feet in advance of the crossing and function best when path user volumes are high.

Raised Path Crossings



This raised path crossing encourages drivers to yield to pedestrians and allows bicyclists to cross traffic one lane at a time.

Further Considerations

- Geometric design should promote a high degree of yielding to path users through raised crossings, horizontal deflection, signing, and striping.
- The approach to designing path crossings of streets depends on an evaluation of vehicular traffic, line of sight, pathway traffic, use patterns, vehicle speed, road type, road width, and other safety issues such as proximity to major attractions.
- Raised crossings should raise 4 inches above the roadway with a steep 1:6 (16%) ramp. Advisory speed signs may be used to indicate the required slow crossing speed.
- A median safety island should allow path users to cross one lane of traffic at a time. The bicycle waiting area should be 8 feet wide or wider to allow for a variety of bicycle types.

Crash Reduction

Studies have shown a 45% decrease in vehicle/pedestrian crashes after a raised crosswalk is installed where none existed previously. (CMF ID: 136)

Construction Costs

- Striped crosswalks costs range from approximately \$100 to 2,100 each.
- Curb extension costs can range from \$2,000 to \$20,000, depending on the design and site condition.
- Median refuge islands costs range from \$3,500 to \$40,000, depending on the design, site conditions, and landscaping.

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CLASS II: ON-STREET BICYCLE LANES

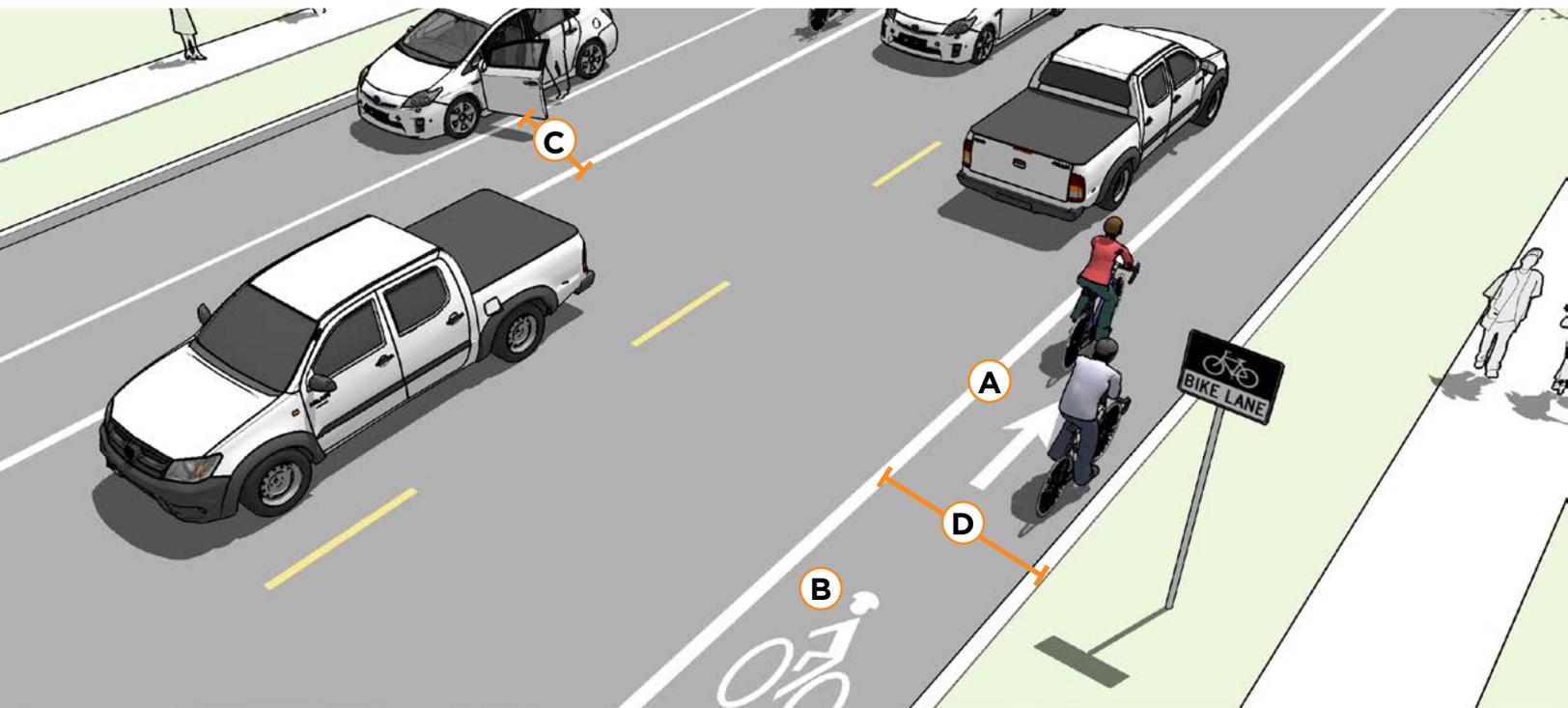


Designated exclusively for bicycle travel, on-street bicycle lanes are separated from vehicle travel lanes by striping, and can include pavement stencils and other treatments. On-street bicycle lanes are most appropriate on collector streets with single-lane of traffic in each direction where moderate traffic volumes and speeds are too high for shared-roadway use.

ON-STREET BICYCLE LANES

BICYCLE LANES

On-street bike lanes (Class II Bikeways) designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is located directly adjacent to motor vehicle travel lanes and is used in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge or parking lane.



Typical Application

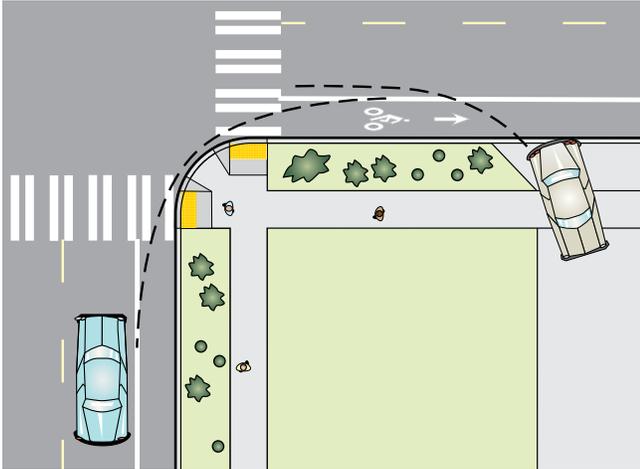
- Streets with moderate volumes $\geq 6,000$ ADT ($\geq 3,000$ preferred).
- Streets with moderate speeds ≥ 25 mph.
- Appropriate for skilled adult riders on most streets.
- May be appropriate for children when configured as 6+ ft wide lanes on lower-speed, lower-volume streets with one lane in each.

Design Features

- A** Mark inside line with 6" stripe. (CAMUTCD 9C.04) Mark 4" parking lane line or "T" markings for stalls.*
- B** Include a bicycle lane marking (CAMUTCD Figure 9C-3) at the beginning of blocks and at regular intervals along the route. (CAMUTCD 9C.04)
- C** 6 foot width preferred adjacent to on-street parking, (5 foot min.) (HDM)
- D** 5-6 foot preferred adjacent to curb and gutter. (4 foot min.) or 3 feet more than the gutter pan width. (HDM)

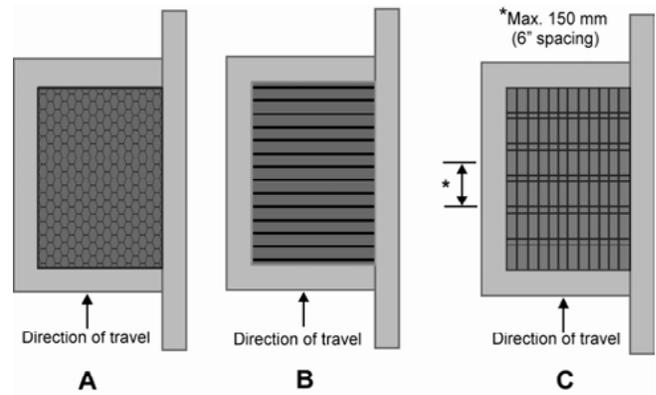
* Studies have shown that marking the parking lane encourages people to park closer to the curb. FHWA. Bicycle Countermeasure Selection System. 2006.

Place Bike Lane Symbols to Reduce Wear



Bike lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed outside of the motor vehicle tread path in order to minimize wear from the motor vehicle path. (NACTO 2012)

Drainage Grates



Utility infrastructure, such as manholes, water valve covers, and drain inlets within the roadway can present significant hazards to bicyclists, potentially causing a collision. Every effort should be made to avoid placing hazards within the likely travel path of bicyclists on new roadway construction.

Further Considerations

- On high speed streets (posted speed limit \geq 40 mph) the minimum bike lane should be 6 feet. (HDM 301.2)
- On streets where bicyclists passing each other is to be expected, where high volumes of bicyclists are present, or where added comfort is desired, consider providing extra wide bike lanes up to 7 feet wide, or configure as a buffered bicycle lane.
- It may be desirable to reduce the width of general purpose travel lanes in order to add or widen bicycle lanes. (HDM 301.2 3)
- On multi-lane streets, the most appropriate bicycle facility to provide for user comfort may be buffered bicycle lanes or physically separated bicycle lanes.

Crash Reduction

Before and after studies of bicycle lane installations show a wide range of crash reduction factors. Some studies show a crash reduction of 35% (CMF ID: 1719) for vehicle/bicycle collisions, other show a crash *increase* of 28% (CMF ID: 4659). Due to a lack of bicyclist volume data, these studies did not account for the potential for increased ridership.

