BERKELEY BICYCLE FACILITY DESIGN TOOLBOX

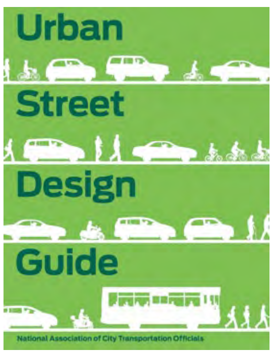
2017

CONTEXT

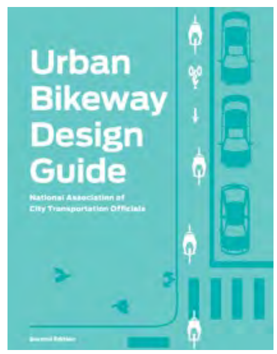
Guidance Basis

The sections that follow serve as an inventory of pedestrian and bicycle design treatments and provide guidelines for their development. 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



A blueprint for designing 21st century streets, the NACTO **Urban Street Design Guide (2013)** *unveils the toolbox and tactics cities use to make streets safer, more livable, and more economically vibrant. The Guide outlines both a clear vision for complete streets and a basic road map for how to bring them to fruition. The document charts the principles and practices of the nation's foremost engineers, planners, and designers working in cities today.*



The National Association of City Transportation Officials' (NACTO) **Urban Bikeway Design Guide (2012)** *provides cities with state-of-the-practice solutions that can help create complete streets that are safe and enjoyable for bicyclists. The designs in this document were developed by cities for cities, since unique urban streets require innovative solutions. In August 2013, the Federal Highway Administration issued a memorandum officially supporting use of the document.*

The NACTO **Transit Street Design Guide (2016)** *provides design guidance for the development of transit facilities on city streets, and for the design and engineering of city streets to prioritize transit, improve transit service quality, and support other goals related to transit. The guide has been developed on the basis of other design guidance, as well as city case studies, best practices in urban environments, research and evaluation of existing designs, and professional consensus. These sources, as well as the specific designs and elements included in the guide, are based on North American street design practice.*

Separated Bike Lane Planning and Design Guide (2015) *is the latest national guidance on the planning and design of separated bike lane facilities released by the Federal Highway Administration (FHWA). The resource documents best practices as demonstrated around the U.S., and offers ideas on future areas of research, evaluation and design flexibility.*

The Massachusetts Department of Transportation's **Separated Bike Lane Planning & Design Guide** *presents considerations and strategies for the development of separated bike lanes. The Guide establishes a framework for determining when separated bike lanes are appropriate and feasible; and presents design guidance for separation strategies, bike lane configuration, and considerations for transit stops, loading zones, utilities, drainage, parking and landscaping.*

CALIFORNIA GUIDANCE

The **California Manual on Uniform Traffic Control Devices (CAMUTCD) (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.*

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.*

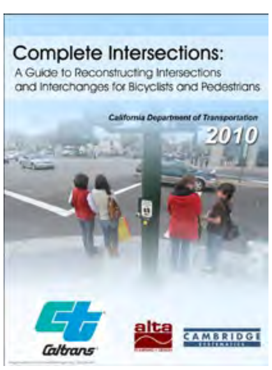

HIGHWAY DESIGN MANUAL

FOREWORD

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.*


Memorandum

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 ma king planning and design decisions on the State highway system and local streets and roads."*



Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians (2010) *is a reference guide 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.*

The **AC Transit Design Standards and Guidelines Manual for Safe and Efficient Multimodal Transit Stops and Corridors** *provides street design guidance that supports efficient and reliable transit operations. The manual equips agencies in control of street design with a useful reference document offering context-sensitive guidance at each stage of the design process. The manual is currently under development.*

Bicycle User Type

As part of public outreach for the Bicycle Plan, a survey was conducted of Berkeley residents asking about their interests, current habits, concerns, and facility preferences around bicycling. Using a bicycling classification system originally developed by Portland City Bicycle Planner, Roger Geller, respondents were sorted into groups by their differing needs and bicycling comfort levels given different roadway conditions. Geller's typologies have been carried forward into several subsequent studies in cities outside Portland at the national level, and were used in the City of Berkeley analysis for consistency with national best practices and comparison to other top cycling cities. These categories of bicyclists are described below.

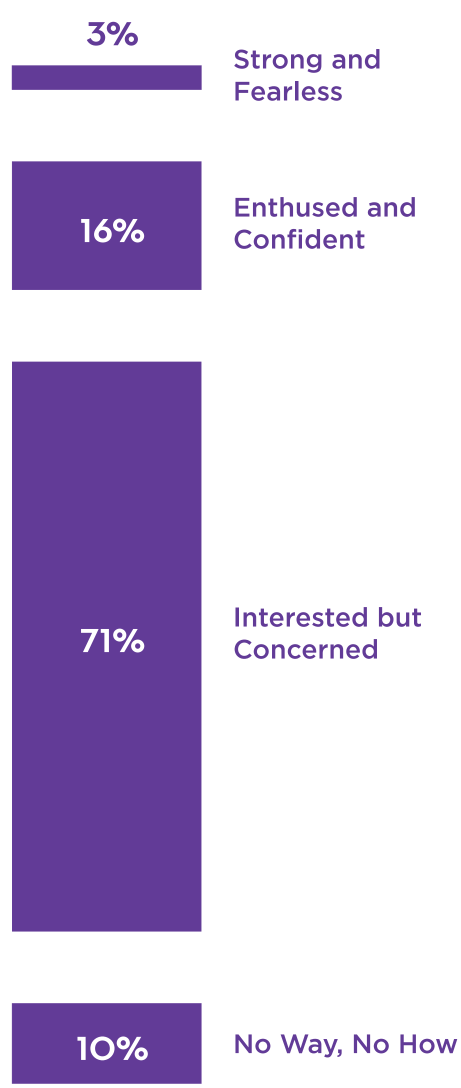
Strong and Fearless – This group is willing to ride a bicycle on any roadway, regardless of traffic conditions. Comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities.

Enthused and Confident - This group of people riding bicycles are riding in most roadway situations but prefer to have a designated facility. Comfortable riding on major streets with a bike lane.

Interested but Concerned – This group is more cautious and has some inclination towards bicycling, but are held back by concern over sharing the road with cars. Not very comfortable on major streets, even with a striped bike lane, and prefer separated pathways or low traffic neighborhood streets.

No Way, No How – This group comprises residents who simply aren't interested in bicycling and may be physically unable or don't know how to ride a bicycle, and are unlikely to adopt bicycling in any way.

Berkeley Distribution of Bicyclist Types



Facility Selection

In order to provide a bikeway network that meets the needs of Berkeley's "Interested but Concerned" residents (who comprise over 2/3 of the population), bikeways must be low-stress and comfortable. By using a metric called Level of Traffic Stress (LTS), specific facility types can be matched to the needs of people who bicycle in Berkeley. Generally, "Interested but Concerned", users will only bicycle on LTS 1 or LTS 2 facilities.

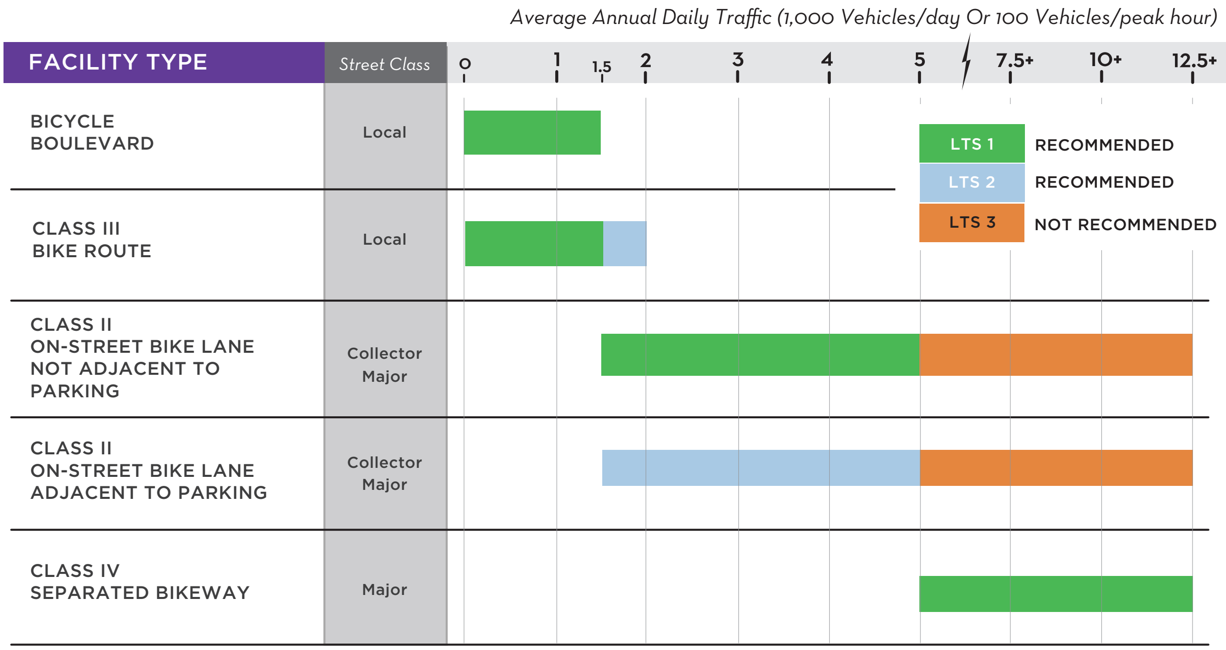
Levels of Traffic Stress (LTS)

LTS LEVEL	DESCRIPTION	WHAT TYPE OF BICYCLISTS WILL RIDE ON THIS LTS FACILITY?		
		STRONG & FEARLESS	*ENTHUSIASTIC & CONFIDENT*	*INTERESTED BUT CONCERNED*
LTS 1	Presents the lowest level of traffic stress; demands less attention from people riding bicycles, and attractive enough for a relaxing bicycle ride. Suitable for almost all people riding bicycles, including children trained to ride in the street and to safety cross intersections.	YES	YES	YES
LTS2	Presents little traffic stress and therefore suitable to most adults riding bicycles, but demandsmore attention than might be expected from children	YES	YES	SOMETIMES
LTS3	More traffic stress than LTS2, yet significantly less than the stress of integrating with multilane traffic.	YES	SOMETIMES	NO
LTS4	A level of stress beyond LTS 3. Includes roadways that have no dedicated bicycle facilities and moderate to higher vehicle speeds and volumes OR high speed and high volume roadways WITH an exclusive riding zone (lane) where there is a significant speed differential with vehicles.	YES	NO	NO

Facility Selection (Continued)

The charts below help to identify the preferred bikeway facility type or crossing treatment, depending on roadway volumes and a target bikeway LTS 1 or 2. For Berkeley's Bicycle Bouelvard network, additional consideration is given to the LTS of street crossings, particularly high-volume or multi-lane crossings.

Recommended Bikeway Type Based on Traffic Volumes



(Average Daily Vehicles, per 1,000)

Bicycle Boulevard Crossing Treatment Recommendations

CROSSING TREATMENT	TRAFFIC VOLUMES						
	VERY LOW	LOW		MEDIUM		HIGH	
	Up to 3 lanes	Up to 3 lanes	4 lanes	Up to 3 lanes	4 or 5 lanes	Up to 3 lanes	4 or 5 lanes
Marked Crossing	LTS 1	LTS 1 or 2	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
Median Refuge Island [1]	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
RRFB [2,3]	X	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 3
RRFB with median [1,2,3]	X	LTS 1	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3
Pedestrian Hybrid Beacon (HAWK) [2]	X	X	LTS 1	LTS 1	LTS 1	LTS 1	LTS 1
Traffic Signal [2]	X	X	X	LTS 1	LTS 1	LTS 1	LTS 1

X No Additional Benefit

1 Minimum 6 ft wide median

2 Subject to successful warrant analysis

3 4-way stop signs may be considered as an alternative to RRFBs

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.

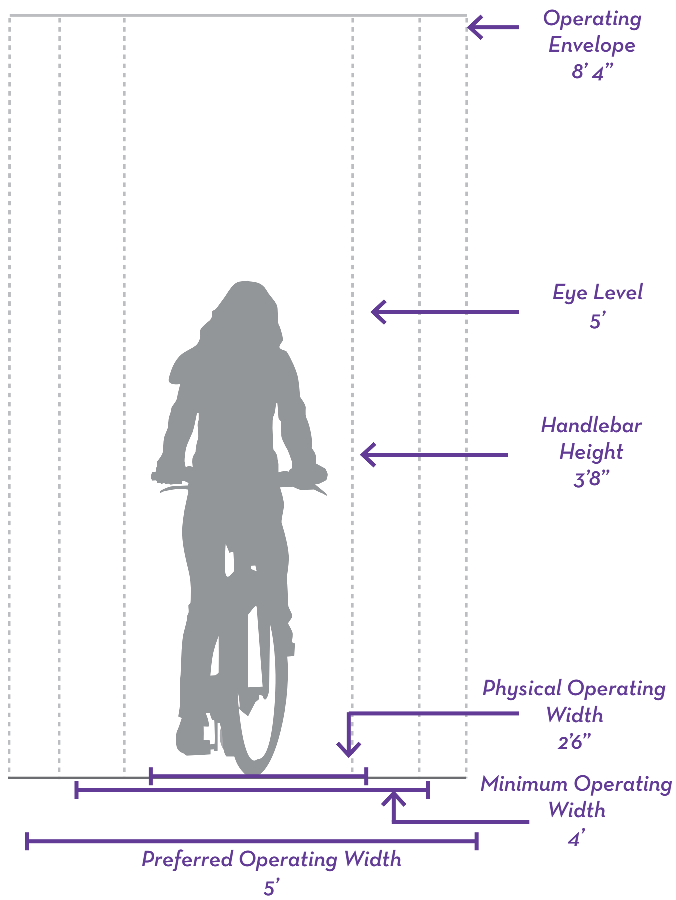
BICYCLE AS A DESIGN VEHICLE

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 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.

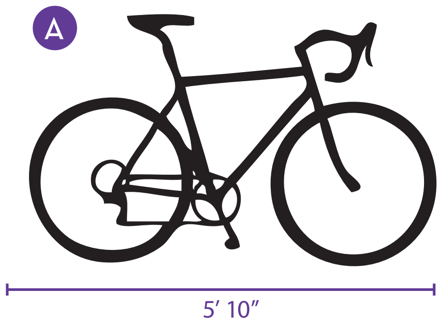
In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories. The figure to the right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

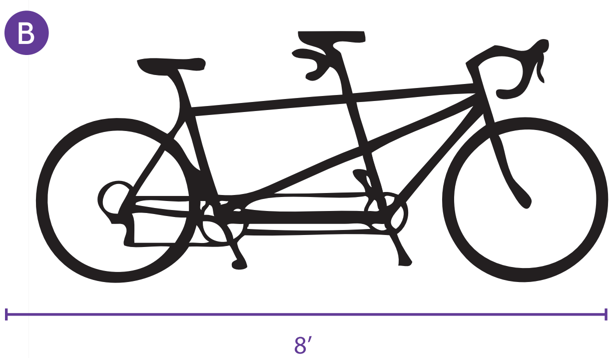
Bicycle Rider - Typical Dimensions

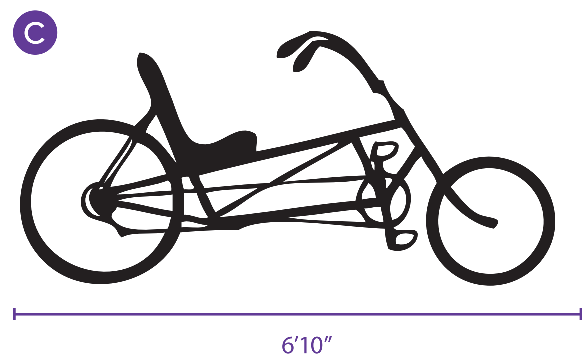


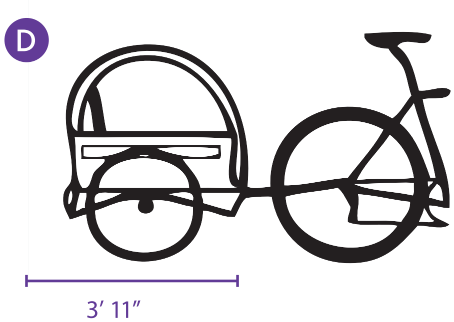
Bicycle Design Vehicle - Typical Dimensions

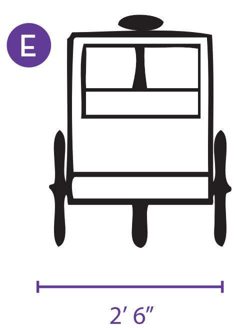
A: Adult Typical Bicycle
B: Adult Tandem Bicycle
C: Adult Recumbent Bicycle
D: Child Trailer Length
E: Child Trailer Width
F: Trailer Bike Length

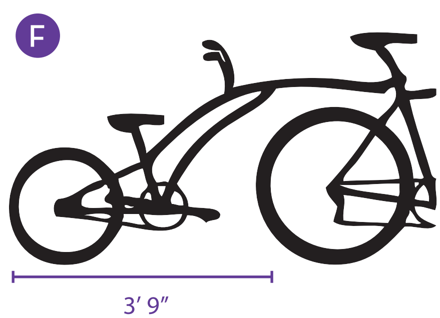












Source: AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition

DESIGN NEEDS OF BICYCLISTS

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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 causal riders per AASHTO 2013.

Complete Streets Design

As defined by the Berkeley Complete Streets Policy, "Complete Streets" describes a comprehensive, integrated transportation network with infrastructure, design, and maintenance that allows safe and convenient travel along and across streets for all users, including people walking, people bicycling, persons with disabilities, people driving motor vehicles, movers of commercial goods, users and operators of public transportation, emergency responders, seniors, youth, and families.

Providing a complete network does not necessarily mean that every street will provide dedicated facilities for all transportation modes, but rather that the transportation network will provide convenient, safe, and connected routes for all modes of transportation within and across the City. For the purposes of bikeway planning, the City of Berkeley considers both the major/collector street and parallel streets part of a Complete Street Corridor; potential bikeways on both the major/collector street bikeway and on parallel streets should be evaluated as part of a Complete Street Corridor Study.

As proposed elsewhere in this Plan, future Complete Street Corridor Studies are proposed as multimodal transportation studies, not as planned projects. In the spirit of Complete Streets, potential bikeways to be considered as part of future Complete Street Corridor Studies will be evaluated in the context of the modal priorities established by the Berkeley General Plan Transportation Element and the Alameda County Transportation Commission Countywide Multimodal Arterial Plan, as well as recommendations from AC Transit's Major Corridors Study.

As defined by the City of Berkeley General Plan Transportation Element, most of the future Complete Street Corridor Studies are either Primary or Secondary Transit Routes. General Plan Policy T-4 "Transit-First Policy" gives priority to alternative transportation and transit over single-occupant vehicles on Transit Routes. The Alameda County Transportation Commission Countywide Multimodal Arterial Plan identifies many of the future Complete Street Corridor Study locations as part of the Transit Emphasis modal priority network. In this planning and policy context and given the importance of approaching Complete Streets from an integrated, layered network perspective, it is critically important to consider how transit service can be maintained and improved as an outcome of future Complete Street Corridor Studies. Studies to consider the inclusion of bikeways will be coordinated with proposed improvements to transit performance on Primary Transit Routes, such as bus boarding islands, transit-only lanes, transit signal priority/queue jump lanes, far-side bus stop relocations, and other improvements as described in the AC Transit Major Corridors Study. In addition, these studies should approach Secondary Transit Routes as opportunities for transit improvements, such as bus stop optimization and relocation, among other potential improvements. At the conclusion of the Complete Streets Corridor Study process, design alternatives which have a significant negative effect on transit on Primary Transit Routes will not be recommended. Criteria to define what constitutes a significant negative effect on transit will be developed and applied during the Study process for each corridor. Consideration of how to allocate limited public right of way among various travel modes will be made consistent with Alameda County Transportation Commission modal priorities and the City of Berkeley General Plan.

Future Complete Street Corridor Studies and design efforts should be undertaken in the context of national design best practices such as the National Association of City Transportation Officials (NACTO) Transit Street Design Guide, Urban Street Design Guide, and Urban Bikeway Design Guide. Local guidance such as the forthcoming AC Transit Design Standards and Guidelines Manual for Safe and

Efficient Multimodal Transit Stops and Corridors will also be consulted. The design of bikeway projects should integrate improvements for all modes of transportation whenever possible, including consideration of people walking, biking, riding transit, driving, and commercial goods movement. Many of the proposed Complete Streets Corridors are also commercial corridors that have goods movement needs related to deliveries and loading/unloading at businesses, which are vital to the economic vitality of these areas. For example, study and design should carefully consider the potential impacts and trade-offs of including bikeways on Primary and Secondary Transit Routes, including potential median reductions, repurposing of parking or travel lanes, and the need to avoid impacts to transit operations that could otherwise occur. Example transit performance criteria that may be considered as part of future Complete Street Corridor Studies could include: on-time performance and reliability; gapping/bunching; transit travel time; operational and safety conflicts with other modes of transportation; maintaining minimum lane widths; and other criteria to be identified through the study process. Likewise, similar performance metrics should be identified and applied in these studies for the safety and convenience of people walking and driving along the subject corridors.

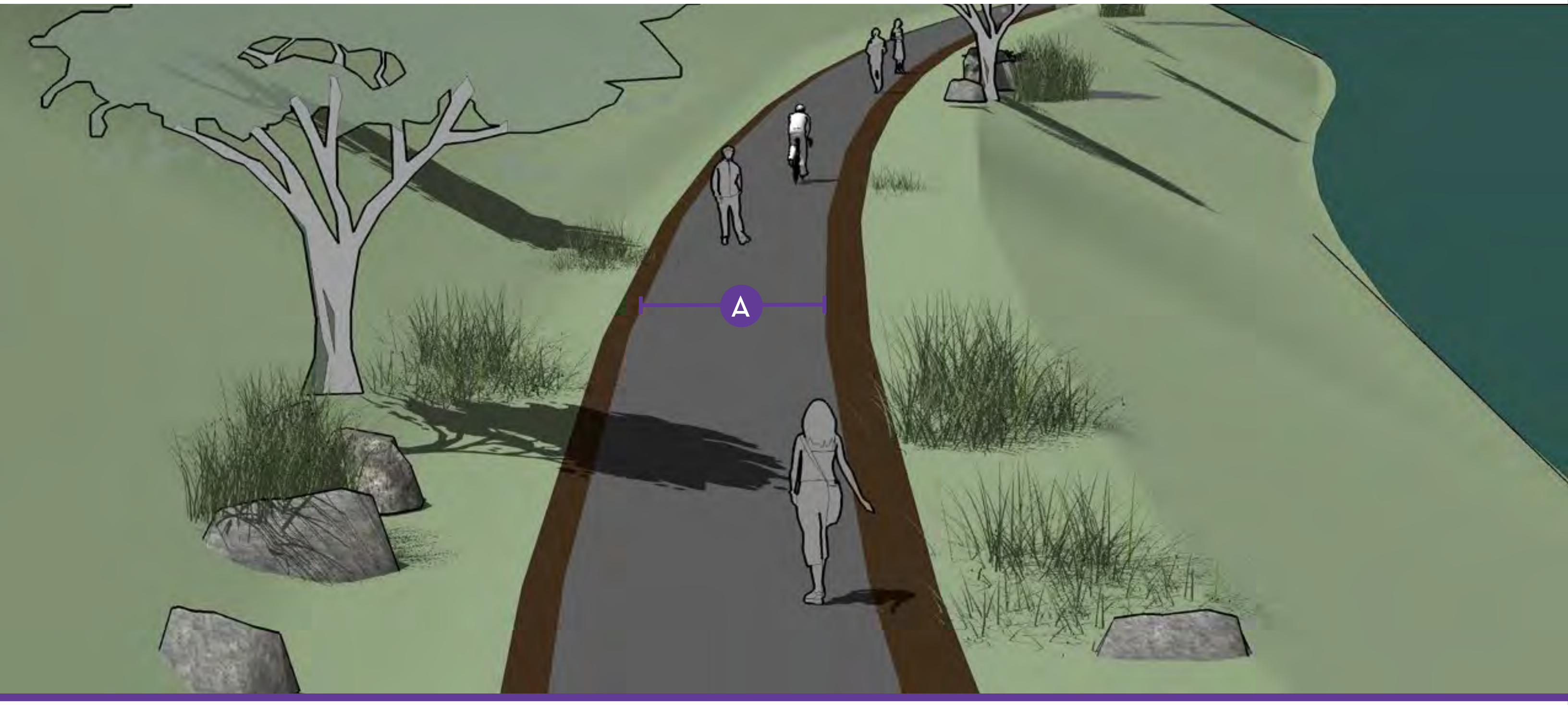
City of Berkeley General Plan:

Page T-12: "Policy T-4 Transit-First Policy: Give priority to alternative transportation and transit over single-occupant vehicles on Transit Routes identified in the Transit Network map (Figure 7, page T-31)."

City of Berkeley Complete Streets Policy:

Page 1: "Complete Streets Serving All Users: The City of Berkeley expresses its commitment to creating and maintaining Complete Streets that provide safe, comfortable, and convenient travel along and across streets (including streets, roads, highways, bridges, and other portions of the transportation system to the extent they are controlled by the City) through a comprehensive, integrated transportation network that serves all categories of users, including pedestrians, bicyclists, persons with disabilities, motorists, movers of commercial goods, users and operators of public transportation, emergency vehicles, seniors, children, youth, and families."

CLASS I BIKEWAYS BIKE PATHS



Shared Use Path

I INTERSECTION MID-BLOCK

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

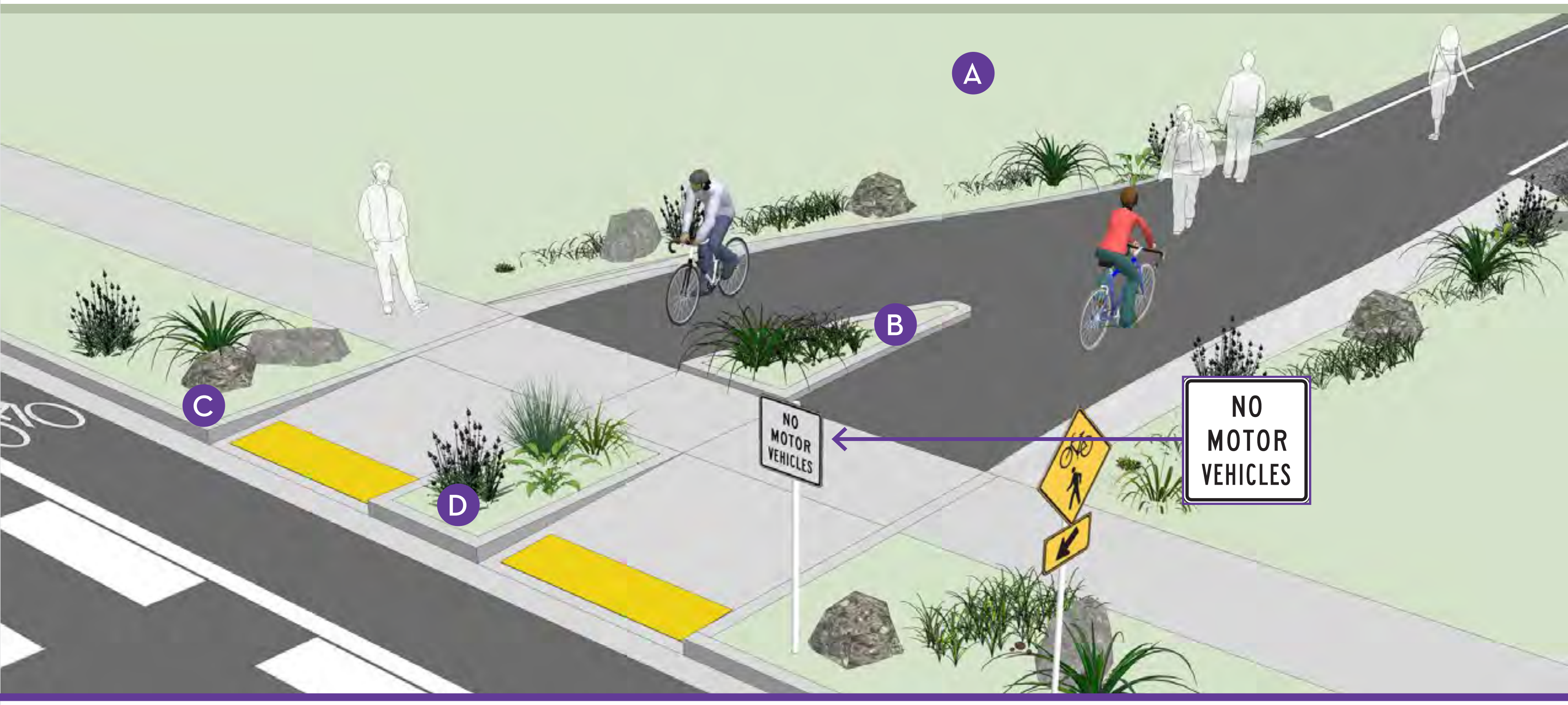
TYPICAL APPLICATION

- 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 12' width to accommodate moderate usage (14' preferred for heavy use). Minimum 10' 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. Alternatively, consolidate into a single 4' wide soft surface side path.
- 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.
- Lighting can improve visibility along the shared use path and intersection crossings at night, if night use is desired. This increases safety for shared use path users. Lighting may also be necessary for day-time use trails in tunnels and underpasses. Typical pedestrian scale lighting is spaced at 30-50 ft and should also be concentrated at trail heads, rest areas, street crossings, and other public spaces.



Bollard Alternatives

I INTERSECTION MID-BLOCK

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.

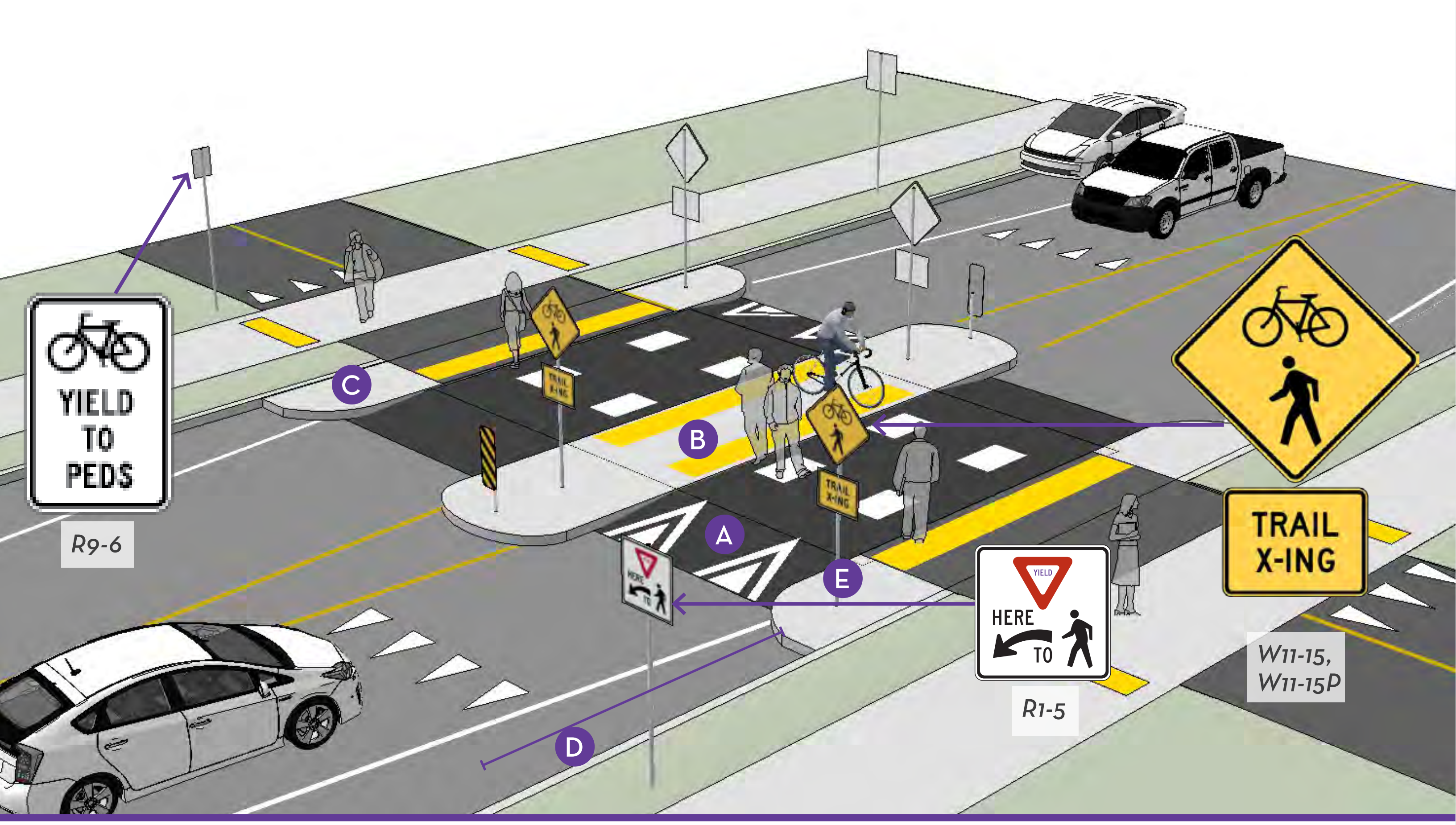
DESIGN FEATURES

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.



Raised Path Crossings

I INTERSECTION
MID-BLOCK

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 Curb extensions 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) 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

Bicycle lanes provide an exclusive space, but may be subject to unwanted encroachment by motor vehicles.

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. The raise should use a sinusoidal profile to facilitate snow plow operation. 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.
- Elements will be constructed with no variation in the surface. The maximum allowable tolerance in vertical roadway surface will be 1/4 of an inch.

