

# SUPPLEMENT: DESIGN GUIDELINES

## CHAPTER OUTLINE:

### OVERVIEW

### DESIGN NEEDS OF BICYCLISTS

### SHARED ROADWAYS

### BICYCLE BOULEVARDS

### SEPARATED BIKEWAYS

### PROTECTED BIKE LANES

### SEPARATED BIKEWAYS AT INTERSECTIONS

### SIGNALIZATION

### BIKEWAY SIGNING

### RETROFITTING STREETS TO ADD BIKEWAY

### SHARED USE PATHS

### SHARED USE PATH/ROAD CROSSINGS

### BICYCLE PARKING

### BIKEWAY MAINTENANCE

## OVERVIEW

The sections that follow serve as an inventory of bicycle design treatments and provide guidelines for their development. These treatments and design guidelines are important because they represent the tools for creating a bicycle-friendly, safe, accessible community. The guidelines are not, however, a substitute for a more thorough evaluation by a landscape architect or engineer upon implementation of facility improvements. Some improvements may also require cooperation with the Colorado DOT for specific design solutions. The following standards and guidelines are referred to in this guide.

- The Federal Highway Administration's **Manual on Uniform Traffic Control Devices (MUTCD)** is the primary source for guidance on lane striping requirements, signal warrants, and recommended signage and pavement markings.
- American Association of State Highway and Transportation Officials (AASHTO) **Guide for the Development of Bicycle Facilities**, updated in June 2012 provides guidance on dimensions, use, and layout of specific bicycle facilities.
- The National Association of City Transportation Officials' (NACTO) 2012 **Urban Bikeway Design Guide** is the newest publication of nationally recognized bikeway design standards, and offers guidance on the current state of the practice designs. All of the NACTO Urban Bikeway Design Guide treatments are in use internationally and in many cities around the US.
- Meeting the requirements of the Americans with Disabilities Act (ADA) is an important part of any bicycle facility project. The United States Access Board's proposed **Public Rights-of-Way Accessibility Guidelines (PROWAG)** and the **2010 ADA Standards for Accessible Design** (2010 Standards) contain standards and guidance for the construction of accessible facilities.

Should the national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions. A qualified engineer or landscape architect should be consulted for the most up to date and accurate cost estimates.



## Pedestrian and Bicycle Information Center



The Pedestrian and Bicycle Information Center, NACTO, AASHTO, the MUTCD, nationally recognized bikeway standards, and other sources have all informed the content of this appendix.