Construction Costs

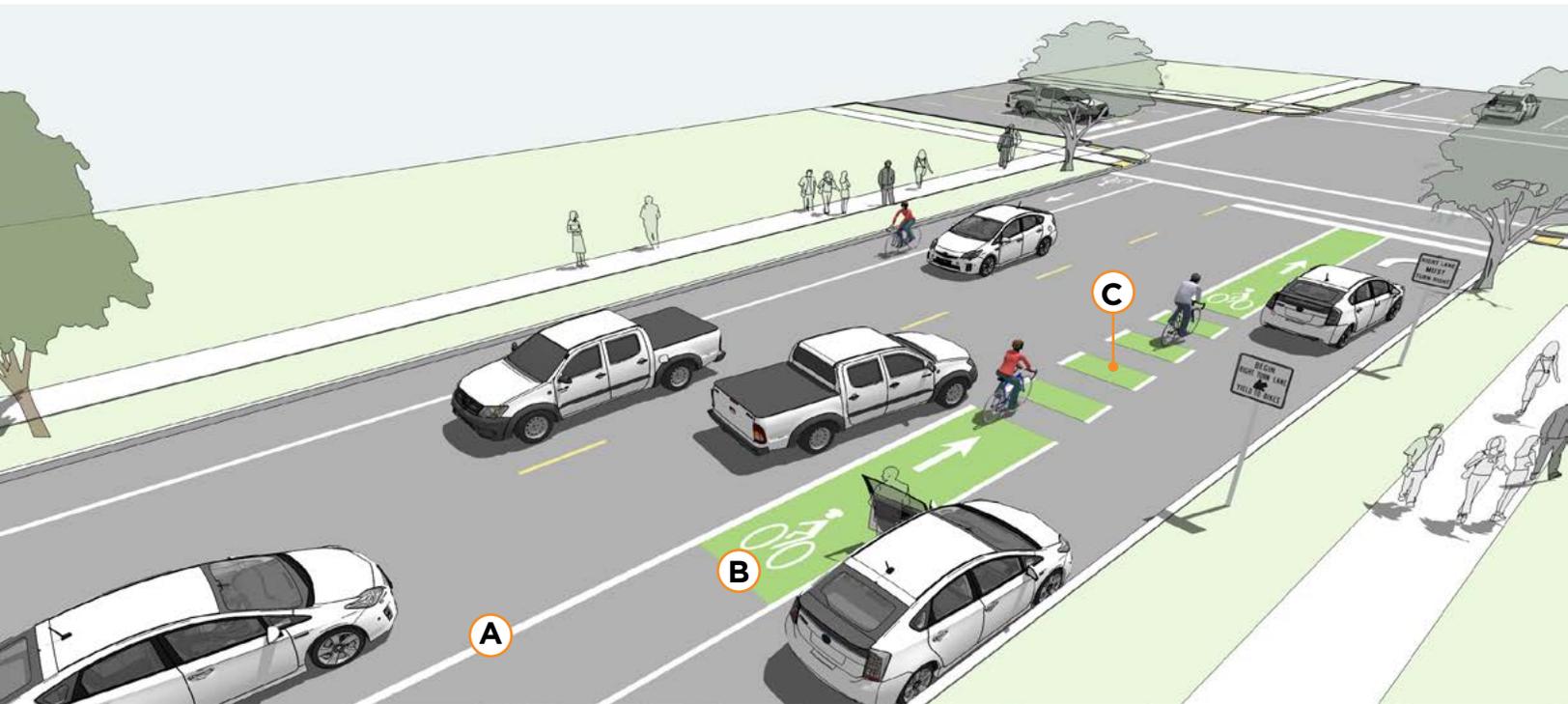
The cost for installing bicycle lanes will depend on the implementation approach. On roadways with adequate width for reconfiguration or restriping, costs may be negligible when provided as part of routine overlay or repaving projects.

Typical costs are \$16,000 per mile for restriping.

ON-STREET BICYCLE LANES

COLORED BICYCLE LANES

Colored pavement within a bicycle lane may be used to increase the visibility of the bicycle facility, raise awareness of the potential to encounter bicyclists and reinforce priority of bicyclists in conflict areas.



Typical Application

- Within a weaving or conflict area to identify the potential for bicyclist and motorist interactions and assert bicyclist priority.
- Across intersections, driveways and Stop or Yield-controlled cross-streets.

Design Features

- A** Typical white bike lanes (solid or dotted 6" stripe) are used to outline the green colored pavement.
- B** In exclusive use areas, color application should be solid green.
- C** In weaving or turning conflict areas, preferred striping is dashed, to match the bicycle lane line extensions.
 - The colored surface should be skid resistant and retro-reflective. (CAMUTCD 9C.02.02)

Colored Bicycle Lane



The use of colored pavement helps denote conflict zones where motorists crossing the bike lane must yield.

Further Considerations

- Green colored pavement shall be used in compliance with FHWA Interim Approval. (CAMUTCD 1A.10) (FHWA IA-14.10)*
- FHWA allows for flexibility in the use of green pavement coloring within bike lanes. Local communities should identify a consistent practice for their application to promote common understanding among road users.
- Green colored pavement may be appropriate to identify driveway conflict zones in high-volume, auto-oriented driveway locations.

* FHWA. Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes (IA-14). 2011.

Crash Reduction

Before and after studies of colored bicycle lane installations have found a reduction in bicycle/vehicle collisions by 38% and a reduction in serious injuries and fatalities of bicyclists by 71%.** A study in Portland, OR found a 38% decrease in the rate of conflict between bicyclists and motorists after colored lanes were installed.***

** Jensen, S.U., et. al., "The Marking of Bicycle Crossings at Signalized Intersections," Nordic Road and Transport Research No. 1, 1997, pg. 27.

*** Hunter, W. W., et. al., Evaluation of the Blue Bike-Lane Treatment Used in Bicycle/Motor Vehicle Conflict Areas in Portland, Oregon, McLean, VA: FHWA, 2000, pg. 25.

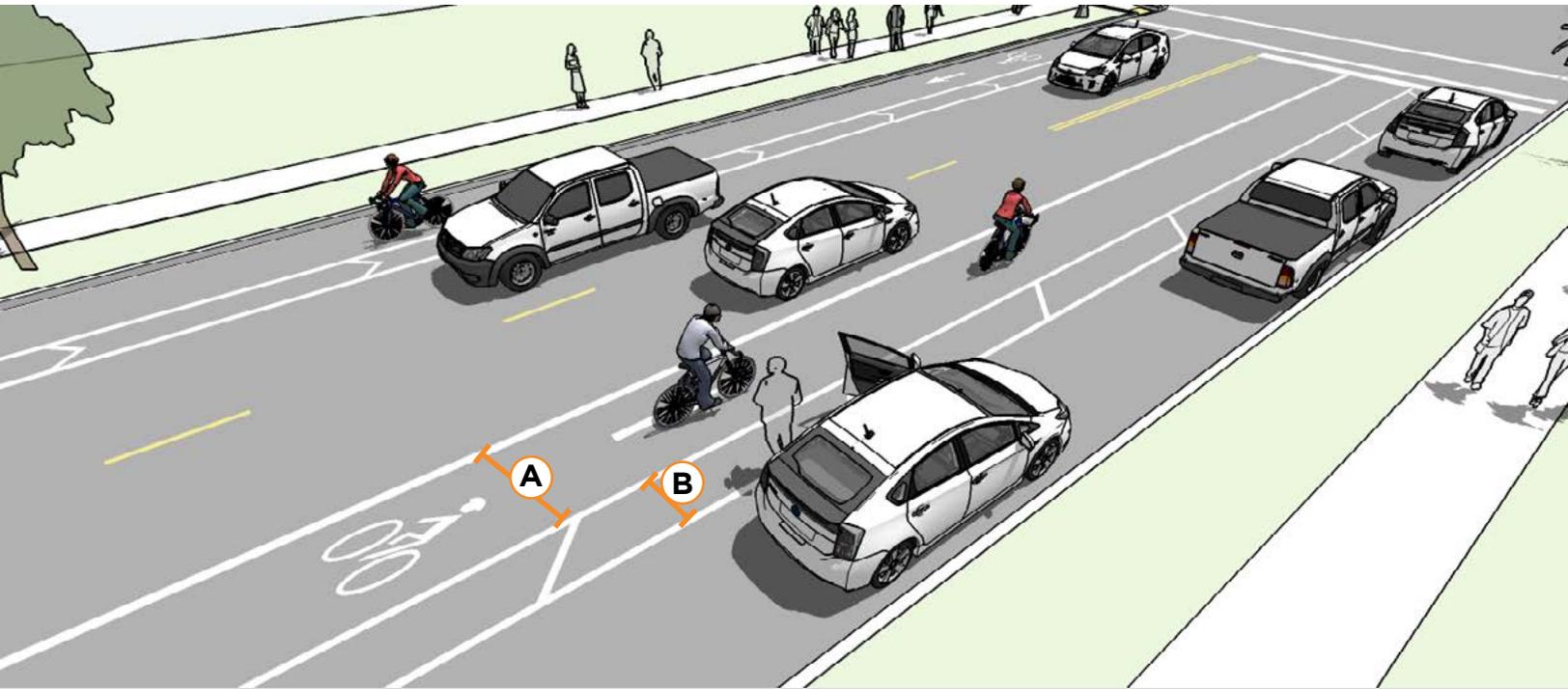
Construction Costs

The cost for installing colored bicycle lanes will depend on the materials selected and implementation approach. Typical costs range from \$1.20/sq. ft. installed for paint to \$14/sq. ft. installed for Thermoplastic. Colored pavement is more expensive than standard asphalt installation, costing 30-50% more than non-colored asphalt.

ON-STREET BICYCLE LANES

BUFFERED BICYCLE LANES

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane.



Typical Application

- Anywhere a conventional bike lane is being considered.
- On streets with high speeds and high volumes or high truck volumes.
- On streets with extra lanes or lane width.
- Appropriate for skilled adult riders on most streets.

Design Features

- A** The minimum bicycle travel area (not including buffer) is 5 feet wide.
- B** Buffers should be at least 2 feet wide. If buffer area is 4 feet or wider, white chevron or diagonal markings should be used. (CAMUTCD 9C-104)
- For clarity at driveways or minor street crossings, consider a dotted line.
- There is no standard for whether the buffer is configured on the parking side, the travel side, or a combination of both.

Buffered Bicycle Lane



The use of pavement markings delineates space for cyclists to ride in a comfortable facility.

Buffered Bicycle Lane



The use of pavement markings delineates space for cyclists to ride in a comfortable facility.

Further Considerations

- Color may be used within the lane to discourage motorists from entering the buffered lane.
- A study of buffered bicycle lanes found that, in order to make the facilities successful, there needs to also be driver education, improved signage and proper pavement markings.*
- On multi-lane streets with high vehicles speeds, the most appropriate bicycle facility to provide for user comfort may be physically separated bike lanes.
- NCHRP Report #766 recommends, when space is limited, installing a buffer space between the parking lane and bicycle lane where on-street parking is permitted rather than between the bicycle lane and vehicle travel lane.**

* Monsere, C.; McNeil, N.; and Dill, J., "Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track and SW Stark/Oak Street Buffered Bike Lanes. Final Report" (2011). Urban Studies and Planning Faculty Publications and Presentations.

** National Cooperative Highway Research Program. Report #766: Recommended Bicycle Lane Widths for Various Roadway Characteristics.