CRASH REDUCTION

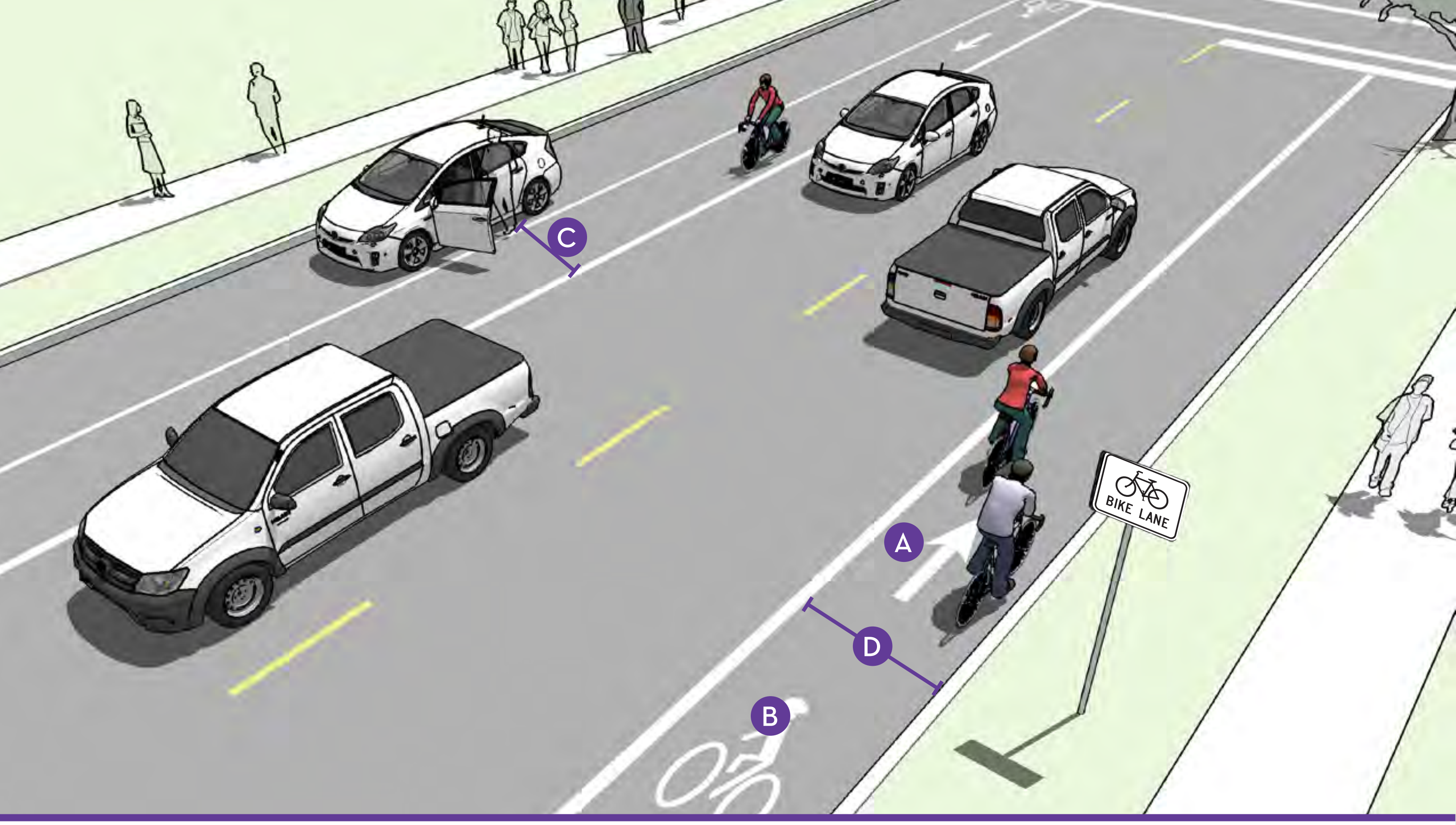
Studies have shown a 45% decrease in vehicle/pedestrian crashes after a raised crosswalk is installed where none existed previously. (CMF ID: 136)

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.


PED

CLASS II BIKEWAYS
BIKE LANES



Bicycle Lanes

II
INTERSECTION
MID-BLOCK

On-street bike lanes (Class II Bikeways) designate an exclusive space for bicyclists through the use of pavement markings and signs. 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

- Bike lanes may be used on any street with adequate space, but are most effective on streets with moderate traffic volumes ≥ 6,000 ADT (≥ 3,000 preferred).
- Bike lanes are most appropriate on 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 direction.

DESIGN FEATURES

A Mark inside line with 6" stripe. **(CAMUTCD 9C.04)** Mark 4" parking lane line or "Ts".[1]

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 4 feet more than the gutter pan width.

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

FURTHER CONSIDERATIONS

- On high speed streets (≥ 40 mph) the minimum bike lane should be 6 feet. **(HDM 301.2)**
- On streets where bicyclists passing each other is 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.

Manhole Covers and Grates:

- Manhole surfaces should be manufactured with a shallow surface texture in the form of a tight, nonlinear pattern
- If manholes or other utility access boxes are to be located in bike lanes within 50 ft. of intersections or within 20 ft. of driveways or other bicycle access points, special manufactured permanent nonstick surfaces are required to ensure a controlled travel surface for cyclists breaking or turning.
- Manholes, drainage grates, or other obstacles should be set flush with the paved roadway. Roadway surface inconsistencies pose a threat to safe riding conditions for bicyclists. Construction of manholes, access panels or other drainage elements should be constructed with no variation in the surface. The maximum allowable tolerance in vertical roadway surface will be 1/4 of an inch.

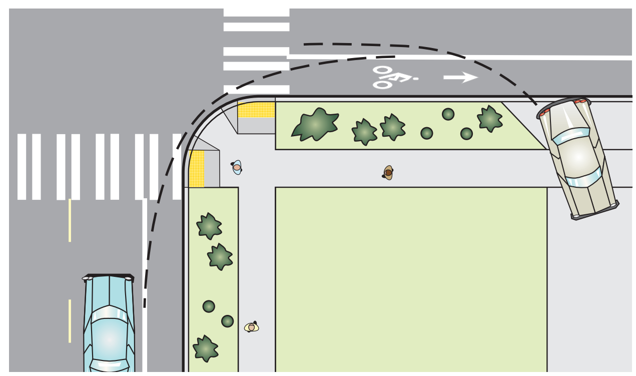
CRASH REDUCTION

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 after bike lane installation.

Bicycle Lane

Bicycle lanes provide an exclusive space, but may be subject to unwanted encroachment by motor vehicles.

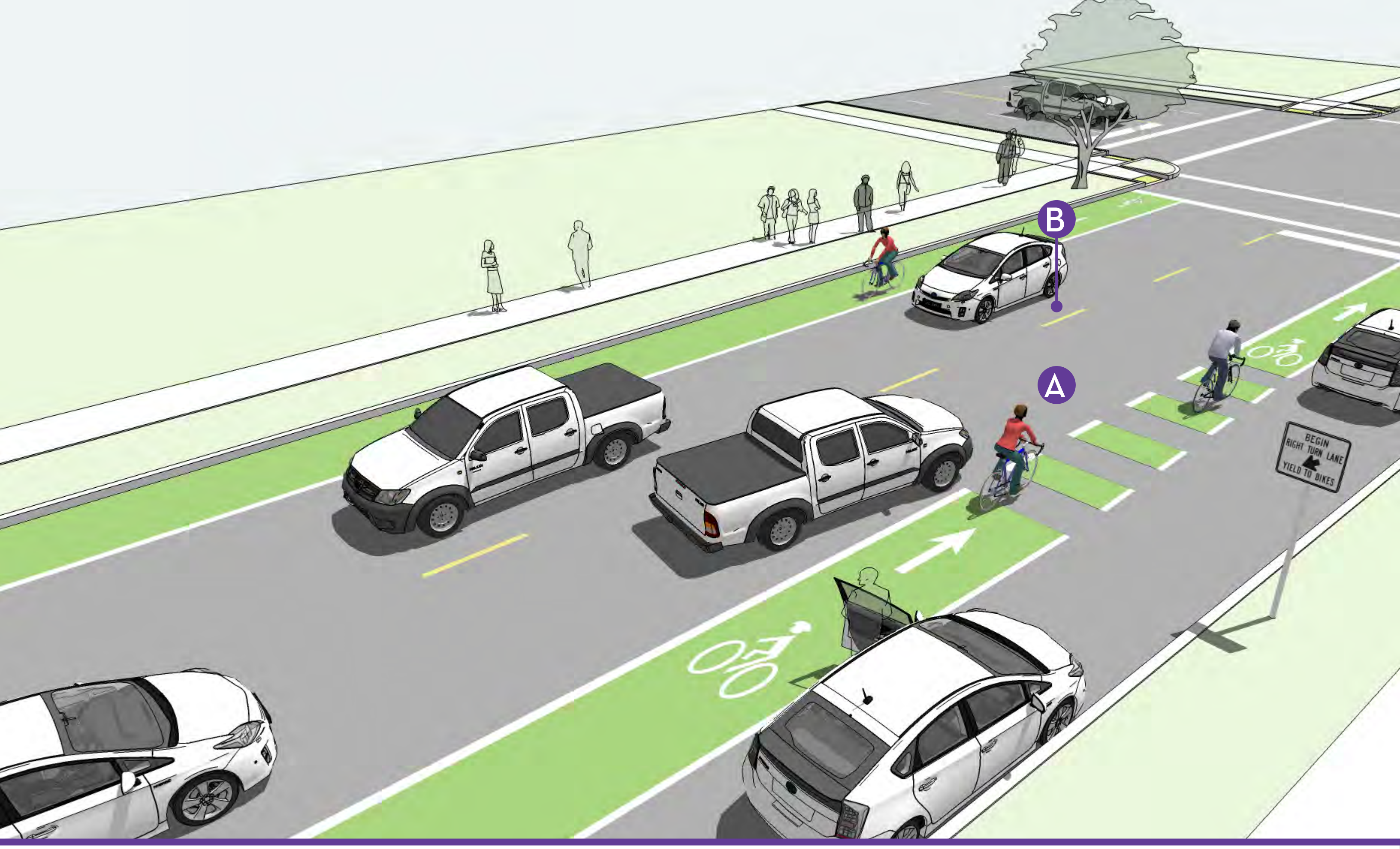
Place Bike Lane Symbols to Reduce Wear



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)

CONSTRUCTION COSTS

The cost for installing bicycle lanes will depend on the implementation approach. Typical costs are $16,000 per mile for restriping.



Colored Bicycle Lanes

II INTERSECTION MID-BLOCK

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 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)**
- In exclusive use areas, such as bike boxes, color application should be solid green.

Colored Bicycle Lane

A colored bicycle lane on Laurel Street in Santa Cruz, CA alerts users to potential merging in advance of an intersection. Photo by Richard Masoner via Flickr (CC BY-SA 2.0).

FURTHER CONSIDERATIONS

- Green colored pavement shall be used in compliance with FHWA Interim Approval. **(CAMUTCD 1A.10) (FHWA IA-14.10)**[1]
- While other colors have been used (red, blue, yellow), green is the recommended color in the U.S.
- The application of green colored pavement within bicycle lanes is an emerging practice. The guidance recommended here is based on best practices in cities around the country.

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%.[2] A study in Portland, OR found a 38% decrease in the rate of conflict between bicyclists and motorists after colored lanes were installed.[3]

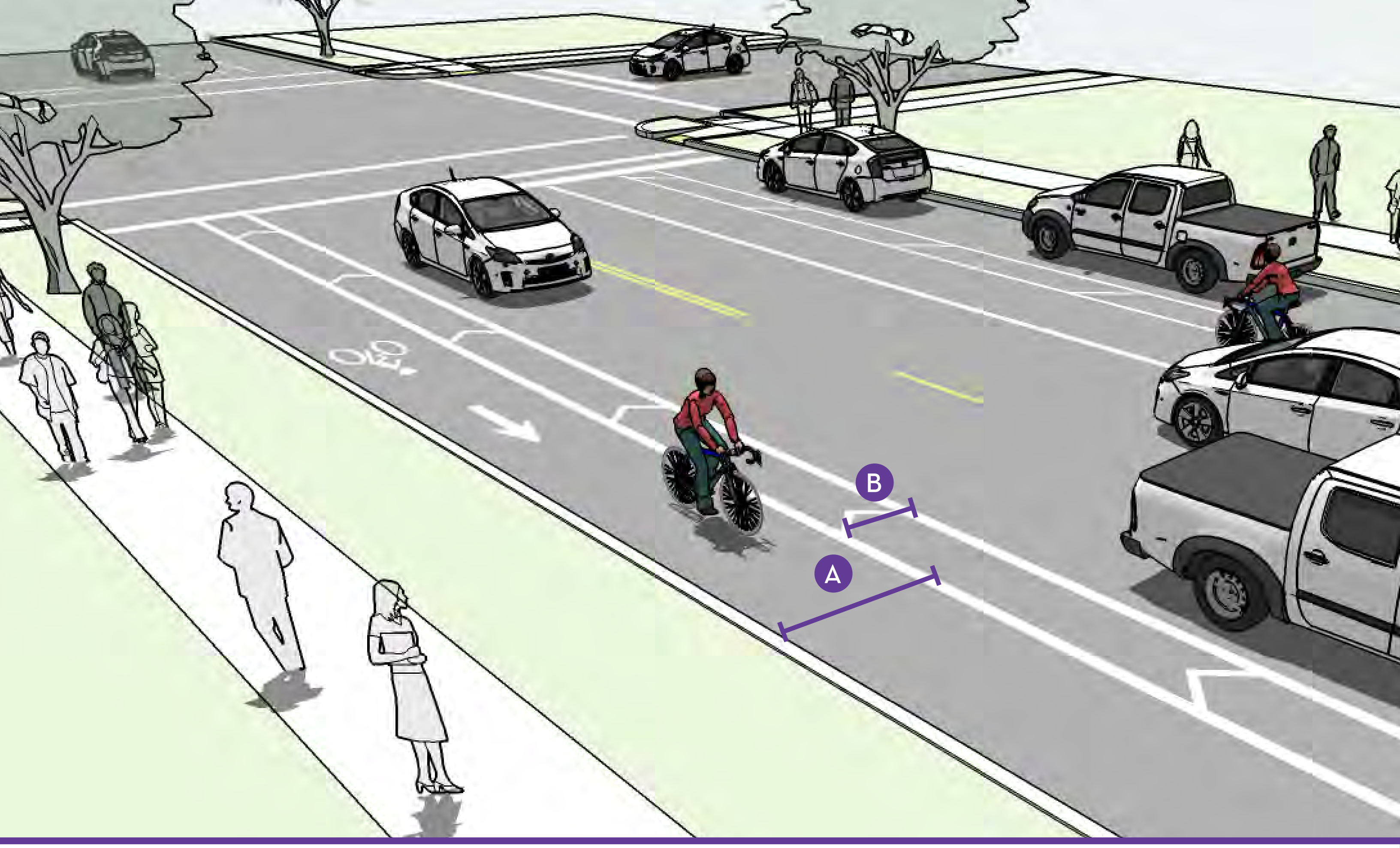
CONSTRUCTION COSTS

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.

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

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

3 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.



Buffered Bicycle Lanes

INTERSECTION
II
MID-BLOCK

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.[1]
- 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 in 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.[2]

1 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.

2 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.[3]

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.

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

CLASS III BIKEWAYS
BIKE ROUTES

Bicycle Boulevards

III INTERSECTION MID-BLOCK

A Bicycle Boulevard is a roadway that has been modified, as needed, to enhance safety and convenience for people bicycling. It provides better conditions for bicycling while maintaining the neighborhood character and necessary emergency vehicle access. Berkeley's Bicycle Boulevards are intended to serve as the primary low-stress bikeway network, providing safe, direct, and convenient routes across Berkeley. Key elements of Bicycle Boulevards are unique signage and pavement markings, traffic calming features to maintain low vehicle volumes, and safe and convenient major street crossings.

TYPICAL APPLICATION

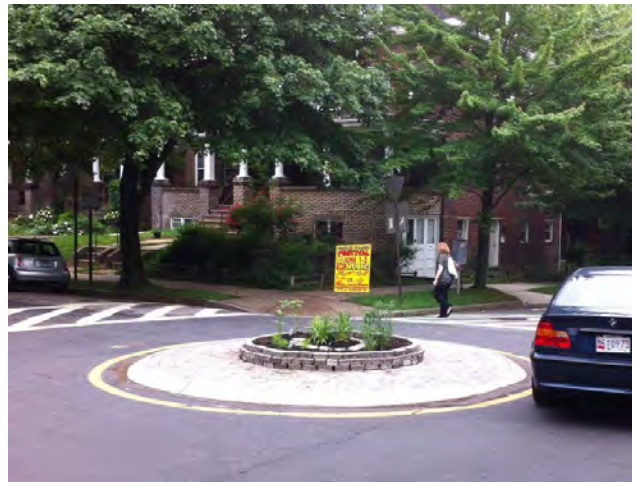
- Parallel with and in close proximity to major thoroughfares (1/4 mile or less).
- Follow a desire line for bicycle travel that is ideally long and relatively continuous (2-5 miles).
- Avoid alignments with excessive zigzag or circuitous routing. The bikeway should have less than 10% out of direction travel compared to shortest path of primary corridor.
- Local streets with traffic volumes of fewer than 1,500 vehicles per day. Utilize traffic calming to maintain or establish low volumes and discourage vehicle cut through / speeding.

DESIGN FEATURES

- Signs and pavement markings are the minimum treatments necessary to designate a street as a bicycle boulevard.

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.



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

- Implement volume control treatments based on the context of the bicycle boulevard, using engineering judgment. Motor vehicle volumes should not exceed 1,500 vehicles per day.
- Intersection crossings should be designed to enhance safety and minimize delay for bicyclists, following crossing treatment progression to achieve Level of Traffic Stress 1 or 2.

FURTHER CONSIDERATIONS

Bicycle boulevard retrofits to local streets are typically located on streets without existing signalized 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.

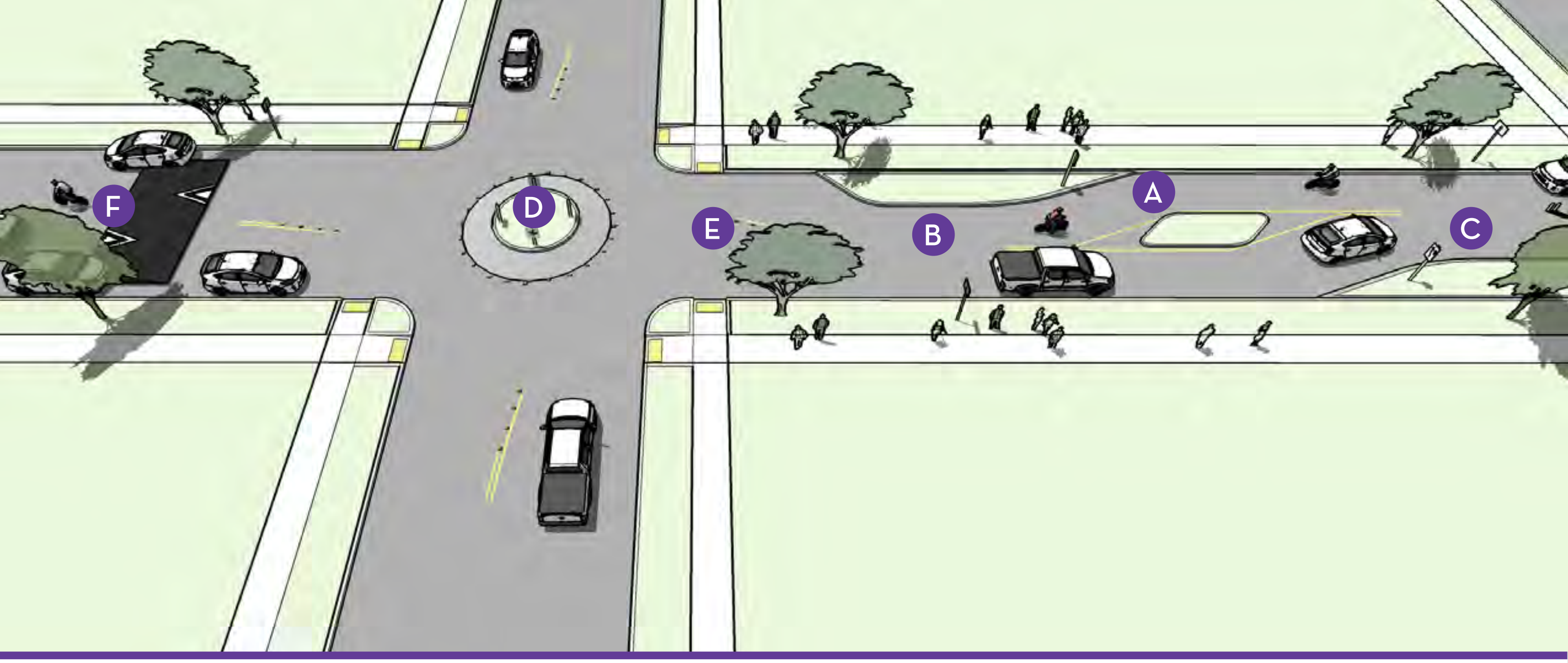
Traffic calming can deter motorists from driving on a street. Anticipate and monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

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 as 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.



Traffic Calming

Traffic calming may include elements intended to reduce the speeds of motor vehicle traffic to be closer to bicyclist travel speeds, or include design elements that restrict certain vehicle movements and discourage motorists from using bicycle boulevards as cut-through corridors.

Traffic calming treatments can cause drivers to slow down by constricting the roadway space for more 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.

TYPICAL APPLICATION

- Bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 20 mph (25 mph maximum). Bikeways 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). Bikeways with daily volumes above this limit should be considered for traffic calming measures.

DESIGN FEATURES - SPEED MANAGEMENT

A Median islands in the center of the roadway create a pinchpoint for vehicles and offer shorter crossing distances for pedestrians when used with a marked crossing.

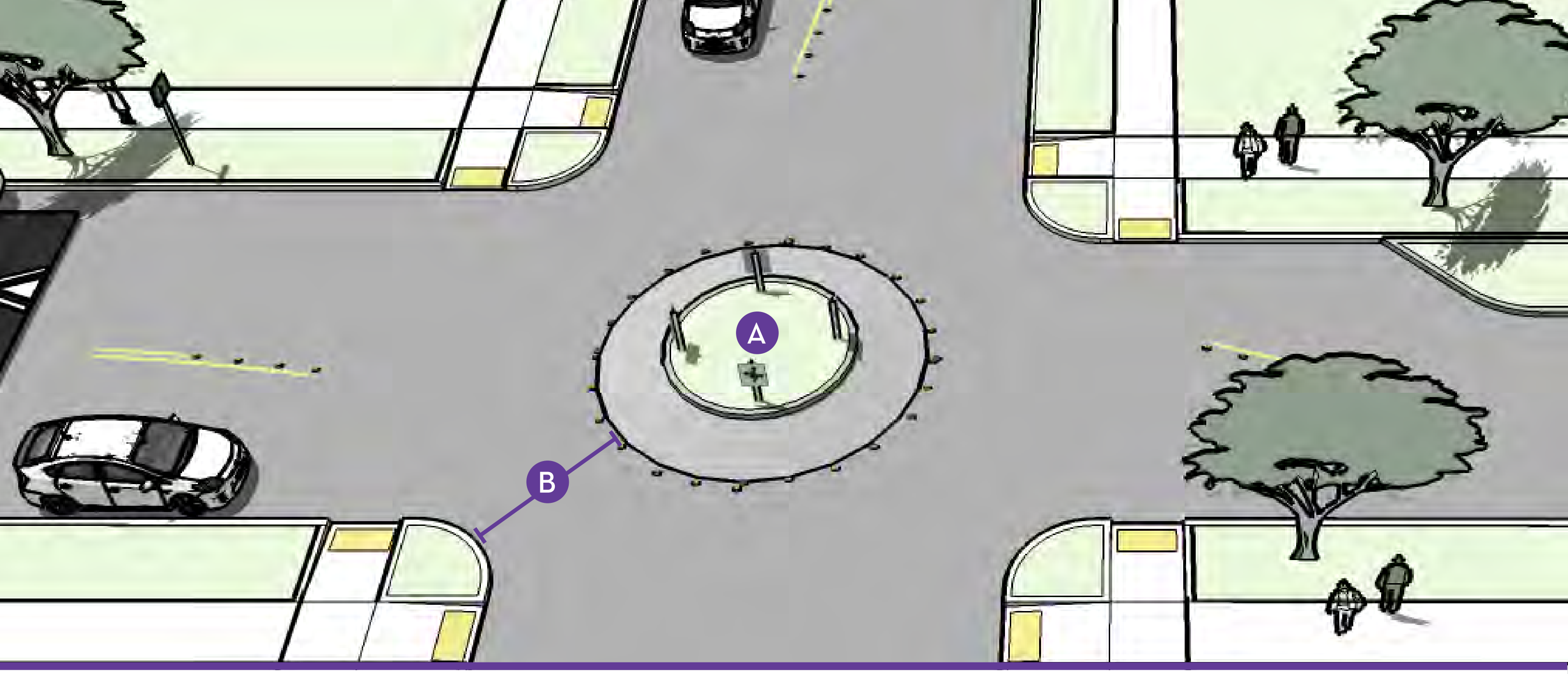
B Chicanes slow drivers by requiring vehicles to shift laterally through narrowed lanes, while preserving sightlines.

C Pinchpoints, chokers, or curb extensions restrict motorists from operating at high speeds on local streets by visually and physically narrowing the roadway. An effective configuration narrows the roadway to a single lane so only one vehicle travelling in either direction can proceed at a time.

D Neighborhood traffic circles reduce vehicle speed at intersections by requiring motorists to move cautiously through conflict points. Traffic circles can be landscaped but must be maintained to preserve sightlines.

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 the 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.



Traffic Circles

III INTERSECTION

Traffic circles are a type of horizontal speed management typically installed along low speed, low volume streets and bicycle boulevards. They are raised islands located in the center of intersections that narrow the roadway, and require motorists and bicyclists to reduce their speed in order to navigate around.

TYPICAL APPLICATION

- Traffic circles can be an effective traffic calming tool on bicycle boulevards and other low speed, low volume bicycle routes with less than 2,000 AADT.
- Placing traffic circles at concurrent intersection locations can have enhanced traffic calming effects.
- Are often installed to replace stop signs at intersections along a bike boulevard.
- Should be installed in consultation with neighborhood residents and emergency vehicle operators.

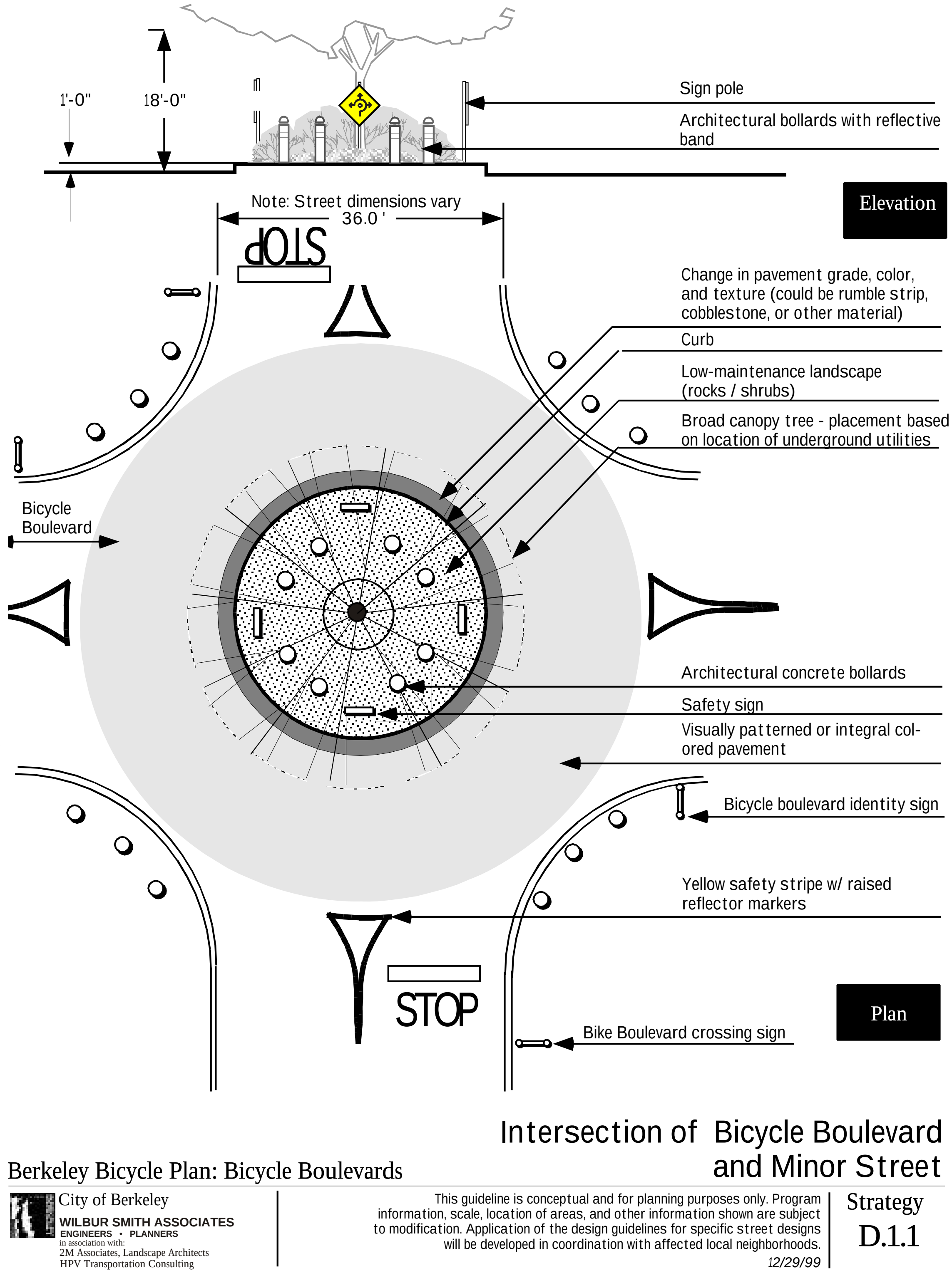
DESIGN FEATURES

A. Traffic circle radius depends on roadway width, and curb radii, to provide adequate horizontal deflection.

B. Distance from traffic circle to curb edge should be approximately 15’ to provide sufficient emergency vehicle access.

- At intersections with a minor street, stop signs should be placed on the minor street approaches.
- At intersections of two bike boulevards, all approaches should yield to oncoming traffic.
- Traffic circles feature raised curbs and/or mountable aprons to provide access for emergency vehicles.
- Approaches can feature mini channelization islands or pavement markings to further narrow the roadway and delineate travelways.
- The visual footprint of the traffic circle can be expanded in the intersection with integral colored pavement, or visually patterned surface treatments.
- Traffic circles can be landscaped but must be maintained to preserve sightlines.

Traffic Circle Design Specifications from 2000 Berkeley Bicycle Boulevard Design Tools and Guidelines



Traffic Diverters

III INTERSECTION

Traffic diverters are an effective traffic volume management tool that allow bicycles and emergency vehicles to proceed through an intersection, but restrict all other vehicle through-movements (requiring vehicles to turn right). Traffic diverters are installed on local roadways designated as bicycle boulevards.

TYPICAL APPLICATION

- Traffic diversion reduces vehicle volumes on bicycle boulevards.
- Existing non-landscaped traffic diverters without cut-throughs can be retrofitted to allow through-access for bicycles and emergency vehicles.
- Traffic Diverter designs should be developed in consultation with neighborhood residents and emergency vehicle operators.
- Design and neighborhood outreach processes should inform the type and precise location of diverters, with consideration given to traffic volume, and the direction of the diversion, with the goal of routing motorized traffic to the nearest collector or major street.

DESIGN FEATURES

- Traffic diverters can be landscaped to enhance the overall attractiveness of the bike boulevard.
- Colored concrete pavers and visually dramatic striping should be used to further delineate the diverter from the roadway, and reinforce the vehicle turn restriction.
- At-grade curb cuts, or mountable curbs provide convenient access for bicycles.
- Bollards, stanchions, and remaining metal and concrete “staples” on existing traffic diverters should be removed. These obstacles pose a crash hazard to cyclists. They can be replaced with small, properly design median islands.

DESIGN FEATURES - VOLUME MANAGEMENT

A 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. Curb extensions with stormwater management features and/or a mountable island can be included.

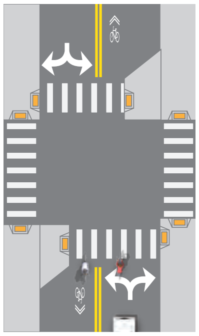
B Right-in/right-out diverters force motorists to turn right while bicyclists can continue straight through the intersection. The island can provide a through bike lane or bicycle access to reduce conflicts with right-turning vehicles. Left turns from the major street onto the bikeway are prohibited, while right turns are still allowed. See Toucan Signalized Crossing for signalized intersection configuration.

C Median refuge island diverters restrict through and left-turn vehicle movements along the bikeway and provide a 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.

D Full/Diagonal diverters block all motor vehicles from continuing on a neighborhood bikeway, while bicyclists can continue unrestricted. Full closures can be constructed to preserve emergency vehicles access.