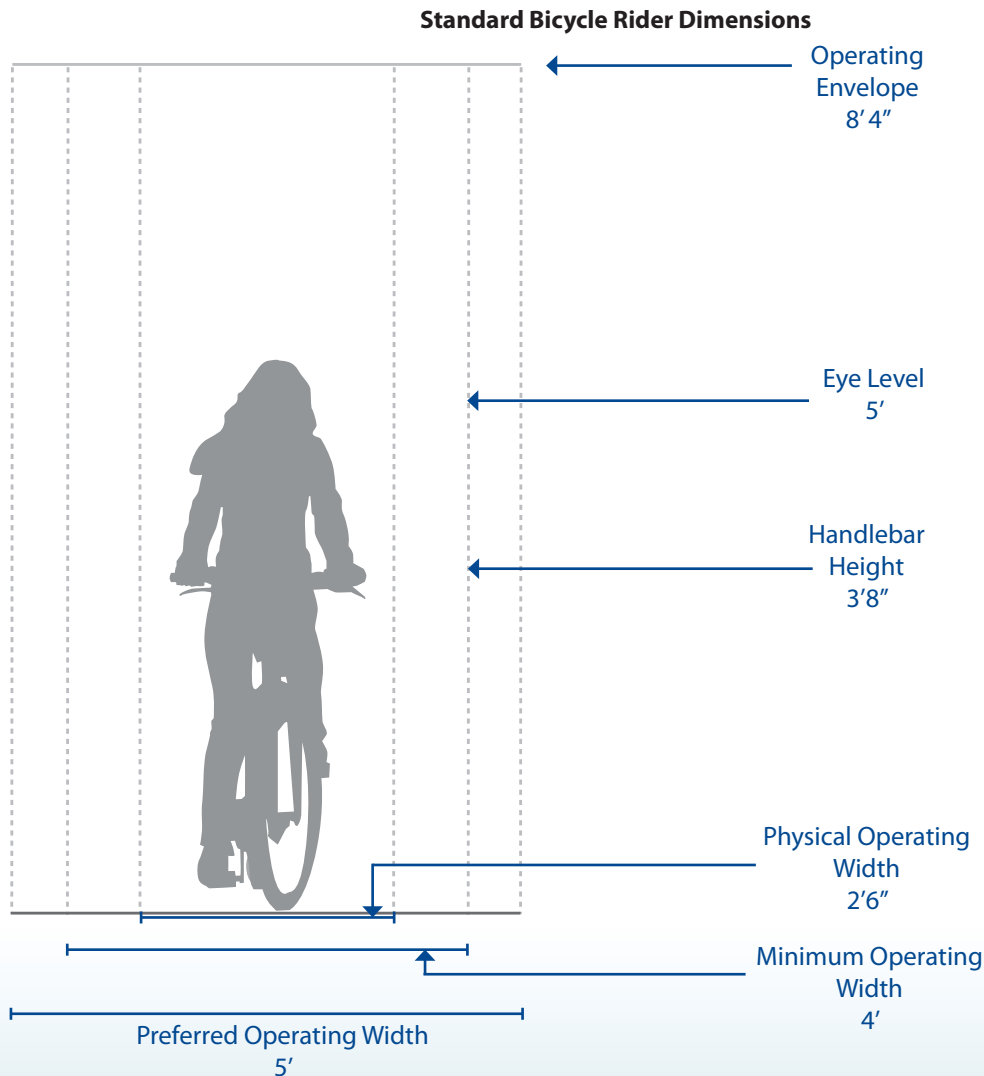
## DESIGN NEEDS OF BICYCLISTS

The purpose of this section is to provide the facility designer with 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. Bicyclists lack the protection from the elements and roadway hazards provided by an automobile's structure and safety features. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

### BICYCLE AS A DESIGN VEHICLE

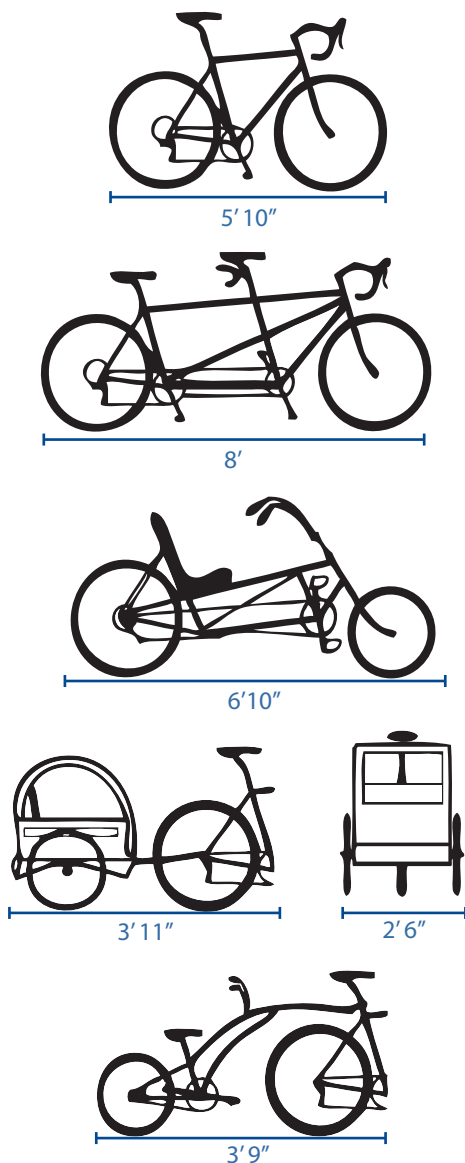
Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The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

The figure below 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.



Source: AASHTO Guide for the Development of Bicycle Facilities, 4th Edition. 2012.

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 and table below summarize the typical dimensions for bicycle types.



**Bicycle as Design Vehicle - Typical Dimensions**

Source: AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition \*AASHTO does not provide typical dimensions for tricycles.

**DESIGN SPEED EXPECTATIONS**

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

**Bicycle as Design Vehicle - Typical Dimensions**

Bicycle Type	Feature	Typical Dimensions
<b>Upright Adult Bicyclist</b>	Physical width	2 ft 6 in
	Operating width (Minimum)	4 ft
	Operating width (Preferred)	5 ft
	Physical length	5 ft 10 in
	Physical height of handlebars	3 ft 8 in
	Operating height	8 ft 4 in
	Eye height	5 ft
	Vertical clearance to obstructions (tunnel height, lighting, etc)	10 ft
Approximate center of gravity	2 ft 9 in - 3 ft 4 in	
<b>Recumbent Bicyclist</b>	Physical length	8 ft
	Eye height	3 ft 10 in
<b>Tandem Bicyclist</b>	Physical length	8 ft
<b>Bicyclist with child trailer</b>	Physical length	10 ft
	Physical width	2 ft 6 in

**Bicycle as Design Vehicle - Design Speed Expectations**

Bicycle Type	Feature	Typical Speed
<b>Upright Adult Bicyclist</b>	Paved level surfacing	15 mph
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5-12 mph
<b>Recumbent Bicyclist</b>	Paved level surfacing	18 mph

\*Tandem bicycles and bicyclists with trailers have typical speeds equal to or less than upright adult bicyclists.