Crash Reduction

A before and after study of buffered bicycle lane installation in Portland, OR found an overwhelmingly positive response from bicyclists, with 89% of bicyclists feeling safer riding after installation and 91% expressing that the facility made bicycling easier.***

*** National Cooperative Highway Research Program. Report #766: Recommended Bicycle Lane Widths for Various Roadway Characteristics.

Construction Costs

The cost for installing buffered bicycle lanes will depend on the implementation approach. Typical costs are \$16,000 per mile for restriping. However, the cost of large-scale bicycle treatments will vary greatly due to differences in project specifications and the scale and length of the treatment.

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A group of children wearing helmets are riding bicycles on a paved road. The child in the foreground is wearing a red long-sleeved shirt and a grey helmet. The child next to them is wearing a green jacket and a black helmet with a colorful design. A race bib with the number 25 is attached to the front of their bicycle. Other children are visible in the background, also riding bicycles. The scene is outdoors with trees and a clear sky.

CLASS III: SHARED ROADWAYS

On shared roadways, bicyclists and motor vehicles use the same roadway space. These facilities are typically used on roads with low speeds and traffic volumes, however they can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.

SHARED ROADWAYS

BICYCLE BOULEVARDS

Bicycle boulevards are low-volume, low-speed streets modified to enhance bicyclist comfort by using treatments such as signage, pavement markings, traffic calming and/or traffic reduction, and intersection modifications. These treatments allow through movements of bicyclists while discouraging similar through-trips by non-local motorized traffic.

**Typical Application**

- Parallel with and in close proximity to major thoroughfares (1/4 mile or less).
- Follow a desire line for bicycle travel that is ideally long and relatively continuous (2-5 miles).
- Avoid alignments with excessive zigzag or circuitous routing. The bikeway should have less than 10% out of direction travel compared to shortest path of primary corridor.
- Streets with travel speeds at 25 mph or less and with traffic volumes of fewer than 3,000 vehicles per day. These conditions should either exist or be established with traffic calming measures.

Design Features

- Signs and pavement markings are the minimum treatments necessary to designate a street as a bicycle boulevard.
- Bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.
- Implement volume control treatments based on the context of the bicycle boulevard, using engineering judgment. Target motor vehicle volumes range from 1,000 to 3,000 vehicles per day.
- Intersection crossings should be designed to enhance safety and minimize delay for bicyclists.

Bicycle Boulevards



Bicycle boulevards are established on streets that improve connectivity to key destinations and provide a direct, low-stress route for bicyclists, with low motorized traffic volumes and speeds, designated and designed to give bicycle travel priority over other modes.

Traffic Calming



Streets along classified neighborhood bikeways may require additional traffic calming measures to discourage through trips by motor vehicles.

Further Considerations

Bicycle boulevard retrofits to local streets are typically located on streets without existing signaled accommodation at crossings of collector and arterial roadways. Without treatments for bicyclists, these intersections can become major barriers along the bicycle boulevard and compromise safety.

Traffic calming can deter motorists from driving on a street. Anticipate and monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

Crash Reduction

In a comparison of vehicle/cyclist collision rates on traffic-calmed side streets signed and improved for cyclist use, compared to parallel and adjacent arterials with higher speeds and volumes, the bicycle boulevard was found to have a crash reduction factor of 63 percent, with rates two to eight times lower when controlling for volume (CMF ID: 3092).

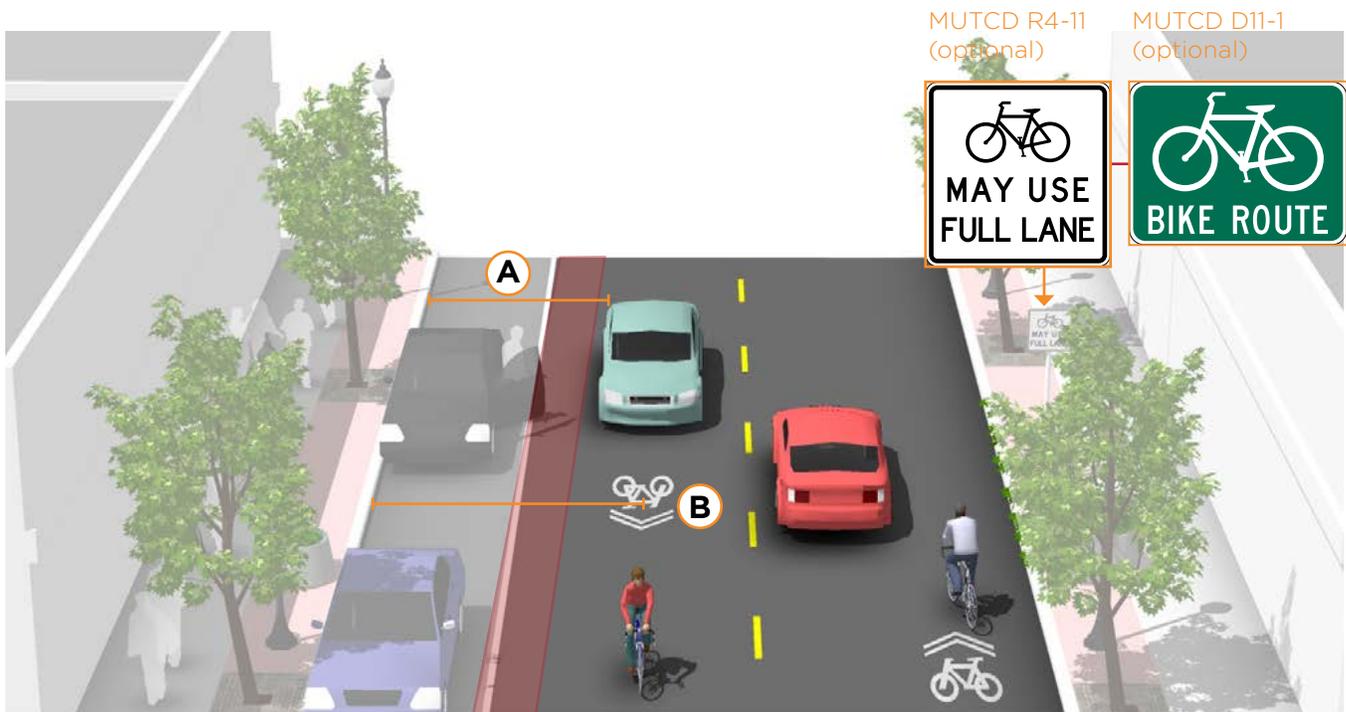
Construction Costs

Costs vary depending on the type of treatments proposed for the corridor. Simple treatments such as wayfinding signage and markings are most cost-effective, but more intensive treatments will have greater impact at lowering speeds and volumes, at higher cost.

SHARED ROADWAYS

SHARED LANE MARKINGS

Shared Lane Marking stencils are used in California as an additional treatment for Bike Route facilities and are currently approved in conjunction with on-street parking. The stencil can serve a number of purposes, such as making motorists aware of the need to share the road with bicyclists, showing bicyclists the direction of travel, and, with proper placement, reminding bicyclists to bike further from parked cars to prevent “dooring” collisions.



Typical Application

- Shared lane markings are not appropriate on paved shoulders or in bike lanes, and should not be used on roadways that have a speed limit above 35 mph.
- Shared Lane Markings pair well with Bikes May Use Full Lane signs.

Design Features

- When placed adjacent to parking, sharrows should be outside of the “door zone”. Minimum placement is 11’ from curb.
- Placement in center of the travel lane is preferred in constrained conditions.
- Markings should be placed immediately after intersections and spaced at 250 ft intervals thereafter.

Shared Lane Markings



Sharrows can be used on higher-traffic streets as positional guidance and raise bicycle awareness where there isn't space to accommodate a full-width bike lane.

Further Considerations

- Consider modifications to signal timing to induce a bicycle-friendly travel speed for all users.
- Though not always possible, placing the markings outside of vehicle tire tracks will increase the life of the markings and the long-term cost of the treatment.

Crash Reduction

A study that compared injury crashes per year per 100 bicycle commuters on facilities in Chicago built between 2008 and 2010 found that sharrows had a significantly weaker effect in reducing injury crashes compared the no-build condition by about 20 percent in contrast to bicycle lanes which saw a 42 percent reduction.*

* The Relative (In)Effectiveness of Bicycle Sharrows on Ridership and Safety Outcomes. Ferenchak, N and W. Marshall. 2015. Transportation Research Board 2016 Annual Meeting.

Construction Costs

Sharrows typically cost \$200 per each marker for a lane-mile cost of \$4,200, assuming the MUTCD guidance of sharrow placement every 250 feet.

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CLASS IV: SEPARATED BIKEWAYS

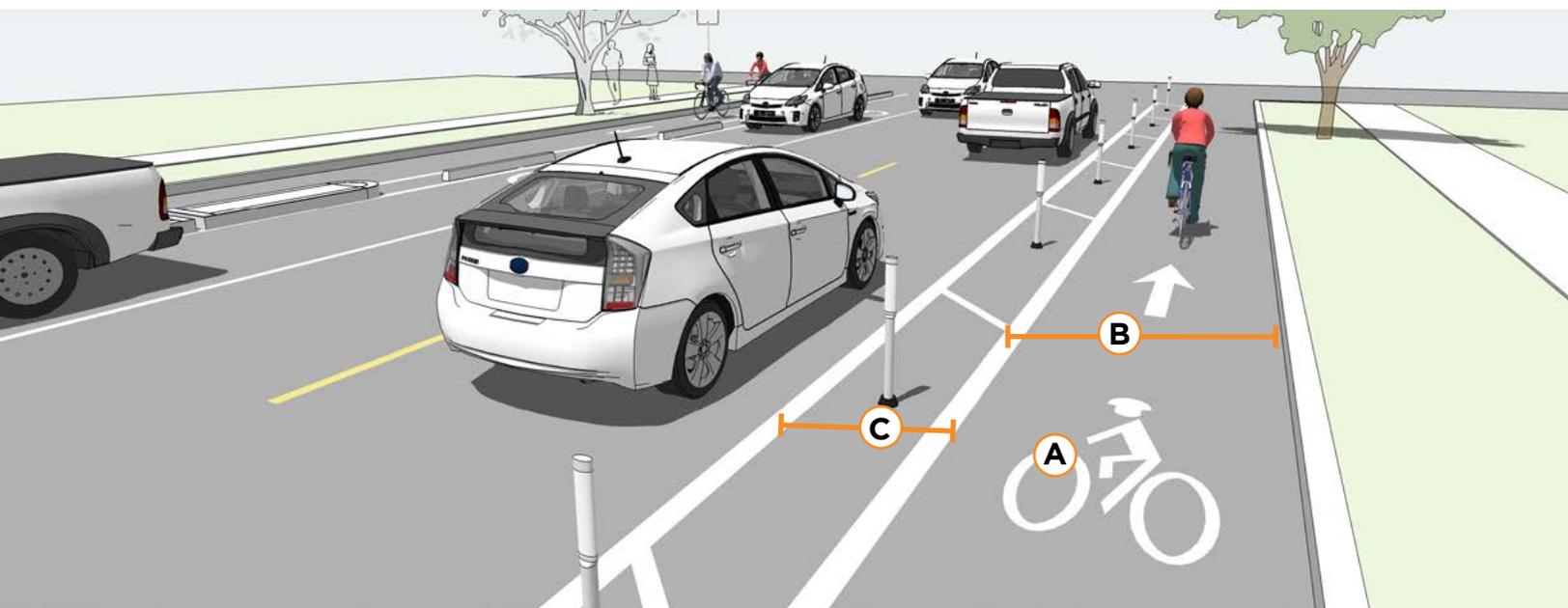
A cyclist wearing a white helmet and dark clothing is riding a road bike on a green-paved separated bikeway. The bikeway is physically separated from the street by a row of metal bollards. To the right of the bikeway is a sidewalk with a red-painted curb and a tree protected by a black metal cage. The background shows a street with cars, buildings, and trees under a clear blue sky.