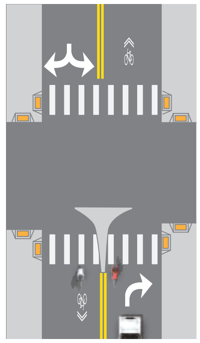
Traffic Calming Treatments to Reduce Motor Vehicle Volumes

A



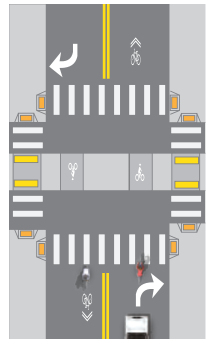
Partial Closure Diverter

B



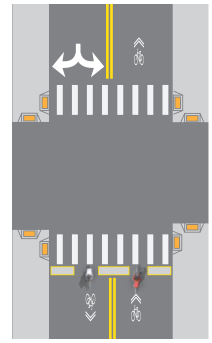
Right-In/Right-Out Diverter

C



Median Refuge Island Diverter

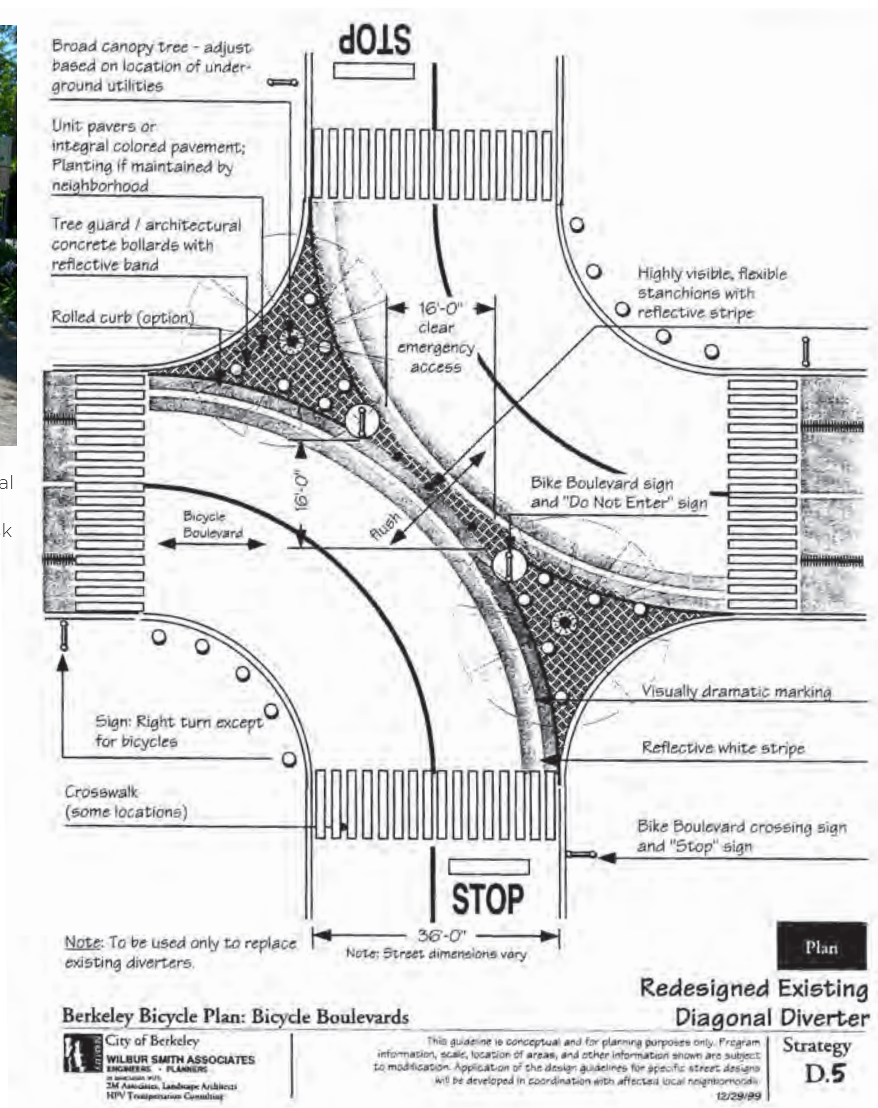
D

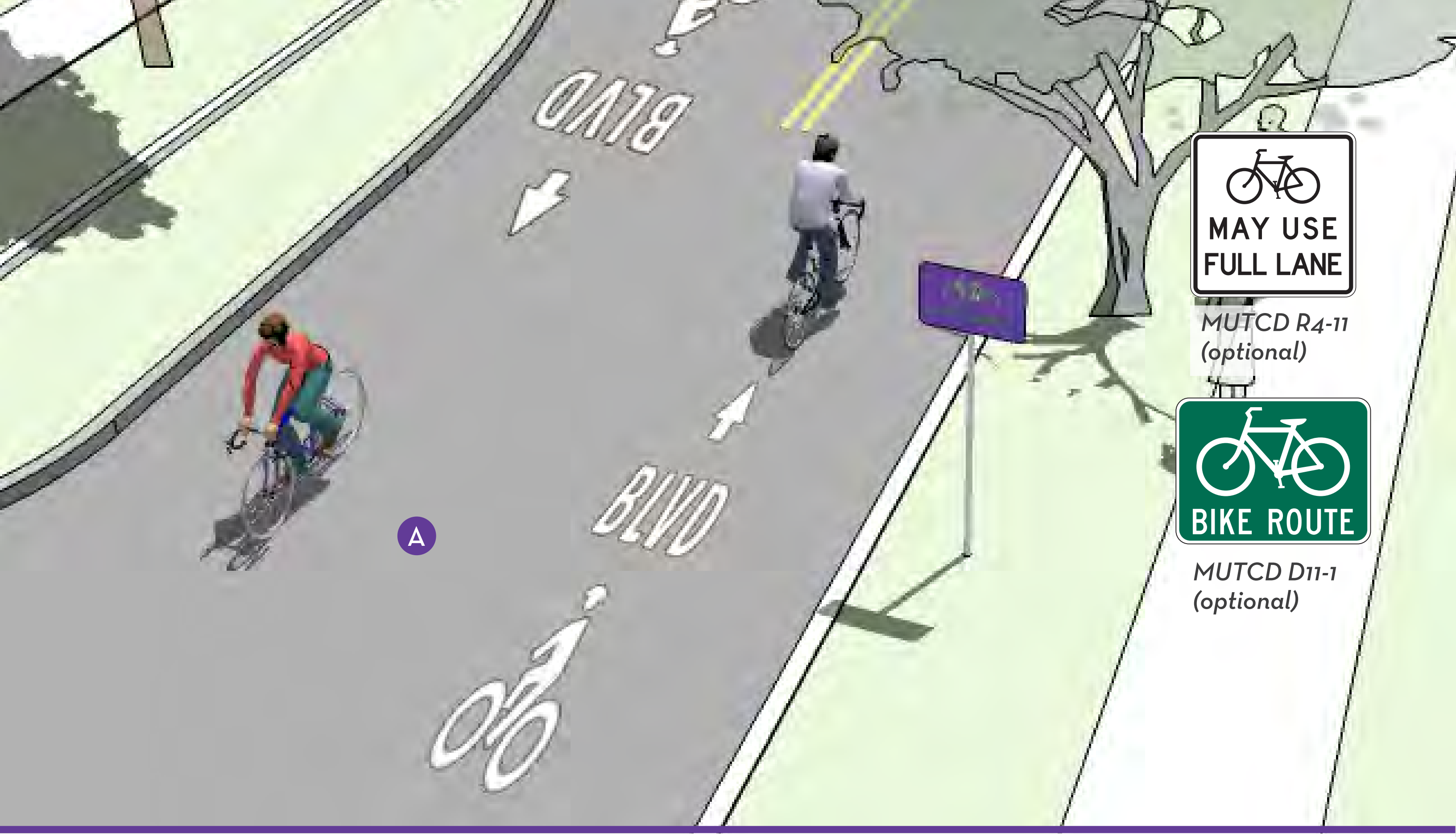


Full Diverter

Traffic Diverter Design Specifications from 2000 Berkeley Bicycle Boulevard Design Tools and Guidelines

Bollards can be removed from older diagonal diverter installations, and replaced with landscaped median islands to reduce the risk of cyclists crashing into them, and enhance the attractiveness of the bike boulevard.





Shared Lane Markings

III INTERSECTION MID-BLOCK

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 collisions with drivers opening car doors.

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 posted speed greater than 35 mph.
- Shared Lane Markings should be implemented in conjunction with BIKES MAY USE FULL LANE signs.

DESIGN FEATURES

(A) Placement in the center of the travel lane is preferred in constrained conditions.

- Markings should be placed immediately after intersections and spaced at 250 foot intervals thereafter.
- When placed adjacent to parking, markings should be outside of the "door zone". Minimum placement is 11 feet from the curb face.

Shared Lane Markings

Sharrows also serve 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.
- A green thermoplastic background can be applied to further increase the visibility of the shared lane marking.

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.[1]

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.

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

Green Infrastructure

III INTERSECTION MID-BLOCK

Green infrastructure treats and slows runoff from impervious surface areas, such as roadways, sidewalks, and buildings, and are appropriate along all Class I, II,III, and IV bikeways, but are especially suitable on bike boulevards. 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 or flooding of local streams and creeks, which can threaten natural habitats. Plants in the swale trap pollutants and silt from entering a river system.

TYPICAL APPLICATION

- Install in areas without conventional stormwater systems 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.

In order 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.

Green Infrastructure

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

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.

FURTHER CONSIDERATIONS

Bioswales

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.

Pervious Pavement

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 ground covers can be used to discourage pedestrian trampling.

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.

CONSTRUCTION COSTS

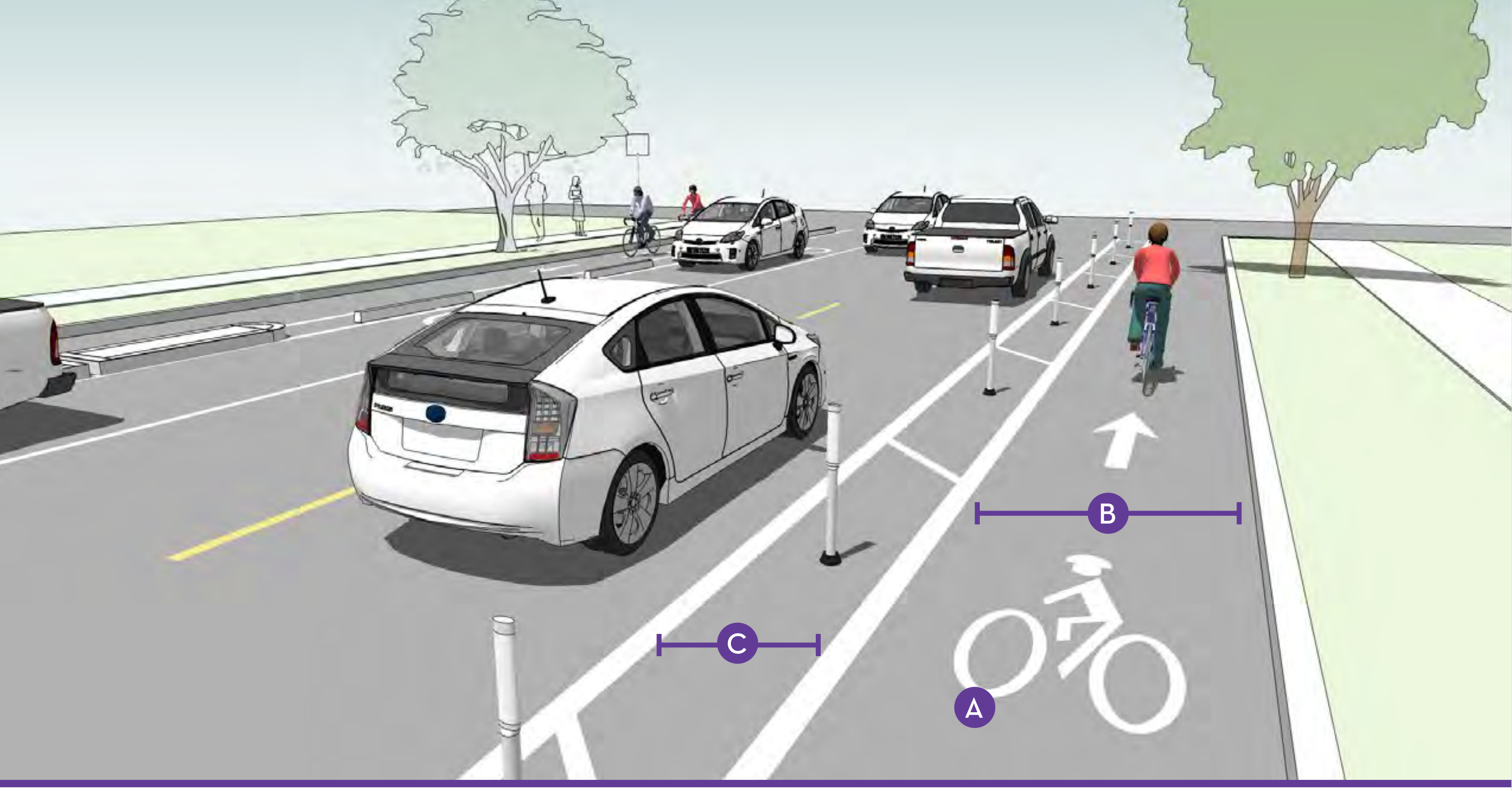
Bioswales range from $6-$24/square foot depending on the type of facility, with $15/square foot representing a typical rate.[1]

Permeable pavers can range from $6/square foot for pavers on the low end to $12/square foot for concrete on the high end. The average cost tends to be around $6-7/square foot.

1 Center for Neighborhood Technology. Green Values Stormwater Toolbox. http://greenvalues.cnt.org/national/cost_detail.php


BN 6272

CLASS IV PHYSICALLY SEPARATED BIKE LANES



One-Way Separated Bikeway

IV INTERSECTION MID-BLOCK

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, however, the bike lane may 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 signalized 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 (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

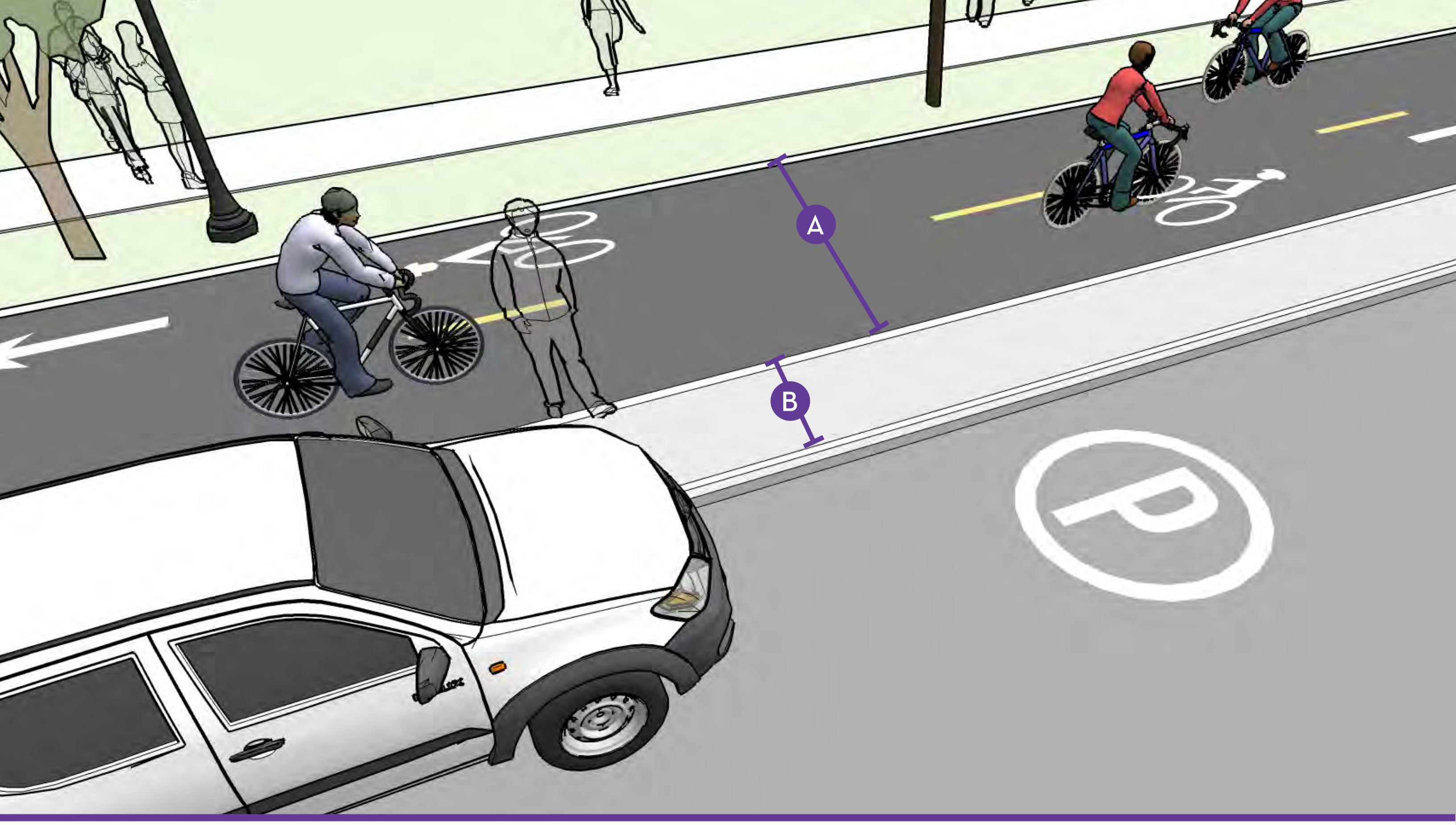
- Separated bike lane buffers and barriers are covered in the CAMUTCD as preferential lane markings (section 3D.01) and channelizing devices (section 3H.01). If buffer area is 4 feet or wider, white chevron or diagonal markings should be used (section 9C.04). Curbs may be used as a channeling device, see the section on islands (section 3I.01). Grade-separation provides an enhanced level of separation in addition to buffers and other barrier types.
- Where possible, physical barriers such as tubular markings or removable curbs should be oriented towards the inside edge of the buffer to provide 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 using a 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, as in the case of a grade-separated facility. A parking lane is the low-cost option for providing a barrier. Other barriers might include concrete medians, bollards, tubular markers, or planters.



Two-Way Separated Bikeway

IV INTERSECTION MID-BLOCK

Two-Way Separated Bicycle Lanes are bicycle facilities that allow bicycle movement in both directions on one side of the road. Two-way separated bicycle lanes 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)**

- A separation narrower than 5 feet may be permitted if a physical barrier is present. **(AASHTO, 2013)**
- Additional signalization and signs may be necessary to manage conflicts.

Two-Way Separated Bicycle Lanes

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

FURTHER CONSIDERATIONS

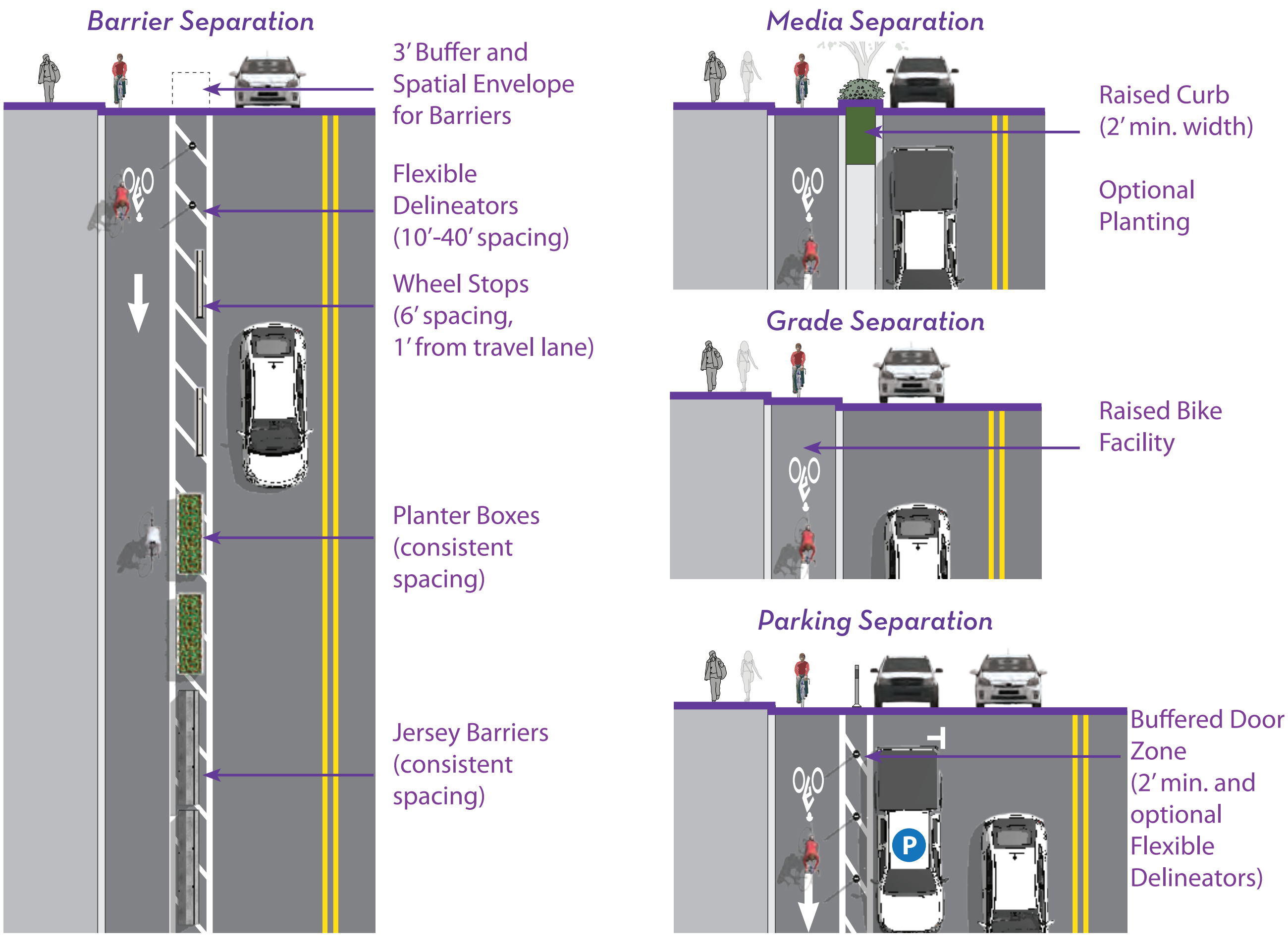
- On-street bike lane buffers and barriers are covered in the CAMUTCD as preferential lane markings (section 3D.01) and channelizing devices, including flexible delineators (section 3H.01). Curbs may be used as a channeling device, see the section on islands (section 3I.01).
- A two-way separated bike lane on one way street should be located on the left side.
- 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.
- Caltrans is developing guidelines to be released in 2016.

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 was detected 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.



Separated Bikeway Barriers

IV INTERSECTION MID-BLOCK

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.

TYPICAL APPLICATION

Appropriate barriers for retrofit projects:

- Parked Cars
- Flexible delineators
- Bollards
- Planters
- Parking stops

Appropriate barriers for reconstruction projects:

- Curb separation
- 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).

CONSTRUCTION COSTS

Separated bikeway costs can vary greatly, depending on the type of material, the scale, and whether it is part of a broader construction project.


EXCEPT
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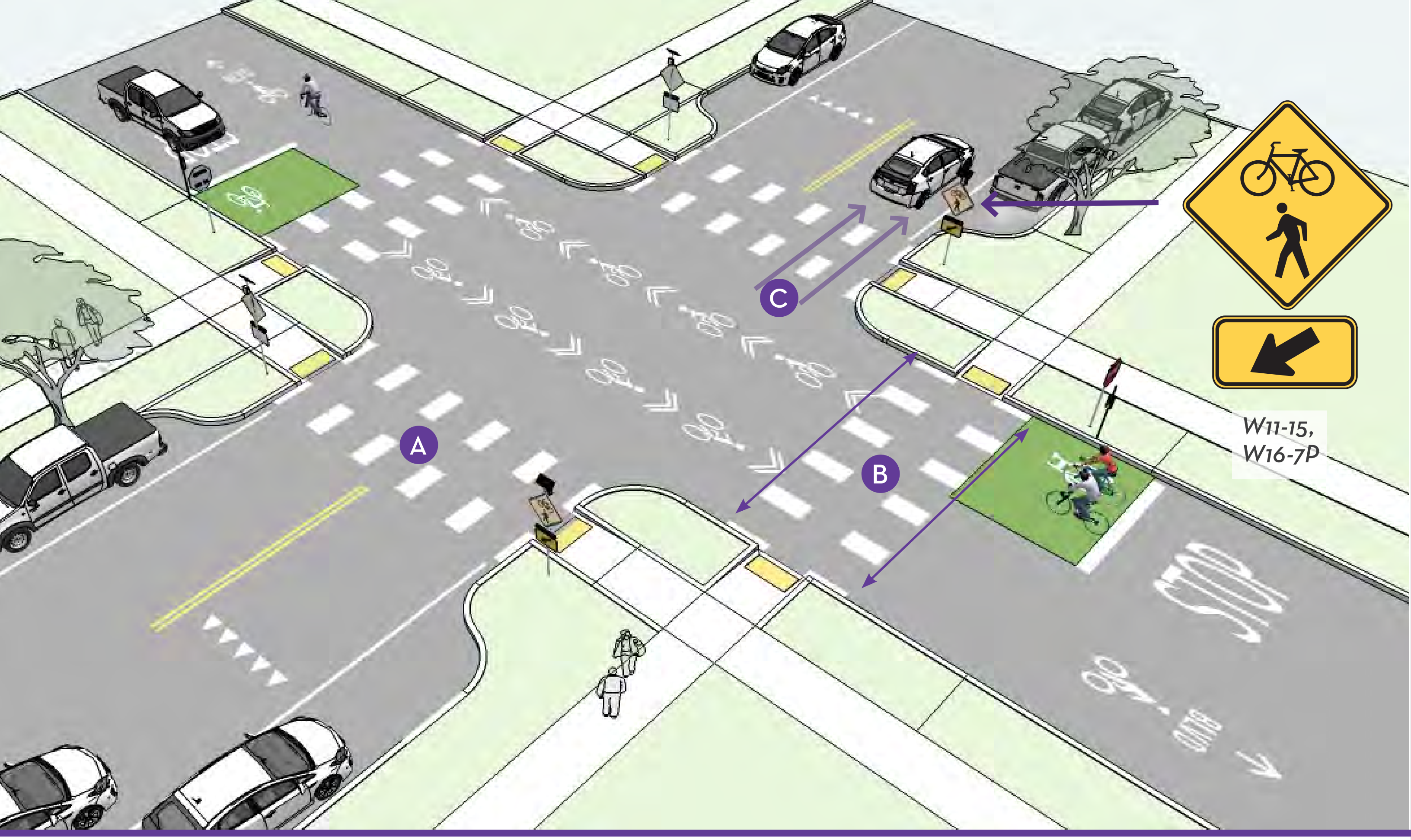
BIKEWAY INTERSECTION TREATMENTS



Marked Crossings

I II III IV

INTERSECTION

MID-BLOCK

Crosswalks exists at the intersection of roadways, whether they are marked or unmarked. The Uniform Vehicle Code requires that motorists yield right-of-way to pedestrians within crosswalks. Marked crosswalks draw attention to the crosswalk area and may remind motorists of the requirement to yield.

TYPICAL APPLICATION

- At the intersection of streets, where increased awareness of a crossing location is desired.
- Where paths intersect with a street in close proximity to an existing signalized intersection, and path users are expected to travel within the crosswalk.

DESIGN FEATURES

A High-visibility crosswalk markings are the preferred marking type at uncontrolled marked crossings. **(FHWA 2013)**

B Crosswalk markings should be located to provide a straight pedestrian path in line with the connecting sidewalk. Crosswalk markings should be located so that the curb ramps are within the extension of the crosswalk markings.

C Continental or Pair Bar style marking should be placed to avoid the wear path of motor vehicle tires.

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

On roadways with high speed and high volumes of motor vehicles, or multiple lanes, crosswalk markings alone are often not a viable safety measure. This should not discourage the implementation of crosswalks, but should rather support the creation of more robust crossing solutions. **(Zeeger 2001)** This includes: measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence.

On roadways with more than two consecutive lanes without a median refuge island, a marked crosswalk alone is not a viable safety measure. Continuous center turn lanes with no median islands are not considered adequate pedestrian refuge areas. **(Zeeger 2001)**

Studies have shown that motorists were statistically more likely to yield righ-tof-way to pedestrians in a marked crosswalk than an unmarked crosswalk. **(Mitman 2008)**

Motorists decrease speed in the vicinity of marked crosswalks, indicating an increased awareness of pedestrians. Crosswalk usage increases with the installations of crosswalk markings. **(Knoblauch 2001)**

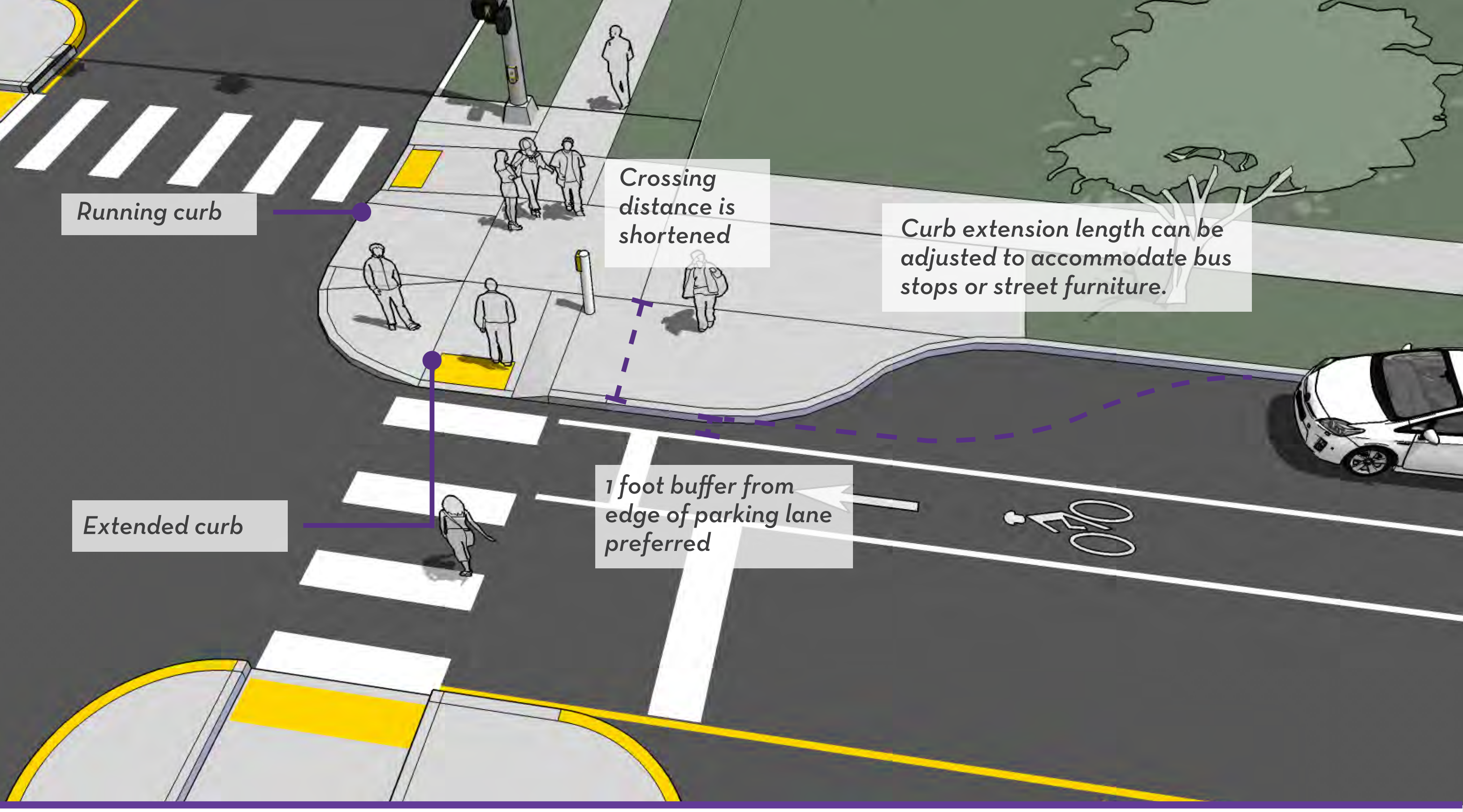
Pedestrians are particularly sensitive to out of direction travel and undesired crossing may become prevalent if the distance to the nearest formal is too great.

CRASH REDUCTION

A study of the installation of a marked crosswalk on the minor approach of a 4-legged stop-controlled intersection showed a 65% decrease in crashes. **(CMF ID: 3019)**

CONSTRUCTION COSTS

The cost of striped crosswalks range from approximately $100 to 2,100 each, or on average approximately $7 per square foot. A high visibility crosswalk can range from $600 to $5,700 each, or around $2,500 on average



Curb Extensions

I II III IV

INTERSECTION
MID-BLOCK

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 on-street parking adhjacent to the curb.
- Curb extensions may also be possible within non-motorized-travel areas of a roadway if there is additional or excess space.
- Curb extensions are particularly helpful at mid-block and/or unsignalized crossing locations.

DESIGN FEATURES

- For purposes of efficient street sweeping, the minimum radius for the reverse curves of the transition is 10 feet and the two radii should be equal where possible.
- When a bike lane is present approaching the intersection, the curb extension should terminate one foot short of the parking lane to maximize bicyclist safety.

Curb Extensions

Curb extensions help to shorten the pedestrian crossing distance and visually narrow the roadway.

Curb extensions can be located at intersections or mid-block locations with an existing parking lane. This creates a de facto parking setback from the curb which increases visability of pedestrians and bicyclists crossing the street.

FURTHER CONSIDERATIONS

Curb extensions that include planting may be designed as a bioswale or infiltration basin for wtormwater management.

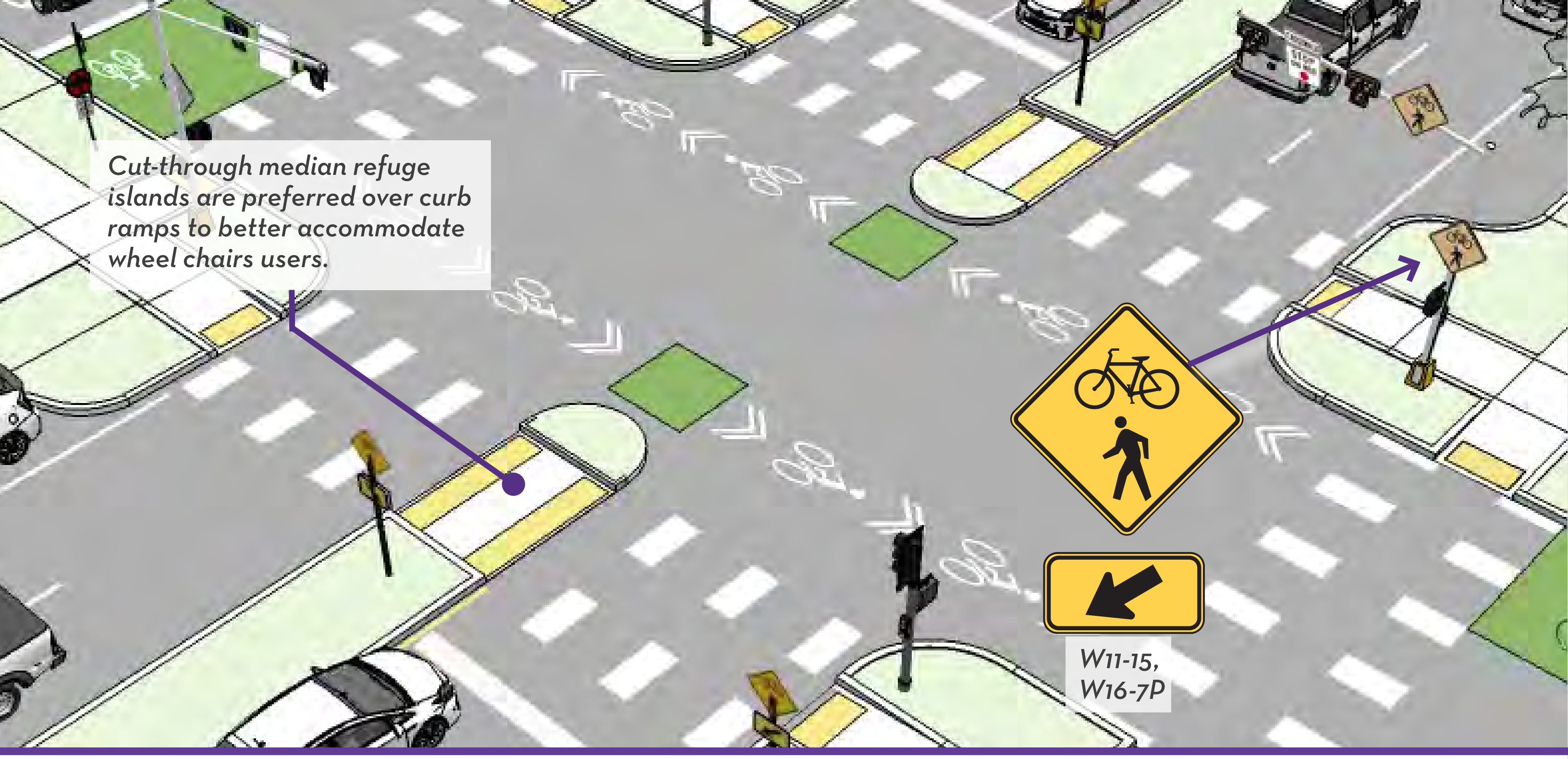
Curb extensions can also provide for a reduced corner curb return radii, and help to facilitate a more direct orthagonal pedestrian crossing.

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.

CRASH REDUCTION

There are no Crash Modification Factors (CMFs) available for this treatment.



Median Refuge Islands

I II III IV

INTERSECTION

MID-BLOCK

Median refuge islands are located at the midpoint of a marked crossing at intersections and midblock locations. They help to improve pedestrian safety by allowing pedestrians to cross one direction of motor vehicle traffic at a time. Refuge islands also improve pedestrian safety by minimizing exposure to traffic by reducing crossing distances, and thereby increase the number of available gaps in traffic for pedestrian crossing opportunities.