## TYPES OF BICYCLISTS

It is important to consider bicyclists of all skill levels when creating a non-motorized plan or project. Bicyclist skill level greatly influences expected speeds and behavior, both in separated bikeways and on shared roadways. Bicycle infrastructure should accommodate as many user types as possible, with decisions for separate or parallel facilities based on providing a comfortable experience for the greatest number of people.

The bicycle planning and engineering professions currently use several systems to classify the population which can assist in understanding the characteristics and infrastructure preferences of different bicyclists. The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs Transportation) and on the level of comfort and skill of the rider (Causal vs Experienced). A more detailed framework for understanding of the US population’s relationship to transportation focused bicycling is illustrated in the figure below. Developed by planners in Portland, OR<sup>1</sup> and supported by research<sup>2</sup>, this classification provides the following alternative categories to address varying attitudes towards bicycling in the US:

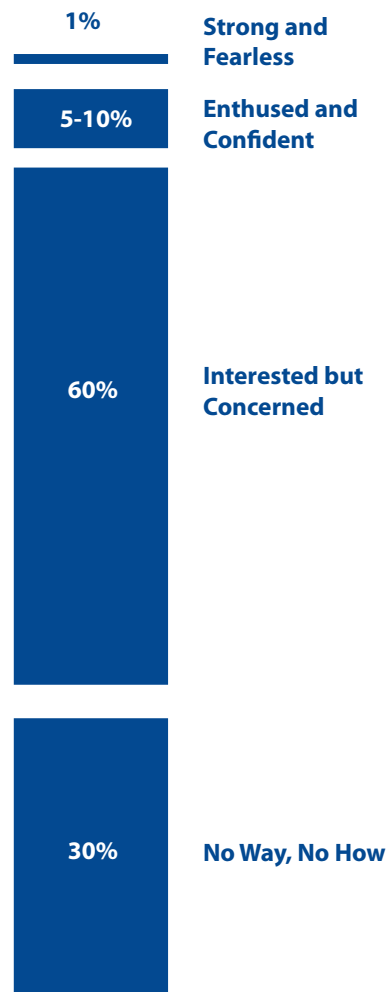
- Strong and Fearless** (approximately 1% of population)

  - Characterized by bicyclists that will typically ride anywhere regardless of roadway conditions or weather. These bicyclists can ride faster than other user types, prefer direct routes and will typically choose roadway connections -- even if shared with vehicles -- over separate bicycle facilities such as shared use paths.
- Enthusied and Confident** (5-10% of population) -

  - This user group encompasses bicyclists who are fairly comfortable riding on all types of bikeways but usually choose low traffic streets or shared use paths when available. These bicyclists may deviate from a more direct route in favor of a preferred facility type. This group includes all kinds of bicyclists such as commuters, recreationalists, racers and utilitarian bicyclists.
- Interested but Concerned** (approximately 60% of population) –

  - This user type comprises the bulk of the cycling population and represents bicyclists who typically only ride a bicycle on low traffic streets or shared use paths under favorable weather conditions. These bicyclists perceive significant barriers to their increased use of cycling, specifically traffic and other safety issues. These people may become “Enthusied & Confident” with encouragement, education and experience.
- No Way, No How** (approximately 30% of population) –

  - Persons in this category are not bicyclists, and perceive severe safety issues with riding in traffic. Some people in this group may eventually become more regular cyclists with time and education. A significant portion of these people will not ride a bicycle under any circumstances.