A separated bikeway is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a on-street bike lane. A separated bikeway is physically separated from motor traffic by a vertical element and distinct from the sidewalk. In situations where on-street parking is allowed, separated bikeways are located between the parking and the sidewalk.

CLASS IV: SEPARATED BIKEWAYS

ONE-WAY SEPARATED BIKEWAY

One-way protected bicycle lanes are on-street bikeway facilities that are separated from vehicle traffic. Separation for protected bicycle lanes is provided through physical barriers between the bike lane and the vehicular travel lane. These barriers can include bollards, parking, planter strips, extruded curbs, or on-street parking. Protected bike lanes using these barrier elements typically share the same elevation as adjacent travel lanes, but the bike lane could also be raised above street level, either below or equivalent to sidewalk level.

**Typical Application**

- Along streets on which conventional bicycle lanes would cause many bicyclists to feel stress because of factors such as multiple lanes, high bicycle volumes, high motor traffic volumes (9,000-30,000 ADT), higher traffic speeds (25+ mph), high incidence of double parking, higher truck traffic (10% of total ADT) and high parking turnover.
- Along streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and other signaled intersection treatments.

Design Features

- A** Pavement markings, symbols and/or arrow markings must be placed at the beginning of the separated bike lane and at intervals along the facility based on engineering judgment to define the bike direction. (CAMUTCD 9C.04)
- B** 7 foot width preferred in areas with high bicycle volumes or uphill sections to facilitate safe passing behavior (5 foot minimum). (HDM 1003.1(1))
- C** 3 foot minimum buffer width adjacent to parking lines (18 inch minimum adjacent to travel lanes), marked with 2 solid white lines (NACTO, 2012).

Street Level Separated Bicycle Lanes



Street Level Separated Bicycle Lanes can be separated from the street with parking, planters, bollards or other design elements.

Further Considerations

- Separated bike lane buffers and barriers are covered in the CAMUTCD as preferential lane markings (section 3D.01) and channelizing devices (section 3H.01). If buffer area is 4 feet or wider, white chevron or diagonal markings should be used (section 9C.04). Curbs may be used as a channeling device; see the section on islands (section 3I.01).
- Where possible, locate physical barriers such as tubular markings or removable curbs towards the inside edge of the buffer. This preserves as much extra width as possible for bicycle use.
- A retrofit separated bike lane has a relatively low implementation cost compared to road reconstruction by making use of existing pavement and drainage and by using parking lane as a barrier.
- Gutters, drainage outlets and utility covers should be designed and configured as not to impact bicycle travel.
- For clarity at driveways or minor street crossings, consider a dotted line for the buffer boundary where cars are expected to cross
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.

Crash Reduction

A before and after study in Montreal of physically separated bicycle lanes shows that this type of facility can result in a crash reduction of 74% for collisions between bicyclists and vehicles. (CMF ID: 4097) In this study, there was a parking buffer between the bike facility and vehicle travel lanes. Other studies have found a range in crash reductions due to SBL, from 8% (CMF ID: 4094) to 94% (CMF ID: 4101).

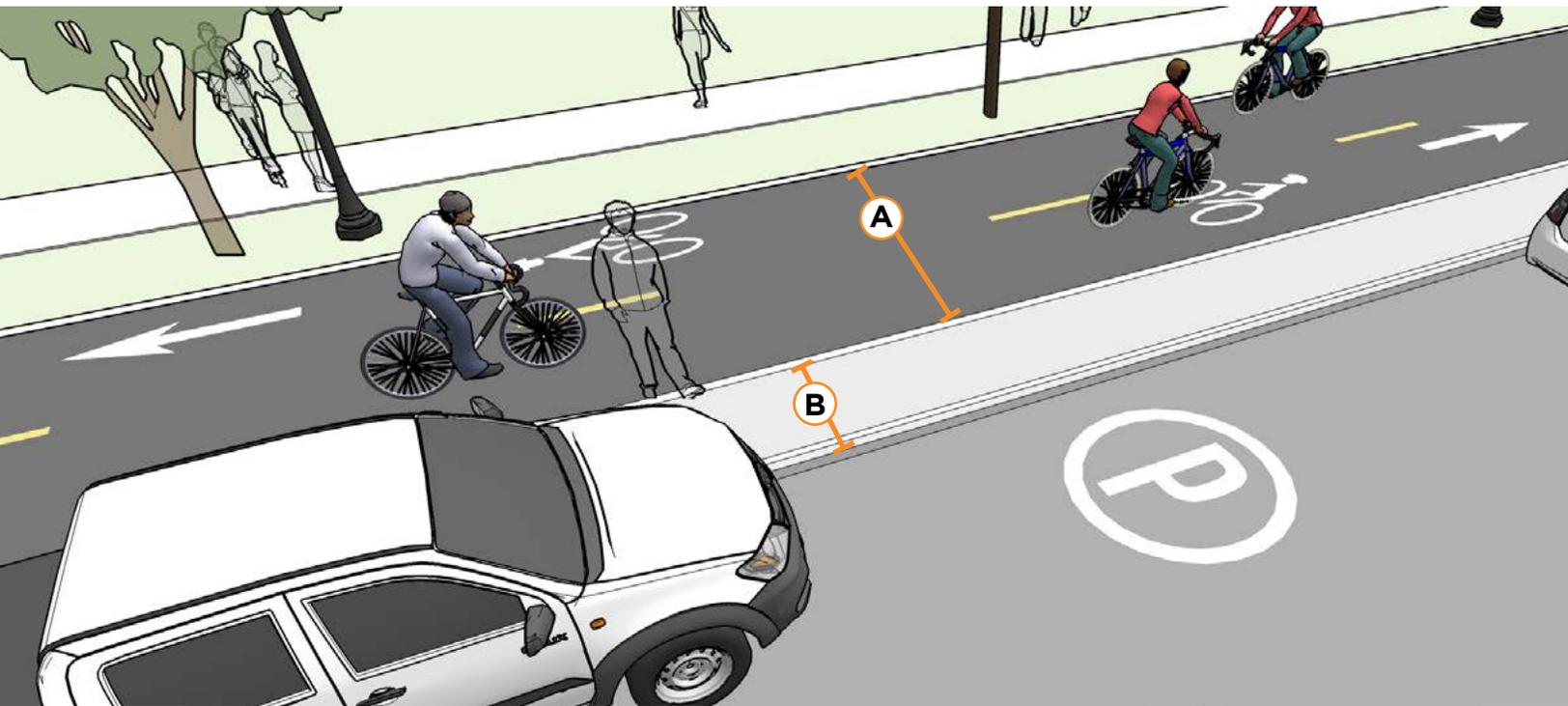
Construction Costs

The implementation cost is low if the project uses existing pavement and drainage, but the cost significantly increases if curb lines need to be moved. A parking lane is the low-cost option for providing a barrier. Other barriers might include concrete medians, bollards, tubular markers, or planters.

CLASS IV: SEPARATED BIKEWAYS

TWO-WAY SEPARATED BIKEWAY

Two-Way Separated Bikeways are bicycle facilities that allow bicycle movement in both directions on one side of the road. Two-way separated bikeways share some of the same design characteristics as one-way separated bicycle lanes, but may require additional considerations at driveway and side-street crossings.

**Typical Application**

- Works best on the left side of one-way streets.
- Streets with high motor vehicle volumes and/or speeds.
- Streets with high bicycle volumes.
- Streets with a high incidence of wrong-way bicycle riding.
- Streets with few conflicts such as driveways or cross-streets on one side of the street.
- Streets that connect to shared use paths.

Design Features

- A** 12 foot operating width preferred (10 ft minimum) width for two-way facility. In constrained an 8 foot minimum operating width may be considered. (HDM 1003.1(1))
- B** Adjacent to on-street parking a 3 foot minimum width channelized buffer or island shall be provided to accommodate opening doors. (NACTO, 2012) . (CAMUTCD 3H.01, 3I.01)
- Separation may be narrower than 5 feet if physical barrier separation is present. (AASHTO, 2013)

Two-Way Separated Bicycle Lanes



A two-way facility can accommodate cyclists in two directions of travel.

Further Considerations

- Two-way bikeways introduce additional complexities at intersections and driveways. Additional signalization and signs may be necessary to manage conflicts.
- On-street bike lane buffers and barriers are covered in the CAMUTCD as preferential lane markings (section 3D.01) and channelizing devices, including flexible delineators (section 3H.01). Curbs may be used as a channeling device, see the section on islands (section 3I.01).
- A two-way separated bike lane on a one way street should be located on the left side where possible.
- A two-way protected bike lane may be configured at street level or as a raised separated bicycle lane with vertical separation from the adjacent travel lane.
- Two-way separated bike lanes should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles.
- Consult Caltrans DIB 89; Class IV Bikeway Guidance for more information.

Crash Reduction

A study of bicyclists in two-way separated facilities found that accident probability decreased by 45% at intersections where the separated facility approach could be seen between 2-5 meters from the side of the main road and when bicyclists had crossing priority at intersections. (CMF ID: 3034) Installation of a two-way separated bike lane 0-2 meters from the side of the main road resulted in an increase in collisions at intersections by 3% (CMF ID: 4033).