TYPICAL APPLICATION

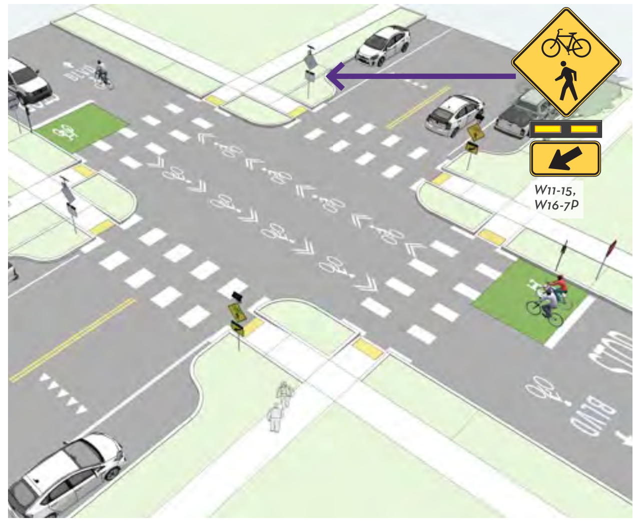
- Median refuge islands can be applied on any roadway with a left center turn lane or existing median that is at least 6 feet wide.
- These may be appropriate on multi-lande roadways depending on speed and volume. Consider configuration with active warning beacons for improved motor vehicle yielding compliance.
- Refuge islands are also appropriate to implement at existing signalized or unsignalized crosswalks.

DESIGN FEATURES

- The island must be ADA accessible, preferably with at-grade passage through the island, as opposed to ramps and landings. Detectable warning surfaces must be full-width and 3 feet in depth from the roadway to warn pedestrians with any visual impairments (DIB 82-05, 2013).
- Refuge islands require a minimum of 6 feet between motor vehicle travel lanes (8-10 feet is preferred to accommodate bikes with trailers and wheelchair users). At minimum, the refuge islands shall be 20 feet in length along the roadway, with 40 feet being preferred. Clear width of 4 is required for the passage through the refuge island, but preferably the clear width should be the same as the crosswalk.
- On streets with speeds higher than 25 mph, there should be double centerline markings, reflectors, and "KEEP RIGHT" advisory signs.

Median Refuge Islands

Offset or diagonal median refuge islands re-direct pedestrians so that they are facing the direction of approaching traffic before crossing the second crosswalk leg.



Median refuge islands provide a place to mount a second pedestrian crossing warning signage and Rectangular Rapid Flashing Beacon, resulting in enhanced visibility of the unit and increased motorist yielding compliance.

FURTHER CONSIDERATIONS

If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Shrubs and ground plantings should be no higher than 1.5 feet.

On multi-lane roadways, consider configuration with active warning beacons for improved motor vehicle yielding compliance.

CRASH REDUCTION

Based on a comparison of crash rates on arterials with 3 to 8 lanes and minimum 15,000 ADT, median refuge islands were found to reduce vehicle/pedestrian collisions by 46% at marked crosswalks (CMF ID: 75). This test controlled for pedestrian and vehicular traffic volumes.

CONSTRUCTION COSTS

The cost to install median refuge islands range from $535 to $1,065 per foot for a typical total cost range from $3,500 to $40,000, depending on the design, site conditions, landscaping and whether the median can be added as part of a larger street rebuild or utility upgrade.

Rectangular Rapid Flashing Beacon (RRFB)

I II III IV

INTERSECTION

MID-BLOCK

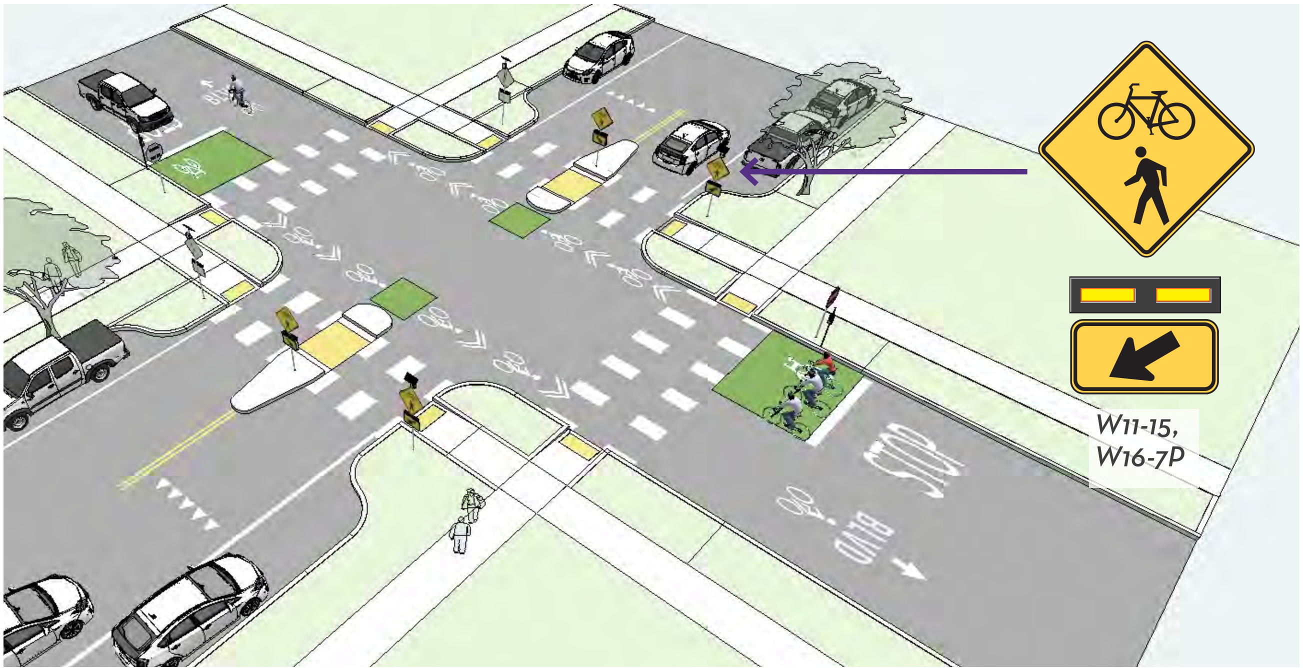
Rectangular Rapid Flashing Beacons (RRFB) - a type of active warning beacons - are user-actuated illuminated devices designed to increase motor vehicle yielding compliance at mid-block crossings or other unsignalized locations, especially high volume multi-lane roadways. RRFBs have been found to elicit the highest increase in compliance of all the active warning beacon options.

TYPICAL APPLICATION

- RRFBs are suitable for collector and arterial streets where posted speeds are 25-45 mph and there are three lanes of traffic (or four lanes with a median refuge island).
- These are implemented at high-volume pedestrian crossings where a signal is not warranted or desired, including midblock locations.
- RRFBs are typically activated by road users manually with a pedestrian and/or bicyclist push-button. They can also be actuated automatically via passive detection systems,

DESIGN FEATURES

- RRFBs shall not be used at crosswalks that are controlled by STOP or YIELD signs, or traffic signals.
- RRFBs shall initiate operation based on pedestrian or bicyclist actuation and shall cease operation at a predetermined interval after actuation to allow an adequate amount of time for any potential users to clear the crossing.
- Median refuge islands may have an additional push-button, and provide additional comfort for pedestrians on longer crossings. Median islands may also be offset or angled to direct users to face oncoming traffic.



Preferred RRFB configuration with median refuge island

FURTHER CONSIDERATIONS

When a median refuge island is present, mounting a second RRFB unit in the median for each approach improves conspicuity and has been shown to improve motorist yielding behavior. A study of the effectiveness of going from a no-beacon arrangement to a two-beacon RRFB installation increased yielding from 18 percent to 81 percent. A four-beacon installation raised compliance to 88%. Additional studies of long-term installations show little to no decrease in yielding behavior over time.

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.

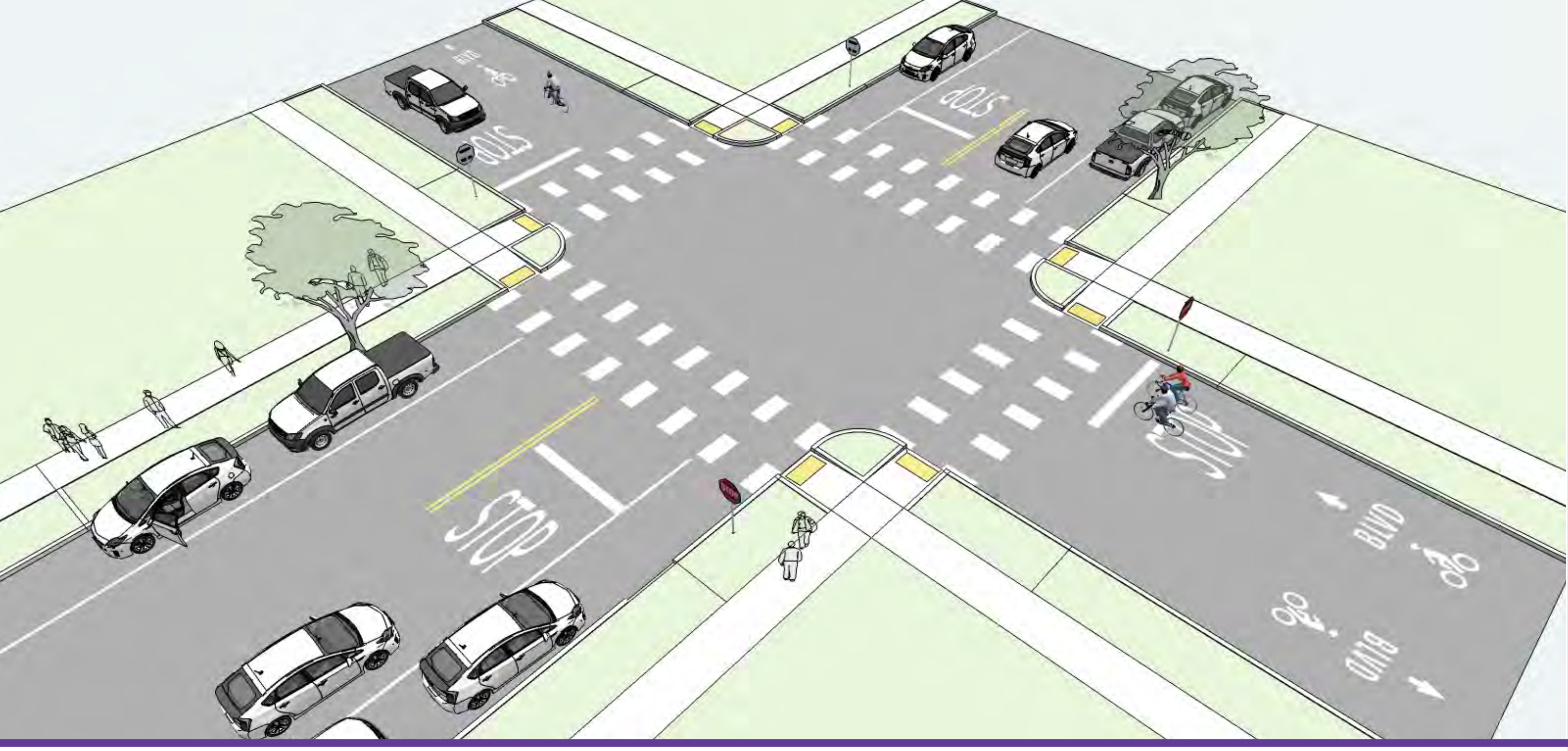
Pedestrian push buttons can be configured to provide additional crossing time when they arrive at the crossing during the flashing don't walk interval. The CAMUTCD requires signage indicating the walk time extension at or adjacent to the push button (R10-32P).

CRASH REDUCTION

A study of the effectiveness of going from a no-beacon arrangement to a two-beacon RRFB installation increased motor vehicle yielding rates for pedestrians from 18 percent to 81 percent. A four-beacon arrangement with units located on medians raised compliance to 88 percent. Additional studies of long-term installations show little to no decrease in yielding behavior over time.

CONSTRUCTION COSTS

RRFB costs average around $23,000 per unit, including installation.



All-Way Stop Controlled Intersections

I II III IV INTERSECTION

All-way controls are used at intersections where traffic volumes on the intersection streets are similar. When all vehicles are required to stop, pedestrian and bicycle delay is minimized, as are conflicts for all road users.

The delay caused to all roadway users should be taken into account before selecting this intersection treatment option. Additionally, all-way stop controls are often utilized as an interim measure, when an intersection signal has met signal warrants and is in the process of being brought up to the standards of full signalization.

TYPICAL APPLICATION

- All-way stop control is especially important in areas with high pedestrian volumes, limited visibility at corners for any or all road users, and intersections with left-turn conflict issues.
- An engineering study should be performed to determine whether crash and minimum volume criteria for an all-way stop treatment are met. On bike -priority streets, other treatments to increase pedestrian safety (such as enhances crossings and/or median refuge islands) should also be considered.

DESIGN FEATURES

- "All-way" stop supplemental signs R1-3P should accompany all stop signs..

FURTHER CONSIDERATIONS

Recommended Minimum Crash Criteria:

5 or more crashes of the type susceptible to correction by all-way stop control (such as right- or left-turn collisions and right angle collisions) in a 12 month period.

Recommended Minimum Volume Criteria:

Average of 300 vehicles per 8 hour period, and average of 200 units for all users in an 8 hour period, and a minimum of a 30 second delay per vehicle during peak hours for vehicles on the minor street.

If the 85th percentile speed on the major street is greater than 40mph, than the volume warrants are reduced to 70%** of the values listed above.

**If at least 80% of each of the above crash and volume criteria are met, this condition does not apply.

See additional criteria in CA-MUTCD section 2B.07 for additional details and exceptions.

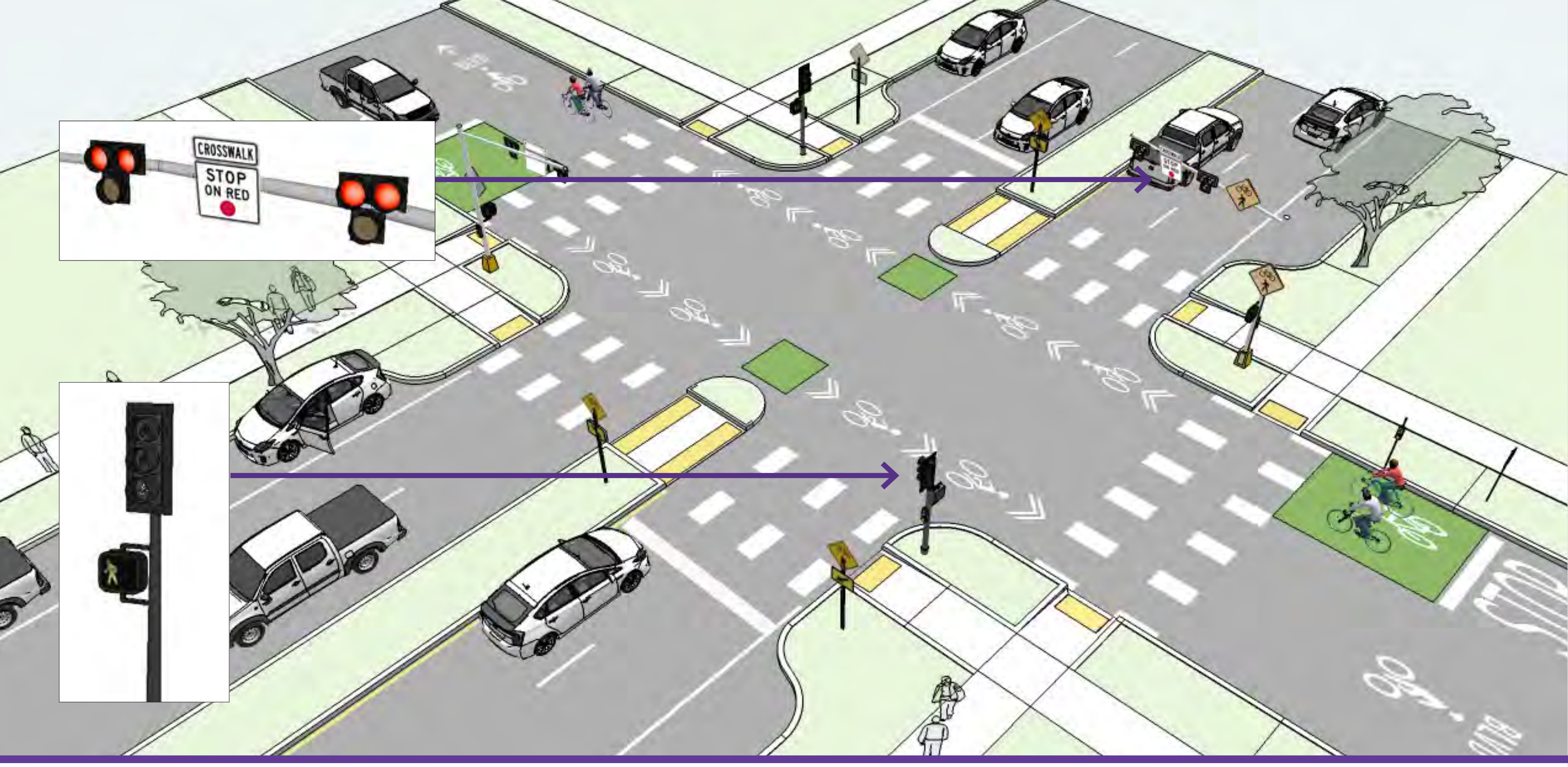
Typical stop sign placement, with R1-3P supplemental placard and stop bars on each leg of the intersection.

CRASH REDUCTION

A recent review of the effectiveness of various strategies in reducing crashes concluded that conversion from two-way to all-way stop control could reduce total intersection crashes by 53%. Another study determined that converting to an all-way stop from a two-way stop may reduce overall crashes at urban locations by up to 71%. Similarly, reductions were seen for left-turn crashes (20%), right-angle crashes (72%), rear-end crashes (13%), and pedestrian crashes (39%).

CONSTRUCTION COSTS

Typical street sign costs range from $100-$250, including the cost of installation.



Pedestrian Hybrid Beacon (HAWK)

I II III IV

INTERSECTION

MID-BLOCK

A hybrid beacon, formerly known as a High-intensity Activated CrosswalK (HAWK), consists of a signal-head with two red lenses over a single yellow lens on the major street, and pedestrian and/or bicycle signal heads for the minor street. There are no signal indications for motor vehicles on the minor street approaches.

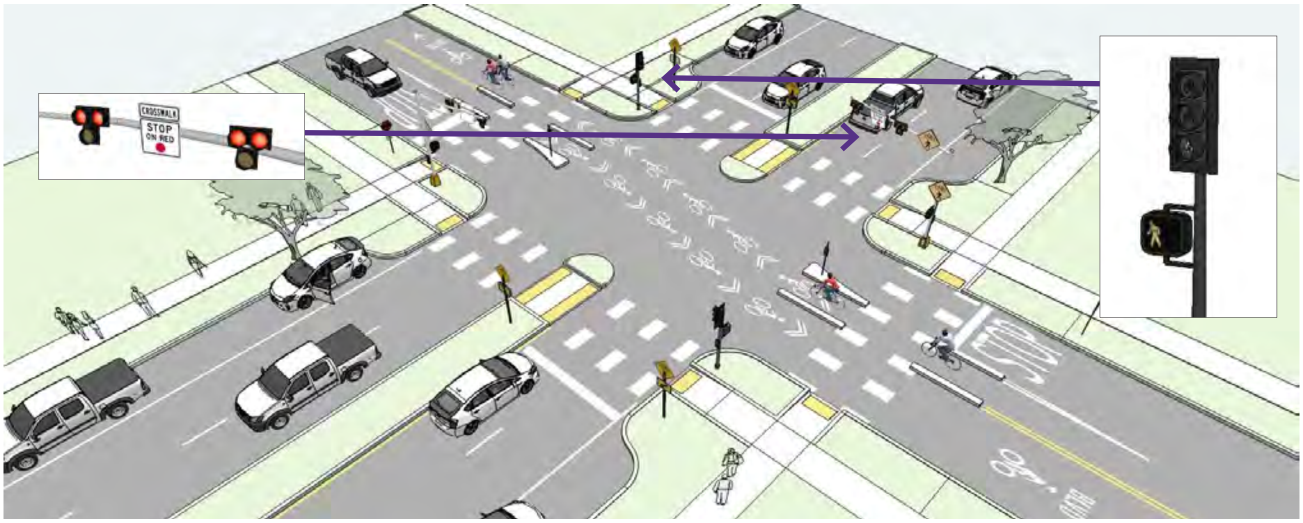
Hybrid beacons are used to improve non-motorized crossings of major streets in locations where side-street volumes do not support installation of a conventional traffic signal or where there are concerns that a conventional signal will encourage additional motor vehicle traffic on the minor street. Hybrid beacons may also be used at mid-block crossing locations.

TYPICAL APPLICATION

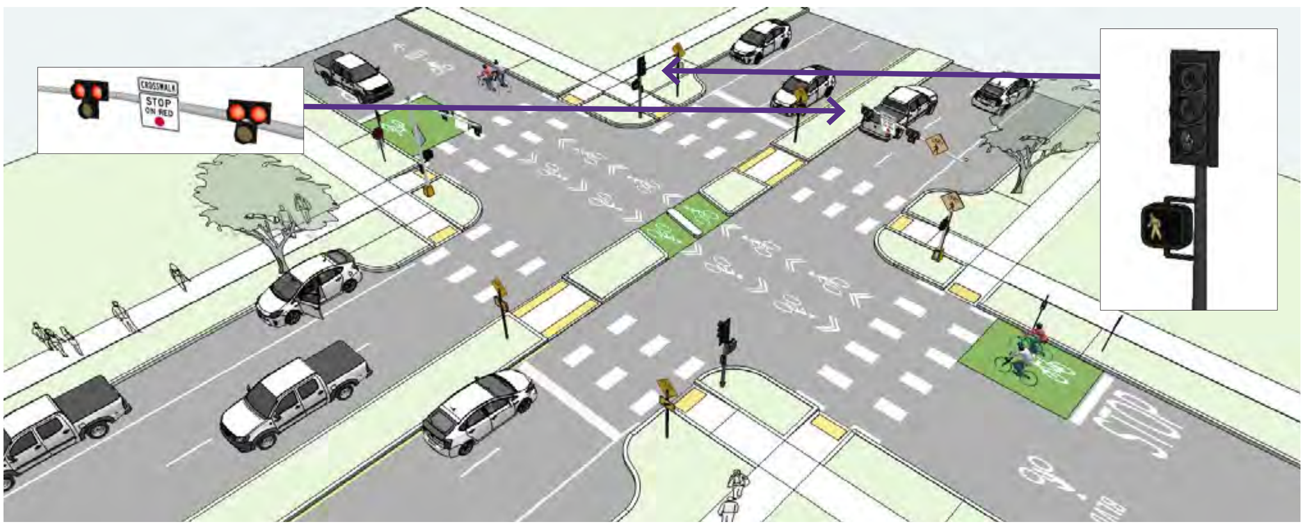
- Suitable for arterial streets where speeds are 30-45 mph and there are three or more lanes of traffic (or two lanes with a median refuge).
- Where off-street bicycle facilities intersect major streets without signalized intersections.
- At intersections or midblock crossings where there are high pedestrian volumes.

DESIGN FEATURES

- Hybrid beacons may be installed without meeting traffic signal control warrants if roadway speed and volumes are excessive for comfortable pedestrian crossings.
- If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals.
- Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk to provide adequate sight distance.



Enhanced Pedestrian Hybrid Beacon (HAWK) configuration with channelization and median refuge islands on a bike boulevard



Preferred Pedestrian Hybrid Beacon (HAWK) configuration with channelization and traffic diverter on a bike boulevard

FURTHER CONSIDERATIONS

Hybrid beacon signals are normally activated by push buttons, but may also be triggered by infrared, microwave or video detectors. The maximum delay for activation of the signal should be two minutes, with minimum crossing times determined by the width of the street. Each crossing, regardless of traffic speed or volume, requires additional review by a registered engineer to identify sight lines, potential impacts on traffic progression, timing with adjacent signals, capacity, and safety. Hybrid beacon systems should be considered for longer crossings where providing a median refuge island of any kind is not feasible.

Bicycle signals used in conjunction with Pedestrian Hybridge Beacons are not currently permitted in FHWA Interim Approval for Optional Use of a Bicycle Signal Face (IA-16).

A bicycle-specific HAWK requires an FHWA/CTCDC Request to Experiment approval to be installed as part of plan implementation.

CRASH REDUCTION

Pedestrian Hybrid Beacons have shown a crash reduction of 29% for all crash types (CMF ID:2911) and 15% for fatal or serious injury crashes (CMF ID: 2917).

CONSTRUCTION COSTS

Full intersections typically range in cost from $50,000 to $130,000 depending on mounting hardware.

Traffic Signal Detection and Actuation

I II III IV INTERSECTION

At fully signalized intersections, bicycle crossings are typically accomplished through the use of a standard green signal indication for Class II and III bikeways. A number of traffic signal enhancements can be made to improve detection and actuation and better accommodate bicyclists. An exclusive bicycle phase provided by bicycle signals offers the higest level of service and protection, especially for Class I and IV bikeways, but feature the same detection and actuation devices used at intersections with standard traffic signals. For more information on bicycle signals, see Protected Bicycle Signal Phase.

TYPICAL APPLICATION

- Bicycle detection and actuation is used to alert the signal controller of bicycle crossing demand on a particular approach. Proper bicycle detection should meet at least two primary criteria: 1) accurately detect bicyclists, and 2) provide clear guidance to bicyclists on how to actuate detection (e.g. what button to push or where to stand). Additionally, new technologies are being developed to provide feedback to bicyclists once they have been detected to increase the likelihood of stop compliance.
- Detection mechanisms can also provide bicyclists with an extended green time before the signal turns yellow so that bicyclists of all abilities can reach the far side of the intersection.
- 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 place 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.

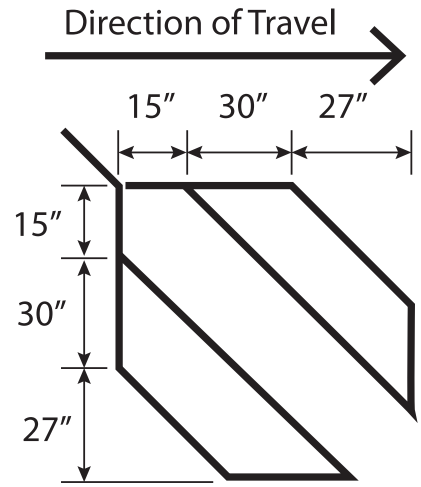
DESIGN FEATURES

- Bicycle detection and actuation systems include user-activated buttons mounted on a pole facing the street, In-pavement loop detectors that trigger a change in the traffic signal when a bicycle is detected, video detection cameras that use digital image processing to detect a change in the image at a location, and/or Remote Traffic Microwave Sensor Detection (RTMS) which uses frequency modulated continuous wvae radio signals to detect objects in the roadway.

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

- The location of pushbuttons should not require bicyclists to dismount or be rerouted out of the way or onto the sidewalk ot activate the phase. Signage should supplement the signal to alert bicyclists of the required activation to prompt the green phase.
- In-pavement Type D Loop detectors are induction circuits installed within the roadway surface to detect bicyclists as they wait for the signal. This allows the bicyclists to stay within the lane of travel. Loop detectors should be sufficiently sensitive to detect bicyclists and be marked with pavement markings instructing bicyclists on where to stand. CAMUTCD provides guidance on stencil markings and signage related to loop detectors.
- Remote Traffic Microwave Sensor Detection (RTMS) is unaffected by temperature and lighting which can affect standard video detection.
- Bicyclists typically need more time to travel through an intersection than motor vehicles. Green light times should be determined using the bicycle crossing time for standing bicycles. See Leading Bicycle Interval for more information on extending the green phase with Bicycle Signals.

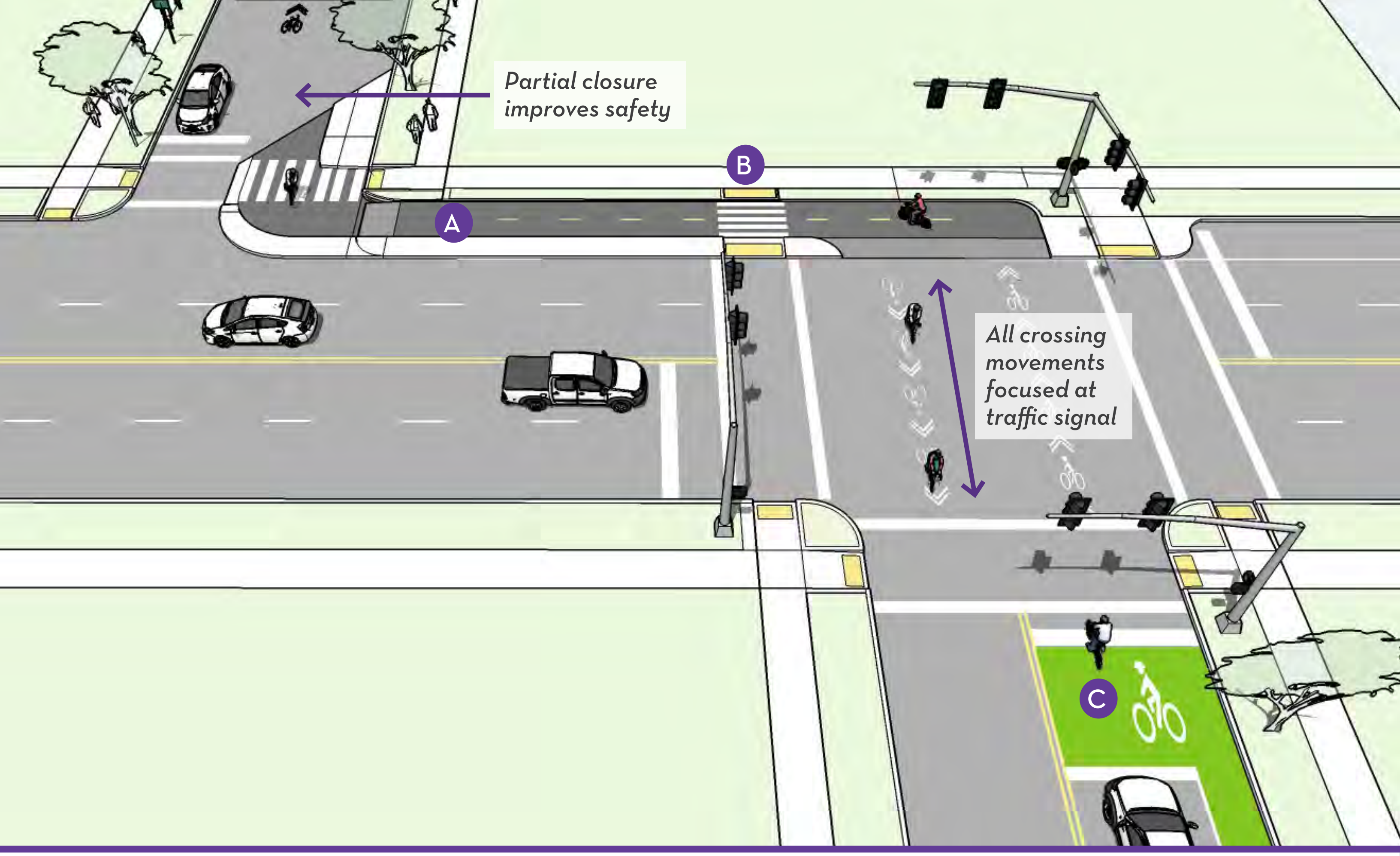
CRASH REDUCTION

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

CONSTRUCTION COSTS

Costs vary depending on the type of technology used, but bicycle loop detectors embedded in the pavement typically cost from a$1,000-$2,000. Video detection camera systems typically range from $20,000 to $25,000 per intersection.

Other traffic signal programming enhancements can be made to existing traffic signal hardware with relatively little to no additional hardware costs



Two-way Separated Bikeway Connector

I II III IV

INTERSECTION

MID-BLOCK

Offset intersections can be challenging for bicyclists who are required to briefly travel along the busier major cross street in order to continue along the bicycle boulevard.

Because bicycle boulevards are located on local streets, the route is often discontinuous. Wayfinding signage and pavement markings assist bicyclists with navigation on the route.

TYPICAL APPLICATION

- Can be constructed to connect multiple facility types, including bicycle boulevards, bike lanes, or separated bikeways.
- Appropriate treatments depend on volume of traffic including turning volumes, traffic speeds and the type of bicyclist using the crossing.

DESIGN FEATURES

A Grade separation and the use of physical barriers such as concrete medians, bollards, planters, etc. provide enhanced protection for bicylists and pedestrians

B Pavement markings provide clear delineation between pedestrian and bicyclists travel spaces

C At signalized crossings, bicyclists should be able to trigger signals and safely maneuver the crossing.

Two-way Separated Bikeway Connector

Pavement markings provide clear delineation between bi-directional bicycle traffic

If located at an unsignalized location, bicycle crossing should align with existing pedestrian crossing locations

FURTHER CONSIDERATIONS

- Partial closure of a two-way street on one or both of the minor unsignalized street legs provides enhanced safety by reducing the likelihood of a collision between a bicycle and a left-turning vehicle
- Bike boxes can be installed to increase visibility and give bicyclists priority positioning during the red signal phase.
- A bicycle signal should be considered for use only when the volume/collision or volume/geometric warrants have been met. **(CAMUTCD 4C.102)**
- FHWA has approved bicycle signals for use, if they comply with requirements from F.C. Interaction Approval 16 (I.A. 16).
- Bicyclists typically need more time to travel through an intersection than motor vehicles. Green light times should be determined using the bicycle crossing time for standing bicycles.
- Bicycle detection and actuation systems include user-activated buttons mounted on a pole, loop detectors that trigger a change in the traffic signal when a bicycle is detected and video detection cameras, that use digital image processing to detect a change in the image at a location.