Typical Distribution of Bicyclist Types

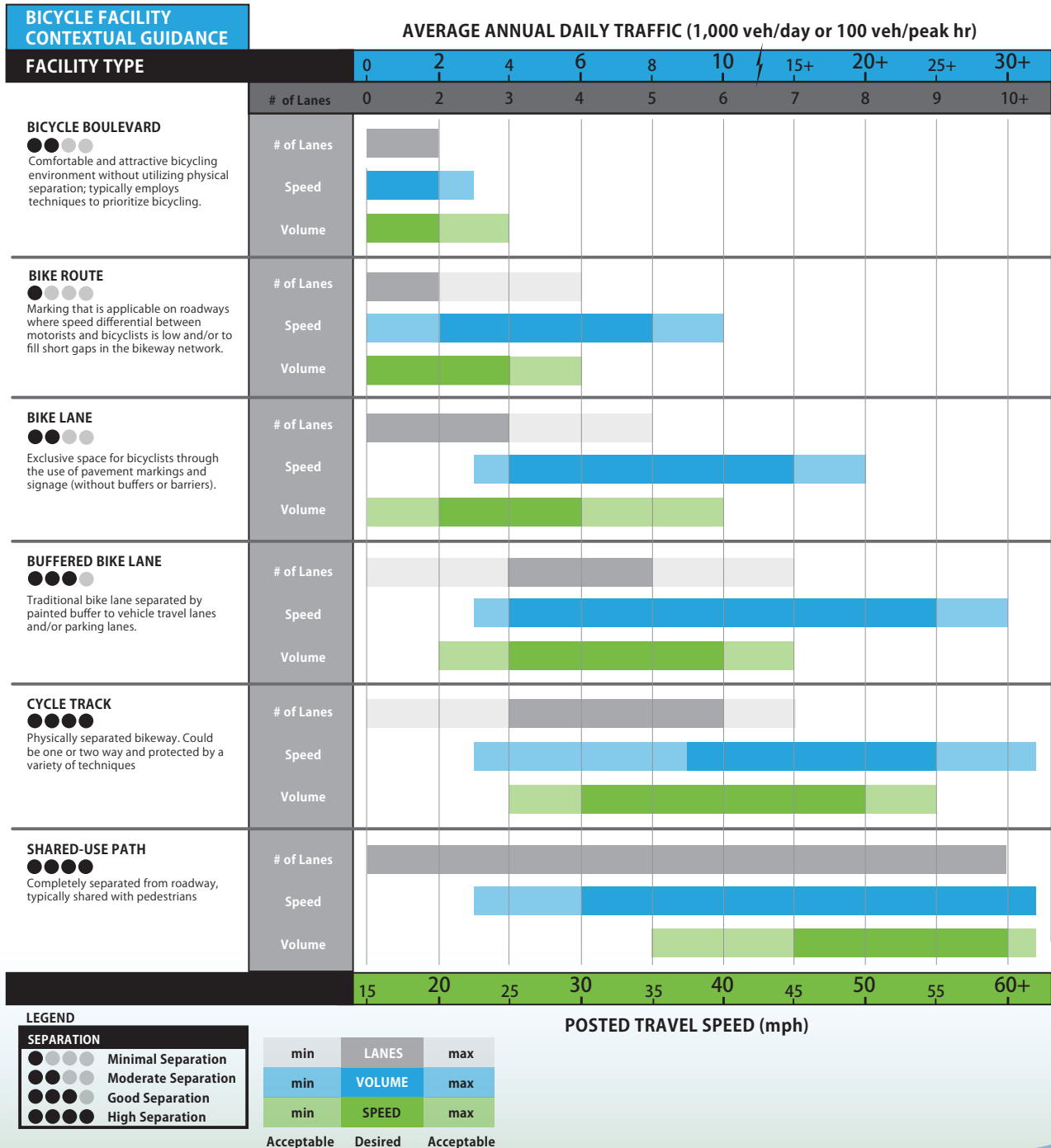
<sup>1</sup> Roger Geller, City of Portland Bureau of Transportation. *Four Types of Cyclists*. <http://www.portlandonline.com/transportation/index.cfm?&a=237507>. 2009.

<sup>2</sup> Dill, J., McNeil, N. *Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential*. 2012.

## BICYCLE FACILITY CONTEXTUAL GUIDANCE

Selecting the best bikeway facility type for a given roadway can be challenging, due to the range of factors that influence bicycle users' comfort and safety. There is a significant impact on cycling comfort when the speed differential between bicyclists and motor vehicle traffic is high and motor vehicle traffic volumes are high. As a starting point to identify a preferred facility, the chart below can be used to determine the recommended type of bikeway to be provided in particular roadway speed and volume situations. To use this chart, identify the appropriate daily traffic volume, travel speed and number of lanes on or the existing or proposed roadway, and locate the facility types indicated by those key variables.

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



## SHARED ROADWAYS

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

Shared roadways employ a large variety of treatments from simple signage and shared lane markings to more complex treatments including directional signage, traffic diverters, chicanes, chokers, and/or other traffic calming devices to reduce vehicle speeds or volumes.

### *Bicycle Boulevards*

Bicycle boulevards are a special type of shared roadway facility designed to be attractive to people of all ages and abilities. They are low-volume local streets where motorists and bicyclists share the same travel lane. Treatments for bicycle boulevards are selected as necessary to create appropriate automobile volumes and speeds, and to provide safe crossing opportunities of busy streets. Because the design of these facilities is more involved than just placing signs and markings, bicycle boulevards are described in their own section within this guide.



**Bike Route - Signed Shared Roadway**



**Sharrow - Marked Shared Roadway**



**Bicycle Boulevard**

## Bike Route - Signed Shared Roadway

### Description

Bike Routes are shared roadways bikeways marked with a sign to designate their classification as a bicycle corridor. On these facilities, bicyclists travel in the same general purpose travel lane as automobiles. The width of the lane influences the preferred lateral position of bicyclists.