Construction Costs

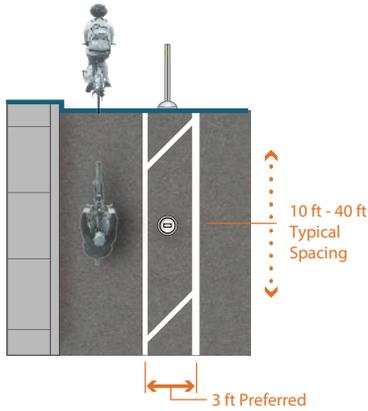
The implementation cost is low if the project uses existing pavement and drainage, but the cost significantly increases if curb lines need to be moved. A parking lane is the low-cost option for providing a barrier. Other barriers might include concrete medians, bollards, tubular markers, or planters.

CLASS IV: SEPARATED BIKEWAYS

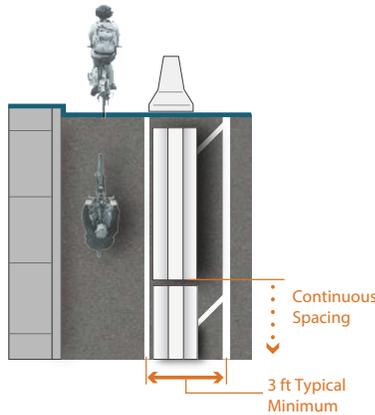
SEPARATED BIKEWAY BARRIERS

Separated bikeways may use a variety of vertical elements to physically separate the bikeway from adjacent travel lanes. Barriers may be robust constructed elements such as curbs, or may be more interim in nature, such as flexible delineator posts.

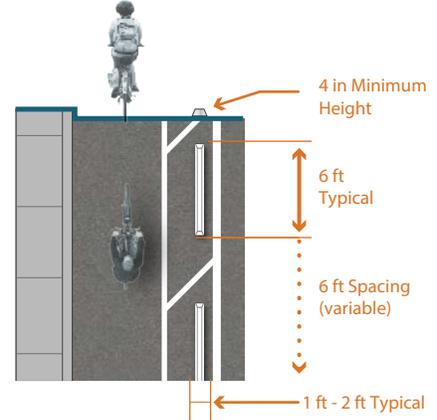
Delineator Posts



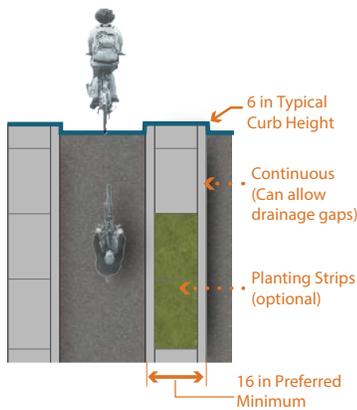
Concrete Barrier



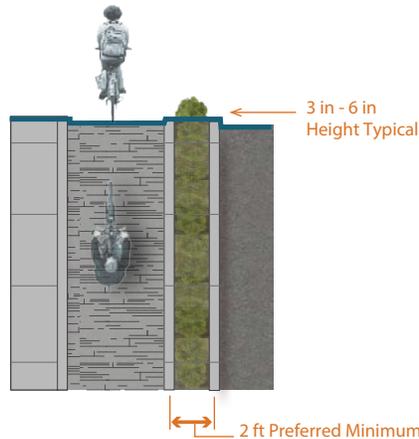
Parking Stops



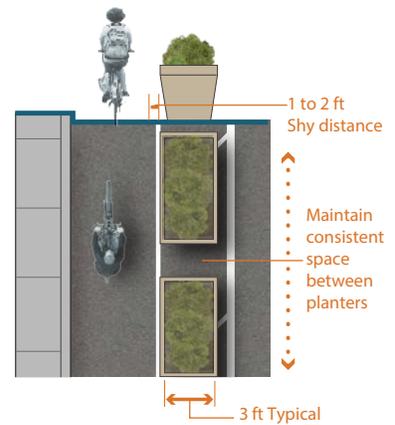
Raised Median



Raised Lane



Planters



Typical Application

Appropriate barriers for retrofit projects:

- Parked cars
- Flexible delineator posts
- Bollards
- Planters
- Parking stops

Appropriate barriers for reconstruction projects:

- Curb separation
- Raised medians
- Landscaped medians
- Raised protected bike lane with vertical or mountable curb
- Pedestrian Safety Islands

Bikeway Separation Methods



Raised separated bikeways are bicycle facilities that are vertically separated from motor vehicle traffic.

Design Features

- Maximize effective operating space by placing curbs or delineator posts as far from the through bikeway space as practicable.
- Allow for adequate shy distance of 1 to 2 feet from vertical elements to maximize useful space.
- When next to parking allow for 3 feet of space in the buffer space to allow for opening doors and passenger unloading.
- The presences of landscaping in medians, planters and safety islands increases comfort for users and enhances the streetscape environment.

Further Considerations

- Separated bikeway buffers and barriers are covered in the CAMUTCD as preferential lane markings (section 3D.01) and channelizing devices (section 3H.01). Curbs may be used as a channeling device, see the section on islands (section 3I.01).
- With new roadway construction a raised separated bikeway can be less expensive to construct than a wide or buffered bicycle lane because of shallower trenching and sub base requirements.
- Parking should be prohibited within 30 feet of the intersection to improve visibility.

Crash Reduction

A before and after study in Montreal of separated bikeways shows that this type of facility can result in a crash reduction of 74% for collisions between bicyclists and vehicles. (CMF ID: 4097) In this study, there was a parking buffer between the bike facility and vehicle travel lanes. Other studies have found a range in crash reductions due to SBL, from 8% (CMF ID: 4094) to 94% (CMF ID: 4101).

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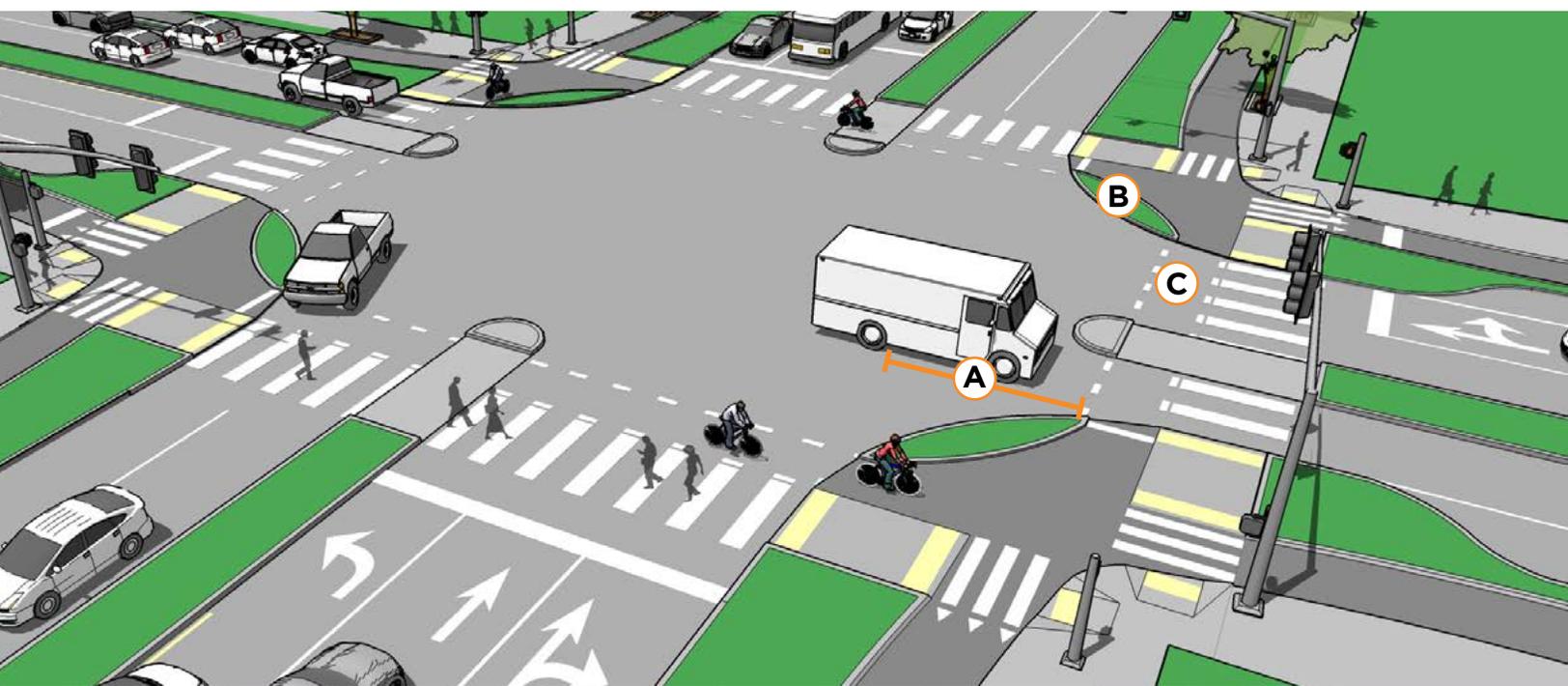
BIKEWAY INTERSECTION TREATMENTS

Intersections are junctions at which different modes of transportation meet and facilities overlap. An intersection facilitates the interchange between bicyclists, motorists, pedestrians and other modes in order to advance traffic flow in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflict between bicyclists and motor vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes.

BIKEWAY INTERSECTION TREATMENTS

PROTECTED INTERSECTION

A protected intersection uses a collection of intersection design elements to maximize user comfort within the intersection and promote a high rate of motorists yielding to people bicycling. The design maintains a physical separation within the intersection to define the turning paths of motor vehicles, slow vehicle turning speed, and offer a comfortable place for people bicycling to wait at a red signal.

**Typical Application**

- Streets with separated bicycle lanes protected by wide buffer or on-street parking.
- Where two separated bicycle lanes intersect and two-stage left-turn movements can be provided for bicycle riders.
- Helps reduce conflicts between right-turning motorists and bicycle riders by reducing turning speeds and providing a forward stop bar for bicycles.
- Where it is desirable to create a curb extension at intersections to reduce pedestrian crossing distance.

Design Features

- A** Setback bicycle crossing of 16.5 feet allows for one passenger car to queue while yielding. Smaller setback distance is possible in slow-speed, space constrained conditions.
- B** Corner safety island with a 15-20 foot corner radius slows motor vehicle speeds. Larger radius designs may be possible when paired with a deeper setback or a protected signal phase, or small mountable aprons. Two-stage turning boxes are provided for queuing bicyclists adjacent to corner islands.
- C** Use intersection crossing markings.

Protected Intersection



Protected intersections feature a corner safety island and intersection crossing markings, and can be used by bicyclists to queue for two-stage left turns.