CRASH REDUCTION

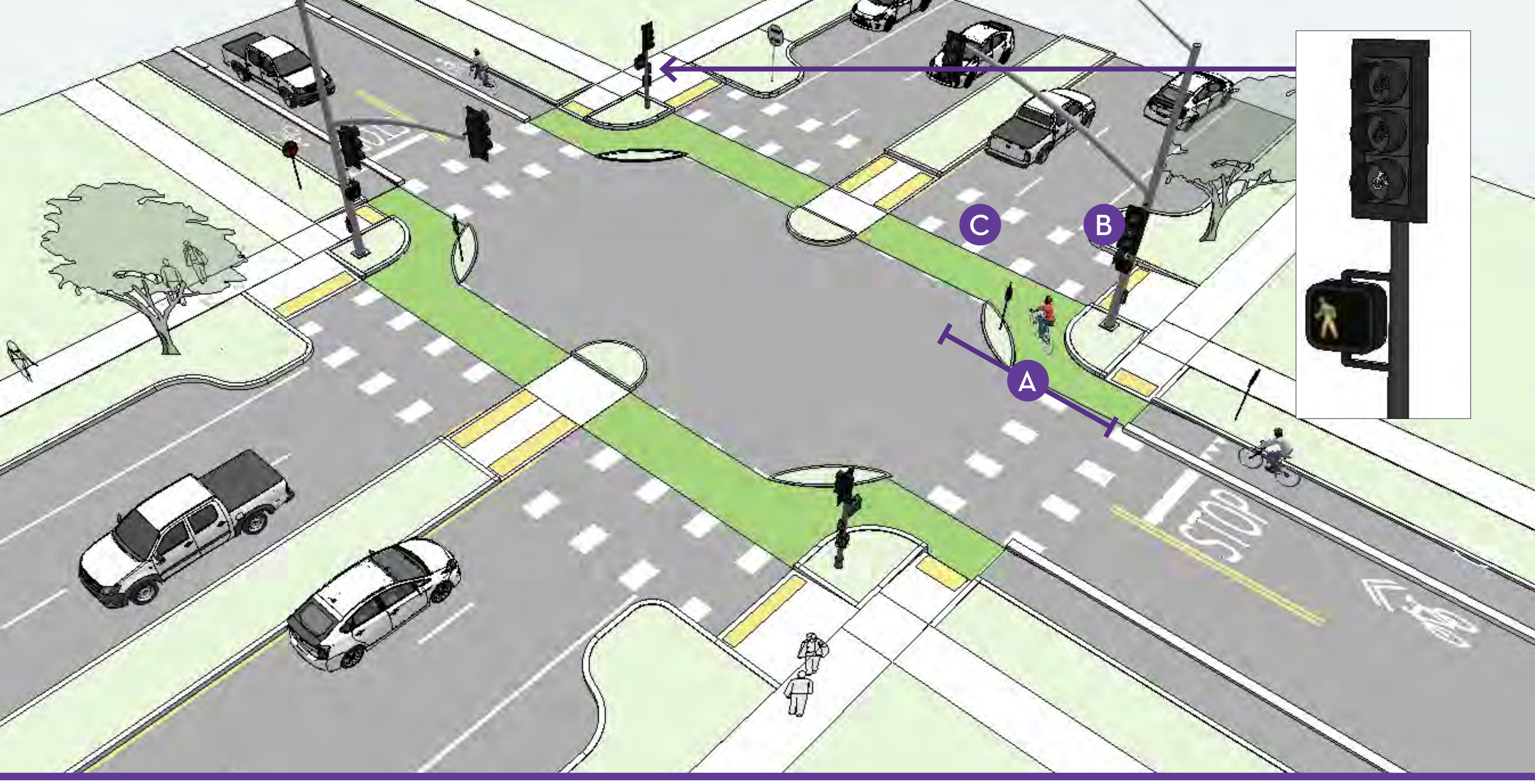
- A two-way separated bike lane as illustrated here provides grade separation from traffic and temporal separation with the use of a bicycle/ pedestrian signal.
- Crossing treatments should be provided on both sides to minimize wrong-way riding.

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 the two-way separated bike lane.

Bicycle signal heads have an average cost of $12,800.

Video detection camera system costs range from $20,000 to $25,000 per intersection.



Protected Intersection

IV 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. Protected intersections may be physically protected and/or protected using signal timing. 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. Time-based separation applications (e.g., bicycle-only signal phases) may also be used reduce bicycle/motor vehicle conflicts.

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.

Protected intersections incorporate queuing areas 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.
- At signalized intersections, time-based separation may take the form of bicycle-only signal phases or a "leading bicycle interval." These applications typically necessitate additional features including bicycle-specific signals (with bicycle signal heads) and supplemental signage aimed at bicyclists (e.g, "Bike Signal") and motorists (e.g., "No Turn on Red").

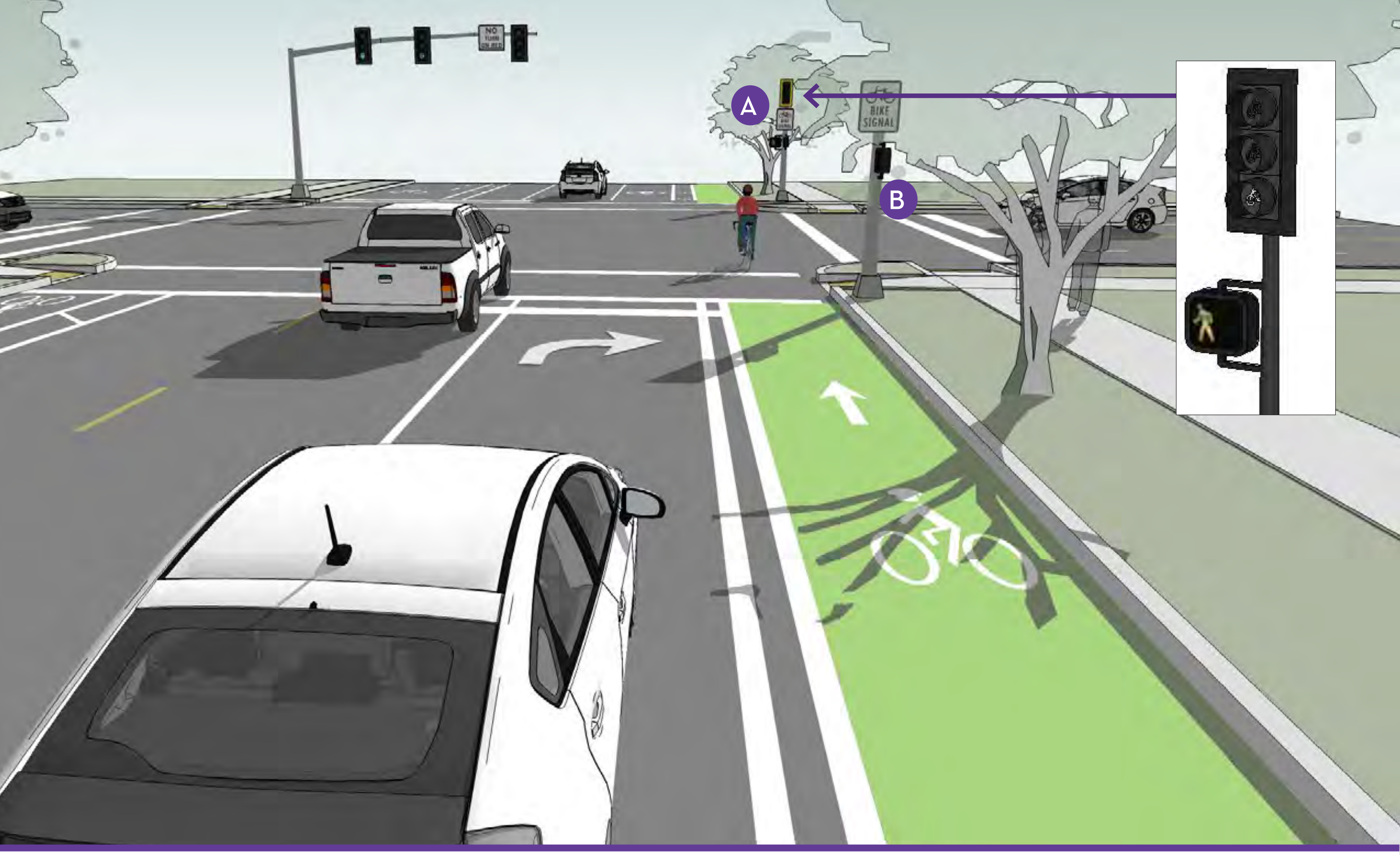
CRASH REDUCTION

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.



Protected Bicycle Signal Phase

I II III IV INTERSECTION

Protected bicycle lane crossings of signalized intersections can be accomplished through the use of a bicycle signal phase which reduces conflicts with motor vehicles by separating bicycle movements from any conflicting motor vehicle movements. Bicycle signals are traditional three lens signal heads with green, yellow and red bicycle stenciled lenses.

TYPICAL APPLICATION

- Two-way protected bike lanes where contraflow bicycle movement or increased conflict points warrant protected operation.
- Bicyclists moving on a green or yellow signal indication in a bicycle signal shall not be in conflict with any simultaneous motor vehicle movement at the signalized location
- Right (or left) turns on red should be prohibited in locations where such operation would conflict with a green bicycle signal indication.

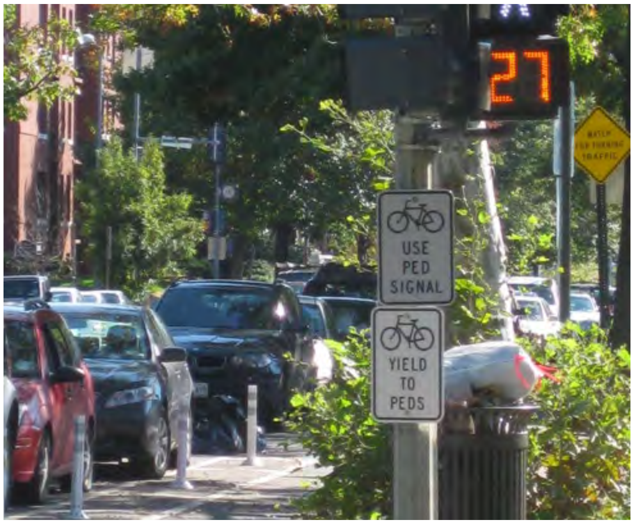
DESIGN FEATURES

A An additional "Bicycle Signal" sign should be installed below the bicycle signal head.

B Designs for bicycles at signalized crossings should allow bicyclists to trigger signals and safely maneuver the crossing.

- On bikeways, signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists. **(CAMUTCD 9D.02)**

Protected Bicycle Signal Phase



A bicycle signal head at a signalized crossing creates a protected phase for cyclists to safely navigate an intersection.

A bicycle detection system triggers a change in the traffic signal when a bicycle is detected.

FURTHER CONSIDERATIONS

- A bicycle signal should be considered for use only when the volume/collision or volume/geometric warrants have been met. **(CAMUTCD 4C.102)**
- FHWA has approved bicycle signals for use, if they comply with requirements from F.C. Interaction Approval 16 (I.A. 16). Bicycle Signals are not approved for use in conjunction with Pedestrian Hybrid Beacons.
- Bicyclists typically need more time to travel through an intersection than motor vehicles. Green light times should be determined using the bicycle crossing time for standing bicycles.
- Bicycle detection and actuation systems include user-activated buttons mounted on a pole, loop detectors that trigger a change in the traffic signal when a bicycle is detected and video detection cameras, that use digital image processing to detect a change in the image at a location.

CRASH REDUCTION

A survey of separated bike lane users in the United States found the 92% of respondents agreed with the statement "I generally feel safe when bicycling through the intersections" when asked about an intersection with a protected bicycle signal phase.[1]

CONSTRUCTION COSTS

Bicycle signal heads have an average cost of $12,800.

Video detection camera system costs range from $20,000 to $25,000 per intersection.

1 NITC. Lessons from the Green Lanes. 2014.

Leading Bicycle Interval

Vehicle conflicts can occur when drivers performing turning movements do not see or yield to bicyclists who have the right-of-way. Bicyclists may also arrive at an intersection late, or may not have any indication of how much time they have to safely cross the intersection. Bicycle traffic signal enhancements can be made to provide bicyclists with a head start, called a Leading Bicycle Interval.

TYPICAL APPLICATION

- Leading Bicycle Intervals (LBI) provides bicyclists with a priority headstart across the intersection.
- Leading Bicycle Intervals (LBI) are used to reduce right turn and permissive left turn vehicle and bicycle conflicts.
- At locations where increased bicyclist stop compliance is needed.
- Can be paired with Leading Pedestrian Intervals (LPI).

DESIGN FEATURES

- Typically employed with a bike signal, and/or pedestrian signal.
- The through bicycle interval is initiated first, in advance of the concurrent through/right/permissive left turn interval by 3-10 seconds.
- If paired with an LPI, bicycle pushbuttons can be configured to provide additional crossing time when bicyclists arrive at the crossing during the concurrent flashing don't walk interval. The MUTCD requires signage indicating the walk time extension at or adjacent to the push button (R10-32P).
- Actuation may be achieved with either a pushbutton or other passive detection devices..

Bicyclists receive a green bike signal indication in advance of adjacent travel lane

Signal louvers or visibility-limited signal faces reduce the likelihood of motorist in adjacent travel lanes mistaking the bike signal indication with a circular or arrow indication for their travel lane

FURTHER CONSIDERATIONS

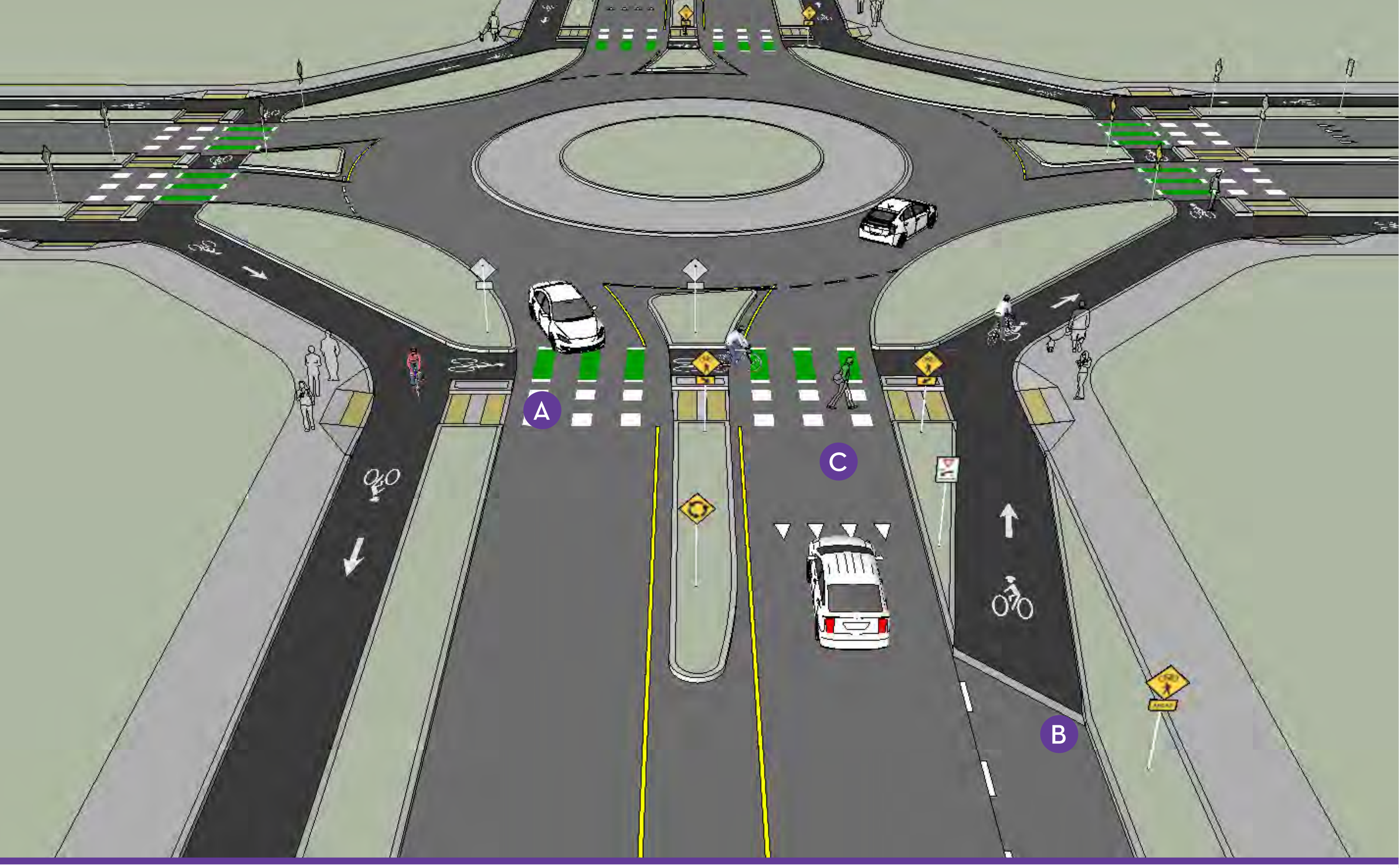
- These signal enhancements facilitate safer, more predictable, and conspicuous crossing conditions. The Leading Bicycle Interval provides additional time for bicyclists who may need more time to cross the street such as the elderly, and children.
- Leading Bicycle Intervals are considered a successful application of bike signals as approved under current FHWA Interim Approval for Optional Use of Bicycle Signal Faces (IA-16).
- See Traffic Signal Detection and Actuation for more information on detection and actuation devices.

CRASH REDUCTION

A Leading Bicycle Interval provides a form of temporal separation from other movements and can reduce vehicle-bicycle conflicts by giving bicyclists a headstart, thereby making them more visible, and minimizing exposure times.

CONSTRUCTION COSTS

Bicycle signal heads have an average cost of $12,800.



Roundabouts

I II III IV INTERSECTION

At roundabouts it is important to indicate to motorists, bicyclists and pedestrians the right-of-way rules and correct way for them to circulate, using appropriately designed signage, pavement markings, and geometric design elements.

TYPICAL APPLICATION

- Where a bike lane or separated bikeway approaches a single-lane roundabout.

DESIGN FEATURES

(A) Design approaches/exits to the lowest speeds possible. 10-15 mph preferred with 25 mph maximum circulating design speed.

(B) Allow bicyclists to exit the roadway onto a separated bike lane or shared use path that circulates around the roundabout.

- Also allow bicyclists navigating the roundabout like motor vehicles to "take the lane."

(C) Maximize yielding rate of motorists to pedestrians and bicyclists at crosswalks with small corner radii and reduced crossing distance.

Bike Box

This roundabout with a separated bikeway and sidewalk help reduce conflicts between motorists and bicycle riders.

FURTHER CONSIDERATIONS

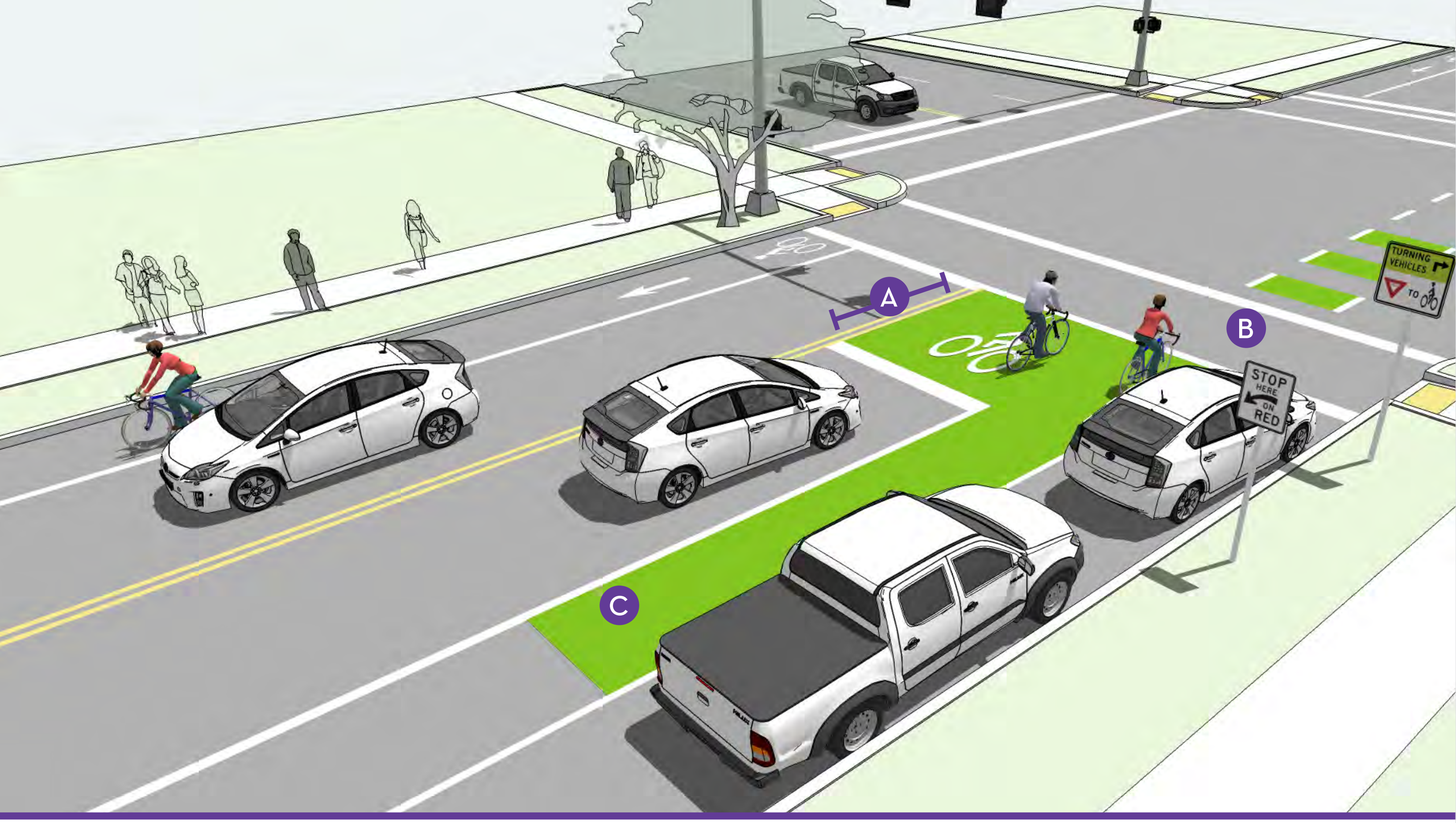
- The publication Roundabouts: Informational Guide states "... it is important not to select a multilane roundabout over a single-lane roundabout in the short term, even when long-term ...traffic predictions..." (NCHRP 2010 p 6-71)
- Other circulatory intersection designs exist but they function differently than the modern roundabout. These include:
  - **Traffic circles** (also known as rotaries) are old style circular intersections used in some cities in the US where traffic signals or stop signs are used to control one or more entry.
  - **Neighborhood Traffic Circles** are small-sized circular intersections of local streets. They may be uncontrolled or stop controlled, and do not channelize entry

CRASH REDUCTION

Research indicates that while single-lane roundabouts may benefit bicyclists and pedestrians by slowing traffic, multi-lane roundabouts may present greater challenges and significantly increase safety problems for these users.

CONSTRUCTION COSTS

- Roundabouts cost $250,000 - $500,000 depending on the size, site conditions, and right-of-way acquisitions. Roundabouts usually have lower ongoing maintenance costs than traffic signals, depending on whether the roundabout is landscaped.



Bike Box

II III INTERSECTION

A bike box is an experimental treatment, designed to provide bicyclists with a safe and visible space to get in front of queuing traffic during the red signal phase. Motor vehicles must queue behind the white stop line at the rear of the bike box. On a green signal, all bicyclists can quickly clear the intersection. This treatment is currently under experiment, and has not been approved by Caltrans.

TYPICAL APPLICATION

- At potential areas of conflict between bicyclists and turning vehicles, such as a right or left turn locations.
- At signalized intersections with high bicycle volumes.
- At signalized intersections with high vehicle volumes

DESIGN FEATURES

A 14 foot minimum depth from back of crosswalk to motor vehicle stop bar. **(NACTO, 2012)**

B A "No Turn on Red" **(CAMUTCD R10-11)** or "No Right Turn on Red" **(CAMUTCD R13A)** sign shall be installed overhead to prevent vehicles from entering the Bike Box. (Refer to CVC 22101 for the signage) A "Stop Here on Red" **(CAMUTCD R10-6)** sign should be post mounted at the stop line to reinforce observance of the stop line.

C A 50 foot ingress lane should be used to provide access to the box.

- Use of green colored pavement is optional.

Bike Box

A bike box allows for cyclists to wait in front of queuing traffic, providing high visibility and a head start over motor vehicle traffic.

FURTHER CONSIDERATIONS

- This treatment positions bicycles together and on a green signal, all bicyclists can quickly clear the intersection, minimizing conflict and delay to transit or other traffic.
- Pedestrian also benefit from bike boxes, as they experience reduced vehicle encroachment into the crosswalk.
- Bike boxes are currently under experiment in California. Projects will be required to go through an official Request to Experiment process. This process is outlined in Section 1A.10 in the CAMUTCD, and jurisdictions must receive approval prior to implementation.

CRASH REDUCTION

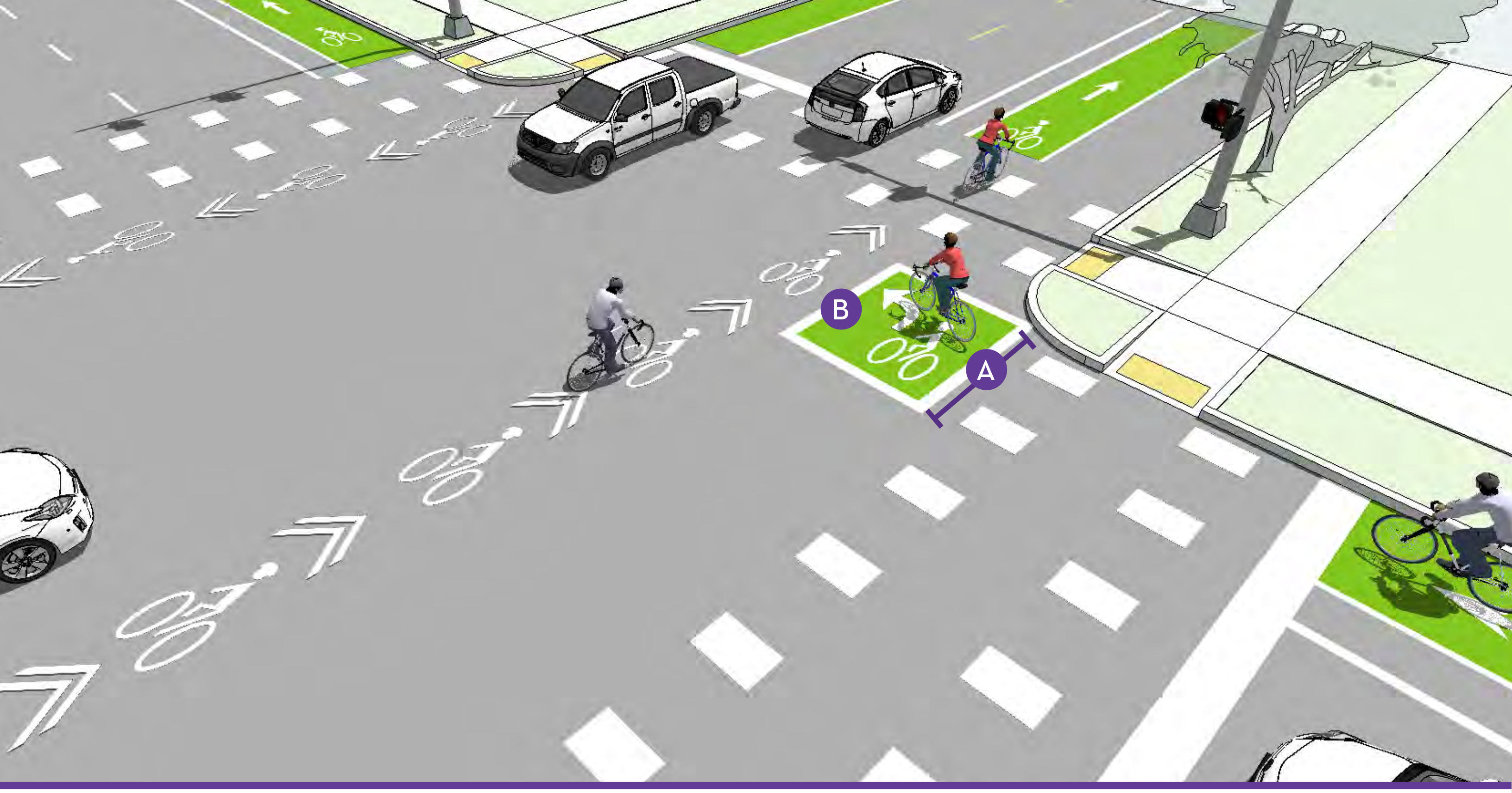
A study of motorist/bicyclist conflicts at bike boxes indicate a 35% decrease in conflicts. (CMF ID: 1718) A study done in Portland in 2010 found that 77% of bicyclists felt bicycling through intersections was safer with the bike boxes.[1]

CONSTRUCTION COSTS

Costs will vary due to the type of paint used and the size of the bike box, as well as whether the treatment is added at the same time as other road treatments.

The typical cost for painting a bike box is $11.50 per square foot.

1 Monsere, C. & Dill, J. (2010). Evaluation of Bike Boxes at Signalized Intersections. Final Draft. Oregon Transportation Research and education Consortium.



Two-Stage Turn Boxes

II III IV INTERSECTION

Two-stage turn boxes offer bicyclists a safe way to make turns at multi-lane signalized intersections from a physically separated or conventional bike lane. On physically separated bike lanes, bicyclists are often unable to merge into traffic to turn due to physical separation, making the provision of two-stage turn boxes critical.

TYPICAL APPLICATION

- Streets with high vehicle speeds and/or traffic volumes.
- At intersections with multi-lane roads with signalized intersections.
- At signalized intersections with a high number of bicyclists making a left turn from a right side facility.

DESIGN FEATURES

The two-stage turn box shall be placed in a protected area. Typically this is within the shadow of an on-street parking lane or protected bike lane buffer area and should be placed in front of the crosswalk to avoid conflict with pedestrians.

A 8 foot x 6 foot preferred depth of bicycle storage area (6 foot x 3 foot minimum).

B Bicycle stencil and turn arrow pavement markings shall be used to indicate proper bicycle direction and positioning. **(NACTO, 2012)**

Two-stage Turn Box

On separated bike lanes, the two-stage turn box can be located in the protected buffer/parking area.

FURTHER CONSIDERATIONS

- Consider providing a "No Turn on Red" (CAMUTCD R10-11) on the cross street to prevent motor vehicles from entering the turn box.
- This design formalizes a maneuver called a "box turn" or "pedestrian style turn."
- Some two-stage turn box designs are considered experimental by FHWA and are not currently under experiment in California.
- Design guidance for two-stage turns apply to both bike lanes and separated bike lanes.
- Two-stage turn boxes reduce conflicts in multiple ways; keep bicyclists from queuing in a bike lane or crosswalk and by separate turning bicyclists from through bicyclists.
- Bicyclist capacity of a two-stage turn box is influenced by physical dimension (how many bicyclists it can contain) and signal phasing (how frequently the box clears.)

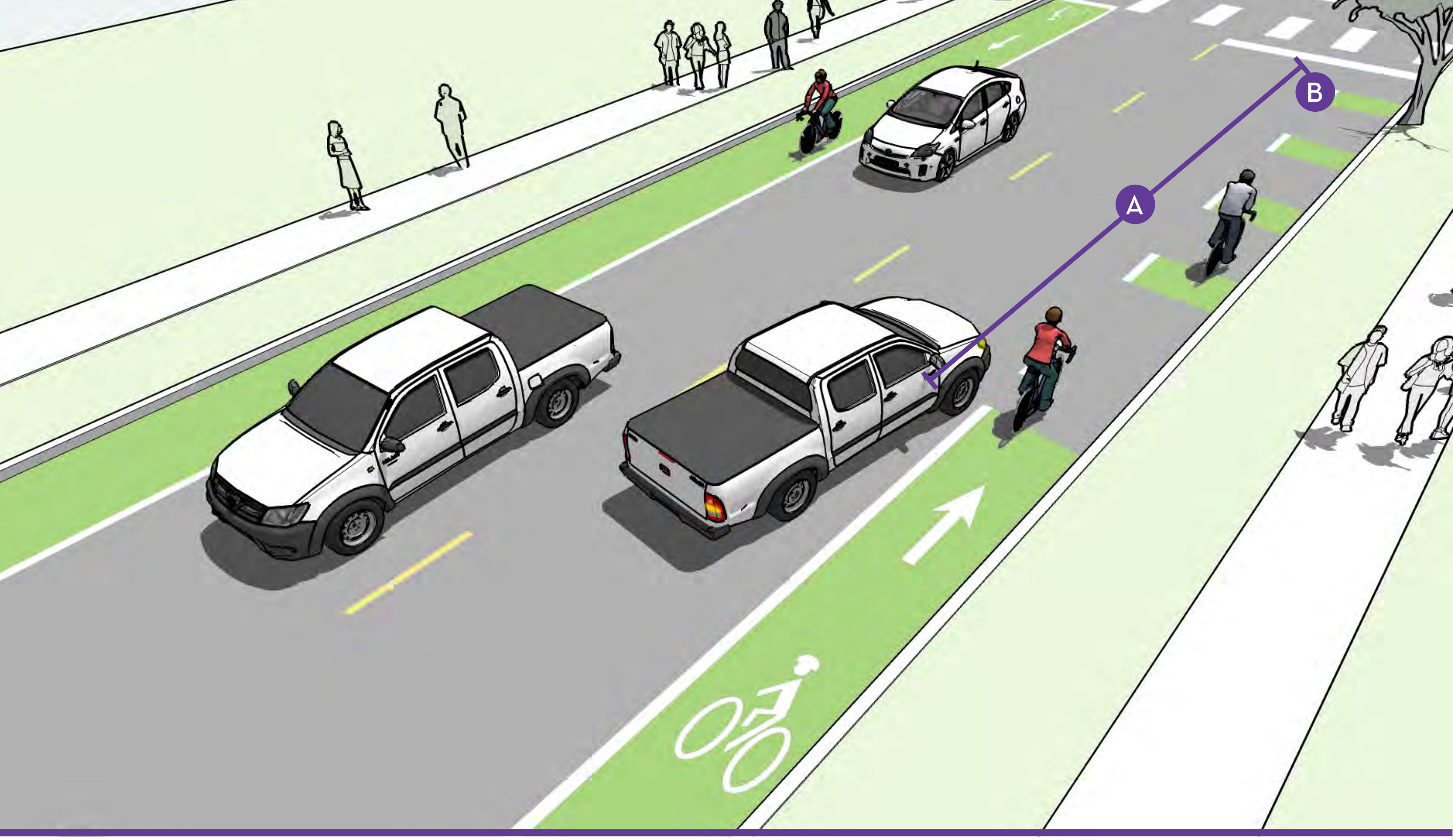
CRASH REDUCTION

There are no Crash Modification Factors (CMFs) available for this treatment.

CONSTRUCTION COSTS

Costs will vary due to the type of paint used and the size of the two-stage turn box, as well as whether the treatment is added at the same time as other road treatments.

The typical cost for painting a two-stage turn box is $11.50 per square foot.



Bike Lanes at Intersections where Right Turns are Permitted

II III IV INTERSECTION

In California, right turning vehicles are required to turn from the lane closest to the curb. When a bicycle lane approaches an intersection adjacent to a through/right option lane, the bicycle lane should be designed to permit right turning vehicles to enter the bicycle lane prior to turning.

TYPICAL APPLICATION

- Streets with curbside bicycle lanes approaching an intersection where right turns are permitted.
- Streets with curb extensions occupying the parking lane at intersections.
- Consider a **Combined Bike Lane/Turn Lane** in areas with on-street parking and high turn volumes, but not enough room for a bicycle lane and a right turn only lane.

DESIGN FEATURES

A Where motorist right turns are permitted from the general purpose travel lane, the solid bike lane should be dashed 50 to 200 feet in advance of the intersection.

B Dashed striping should be 6 inch lines in 4 foot segments with 8 foot gaps. **(CAMUTCD Detail 39A)**

Dashed Bike Lane in Advance of the Intersection

The dashed bike lane line reminds drivers that they should enter the bike lane to make their right turn.

FURTHER CONSIDERATIONS

- The City of Sacramento is experimenting with dashed green pavement in the approach to intersections.