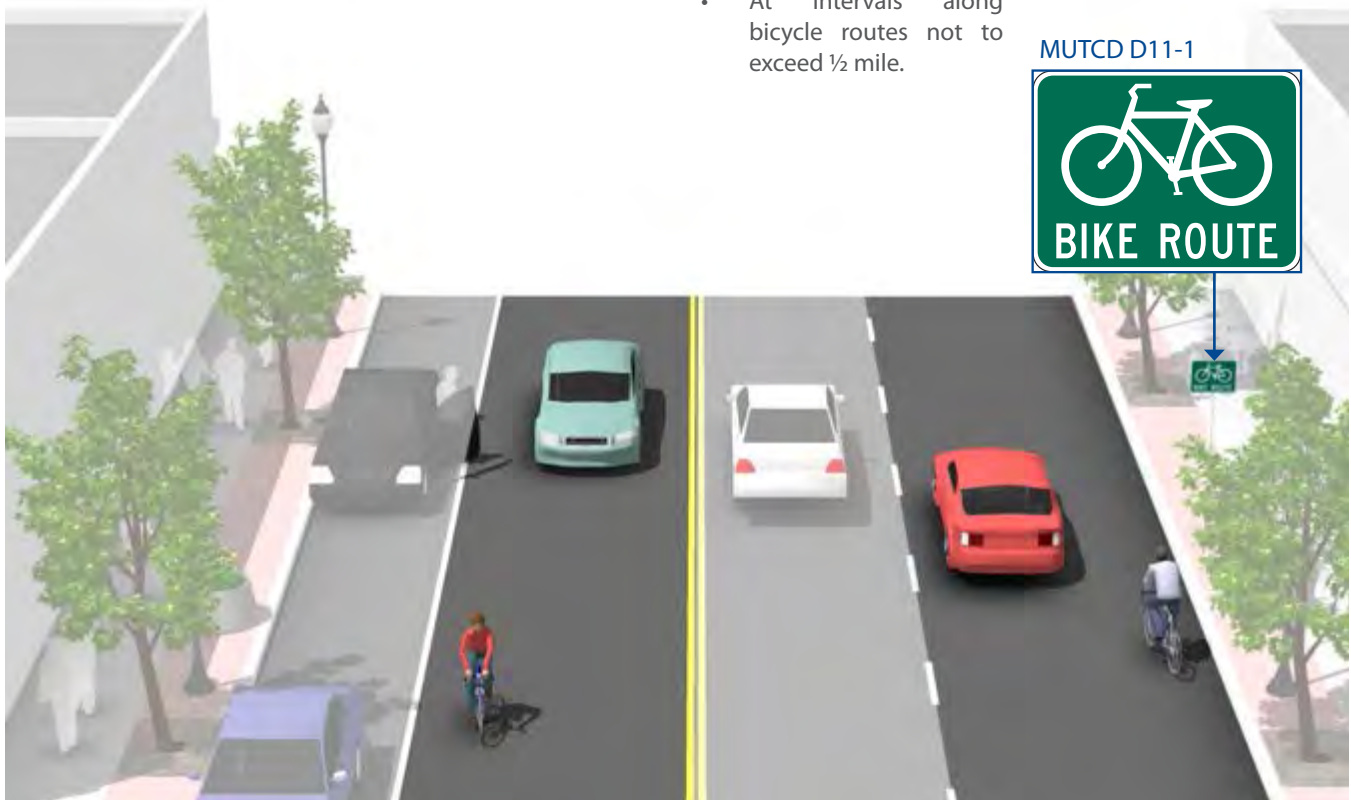
### Guidance

Lane width varies depending on roadway configuration.

Bike route signage (D11-1) should be applied at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists. Commonly, this includes placement at:

- Beginning or end of Bicycle Route.
- At major changes in direction or at intersections with other bicycle routes.
- At intervals along bicycle routes not to exceed ½ mile.

MUTCD D11-1



### Discussion

Signed shared roadways serve either to provide continuity with other bicycle facilities (usually bike lanes) or to designate preferred routes through high-demand corridors.

This configuration differs from a bicycle boulevard due to a lack of traffic calming, wayfinding, pavement markings and other enhancements designed to provide a higher level of comfort for a broad spectrum of users.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
FHWA. *Manual on Uniform Traffic Control Devices*. 2009.

### Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs, and will need periodic replacement due to wear.