Further Considerations

- Pedestrian crosswalks may need to be further set back from intersections in order to make room for two-stage turning queue boxes.
- Wayfinding and directional signage should be provided to help bicycle riders navigate through the intersection.
- Colored pavement may be used within the corner refuge area to clarify use by people bicycling and discourage use by people walking or driving.
- Intersection approaches with high volumes of right turning vehicles should provide a dedicated right turn only lane paired with a protected signal phase. Protected signal phasing may allow different design dimensions than are described here.

Crash Reduction

Studies of “bend out” intersection approaches find that separation distance of 6.5 – 16.5 ft offer the greatest safety benefit, with a better safety record than conventional bike lane designs. (Schepers 2011).

Schepers et al. Road factors and Bicycle-Motor vehicle crashes at unsignalized priority intersections. 2011.

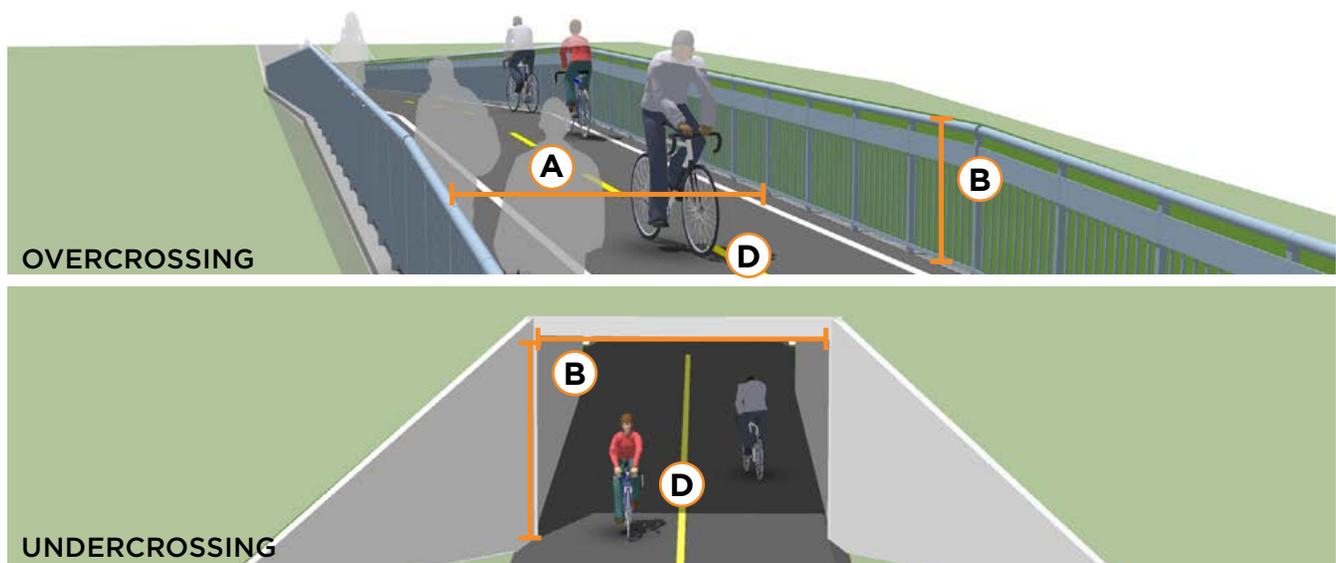
Construction Costs

- Reconstruction costs comparable to a full intersection.
- Retrofit implementation may be possible at lower costs if existing curbs and drainage are maintained.

BIKEWAY INTERSECTION TREATMENTS

GRADE-SEPARATED CROSSINGS

Grade-separated crossings provide critical non-motorized system links by joining areas separated by barriers such as railroads, waterways and highway corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist. There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group, grade separation may be considered in many types of projects.

**Typical Application**

- Where shared-use paths cross high-speed and high-volume roadways where an at-grade signalized crossing is not feasible or desired, or where crossing railways or waterways.

Design Features

- A** Overcrossings should be at least 8 feet wide with 14 feet preferred and additional width provided at scenic viewpoints.
- B** Railing height must be a minimum of 42 inches for overcrossings.
- C** Undercrossings should be designed at minimum 10 feet height and 14 feet width, with greater widths preferred for lengths over 60 feet.
- D** Centerline stripe is recommended for grade-separated facility.

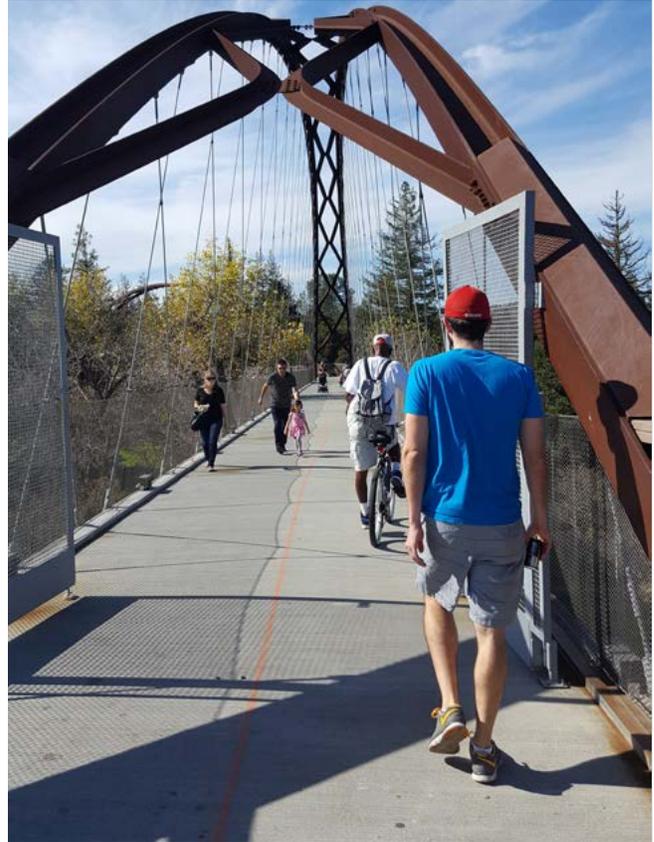
Further Considerations

- Overcrossings require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an undercrossing. This can result in greater elevation differences and much longer ramps for bicycles and pedestrians to negotiate.
- Overcrossings for bicycles and pedestrians typically fall under the Americans with Disabilities Act (ADA), which strictly limits ramp slopes to 5% (1:20) with landings at 400 foot intervals, or 8.33% (1:12) with landings every 30 feet.
- Overcrossings pose potential concerns about visual impact and functional appeal, as well as space requirements necessary to meet ADA guidelines for slope.
- To mitigate safety concerns, an undercrossing should be designed to be spacious, well-lit, equipped with emergency cell phones at each end and completely visible for its entire length from end to end.

Crash Reduction

Grade separated crossings, when used, eliminate conflicts between users that would be present at at-grade crossing locations.

Overcrossings



Undercrossings

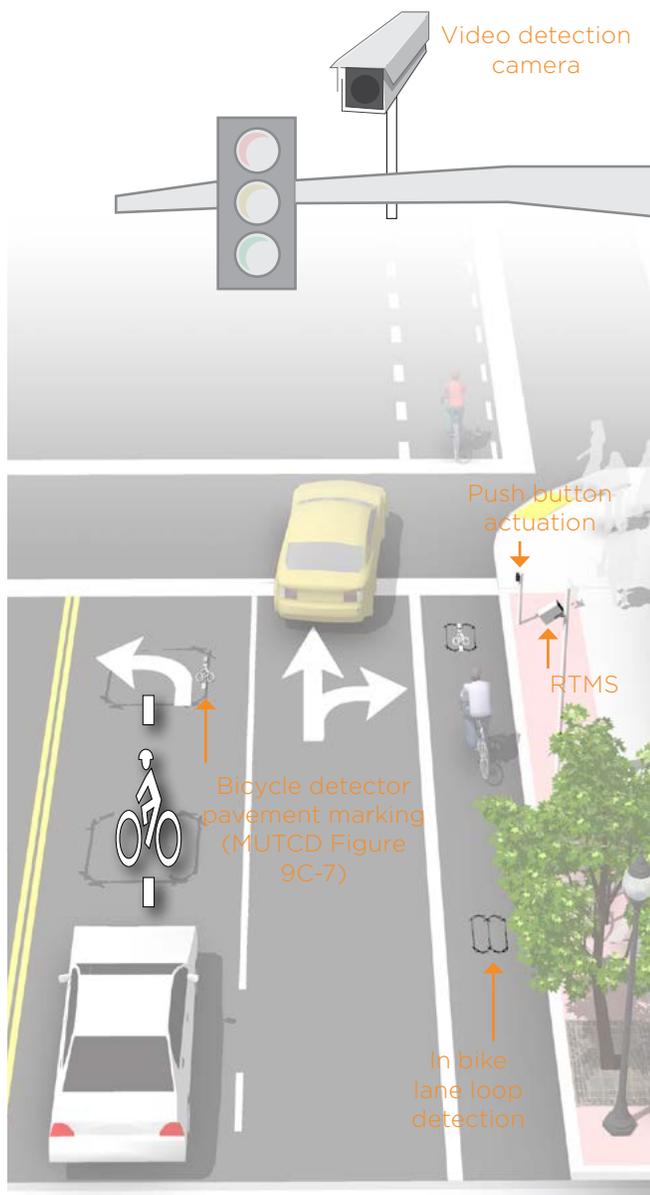


Grade-separated crossings help people walking or biking cross barriers such as freeways, railroads, and rivers.

BIKEWAY INTERSECTION TREATMENTS

BICYCLE DETECTION AND ACTUATION

Proper bicycle detection should meet two primary criteria: 1) accurately detects bicyclists and 2) provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand). Bicycle loops and other detection mechanisms can also provide bicyclists with an extended green time before the light turns yellow so that bicyclists of all abilities can reach the far side of the intersection.



Typical Application

- All new or modified traffic signals in California must be equipped for bicyclist detection, or be placed on permanent recall or fixed time operation. (CalTrans Traffic Operations Policy Directive (TOPD) 09-06.
- Detection shall be placed where bicyclists are intended to travel and/or wait.
- On bicycle priority corridors with on-street bike lanes or separated bikeways, consider the use of advance detection placed 100-200' upstream of the intersection to provide an early trigger to the signal system and reduce bicyclist delay.

Design Features

TOPD 09-06 requires push button, in-pavement detectors or video detection systems.

Push Button Actuation

User-activated button mounted on a pole facing the street. Device location should not require bicyclists to dismount or be rerouted out of the way or onto the sidewalk to activate the phase.