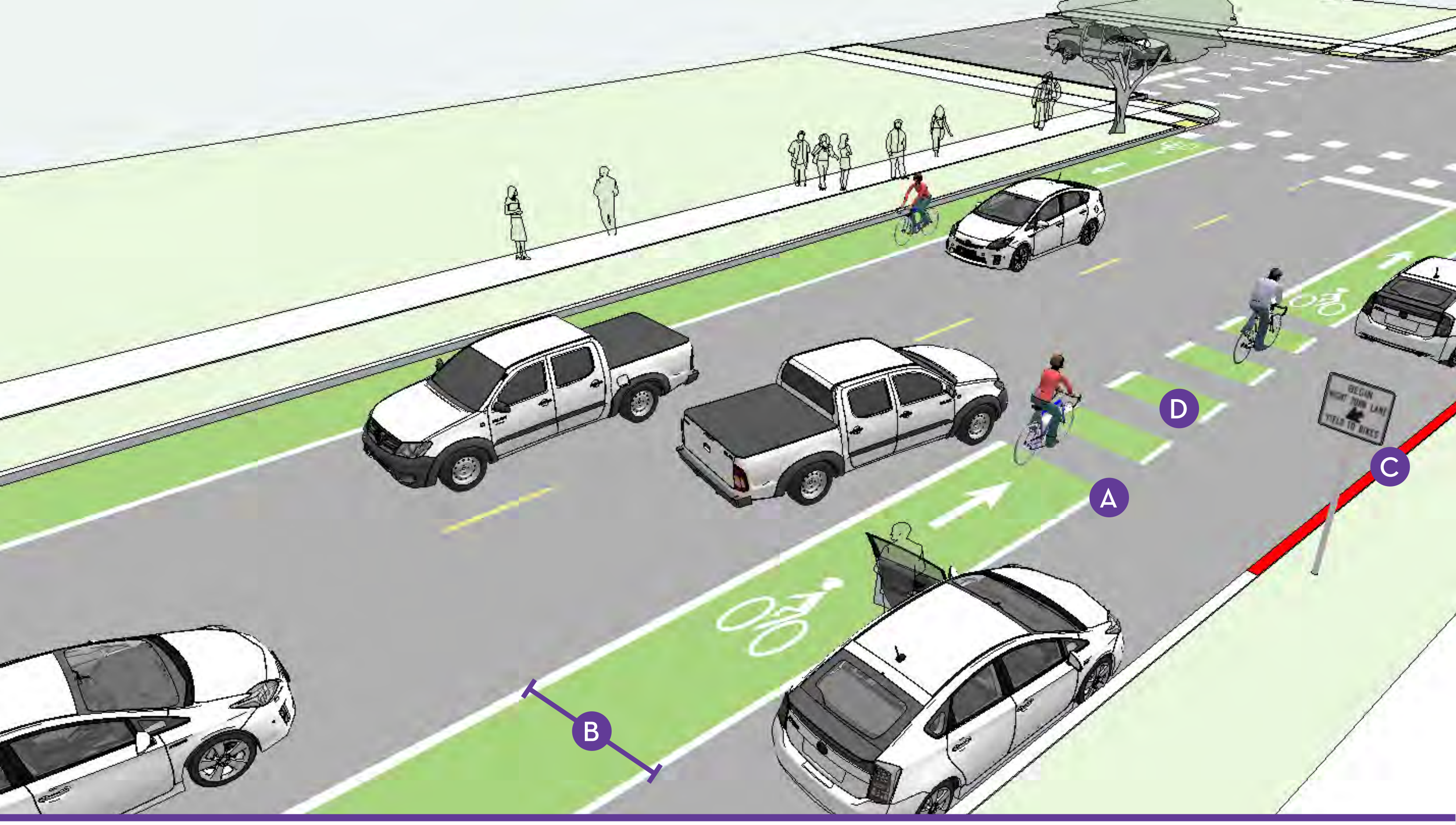
CRASH REDUCTION

Studies have shown a 40% decrease in crashes at signalized intersections with through/right lanes when compared to sharing the roadway with motor vehicles. (CMF ID: 3255)

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.



Bike Lanes at Added Right Turn Lanes

II III INTERSECTION

The appropriate treatment at right turn only lanes is to introduce an added turn lane to the outside of the bicycle lane. The area where people driving must weave across the bicycle lane should be marked with dotted lines and dotted green pavement to identify the potential conflict areas. Signage should indicate that motorists must yield to bicyclists through the conflict area.

TYPICAL APPLICATION

- Streets with right-turn lanes and right side bike lanes.
- Streets with left-turn lanes and left side bike lanes.

DESIGN FEATURES

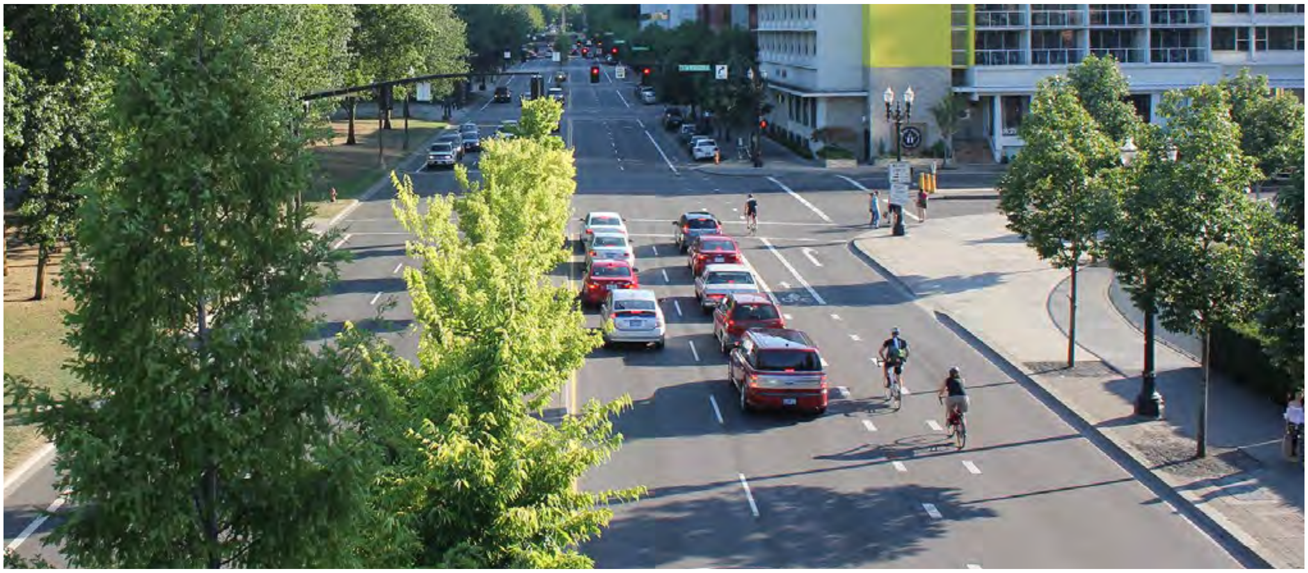
A Mark inside line with 6" stripe.

B Continue existing bike lane width; standard width of 5 to 6 feet (4 feet in constrained locations.)

C Use R4-4 BEGIN RIGHT TURN LANE YIELD TO BIKES signage to indicate that motorists should yield to bicyclists through the conflict area.

D Consider using colored in the conflict areas to promote visibility of the dashed weaving area.

Through Bicycle Lane to the Left of a Right Turn Only Lane



Drivers wishing to enter the right turn lane must transition across the bicycle lane in advance of the turn. Maintaining a straight path for bicyclists is important to emphasize their priority over weaving traffic.

FURTHER CONSIDERATIONS

- The bicycle lane maintains a straight path, and drivers must weave across, providing clear right-of-way priority to bicyclists.
- Maintaining a straight bicycle path reinforces the priority of bicyclists over turning cars. Drivers must yield to bicyclists before crossing the bike lane to enter the turn only lane.
- Through lanes that become turn only lanes are difficult for bicyclists to navigate and should be avoided.

The use of dual right-turn-only lanes should be avoided on streets with bike lanes (AASHTO, 2013). Where there are dual right-turn-only lanes, the bike lane should be placed to the left of both right-turn lanes, in the same manner as where there is just one right-turn-only lane.

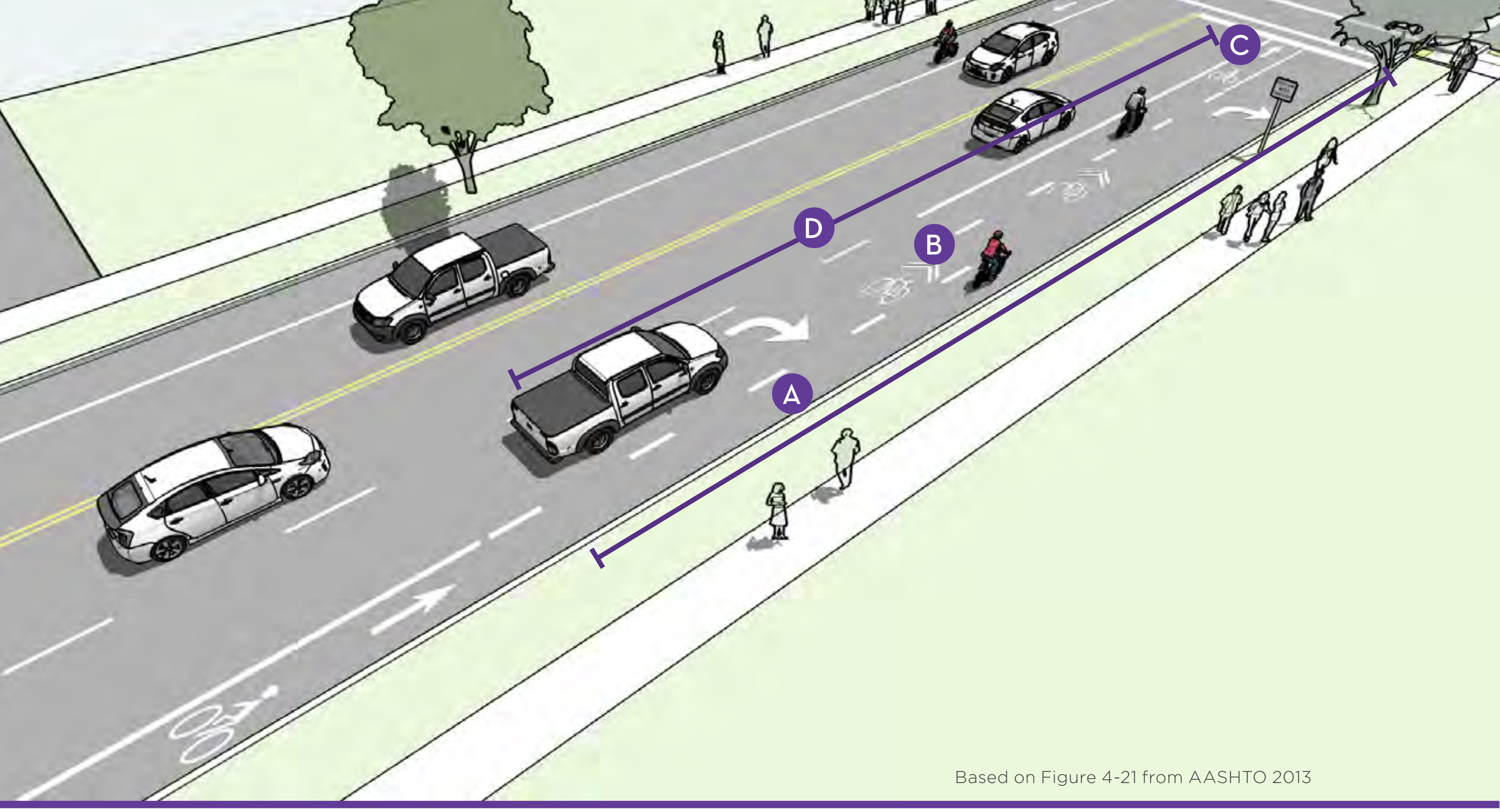
CRASH REDUCTION

Studies have shown a 3% decrease in crashes at signalized intersections with exclusive right turn lanes when compared to sharing the roadway with motor vehicles. (CMF ID: 3257)

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.



Based on Figure 4-21 from AASHTO 2013

Bike Lanes at Through Lane to Right Turn Lane Transition

II INTERSECTION

When a through lane transitions directly into a right turn only lane, bicyclists traveling in a curbside bike lane must move laterally to the left of the right turn lane. Designers should provide the opportunity for bicyclists to accept gaps in traffic and control the transition.

TYPICAL APPLICATION

- Streets with curbside bike lanes where a moderate-high speed (≥30 mph) through travel lane transitions into a right turn only lane.
- This treatment functions for skilled riders, but is not appropriate for riders of all ages and abilities. If a low stress crossing is desired in these locations, consider a Protected Bicycle Signal Phase.

DESIGN FEATURES

A End the curbside bike lane with dashed lines at least 125 feet in advance of the intersection to indicate to bicyclists to enter the general purpose travel lane. (CAMUTCD 9C.04)

B Use Shared Lane markings in the general purpose to raise awareness to the presence of bicyclists in the travel lanes during the transition segment..

C Reestablish a standard or wide bicycle lane to the left of the right turn only lane.

D The transition area should be a minimum of 100 feet long. **(CAMUTCD Figure 9C-4b)**

Bike Lanes at Right Turn "Drop" Lanes

After having transitioned from the curbside bike lane across the shared space in advance of the intersection, bicyclists are positioned to the left of the right-turn lane, in a "pocket bike lane" to reduce the likelihood of conflicts with right turning vehicles at the intersection. In this example, the bike lane continues across the intersection and transitions back to a curbside bike lane.

FURTHER CONSIDERATIONS

The design should not suggest to bicyclists that they do not need to yield to motorists when moving laterally. This differs from added right turn lanes in important details:

- Do not use a R4-4-YIELD TO BIKES sign
- The bike lane line should not be striped diagonally across the travel lane (with or without colored pavement), as this inappropriately suggests to bicyclists that they do not need to yield to motorists when moving laterally.

Right turn only drop lanes should be avoided where possible. Alternative design strategies include roadway reconfigurations to remove the dropped lane, or bicycle signals with a protected signal phase to eliminate turning conflicts.

CRASH REDUCTION

There are no Crash Modification Factors (CMFs) available for this treatment.

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.

Combined Bike Lane/ Turn Lane

II III INTERSECTION

Where there isn't room for a conventional bicycle lane and turn lane a combined bike lane/turn lane creates a shared lane where bicyclists can ride and turning motor vehicles yield to through traveling bicyclists. The combined bicycle lane/ turn lane places shared lane markings within a right turn only lane.

TYPICAL APPLICATION

- Most appropriate in areas with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less).
- May not be appropriate for high speed arterials or intersections with long right turn lanes.
- May not be appropriate for intersections with large percentages of right-turning heavy vehicles.

DESIGN FEATURES

A. Maximum shared turn lane width is 13 feet; narrower is preferable. **(NACTO, 2012)**

B. Shared Lane Markings should indicate preferred positioning of bicyclists within the combine lane.

C. A "RIGHT LANE MUST TURN RIGHT" sign with an "EXCEPT BIKES" plaque may be needed to permit through bicyclists to use a right turn lane.

D. Use R4-4 BEGIN RIGHT TURN LANE YIELD TO BIKES signage to indicate that motorists should yield to bicyclists through the conflict area.

Combined Bike Lane/Turn Lane (Billings, MT)

Shared lane markings and signs indicate that bicyclists should right in the left side of this right turn only lane.

FURTHER CONSIDERATIONS

- This treatment is recommended at intersections lacking sufficient space to accommodate both a standard through bike lane and right turn lane.
- Not recommended at intersections with high peak motor vehicle right turn movements.
- Combined bike lane/turn lane creates safety and comfort benefits by negotiating conflicts upstream of the intersection area.

CRASH REDUCTION

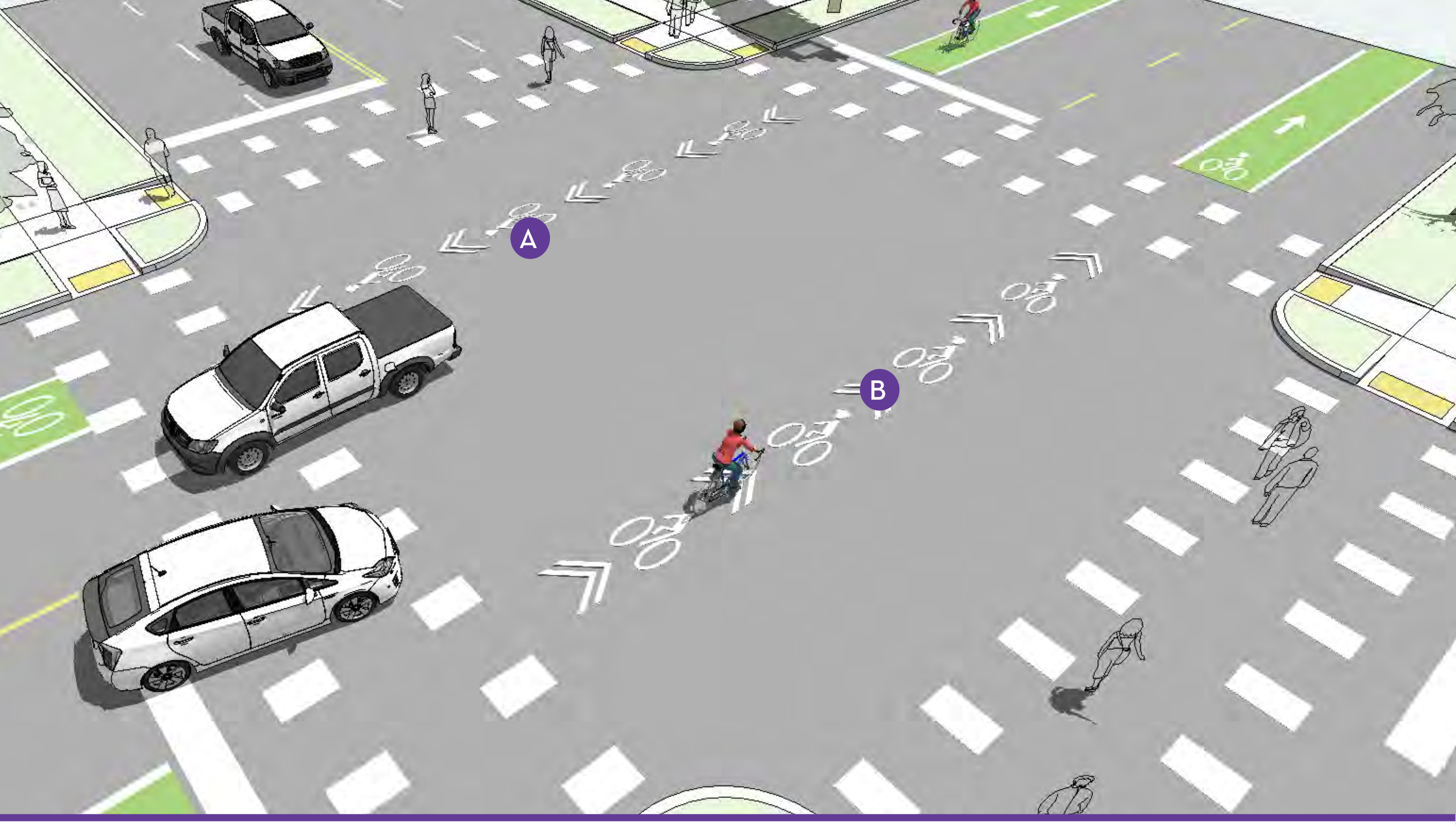
A survey in Eugene, OR found that more than 17 percent of the surveyed bicyclists using the combined turn lane felt that it was safer than the comparison location with a standard-width right-turn lane, and another 55 percent felt that the combined-lane site was no different safety-wise than the standard-width location.[1]

CONSTRUCTION COSTS

The cost for installing a combined turn lane 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. Typical yield lines cost $10 per square foot or $320 each. Typical shared lane markings cost $180 each.

1 Hunter, W.W. (2000). Evaluation of a Combined Bicycle Lane/Right-Turn Lane in Eugene, Oregon. Publication No. FHWA-RD-00-151, Federal Highway Administration, Washington, DC.



Intersection Crossing Markings

II III IV INTERSECTION

Bicycle pavement markings through intersections guide bicyclists on a safe and direct path through the intersection and provide a clear boundary between the paths of through bicyclists and vehicles in the adjacent lane.

TYPICAL APPLICATION

- Streets with conventional, buffered or separated bike lanes.
- At direct paths through intersections.
- Streets with high volumes of adjacent traffic.
- Where potential conflicts exist between through bicyclist and adjacent traffic.

DESIGN FEATURES

- Intersection markings should be the same width and in line with leading bike lane.

A Dotted lines should be a minimum of 6 inches wide and 4 feet long, spaced every 12 feet. **(CAMUTCD Figure 39A)**

- All markings should be white, skid resistant and retroreflective **(CAMUTCD 9C.02.02)**

B Green pavement markings may also be used.

Intersection Crossing Markings

Intersection crossing markings can be used at signalized intersections or high volume minor street and driveway crossings, as illustrated above.

FURTHER CONSIDERATIONS

The National Committee on Uniform Traffic Control Devices has submitted a request to include additional options bicycle lanes extensions through intersections as a part of future MUTCD updates[1]. Their proposal includes the following options for striping elements within the crossing:

- Bicycle lane markings.
- Double chevron markings, indicating the direction of travel.
- Green colored pavement.

1 Letter to FHWA from the Bicycle Technical Committee for the MUTCD. Bicycle Lane Extensions through Intersections. June 2014.

CRASH REDUCTION

A study on the safety effects of intersection crossing markings found a reduction in accidents by 10% and injuries by 19%[2]

A study in Portland, OR found that significantly more motorists yielded to bicyclists after the colored pavement had been installed (92 percent in the after period versus 72 percent in the before period.)[3]

CONSTRUCTION COSTS

The cost for installing intersection crossing markings 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 shared lane markings cost $180 each.

2 Jensen, S.U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2), 742-750.

3 Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

Mixing Zone

II III IV INTERSECTION

A mixing zone creates a shared travel lane where turning motor vehicles yield to through traveling bicyclists. Geometric design is intended to slow motor vehicles to bicycle speed, provide regulatory guidance to people driving, and require all users to negotiate conflicts upstream of the intersection.

TYPICAL APPLICATION

- Most appropriate in areas with low to moderate right-turn volumes.
- Streets with a right turn lane but not enough width to have a standard width bicycle lane at the intersection.

DESIGN FEATURES

A. Use short transition taper dimensions and short storage length to promote slow motor vehicle travel speeds.

B. The width of the mixing zone should be 9 feet minimum and 13 feet maximum.

C. The transition to the mixing zone should begin 70 feet in advance of the intersection.

D. Shared lane markings (CAMUTCD 9C-9) should be used to illustrate the bicyclist's position within the lane.

E. A yield line should be used in advance of the intersection.

Mixing Zone (New York City, NY)

Mixing zone (Photo via NACTO)

FURTHER CONSIDERATIONS

- Not recommended at intersections with high peak motor vehicle right turn movements.
- The zone creates safety and comfort benefits by having the mixing zone upstream of the intersection conflict area.

CRASH REDUCTION

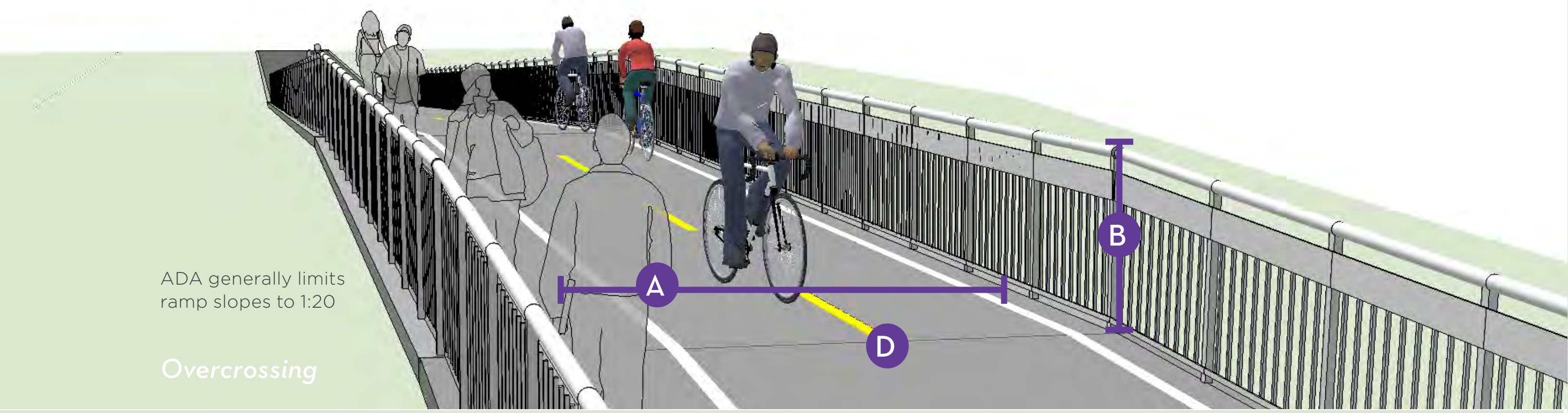
A survey of separated bike lane users in the United States found the 60-80% of respondents agreed with the statement "I generally feel safe when bicycling through the intersections" when asked about intersections with mixing zone approaches.[1]

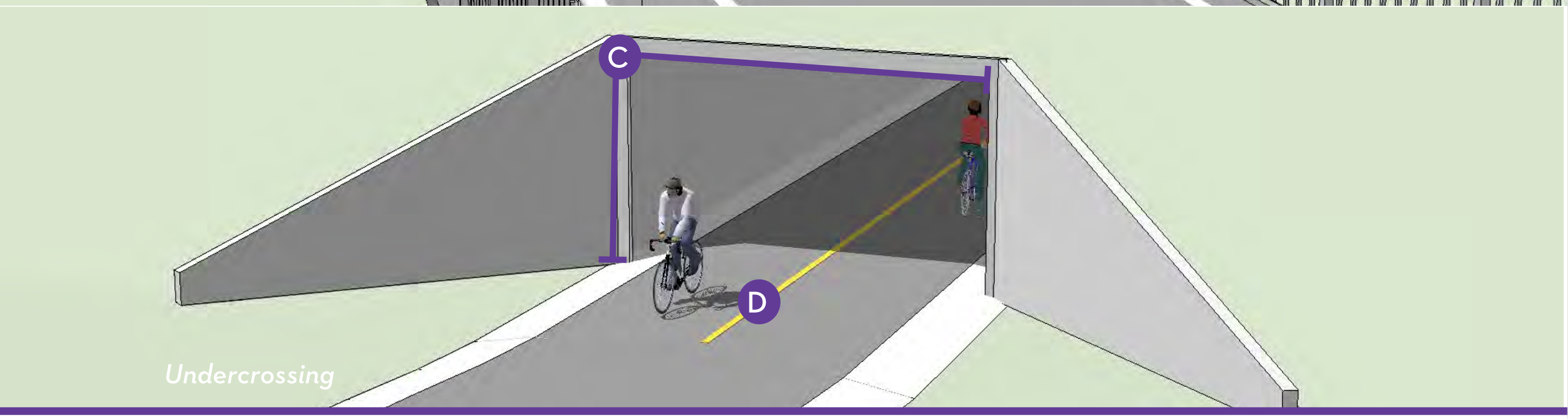
CONSTRUCTION COSTS

The cost for installing mixing zone 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. Typical yield lines cost $10 per square foot or $320 each. Typical shared lane markings cost $180 each.

1 NITC. Lessons from the Green Lanes. 2014.





Grade Separated Crossings

I INTERSECTION
MID-BLOCK

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 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.

Overcrossings

Undercrossings

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

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.

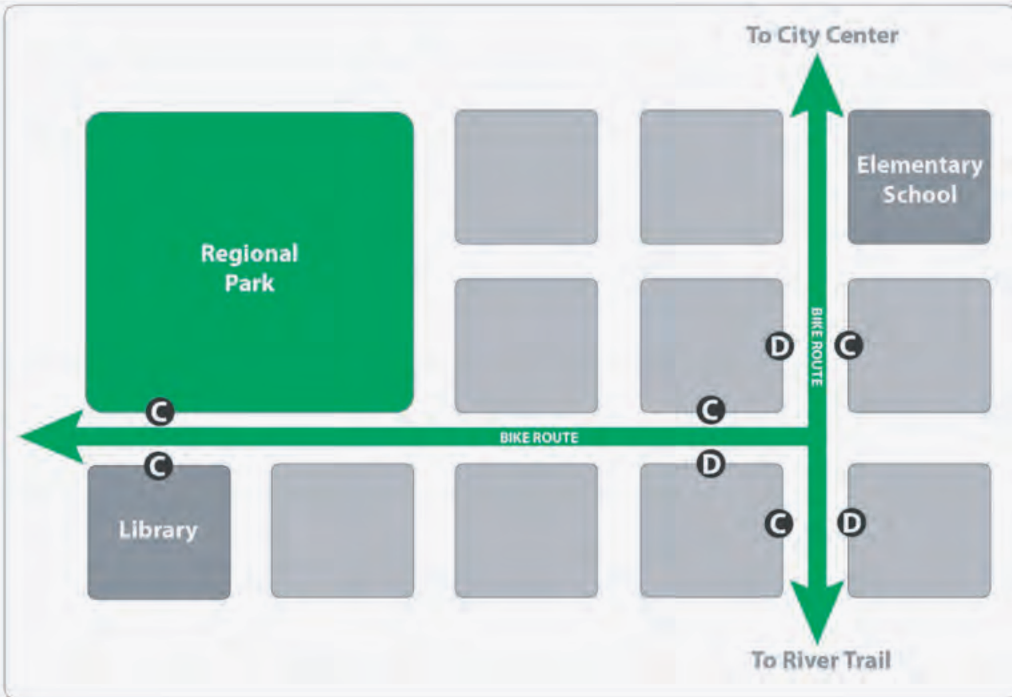
CRASH REDUCTION

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

CONSTRUCTION COSTS

Costs will vary greatly based on site conditions, materials, etc. Overpasses have a range from $150 to $250 per square foot or $1,073,000 to $5,366,000 per complete installation, depending on site conditions. Underpasses range from slightly less than $1,609,000 to $10,733,000 in total or around $120 per square foot. (PBIC).

BIKEWAY SIGNING AND AMENITIES

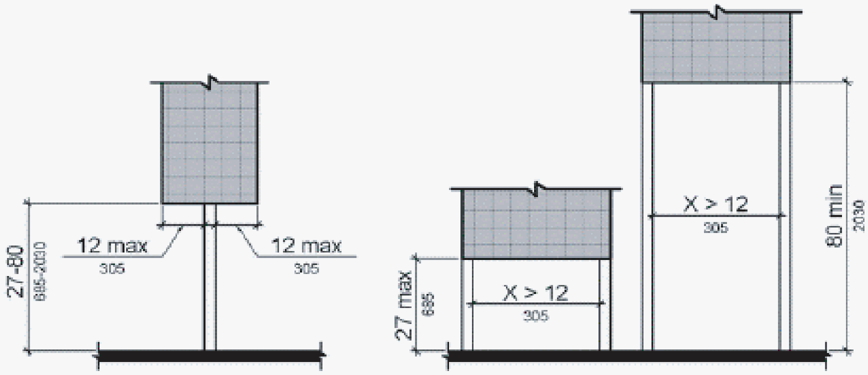


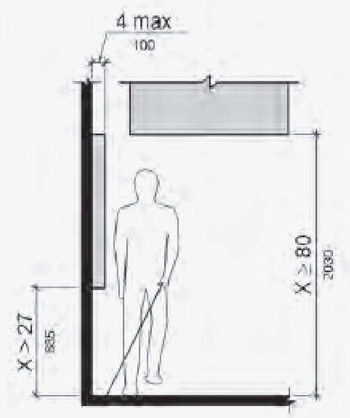
Wayfinding Sign Placement

I II III IV

INTERSECTION
MID-BLOCK

Above is a typical wayfinding sign placement scenario showing a decision sign (D) being located prior to an intersection of two bicycle facilities. A confirmation sign (C) is provided after the turn movement as well as periodically along the route to confirm for users that they are still on the intended facility.





Above: Current proposed standards for post mounted objects.

Left: Limits of protruding objects.

For more information on protruding objects and clearances, see 2010 ADA Standards for Accessible Design, Chapter 3, section 307.

Accessibility Standards

As wayfinding systems often relate to accessible routes or pedestrian circulation, it is important to consider technical guidance from the ADA so that signs and other elements do not impede travel or create unsafe situations for pedestrians and/or those with disabilities. The Architectural and Transportation Barriers Compliance Board provides the following guidance for the design and placement of wayfinding guide signs:

- **Vertical Clearance:** Shall be 80 inches mimimum, or 27 inches maximum when the signs protrude more than 12 inches from the sign post.
- **Post-Mounted Objects:** Where a sign is mounted between posts or pylons and the clear distance between the posts is greater than 12 inches, the lowest edge of the sign shall be 27 inches maximum or 80 inches minimum above the existing grade.
- **Protruding Objects:** Objects with leading edges more than 27 inches and not more than 80 inches above the existing grade shall protrude 4 inches maximum horizontally into the circulation path.
- **Required Clear Width:** Protruding objects shall not reduce the clear width required for accessible routes. Generally this requirement is met by maintaining four feet minimum clear width for maneuvering. This requirement applies to both sidewalks and pedestrian circulation paths.

R117 (CA)

W11-1 with custom "ON ROADWAY" legend plaque

R4-11

Safety & Warning Signs

I II III IV

INTERSECTION
MID-BLOCK

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.

TYPICAL APPLICATION

- In higher speed 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 relatively dense 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.

FURTHER CONSIDERATIONS

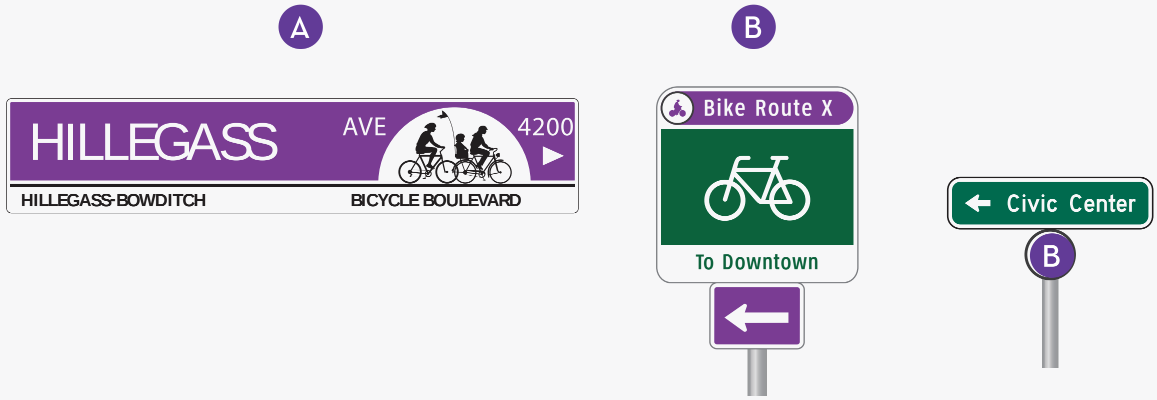
- Regulatory signage specific to bicycle and pedestrian travel are typically rectangular in shape with a white background and a black border. Bicycle and/or pedestrian warning signage is yellow or fluorescent yellow-green with a black border, and diamond -shaped. Consult CAMUTCD Chapter 2 for more information regarding design, size, placement of regulatory and warning signage.
- Monitor signs along bikeways for vandalism, graffiti, and normal wear and replace signs in the bikeway network as needed.