# Sharrow - Marked Shared Roadway

## Description

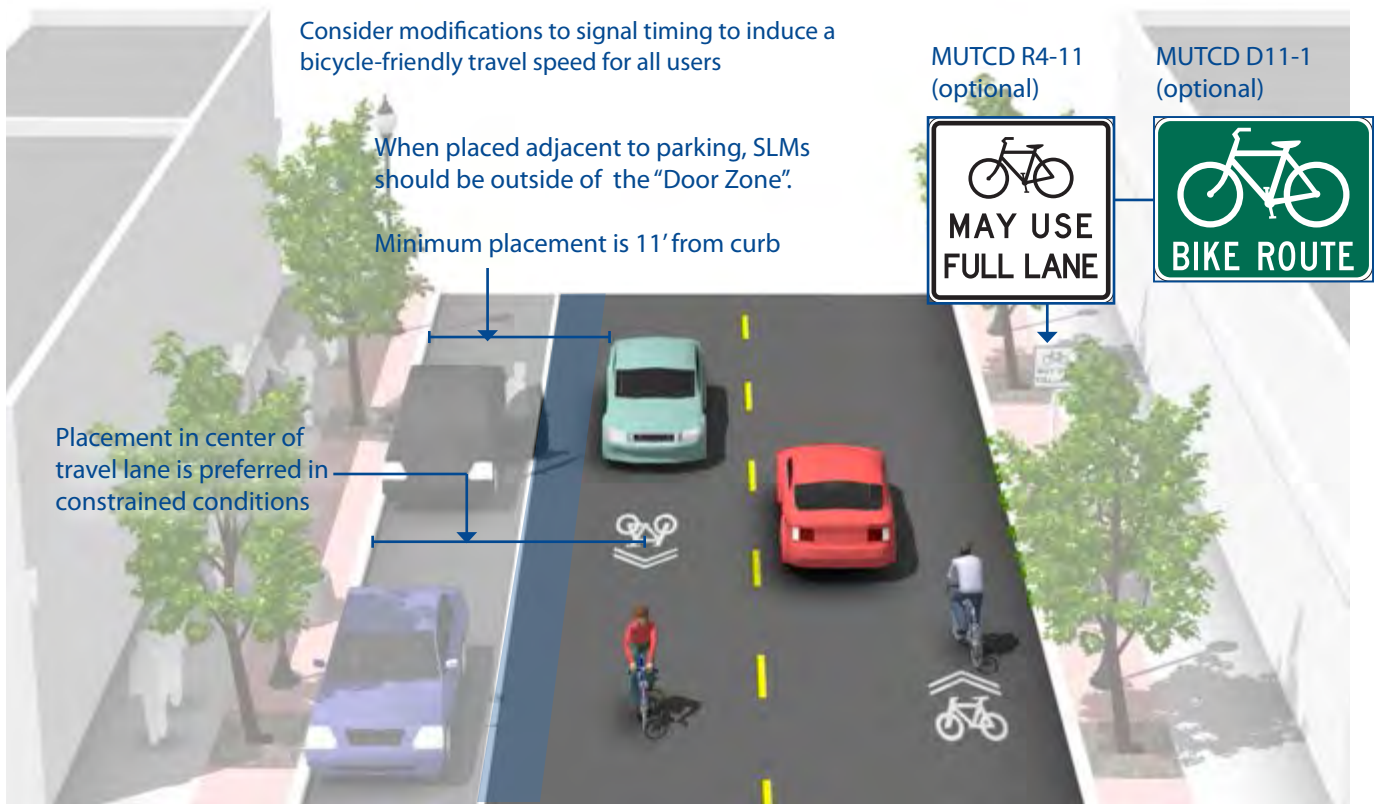
A marked shared roadway is a general purpose travel lane marked with shared lane markings (SLM) used to encourage bicycle travel and proper positioning within the lane.

In constrained conditions, the SLMs are placed in the middle of the lane. On a wide outside lane, the SLMs can be used to promote bicycle travel to the right of motor vehicles.

In all conditions, SLMs should be placed outside of the door zone of parked cars.

## Guidance

- May be used on streets with a speed limit of 35 mph or under. Lower than 30 mph speed limit preferred.
- In constrained conditions, preferred placement is in the center of the travel lane to minimize wear and promote single file travel.
- Minimum placement of SLM marking centerline is 11 feet from edge of curb where on-street parking is present, 4 feet from edge of curb with no parking. If parking lane is wider than 7.5 feet, the SLM should be moved further out accordingly.



## Discussion

If collector or arterial, this should not be a substitute for dedicated bicycle facilities if space is available.

Bike Lanes should be considered on roadways with outside travel lanes wider than 15 feet, or where other lane narrowing or removal strategies may provide adequate road space. SLMs shall not be used on shoulders, in designated bike lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07)

## Additional References and Guidelines

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
- NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Placing SLMs between vehicle tire tracks will increase the life of the markings and minimize the long-term cost of the treatment.

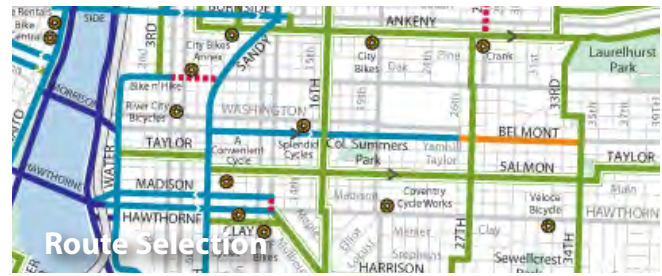


## BICYCLE BOULEVARDS

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

Jurisdictions throughout the country use a wide variety of strategies to determine where specific treatments are applied. While no federal guidelines exist, several best practices have emerged for the development of bicycle boulevards. At a minimum, bicycle boulevards should include distinctive pavement markings and wayfinding signs. They can also use combinations of traffic calming, traffic diversion, and intersection treatments to improve the bicycling environment. The appropriate level of treatment to apply is dependent on roadway conditions, particularly motor vehicle speeds and volumes.