In Pavement Detection (Type D inductive loop)

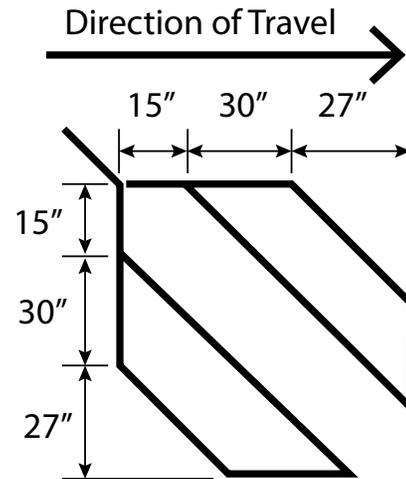
Bicycle-activated loop detectors are installed within the roadway to allow the presence of a bicycle to trigger a change in the traffic signal. This allows the bicyclist to stay within the lane of travel without having to maneuver to the side of the road to trigger a push button. Loops should be supplemented with pavement markings to instruct bicyclists how to trip them.

Push Button Actuation



Bicycle push button actuators are positioned to allow bicycle riders in roadway to stop traffic on busy cross-streets.

Type D Loop Detector



Type D loop detector have been shown to most reliably detect bicyclists at all points over their surface.

Further Considerations

- Video detection systems use digital image processing to detect a change in the image at a location. These systems can be calibrated to detect bicycles, although some video detection systems may have problems detecting bicyclists under poor lighting or poor weather conditions.
- It is important for signal timing to account for the differing bicycle start up and clearance time through the intersection. The sum of the minimum green time, plus the yellow change interval plus any red clearance interval should allow a 6 ft bicyclist to clear the last conflicting lane at a speed of 14.7 ft/sec plus an additional start up time of 6 seconds.
- Signal detection and actuation for bicyclists should be maintained with other traffic signal detection and roadway pavement markings. In street detection markings are often placed within the wheel tread of motor vehicles and may be susceptible to early wear.

- Studies have shown limited comprehension of the bicycle detection pavement marking by bicyclists. The MUTCD R10-22 sign may be used to help educate and inform road users.

Crash Reduction

Properly designed bicycle detection can help deter red light running and unsafe behaviors by reducing delay at signalized intersections.

Construction Costs

Costs vary depending on the type of technology used. Embedded in pavement loop detectors have an average cost of \$1,900. Video camera system costs range from \$20,000 to \$25,000 per intersection.

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BIKEWAY SIGNING AND AMENITIES



The ability to navigate through a city is informed by landmarks, natural features and other visual cues. Bicycle wayfinding can assist in navigation to guide bicyclists to their destinations along preferred bicycle routes. Signs are typically placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

BIKEWAY SIGNING AND AMENITIES

SAFETY AND WARNING SIGNS

Signs may be used to raise awareness of the presence of bikes on the roadway beyond that of the conventional “Bike Route” sign. These signs are intended to reduce motor vehicle/bicyclist conflict and are appropriate to be placed on routes that lack paved shoulders or other bicycle facilities.



R117 (CA)



W11-1 with custom “ON ROADWAY” legend plaque



R4-11

Typical Application

- In higher speed rural contexts, a bicycle warning sign (W11-1) paired with a legend plaque reading “ON ROADWAY” may clarify to motor vehicle drivers to expect bicyclists.
- In more developed areas, “Bikes May Use Full Lane” (BMUFL) (R4-11) signs encourage bicyclists to take the lane when the lane is too narrow. They typically work best when placed near activity centers such as schools, shopping centers and other destinations that attract bicycle traffic.
- The “SHARE THE ROAD” (W16-1P) plaque is discouraged for use due to a lack of shared understanding among road users.
- In California, the state-specific “PASS Bicycle (symbol) 3FT MIN” symbol (R117) can be used to remind motorists to provide adequate space when passing.

Design Features

- Use with travel lanes less than 14 feet wide, which are too narrow for safe passing within the lane.
- Signs should be placed at regular intervals along routes with no designated bicycle facilities.
- Dedicated bicycle facilities are recommended for roadways with speed limits above 35 mph where the need for bicycle access exists.

BIKEWAY SIGNING AND AMENITIES

SHARED USE PATH SIGNAGE

Signs may be used to raise awareness of trail etiquette. Bicyclists should alert other users when approaching from behind. Pedestrians should move to the side of the trail as to not block joggers or bicyclists.

**Typical Application**

- Shared Use Path courtesy signs can be placed at trail heads, trail entrances, in parking lots, and before bridges, curves, or other narrow trail segments with low visibility.

Design Features

- Use graphics to supplement text.
- Include “Slow to the Right” or other appropriate language on signs during sign development.
- Use speed limit signs at regular intervals with accompanying “Use Courtesy When Passing” language.

WAYFINDING

COMMUNITY WAYFINDING SIGNS

Community wayfinding guide signs are part of a coordinated and continuous system of signs that direct tourists and other road users to key civic, cultural, visitor, and recreational attractions and other destinations within a city or a local urbanized or downtown area.



Typical Application

- Within a downtown or neighborhood district area to provide a cohesive local wayfinding system to road users, including pedestrians.
- Community wayfinding guide signs should not be used on a regional or statewide basis. For wayfinding systems at these scales, conventional MUTCD destination and guide signing should be used.
- The use of community wayfinding guide signs is limited to conventional roads, and should not be used on limited access highways.

Design Features

- A** Except for the informational guide sign posted at the boundary of the wayfinding guide sign area, community wayfinding guide signs may use background colors other than green in order to provide a color identification for the wayfinding destinations by geographical area within the overall wayfinding guide signing system
- B** Other graphics that specifically identify the wayfinding system, including identification enhancement markers, may be used on the overall sign assembly and sign supports.
- C** Non-conventional designs that adhere to MUTCD signage regulations can be used in areas with unique historic character.

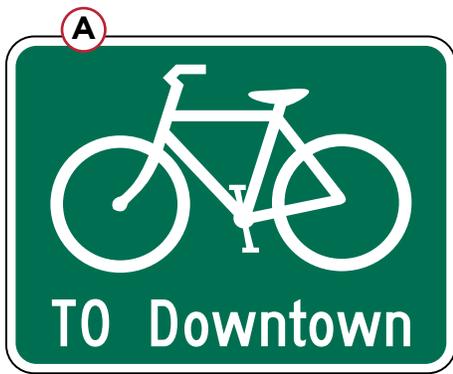
Further Considerations

The standard colors of red, orange, yellow, purple, or the fluorescent versions thereof, fluorescent yellow-green, and fluorescent pink shall not be used as background colors for community wayfinding guide signs, in order to minimize possible confusion with critical, higher-priority regulatory and warning sign color meanings readily understood by road users.

BIKEWAY SIGNING AND AMENITIES

WAYFINDING SIGN TYPES

The ability to navigate through a city is informed by landmarks, natural features and other visual cues. Signs throughout the city should indicate to bicyclists the direction of travel, the locations of destinations and the travel time/distance to those destinations. A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes.



D11-1c



D11-1



D11-1/D1-3a

Typical Application

- Wayfinding signs will increase users' comfort and accessibility to the bicycle systems.
- Signage can serve both wayfinding and safety purposes including:
 - Helping to familiarize users with the bicycle network
 - Helping users identify the best routes to destinations
 - Helping to address misconceptions about time and distance
 - Helping overcome a "barrier to entry" for people who are not frequent bicyclists (e.g., "interested but concerned" bicyclists)

Design Features

- A** Confirmation signs indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route. Can include destinations and distance/time but do not include arrows.
- B** Turn signs indicate where a bikeway turns from one street onto another street. These can be used with pavement markings and include destinations and arrows.
- C** Decision signs indicate the junction of two or more bikeways and inform bicyclists of the designated bike route to access key destinations. These include destinations, arrows and distances. Travel times are optional but recommended.

Community Logos on Signs



Wayfinding signs can include a local community identification logo, as this example from Oakland, CA.

Custom Street Signs (Berkeley, CA)



Custom street signs can also act as a type of confirmation sign, to let all users know the street is prioritized for bicyclists.

Further Considerations

- Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes.
- Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists rather than per vehicle signage standards.
- A community-wide bicycle wayfinding signage plan would identify:
 - Sign locations
 - Sign type - what information should be included and design features
 - Destinations to be highlighted on each sign - key destinations for bicyclists
 - Approximate distance and travel time to each destination
- Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MUTCD.
- Check wayfinding signage along bikeways for signs of vandalism, graffiti, or normal wear and replace signage along the bikeway network as-needed.

Crash Reduction

There is no evidence that wayfinding signs have any impact on crash reduction or user safety.

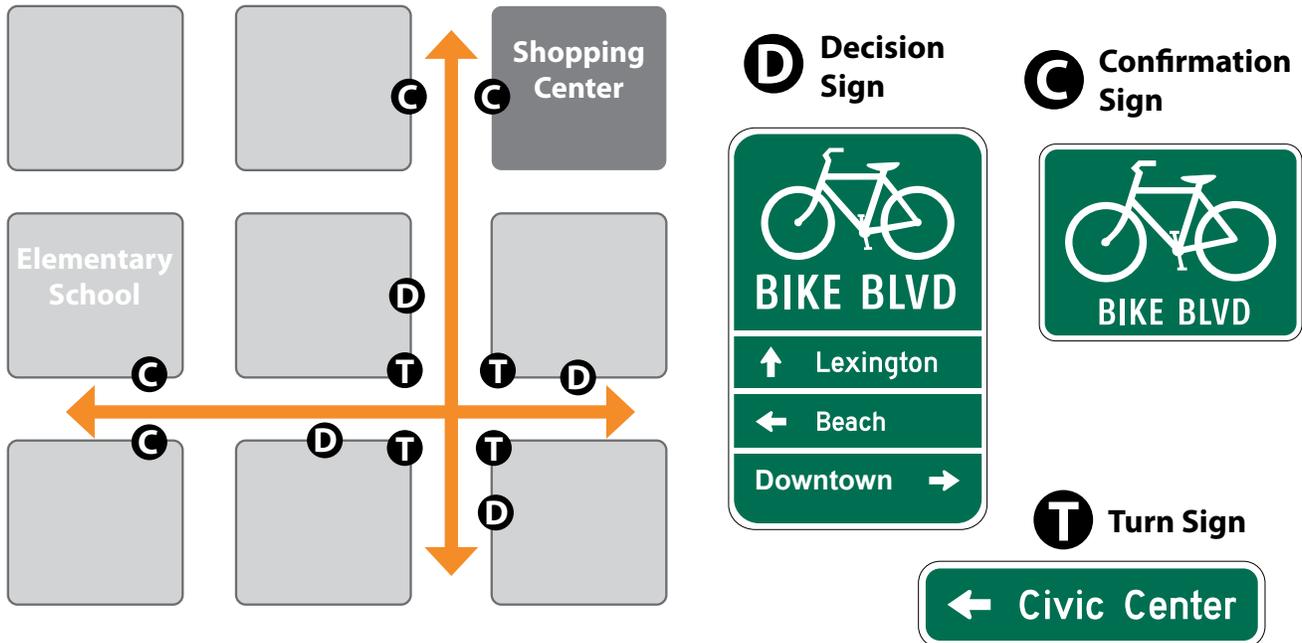
Construction Costs

Trail wayfinding signs range from \$500-\$2000.