CRASH REDUCTION

Regulatory and warning signs as set forth in the CAMUTCD, are designed to indicate the traffic laws and regulations of the road and provide warning of specific roadway conditions to reduce the likelihood of motor vehicle, bicycle and pedestrian-involved crashes and injury.

CONSTRUCTION COSTS

The cost of a safety and warning sign needs depend on the scale and complexity of the approach. Signs and posts range from $200 to $1,000, including installation costs. Costs are further reduced if mounted on existing posts.



Community Wayfinding Signs

I II III IV

INTERSECTION

MID-BLOCK

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, standard MUTCD wayfinding signs should be used.
- These informational guide signs shall not be installed on freeway or expressway mainlines or ramps.

DESIGN FEATURES

A 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, and per MUTCD guidance, 70% contrast must be maintained between the sign lettering and background color.

B Other graphics that specifically identify the wayfinding system, including enhancement markers, may be used on the sign assembly and sign supports. Up to 20% of the sign blade may be used for identity graphics and logos.

FURTHER CONSIDERATIONS

The standard colors of red, orange, yellow, purple, or the fluorescent versions thereof shall not be used as background colors for community wayfinding guide signs, as these colors are reserved for other specific sign types (e.g. advisory and regulatory signs).

While community wayfinding signs are allow more flexibility than standard wayfinding signs, the use of federal funds is more likely to be approved when the MUTCD is more closely followed. Options for adhering to the MUTCD include adding unique mounting structures, colors, and/or an identifying enhancement marker. Section 2D.50 of the MUTCD describes standards for Community Wayfinding.

The spectrum on the following page shows a range of wayfinding elements that have been implemented by municipalities around the nation. The range extends from more rigid adherence MUTCD to those having a more flexible interpretation.

Refer to chapter 9 of the MUTCD for more information on guide sign standards for bicycle facilities.

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BIKE PARKING

Bike Parking Treatments

INTERSECTION
MID-BLOCK

SHORT-TERM BICYCLE PARKING

Short-term bicycle parking is for use by shoppers, customers, messengers, and other visitors by providing a convenient and readily accessible place to park their bicycles for less than roughly two (2) hours. Short-term bicycle parking shall serve the main entrance of a building and be visible to pedestrians and bicyclists, with the goal of providing such parking at each principal building entrance.

A. Short-term bicycle parking located on the project site shall be:

- Visible from the public right-of-way,
- Within 50 feet of a main building entrance,
- At the same grade as the adjacent right-of-way or accessible along a clear path of travel with an ADA compliant grade and a minimum width of six feet

B. Short-term bicycle parking located in the public right-of-way shall be:

- Within 50 feet of a main building entrance,
- Approved by the Traffic Engineer,
- In compliance with the minimum layout requirements contained within this document

LONG-TERM BICYCLE PARKING

Long-term bicycle parking serves employees, students, residents, commuters, customers and others who need a secure location to park a bicycle for a longer duration. Long-term bicycle parking provides a secure and weather-protected place to park bicycles for more than roughly two (2) hours on the project site.

A. Long-term bicycle parking shall be:

- Accessible only to the intended users of the parking
- Covered such that bicycles are fully protected from inclement weather

BIKE PARKING RACK GUIDELINES

- The rack type must be a City of Berkeley approved style of rack or an artistic rack (subject to approval).
- The bicycle frame and one wheel can be locked to the rack with a high security, U-shaped shackle lock if both wheels are left on the bicycle.
- A bicycle six feet long can be securely held with its frame supported in two locations so that the bicycle cannot be pushed or fall in a manner that will damage the wheels or components.
- The rack must be securely anchored.

SIGNS

Bicycle parking signs must be provided in the following circumstances:

- 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.
- Signs Along Path of Travel. If the parking is located more than 150 feet from the entrance, signs shall be placed on the street or nearest bikeway guiding the user to the bicycle parking.

PARKING AND MANEUVERING

- Each required bicycle parking space must be accessible without moving another bicycle.
- The area devoted to bicycle parking must be hard surfaced: concrete, asphalt, decomposed granite, or equivalents.

Short-term parking shall be located:

Outside of the building, unless the minimum, or portion thereof, amount of bicycle parking requirement can provided indoors. If all or a portion of the minimum parking requirement is met indoors, the parking should be visible from the building entrance and accessible along a clear path of travel wide enough to walk a bicycle free of conflicts with other users.

FACILITY DESIGN

The City recommends that the lot coverage conditions of the project site dictate the type of long-term parking strategy. For instance, parcels with relatively high lot coverage (>85%) should provide long-term parking indoors, via a secure bike room or cage (if indoor or basement space is available). Parcels with lower lot coverage (<85%) can provide exterior long-term parking in the form of bike lockers or a sheltered, secure bicycle cage.

BIKE RACK STYLES

Racks installed on City ROW shall be of one of three styles:

Inverted U style

- Racks shall be constructed of 2"x2"x.188" wall square pipe, galvanized or stainless steel.
- Racks shall be 32" tall by 30" wide.
- Flanges for surface mounted racks must be 3/8" thick and drilled with 9/16" holes to admit 1/2" fasteners.
- For installation of multiple racks side-by-side, Rail Mounted Inverted U racks can be used.
- The capacity of each inverted U rack is two bicycles, locked parallel to the rack.

Circle style

- Racks shall be constructed of 2"x2"x.188" wall square pipe, galvanized or stainless steel.
- Racks shall be 32.375" tall.
- Flanges for surface mounted racks must be 3/8" thick and drilled with 9/16" holes to admit 1/2" fasteners.
- The capacity of each circle rack is two bicycles, locked parallel to the rack.

Post-and-Ring style

- Racks consist of two components: a vertical pipe sleeve and two halfcircle locking loop elements welded to either side of the sleeve.
  - » The vertical sleeve shall be constructed of 2 1/2" I.D. Schedule 40 pipe.
  - » The half-circle locking loops shall be constructed of 2"x2"x.188" wall square pipe.
  - » All materials galvanized or stainless steel.
- Racks shall be 37 3/8" tall or as specified by City to fit height of existing parking meter poles.
- Locking loop elements shall be 18" tall an d 8" wide, attached at a height of 12" from the bottom of the sleeve, measured to the bottom edge of locking loop.
- Sleeve must be drilled with hole for 3/8" security bolt to affix rack to existing parking meter pole.
- The capacity of each post-and-ring rack is two bicycles, locked parallel to the locking loops.

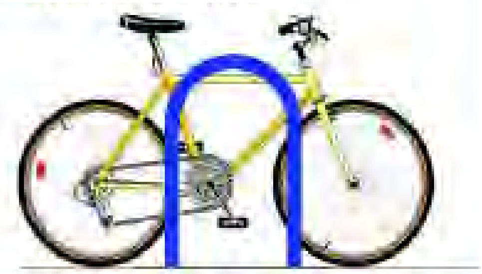
MOUNTING

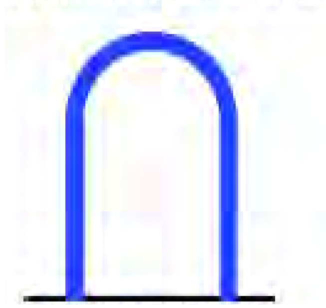
- Inverted U and Circle racks installed on concrete should be surface flange mount style.
- Fasteners for use in flange mounting must be 1/2" x 3" mushroom head stainless steel.
- Powers spike, or equivalent (manufacturer information attached).
- Post-and-Ring style racks are sleeved onto existing parking meter poles and secured using a fastening wedge and 3/8" mushroom head stainless steel bolt with security nut in top of rack.

Short-Term Parking

The rack should:

- Support the bicycle upright by its frame in two places.
- Prevent the wheel of the bicycle from tipping over.
- Enable the frame and one or both wheels to be secured.
- Support bicycles without a diamond-shaped frame with a horizontal top tube (e.g. a mixte frame).
- Allow front-in parking; a U-lock should be able to lock the front wheel and the down tube of an upright bicycle.
- Allow back-in parking; a U-lock should be able to lock the rear wheel and seat tube of the bicycle.





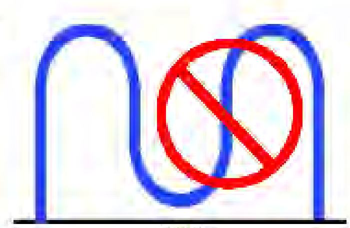
Inverted "U"

Post and Loop

Comb, Toast, School-yard, and other wheel bending racks that provide no support for the bicycle frame are NOT recommended.

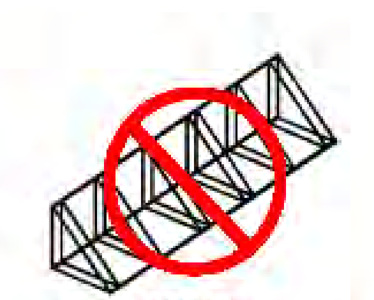
The rack should resist being cut or detached using common hand tools, especially those that can be concealed in a backpack. Such tools include bolt cutters, pipe cutters, wrenches, and pry bars.

Comb



Wave

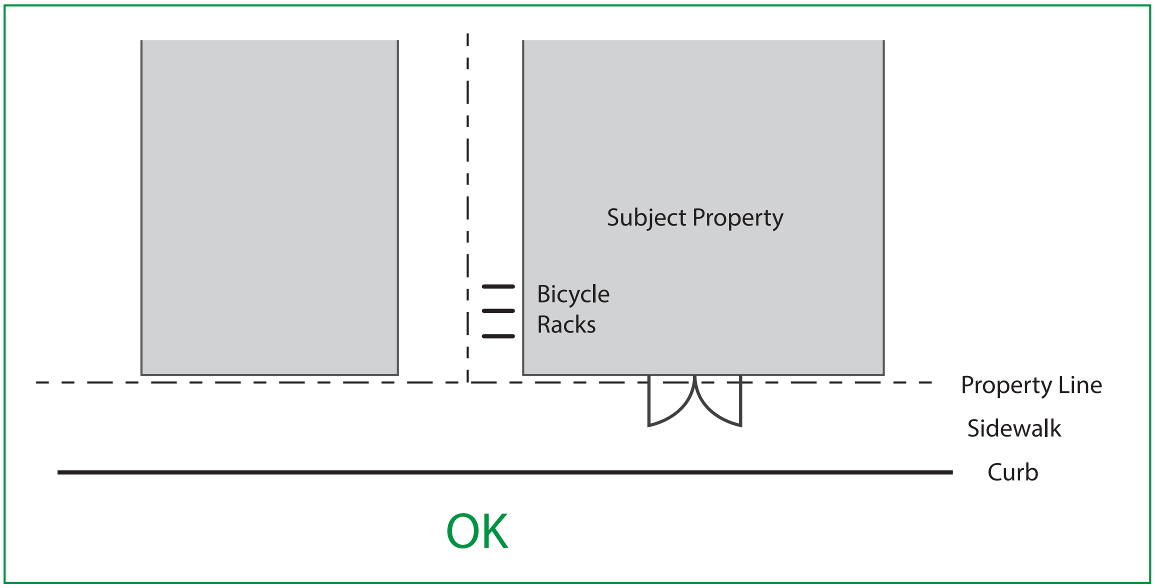
One rack element is a vertical segment of the rack

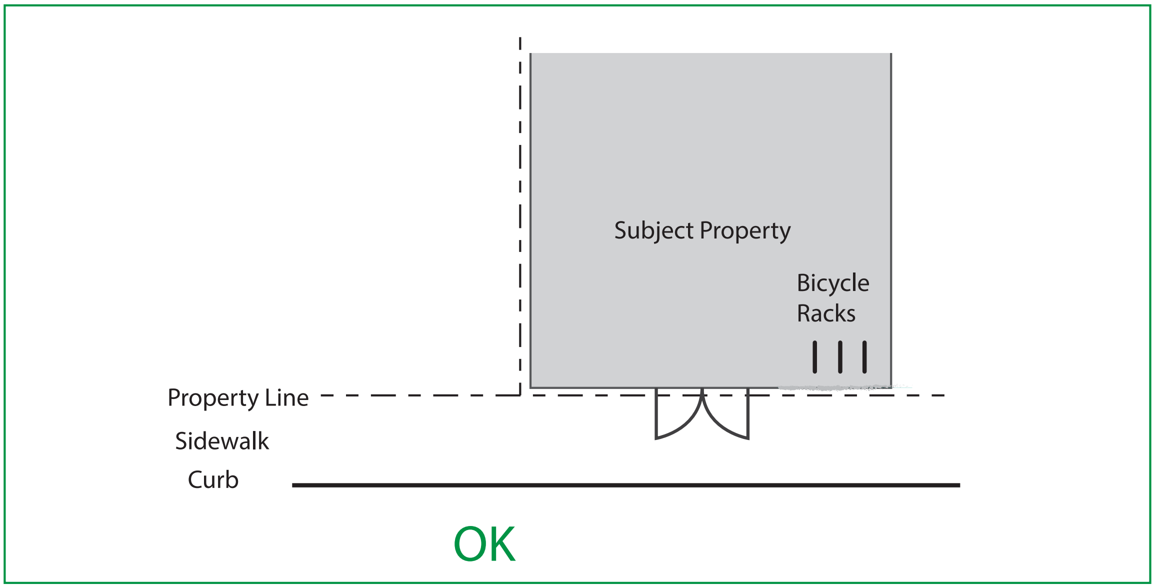


Toast

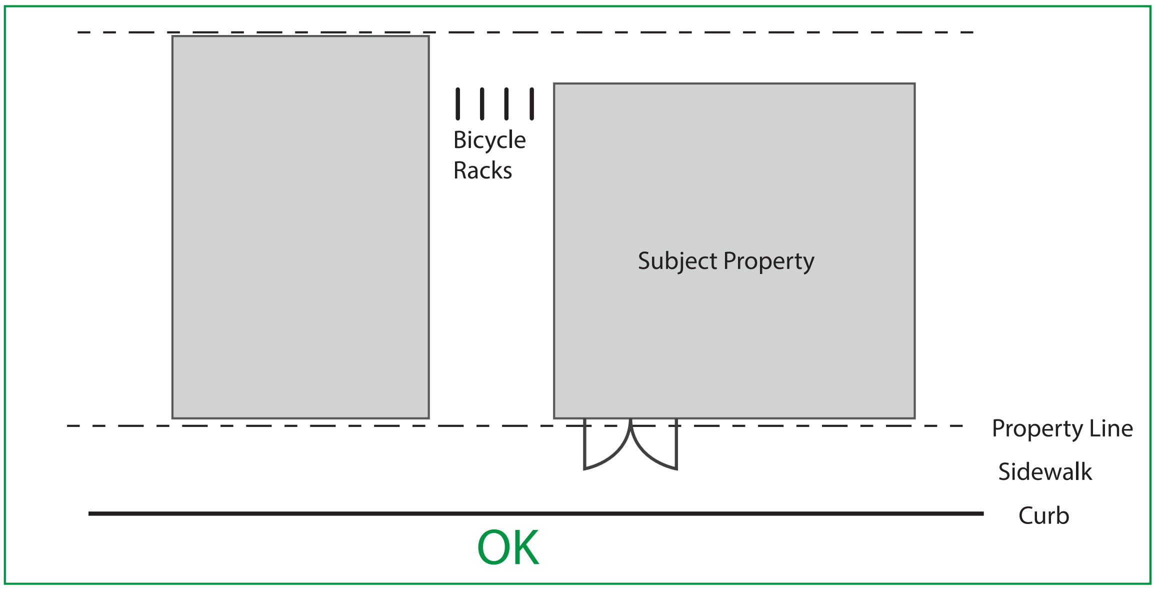
One rack element holds one wheel of a bike

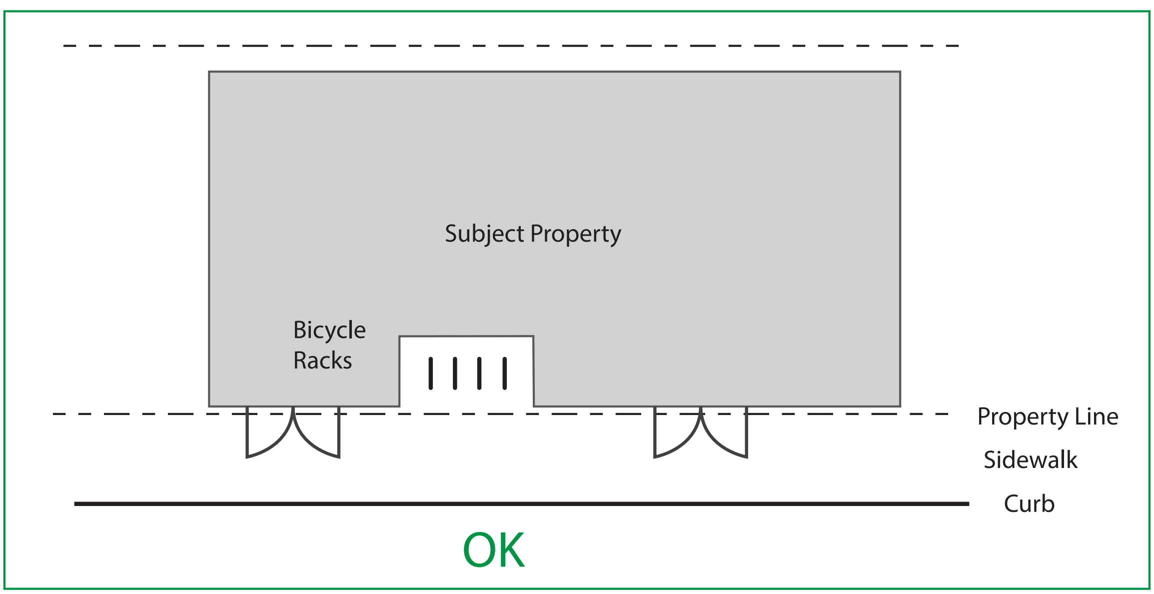
These examples assume the parking is located **no more than FIFTY FEET** from the main entrance and is visible from the sidewalk OR indicated with clear signage.





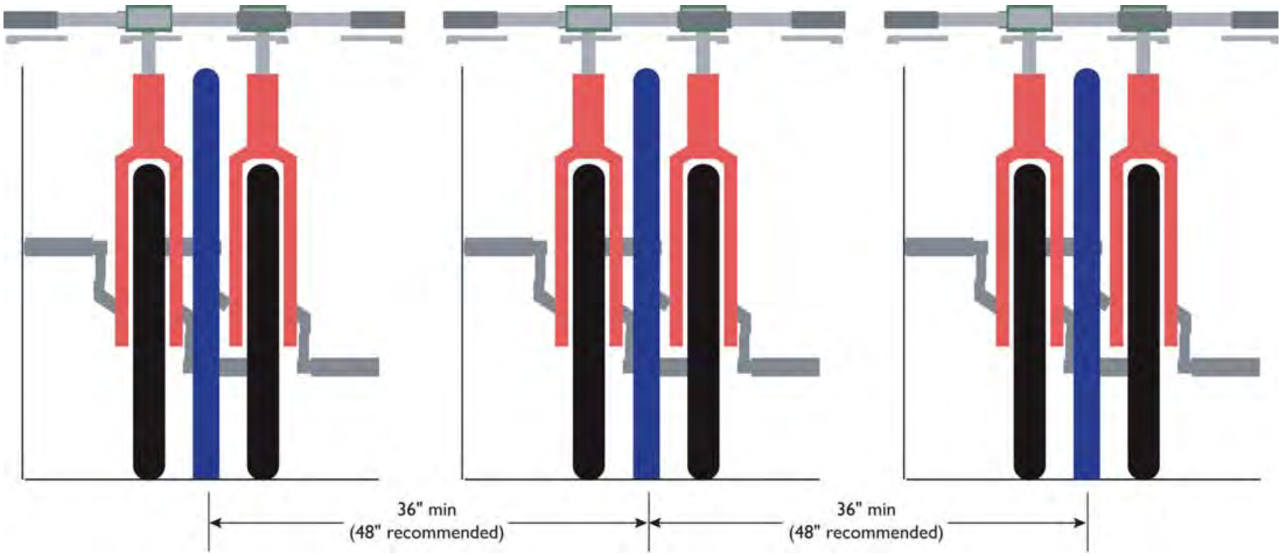
These examples assume the parking is located **no more than FIFTY FEET** from the main entrance and is visible from the sidewalk OR indicated with clear signage.

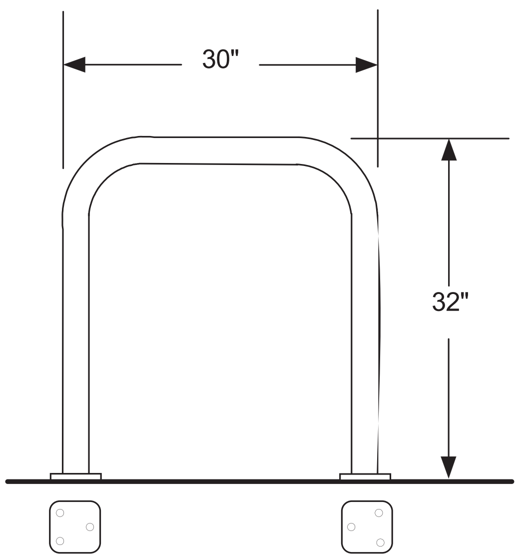




PLACEMENT, ORIENTATION, AND CLEARANCE IN THE PUBLIC RIGHT-OF-WAY

- Racks are designed to accommodate bikes parked parallel to the rack, resting against one or both upright members.
- Typically the City does not allow installation of racks on sidewalks narrower than 10' in width.
- On sidewalks 10'-14' in width, racks should be installed parallel to the curb so as to minimize needlessly taking up sidewalk space.
- On sidewalks 14' or wider or where racks are placed in the roadway, racks can be placed perpendicular to the curb.
- Multiple individual racks installed parallel to the curb, end to end, must be separated by a minimum of 48". 72" is preferred.
- Multiple racks placed perpendicular to the curb, side-by-side, must be separated by a minimum of 36", 48" is preferred.
- Racks must be oriented such that they do not interfere with pedestrian path of travel on the sidewalk, yet are not so close to the curb that the rack can be inadvertently hit by the overhang of a car as it parks.
- Check for any sidewalk utility boxes (such as water or sewer) that need to be accessed.
- Check for any vaulted sidewalks such as over building basements, utility vaults and transit stations.
- Make sure that the racks posts are not in conflict with rain water leaders or drain lines under the sidewalk
- Do not locate racks where they interfere with opening car doors and persons exiting from vehicles parked at the curb
- There should be a minimum of 5 1/2' clear for pedestrian right-of-way outside the footprint; 7' in areas of heavy pedestrian traffic.
- Rack should be located a minimum of:
  - » 24" from: the curb
  - » 36-48" from: Newspaper Racks, Mailbox, Light Pole, Sign Pole, Bus Shelter, Driveway, Surface Hardware (PG&E, Cable grates, etc.), Street Furniture, Standpipes, Bus Benches, Trash Cans, Other sidewalk obstructions
  - » 4' from: AC Transit Red Zone, Loading Zone, Blue Zone (disabled parking), Curb/Curb ramps, Crosswalk, BART entrance
  - » 5' from: Fire Hydrant





Surface Mounted Single Inverted U

Height: 32”

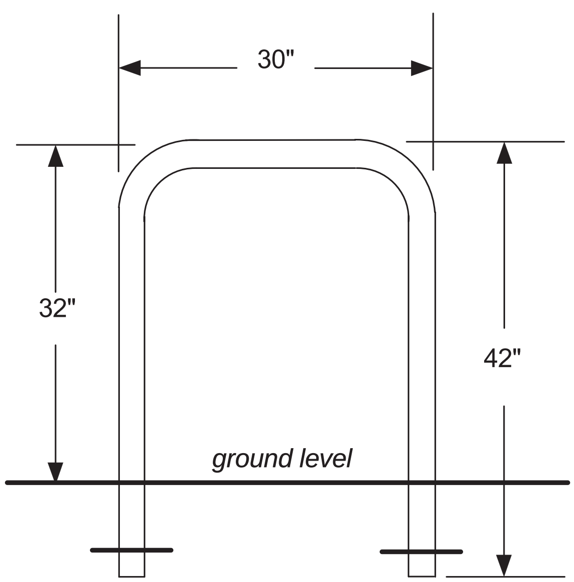
Width: 30”

Flanges: 5” x 6” x 3/8”

Mounting Holes: (6) 9/16” dia.

Square Tubes: 2” x 2” x .188” wall

Finish: Hot-dipped Galvanized



Sub-Surface Mounted Single Inverted U

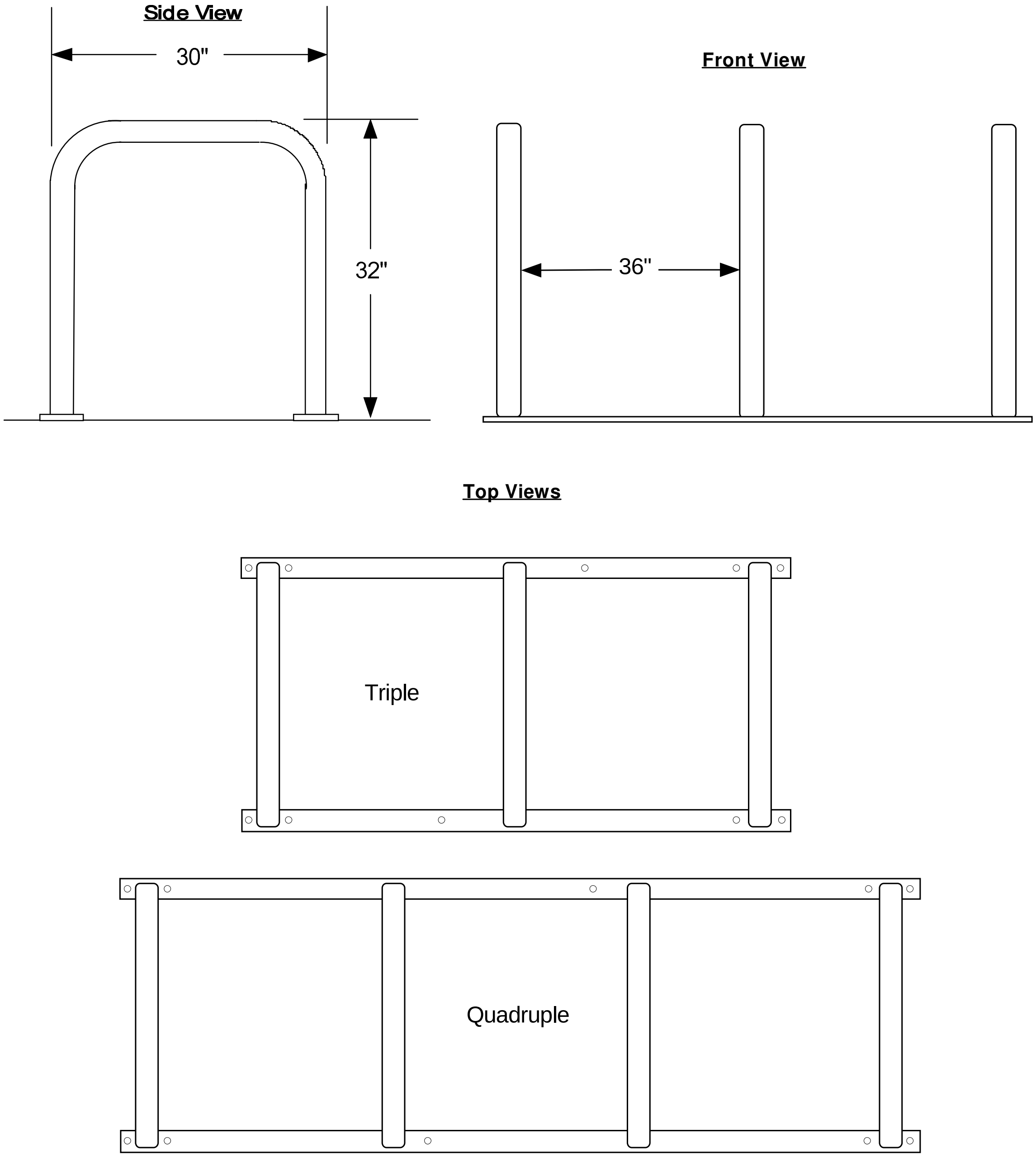
Height: 42”

Width: 30”

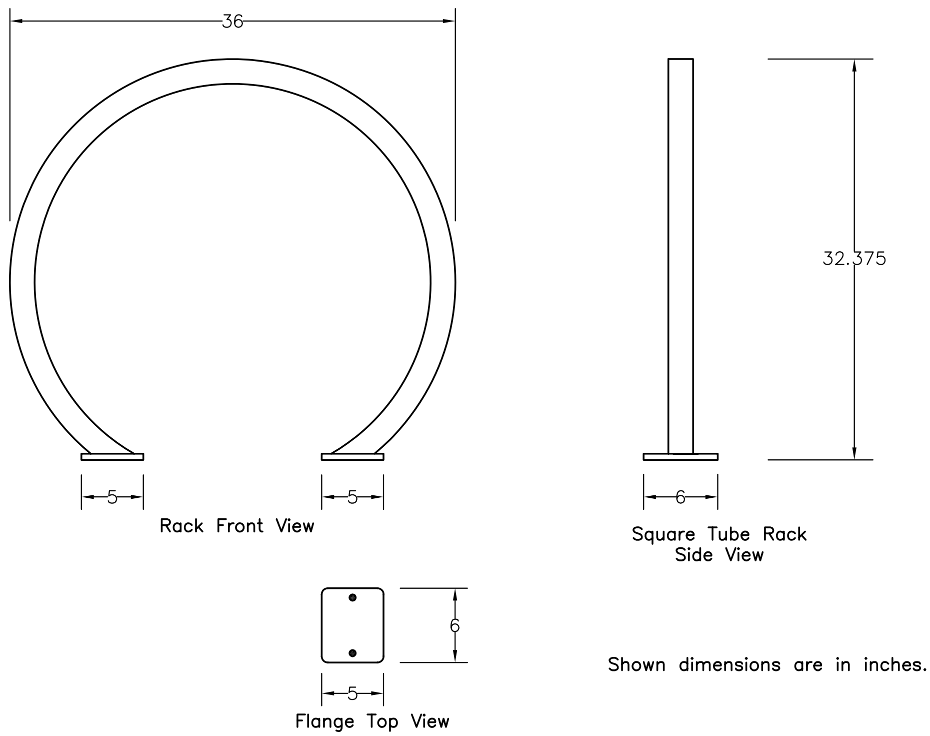
Square Tubes: 2” x 2” x .188” wall

Finish: Hot-dipped Galvanized

CITY OF BERKELEY RAIL MOUNTED INVERTED U RACK SPECIFICATIONS



CITY OF BERKELEY SURFACE MOUNTED SINGULAR CIRCULAR RACK SPECIFICATIONS



Surface Mounted Single Circular Rack

Height: 32.375"

Width: 36"

Flanges: 5" x 6" x 3/8"

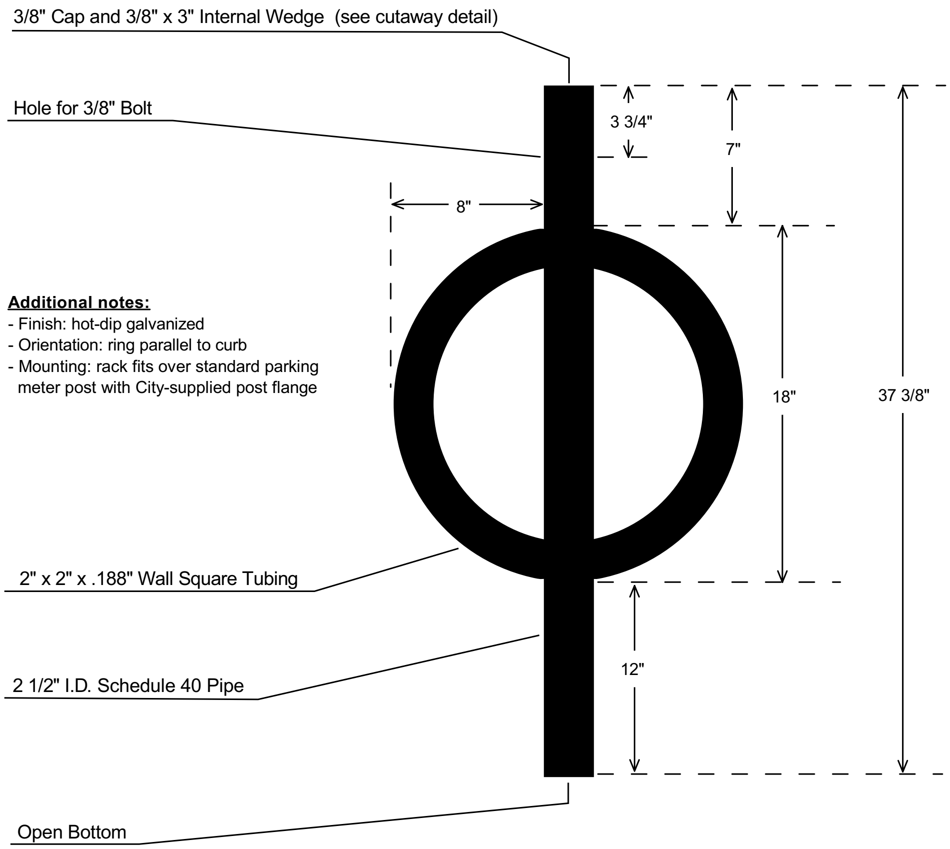
Mounting Holes: (4) 9/16" dia.

Mounting Bolts: 1/2" x 3.75" Wedge Anchor Bolt, or 1/2" x 3.75" Anchor Rawl Spike

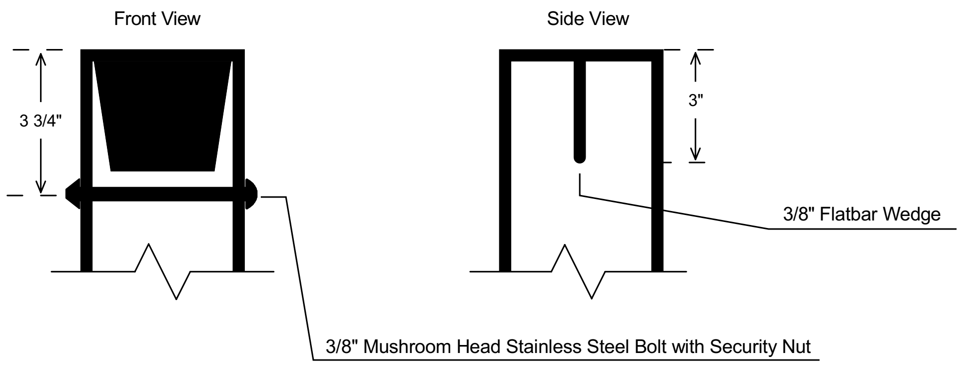
Hoop: 2" x 2" x0.188" Square tube

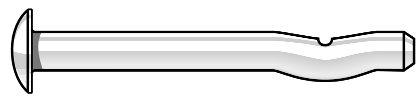
Finish: Hot-dipped Galvanized (-G), Powder-coated (-P), Stainless #4 Brush Finish (-SS)

CITY OF BERKELEY POST-AND-RING RACK SPECIFICATIONS



Cutaway Detail:
Fastening Wedge and Bolt with Security Nut in Top of Rack





SPIKE®

BASE MATERIAL

Concrete, Block, Brick, Stone

SIZE RANGE

3/16" x 1" to 1/2" x 6-1/2"

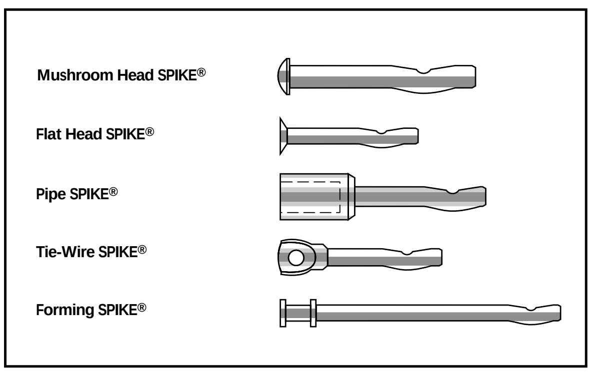
ANCHOR MATERIAL

Carbon Steel and Type 316 Stainless Steel

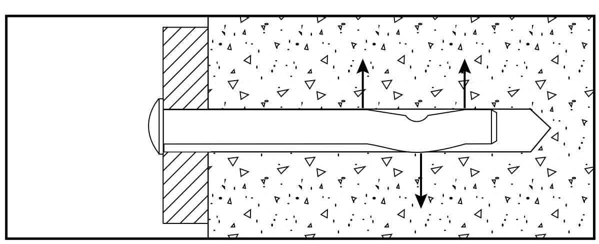
PRODUCT DESCRIPTION

The SPIKE is a patented, one-piece, vibration resistant anchor for use in concrete, block, brick, or stone. Several head styles and anchor materials are available. Some sizes are tamperproof and others are removable.

The pre-expanded mechanism of the SPIKE anchor is activated as the anchor is driven into the drilled hole creating a spring type compression force against the walls of the hole.

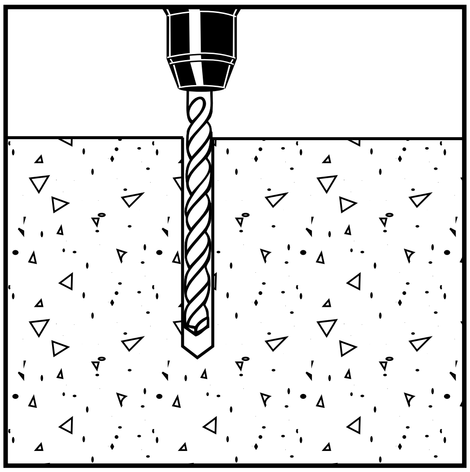


Once seated at the required embedment, residual spring force developed in the expansion mechanism provides three compression forces at the bottom of the anchor hole. When a vibratory load is applied to some other anchor types, the area of the base material around the expansion mechanism may experience localized pulverization at the point of contact. The SPIKE has been designed to overcome this problem. When subjected to vibratory loads, the SPIKE will expand due to the residual spring action of the expansion mechanism if localized pulverization occurs.

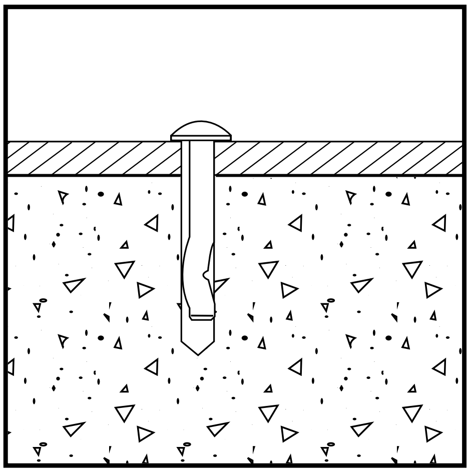


SPIKE is a proprietary anchor that can be used in applications that traditionally have been addressed by wedge and sleeve type expansion anchors, drop-in style anchors and concrete screws. Use of the SPIKE anchor reduces installation time. Since the anchor is pre-expanded, there is no secondary tightening or expanding operation required which greatly reduces the overall cost of an anchor installation.

INSTALLATION PROCEDURES



Drill a hole into the base material to a depth of at least 1/2" deeper than the embedment required. The tolerances of the drill bit used should meet the requirements of ANSI Standard B212.15. Blow the hole clean of dust and other material.



Where a fixture is used, drive the anchor through the fixture into the anchor hole until the head is firmly seated against the fixture. Be sure the anchor is driven to the required embedment depth. The Tie-Wire and Pipe SPIKE versions should be driven in until the head is seated against the surface of the base material.

ANCHOR SIZES AND STYLES

To select the proper minimum anchor length, determine the embedment depth required to obtain the desired load capacity. Then add the thickness of the fixture, including any spacers or shims, to the embedment depth. On the Tie-Wire and Pipe SPIKE versions, no fixture is used. These anchors should be driven in until the head is seated against the surface of the base material.

LONG-TERM PARKING STANDARDS

Covered Spaces

100 percent of required long-term bicycle parking must be covered and meet the following standards:

Covered bicycle parking shall be located:

» Inside a structure,

» Under a roof overhang or awning,

» In bicycle lockers, or

» Within or under other structures.

If covered bicycle parking is not within a building or locker, the cover must be:

» Permanent (and constructed of durable, waterproof materials)

» Designed to protect the bicycle from rainfall and inclement weather; and

» At least 7 feet above the floor or ground.

Access

No fee shall be charged for long-term residential bicycle parking. Long-term bicycle parking must be provided in racks or lockers that meet the standards of the City of Berkeley Bicycle Parking Design Guidelines & Specifications.

Visibility

The location of long-term bicycle parking must be clearly posted and marked at locations in which users will access said parking.

Security

The following guidelines must be followed when determine a suitable location for long-term bicycle parking. To provide security, long-term bicycle parking must in one of the following locations:

» In a locked room accessible only to building users, or;

» In an area that is enclosed by a fence with a locked gate (such as a residential courtyard)

The fence must be at least 8 feet high and secured overhead, or be floor-to-ceiling. The gate door must be self-closing. To provide additional security, it is required that long-term bicycle parking have active or passive surveillance. This requirement may be met by one (1) of the following conditions:

» Within view of an attendant or security guard;

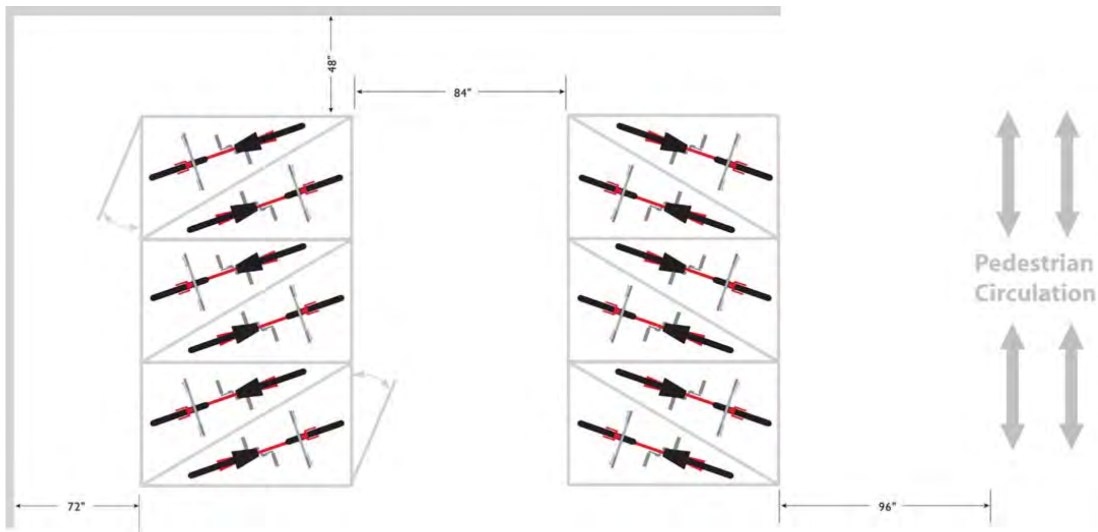
» In an area that is monitored by a security camera;

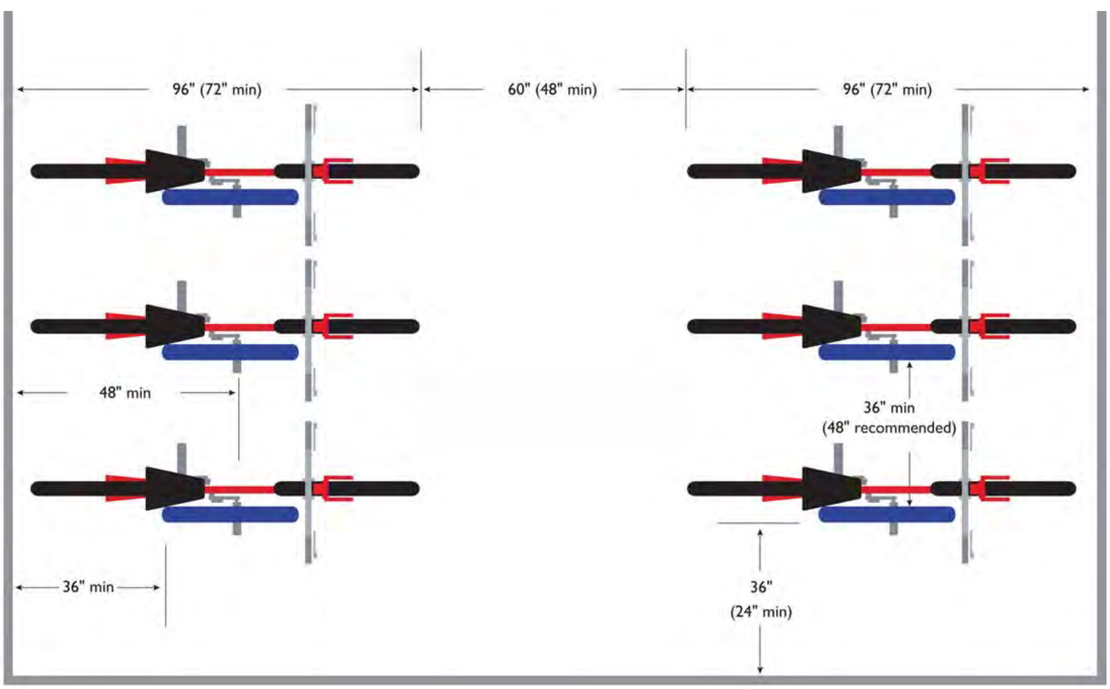
» In an area that is visible from employee work areas, or

» In an area that receives significant customer, resident, or employee traffic

LONG-TERM PARKING: LAYOUT AND DIMENSIONS

- Lockers: Minimum 72" from walls, minimum 84" aisles
- Interior U-racks: Minimum 36" from rack to wall, minimum 48" aisle, recommended 48" between racks

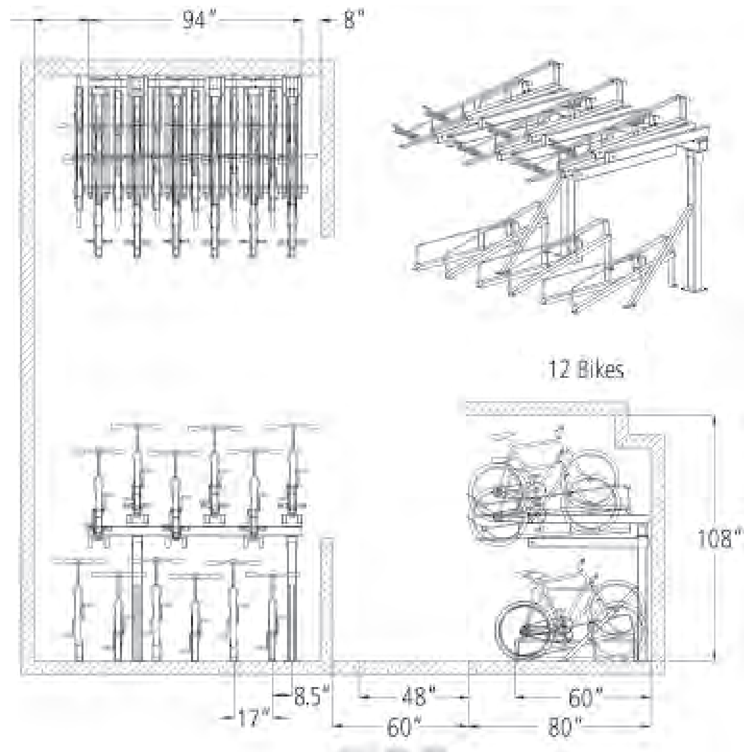


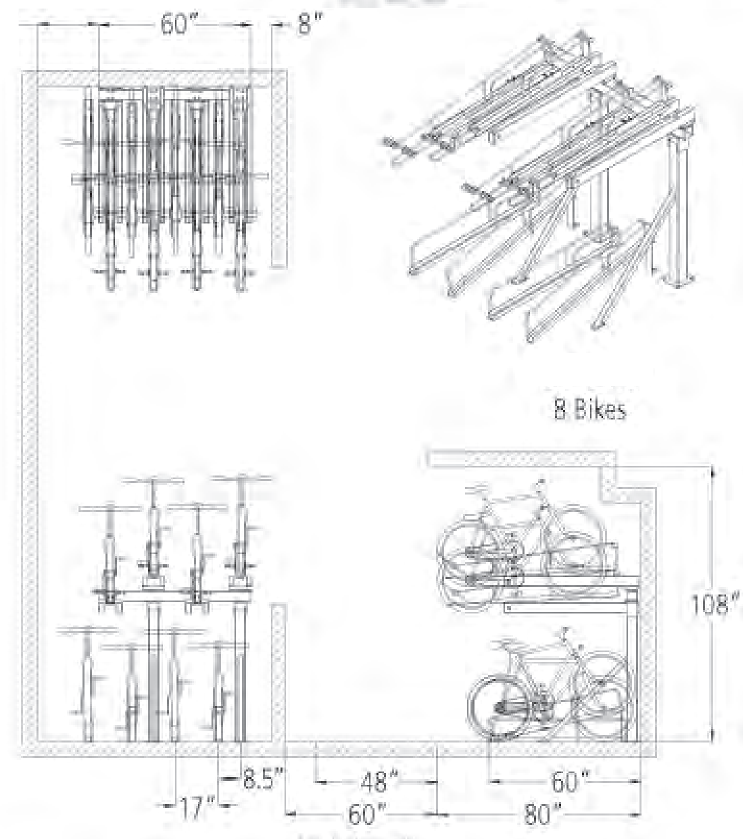


HORIZONTAL, TWO-TIERED PARKING RACK

Lift-assist top tray, modular/stacking

- Recommended access aisle of 60", minimum access aisle of 48".
- Each unit requires 80" of depth.
- Minimum ceiling height of 108".



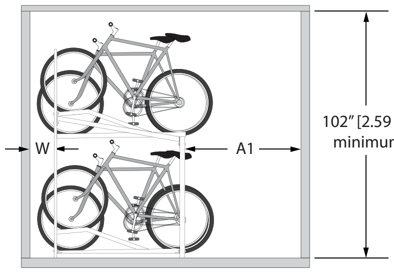


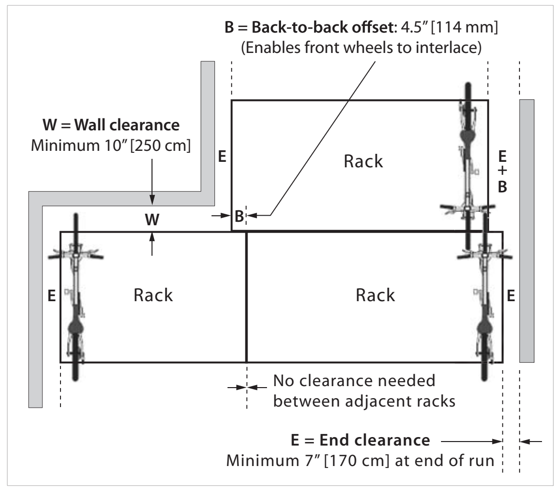
HORIZONTAL, TWO-TIERED PARKING RACK NON-LIFT ASSIST

Minimum aisle width of 54", recommended width of 60".

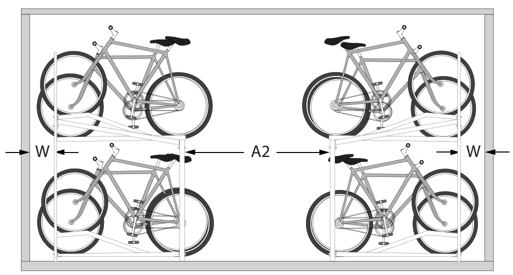
NOTE: Side views illustrate minimum values of A1 and A2

① 1 Aisle Single Loaded

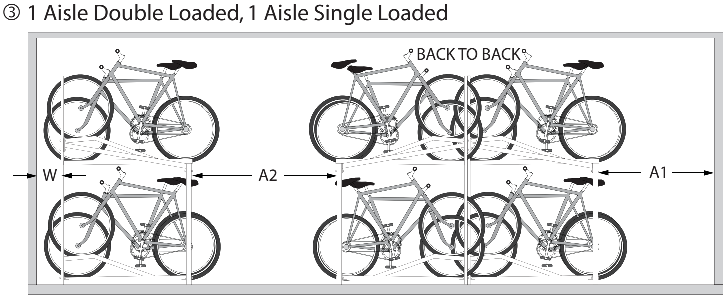




② 1 Aisle Double Loaded

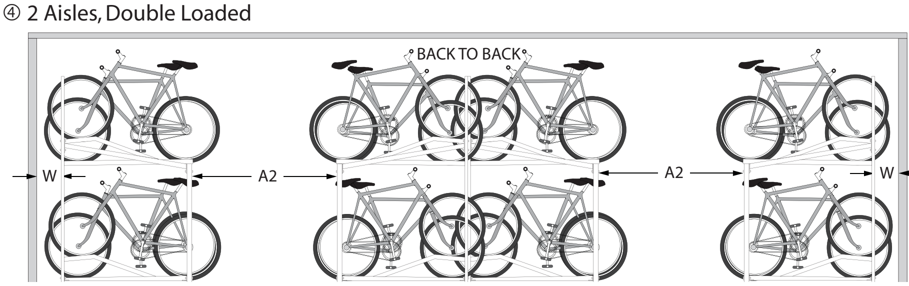


③ 1 Aisle Double Loaded, 1 Aisle Single Loaded



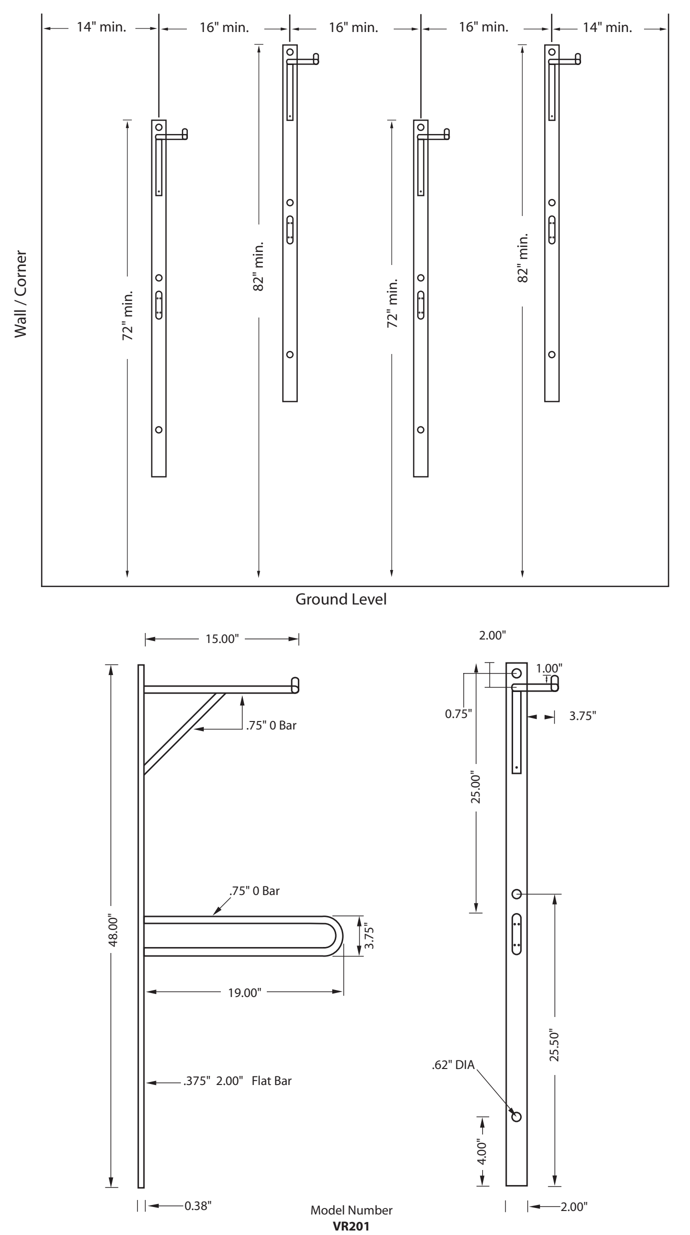
DoubleDecker™ Room Widths		
Aisle	**Minimum**	**Optimal**
A1	54″ [1.4 m]	60″ [1.5 m]
A2	60″ [1.5 m]	72″ [1.8 m]
Layout	**Minimum**	**Optimal**
①	112″ (9′-4″) [2.84 m]	124″ (10′-4″) [3.15 m]
②	188″ (15′-8″) [4.78 m]	200″ (16′-8″) [5.08 m]
③	280″ (23′-4″) [7.11 m]	304″ (25′-4″) [7.72 m]
④	356″ (29′-8″) [9.04 m]	380″ (31′-8″) [9.65 m]

④ 2 Aisles, Double Loaded



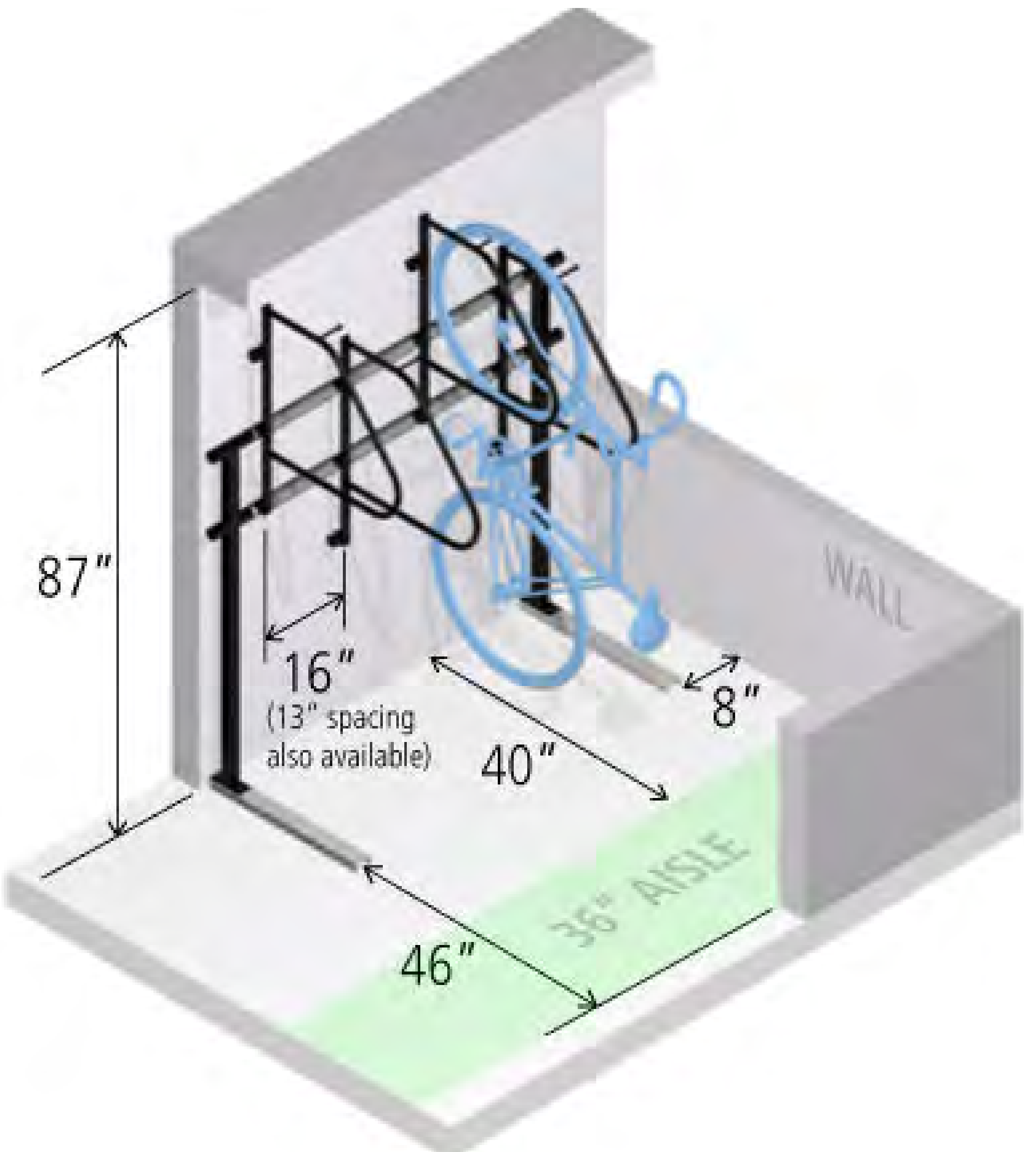
VERTICAL, STAGGERED RACK MOUNTING SYSTEM

- Recommended rack spacing of 16" with vertical stagger of 10"
- Allow one foot minimum between wall and rack
- Minimum floor to ceiling distance of 88", minimum depth of 42"
- Sheetrock walls will generally need a plywood backing



VERTICAL, MODULAR STAGGERED RACK MOUNTING SYSTEM

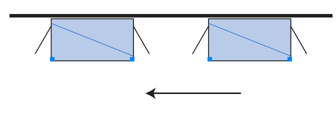
- Can be wall mount, floor mount (freestanding) or double-sided
- Minimum depth of 40"
- Minimum ceiling height of 88"
- Bicycle spacing either 16" or 13"



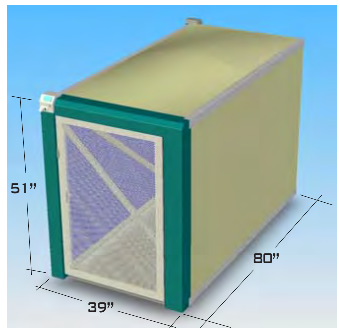
LONG-TERM PARKING: LOCKERS

RECTANGULAR

2 spaces, 2 Electronic Controllers
best for limited clearance situations

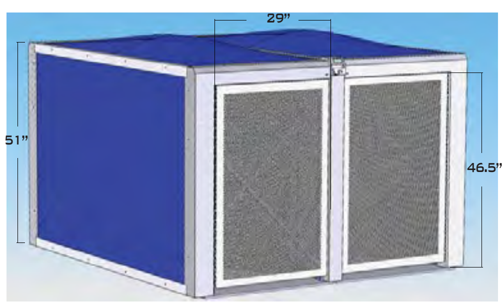


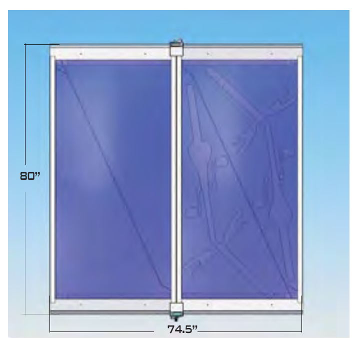
Both doors hinge from same side to make getting your bike in and out easier when locker is placed against a wall.



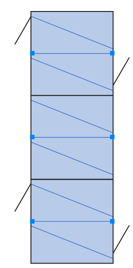
QUAD

4 spaces, 2 Electronic Controllers
lowest cost per space



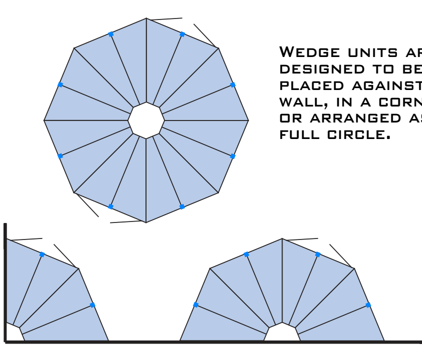


Save locker costs & simplify direct power supply by grouping quads.

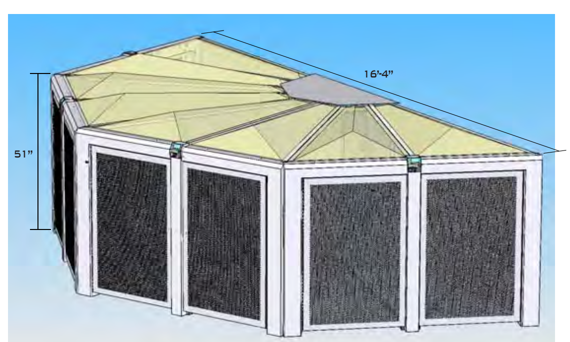


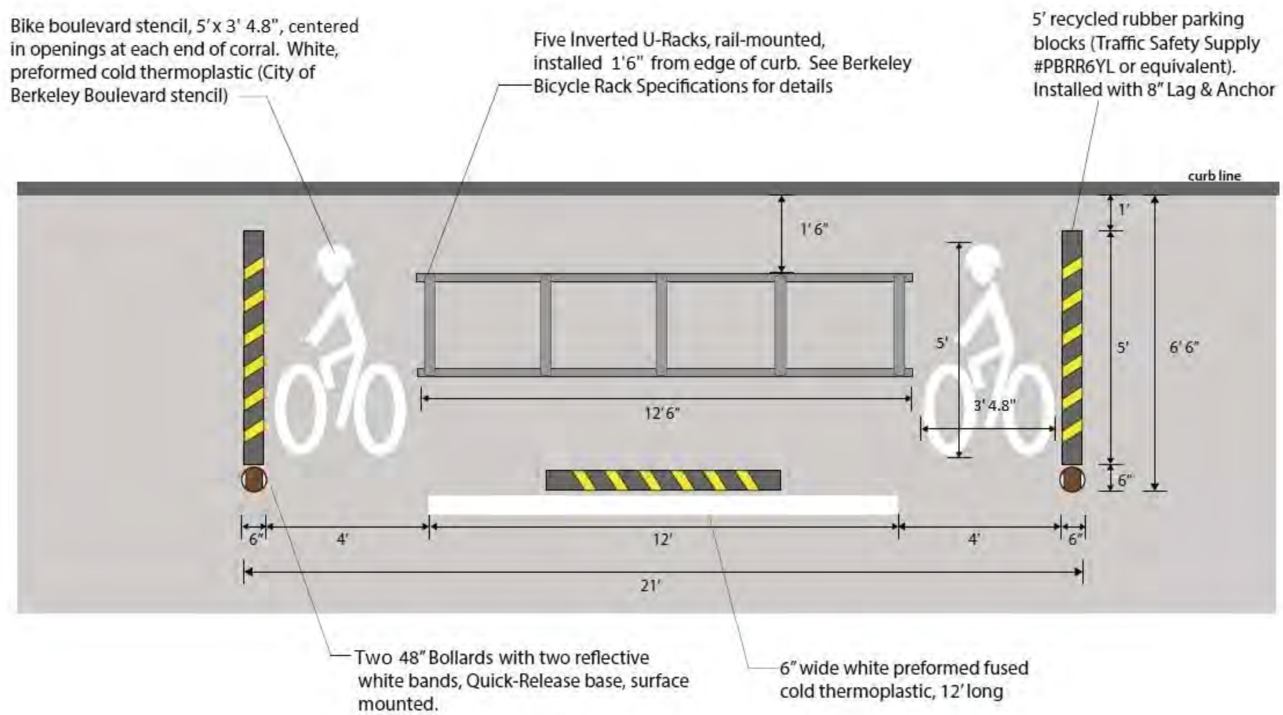
WEDGE

Each wedge has 2 spaces served by 1 Electronic Controller
best when open visibility and free traffic flow are important



Wedge units are designed to be placed against a wall, in a corner, or arranged as a full circle.




Bike boulevard stencil, 5' x 3' 4.8", centered in openings at each end of corral. White, preformed cold thermoplastic (City of Berkeley Boulevard stencil)
Five Inverted U-Racks, rail-mounted, installed 1'6" from edge of curb. See Berkeley Bicycle Rack Specifications for details
5' recycled rubber parking blocks (Traffic Safety Supply #PBRR6YL or equivalent). Installed with 8" Lag & Anchor
curb line
1'6"
1'
5'
5'
6'6"
12'6"
3'4.8"
6"
6"
4'
12'
4'
6"
21'
Two 48" Bollards with two reflective white bands, Quick-Release base, surface mounted.
6" wide white preformed fused cold thermoplastic, 12' long

Minimum Bike Parking Requirements

Uses listed below shall meet the district minimum bike parking requirement of two long term spaces and two short term spaces, unless otherwise stated in the table. In all cases, the greater of the requirements shall apply. No bike parking is required for uses not specified in this table. Applicants are encouraged to provide more bike parking than the minimums specified below.

NOTE: For mixed-use buildings, bike parking shall be required for each use.

USE	LONG-TERM PARKING REQUIREMENT	SHORT-TERM PARKING REQUIREMENT
General Commercial (retail sales, personal household services, food and alcohol service)	1, or 1 per 10,000 square feet of gross floor area	2, or 1 per 2,000 square feet of gross floor area
Community and Institutional Uses and Lodging, except schools and entertainment and assembly uses	1, or 1 per 10,000 square feet of gross floor area	2, or 1 per 15,000 square feet of gross floor area
Schools, Public or Private	1, or 4 spaces per classroom, or 1 per five students, or 1 per 2,500 square feet	2, or 2 spaces per classroom, or 1 per 3,500 square feet of gross floor area
Daycare or Child Care Centers	1, or 1 space per 25 students, or one per 6,000 square feet of gross floor area	2, or 1 space per 25 students, or 1 per 6,000 square feet of gross floor area
Office Uses	2, or 1 space per 2,500 square feet of gross floor area	2, or 1 space per 10,000 square feet of gross floor area
Industrial, Manufacturing and Wholesale Trade	1, or 1 space per 30,000 square feet of gross floor area	No Spaces Required
Dwelling Units (fewer than four) and Accessory Dwelling Units	No Spaces Required	No Spaces Required
Dwelling Units (five or more)	1 space per three bedrooms	2, or 1 space per 40 bedrooms
Group Living Accommodations (Dormitories, Fraternity and Sorority Houses, Rooming and Boarding Houses, Transitional Housing)	2, or 1 space per 2.5 bedrooms	2, or 1 space per 20 bedrooms
Nursing Homes and Senior Congregate Housing	1, or 1 space per 10 bedrooms	2, or 1 space per 30 bedrooms
Live/Work Units	No Spaces Required	2, or 1 space per 5 units