Bikeway Signing and Amenities

WAYFINDING SIGN PLACEMENT

Signs are placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

**D Decision Sign****C Confirmation Sign****T Turn Sign****Typical Application****Confirmation Signs**

- Placed every $\frac{1}{4}$ to $\frac{1}{2}$ mile on off-street facilities and every 2 to 3 blocks along on-street bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign).
- Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

Turn Signs

- Near-side of intersections where bike routes turn (e.g., where the street ceases to be a bicycle route or does not go through).
- Pavement markings can also indicate the need to turn to the bicyclist.

Decision Signs

- Near-side of intersections in advance of a junction with another bicycle route.
- Along a route to indicate a nearby destination.

Design Features

- MUTCD guidelines should be followed for wayfinding sign placement, which includes mounting height and lateral placement from edge of path or roadway.
- Pavement markings can be used to reinforce routes and directional signage.

Wayfinding Pavement Markings



Some cities use pavement markings to indicate required turns or jogs along the bicycle route.

Further Considerations

It can be useful to classify a list of destinations for inclusion on the signs based on their relative importance to users throughout the area. A particular destination's ranking in the hierarchy can be used to determine the physical distance from which the locations are signed. For example, primary destinations (such as the downtown area) may be included on signage up to five miles away. Secondary destinations (such as a transit station) may be included on signage up to two miles away. Tertiary destinations (such as a park) may be included on signage up to one mile away.

Crash Reduction

There is no evidence that wayfinding signs have any impact on crash reduction or user safety.

Construction Costs

The cost of a wayfinding sign placement plan depends on the scale and scope of the approach. Trail wayfinding signage range from \$500-\$2000.



BIKE PARKING

Safe and easy access to bicycle parking facilities is necessary to encourage commuters to access transit via bicycle. Short and long term parking should be provided at transit centers and other destinations.

BIKE PARKING

BIKE PARKING

Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. This may be short-term parking of 2 hours or less, or long-term parking for employees, students, residents, and commuters.



Typical Application

- Bike racks provide short-term bicycle parking and are meant to accommodate visitors, customers, and others expected to depart within two hours. Short-term parking should consist of approved standard racks, with appropriate location and placement to serve nearby uses. Bike racks can also incorporate a canopy for weather protection.
- Bike corrals consist of bicycle racks grouped together in a common area within the street traditionally used for automobile parking, or on the sidewalk within the furnishing zone as space allows. Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking, or as part of a curb extension for off-street bicycle parking. Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces. Bike corrals can also incorporate a canopy for weather protection.
- Bicycle lockers are intended to provide long-term bicycle storage for employees, students, residents, commuters, and others expected to park more than two hours. Long-term facilities protect the entire bicycle, its components and accessories against theft and against inclement weather, including snow and wind-driven rain. Lockers should be placed in visible, easily accessible locations while maintaining security.

Design Features

Bike Racks

- A** 2 feet minimum from the curb face to avoid 'dooring.'
- B** 4 feet between racks to provide maneuvering room.
- C** Locate close to destinations; 50 feet maximum distance from main building entrance.
- D** Minimum clear distance of 6 feet should be provided between the bicycle rack and the property line.

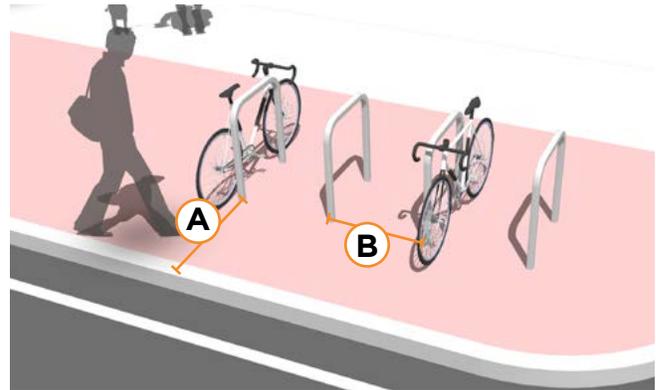
Bike Corrals

- Bicyclists should have an entrance width from the roadway of 5-6 feet for on-street corrals.
- Can be used with parallel or angled parking.
- Parking stalls adjacent to curb extensions are good candidates for on-street bicycle corrals since the concrete extension serves as delimitation on one side.
- Off-street bike corrals are appropriate where there is a wide sidewalk furnishing zone (7 feet or greater), or as part of a curb extension.

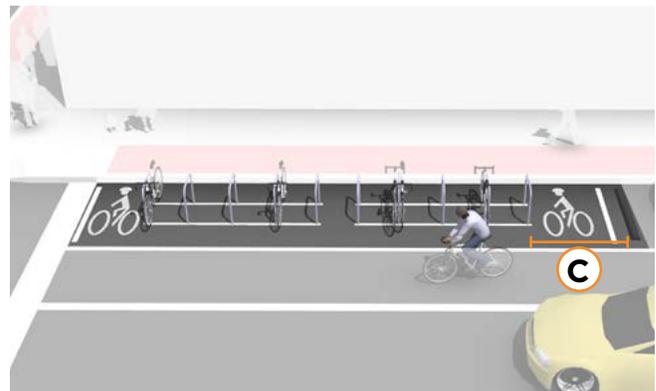
Bike Lockers

- Minimum dimensions: width (opening) 2.5 feet; height 4 feet; depth 6 feet.
- 4 foot side clearance and 6 foot end clearance.
- 7 foot minimum distance between facing lockers.

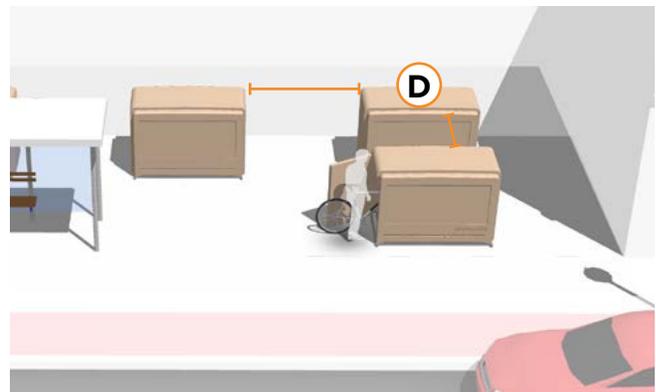
Perpendicular Bike Racks



Bike Corral



Bike Locker



Construction Costs

Costs can vary based on the design and materials used. Bicycle rack costs can range from approximately \$60 to \$3,600, depending on design and materials used. On average the cost is approximately \$660. Bicycle locker costs range from \$1,280 to \$2,680.

Further Considerations

Minimum Specifications for Required Bicycle Parking

- All bicycle parking facilities shall be dedicated for the exclusive use of bicycle parking and shall not be intended for the use of motorized two-wheeled or similar vehicles.
- All required short-term bicycle parking spaces shall permit the locking of the bicycle frame and one (1) wheel with a

U-type lock; support the bicycle in a stable horizontal position without damage to wheels, frame, or components; and provide two (2) points of contact with the bicycle's frame. Art racks are subject to review by the City.

- All required long-term bicycle parking spaces, with the exception of individual bicycle lockers, shall permit the locking of the bicycle frame and one (1) wheel with a U-type lock and support the bicycle in a stable position without damage to wheels, frame, or components.
- Bicycle parking facilities shall be securely anchored so they cannot be easily removed and shall be of sufficient strength and design to resist vandalism and theft.

Location and Design of Required Bicycle Parking.

- A short-term bicycle parking space shall be at least two and one-half (2.5) feet in width by six (6) feet in length to allow sufficient space between parked bicycles.



- Bicycle parking facilities shall not impede pedestrian or vehicular circulation. Bicycle parking racks located on sidewalks should be kept clear of the pedestrian through zone.
- Short-term bicycle racks shall be located with at least 30 inches clearance in all directions from any obstruction, including but not limited to other racks, walls, and landscaping. Large retail uses, supermarkets, and grocery stores are encouraged to locate racks with a 36-inch clearance in all directions from any vertical obstruction, including but not limited to other racks, walls, and landscaping.
- All bicycle facilities shall provide a minimum four (4) foot aisle to allow for unobstructed access to the designated bicycle parking area.
- Bicycle parking facilities within auto parking facilities shall be protected from damage by cars by a physical barrier such as curbs, wheel stops, poles, bollards, or other similar features capable of preventing automobiles from entering the designated bicycle parking area.
- Short-term bicycle parking facilities serving community activity centers such as libraries and community centers should incorporate weather-protective enclosures shielding the designated bicycle area from typical inclement weather when feasible.
- Bicycle parking facilities shall be located in highly visible well-lighted areas. In order to maximize security, whenever possible short-term bicycle parking facilities shall be located in areas highly visible from the street and from the interior of the building they serve (i.e., placed adjacent to windows).
- Long-term bicycle parking shall be covered and shall be located on site or within 200 feet of the main building entrance. The main building entrance is defined as publicly accessible entrances and shall exclude gated private garage entrances, trash room entrances, and other building entrances that are not publicly accessible.



- Short-term bicycle parking must be along project frontage and within 50 feet of the main entrance to the building or commercial use or up to 100 feet where existing conditions do not allow placement within 50 feet. It should be in a well-trafficked location visible from the entrance. The main building entrance excludes garage entrances, trash room entrances, and other building entrances that are not publicly accessible.
- If required bicycle parking is not visible from the street or main building entrance, a sign must be posted at the main building entrance indicating the location of the bicycle parking.



PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN FURNITURE

Seating, water fountains, trash receptacles, and other amenities can enhance the pedestrian experience by creating spaces that are inviting, where people want to spend time rather than pass through.

PEDESTRIAN INFRASTRUCTURE

PEDESTRIAN SCALE LIGHTING

Pedestrian scale lighting improves pedestrian safety and comfort at night. Lighting serves not only to illuminate the walking area for pedestrians, but also makes pedestrians visible to motorists and can eliminate dark hiding places that contribute to personal safety concerns.