Traffic conditions on bicycle boulevards should be monitored to provide guidance on when and where treatments should be implemented. When motor vehicle speeds and volumes or bicyclist delay exceed the preferred limits, additional treatments should be considered for the bicycle boulevard.



Basic Treatments



Traffic Calming



Traffic Diversion



Intersection Treatments

# Route Selection

## Description

Bicycle boulevards should be developed on streets that improve connectivity to key destinations and provide a direct route for bicyclists. Local streets with existing traffic calming, traffic diversions, or signalized crossings of major streets are good candidates, as they tend to be existing bicycle routes and have low motor vehicle speeds and volumes. Other streets where residents have expressed a desire for traffic calming are also good options.

Bicycle boulevards parallel to commercial streets improve access for “interested but concerned” bicyclists and complement bike lanes on major roadways.

## Guidance

- Streets are signed at 25 mph or less to improve the bicycling environment and decrease the risk and severity of crashes.
- Traffic volumes are limited to 3,000 vehicles per day (ideally less than 1,500) to minimize passing events and potential conflicts with motor vehicles.
- Use of streets that parallel major streets can discourage non-local motor vehicle traffic without significantly impacting motorists.
- Use of streets where a relatively continuous route for bicyclists exists and/or where treatments can provide wayfinding and improve crossing opportunities at offset intersections.
- Use of streets where bicyclists have right-of-way at intersections or where right-of-way is possible to assign to bicyclists.



In Portland, OR, the bicycle network includes a high density of bicycle boulevards parallel to streets with bike lanes.

- MULTI-USE PATH  
Closed to motor vehicles
- - - MULTI-USE PATH (unpaved)
- BIKE BOULEVARDS / NEIGHBORHOOD GREEN STREETS  
pavement markings & directional signs to guide cyclists
- SHARED ROADWAY  
on lower traffic street
- BIKE LANE  
or wide shoulder, usually on higher traffic streets
- SHARED ROADWAY WITH WIDER OUTSIDE LANE  
on moderate and higher traffic street

## Discussion

Bicycle boulevards should form a continuous network of streets or off-street facilities that accommodate bicyclists who are less willing to ride on streets with motorized traffic. Most bicycle boulevards are located on residential streets, though they can also be on commercial or industrial streets. Due to the presence of trucks and commercial vehicles, as well as the need to maintain good traffic flow and retain motor vehicle parking, bicycle boulevards on commercial or industrial streets can tolerate higher automobile speeds and volumes than would be desired on neighborhood streets. Vertical traffic calming can minimize impacts to large vehicles and parking.

## Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.  
 Alta Planning + Design and IBPL. *Bicycle Boulevard Planning and Design Handbook*. 2009.  
 City of Emeryville. *Bicycle Boulevard Treatments*. 2011.

## Materials and Maintenance

Repaving, street sweeping and other maintenance should occur with higher frequency than on other local streets.

## Basic Treatments

### Description

Signs and pavement markings are the minimum treatments necessary to designate a street as a bicycle boulevard. Together, they visibly designate a roadway to both bicyclists and motorists. Signs, and in some cases pavement markings, provide wayfinding to help bicyclists remain on the designated route.

### Guidance

#### Pavement Markings

Place symbols every 250-800 feet along a linear corridor, as well as after every intersection.

On narrow streets where a motor vehicle cannot pass a bicyclist within one lane of traffic, place stencils in the center of the travel lane.

See Marked Shared Roadway guidance for additional information on the use of shared lane markings.

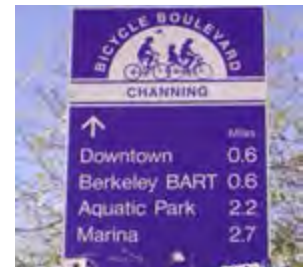
A bicycle symbol can be placed on a standard road sign, along with distinctive coloration.

#### Signs

See Bikeway Signing for guidance on developing bicycle wayfinding signage. Some cities have developed unique logos or colors for wayfinding signs that help brand their bicycle boulevards.

Be consistent in content, design, and intent; colors reserved by the Manual on Uniform Traffic Devices (MUTCD) for regulatory and warning road signs are not recommended.

Signs can include information about intersecting bikeways and distance/time information to key destinations.



### Discussion

Wayfinding signs displaying destinations, distances, and “riding time” can dispel common misperceptions about time and distance while increasing users’ comfort and accessibility to the bicycle boulevard network. Bicycle boulevards frequently include offset intersections or ‘jog’ onto another street. Signs and pavement markings can help bicyclists remain on the route. In addition, fewer businesses or services are located along local streets, and signs inform bicyclists of the direction to key destinations, including commercial districts, transit hubs, schools and universities, and other bikeways.

### Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Pavement markings should be repainted and signs replaced as needed. Wayfinding signs should be regularly updated with new major destinations and bikeways.

## Vertical Traffic Calming

### Description

Motor vehicle speeds affect the frequency at which automobiles pass bicyclists as well as the severity of crashes that can occur. Maintaining motor vehicle speeds closer to those of bicyclists' greatly improves bicyclists' comfort on a street. Slower vehicular speeds also improve motorists' ability to see and react to bicyclists and minimize conflicts at driveways and other turning locations.

Vertical speed control measures are composed of slight rises in the pavement, on which motorists and bicyclists must reduce speed to cross.

### Guidance

- Bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.
- Speed humps are raised areas usually placed in a series across both travel lanes. A 14' long hump reduces impacts to emergency vehicles. Speed humps can be challenging for bicyclists, gaps can be provided in the center or by the curb for bicyclists and to improve drainage. Speed humps can also be offset to accommodate emergency vehicles.
- Speed lumps or cushions have gaps to accommodate the wheel tracks of emergency vehicles.
- Speed tables are longer than speed humps and flat-topped. Raised crosswalks are speed tables that are marked and signed for a pedestrian crossing.
- For all vertical traffic calming, slopes should not exceed 1:10 or be less steep than 1:25. Tapers should be no greater than 1:6 to reduce the risk of bicyclists losing their balance. The vertical lip should be no more than a 1/4" high.



Speed Hump



Offset Speed Hump



Temporary Speed Cushion



Raised Crosswalk

### Discussion

Emergency vehicle response times should be considered where vertical deflection is used. Because emergency vehicles have a wider wheel base than passenger cars, speed lumps/cushions allow them to pass unimpeded while slowing most other traffic. Alternatively, speed tables are recommended because they cannot be straddled by a truck, decreasing the risk of bottoming out. Traffic calming can also deter motorists from driving on a street. Monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

### Additional References and Guidelines

NACTO. *Urban Street Design Guide*. 2013.

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

Alta Planning + Design and IBPI. *Bicycle Boulevard Planning and Design Handbook*. 2009.

### Materials and Maintenance

Traffic calming should be designed to minimize impacts to snowplows. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

# Horizontal Traffic Calming

## Description

Horizontal traffic calming devices cause drivers to slow down by constricting the roadway space or by requiring careful maneuvering.

Such measures may reduce the design speed of a street, and can be used in conjunction with reduced speed limits to reinforce the expectation of lowered speeds.

## Guidance

- Maintain a minimum clear width of 20 feet (or 28 feet with parking on both sides), with a constricted length of at least 20 feet in the direction of travel.
- Chicanes are a series of raised or delineated curb extensions, edge islands, or parking bays on alternating sides of a street forming an “S”-shaped curb, which reduce vehicle speeds by requiring motorists to shift laterally through narrowed travel lanes.
- Pinchpoints are curb extensions placed on both sides of the street, narrowing the travel lane and encouraging all road users to slow down. When placed at intersections, pinchpoints are known as chokers or neckdowns. They reduce curb radii and further lower motor vehicle speeds.
- Traffic circles are raised or delineated islands placed at intersections that reduce vehicle speeds by narrowing turning radii and the travel lane. Traffic circles can also include a paved apron to accommodate the turning radii of larger vehicles like fire trucks or school buses.



Temporary Curb Extension



Chicane



Choker or Neckdown



Pinchpoint with Bicycle Access

## Discussion

Horizontal speed control measures should not infringe on bicycle space. Where possible, provide a bicycle route outside of the element so bicyclists can avoid having to merge into traffic at a narrow pinch point. This technique can also improve drainage flow and reduce construction and maintenance costs. Traffic calming can also deter motorists from driving on a street. Monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
Alta Planning + Design and IBPI. *Bicycle Boulevard Planning and Design Handbook*. 2009.  
Ewing, Reid and Brown, Steven. *U.S. Traffic Calming Manual*. 2009.  
NACTO. *Urban Street Design Guide*. 2013.

## Materials and Maintenance

Traffic calming should be designed to minimize impacts to snowplows. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

## Traffic Diversion

### Description

Motor vehicle traffic volumes affect the operation of a bicycle boulevard. Higher vehicle volumes reduce bicyclists' comfort and can result in more conflicts.

Implement volume control treatments based on the context of the bicycle boulevard, using engineering judgment. Target motor vehicle volumes range from 1,000 to 3,000 vehicles per day, above which the route should be striped as a bike lane or considered a signed shared roadway.

### Guidance

- Traffic diversion treatments reduce motor vehicle volumes by completely or partially restricting through traffic on a bicycle boulevard.
- Partial closures allow full bicycle passage while restricting vehicle access to one way traffic at that point.
- Diagonal diverters require all motor vehicle traffic to turn.

Median diverters (see Major Intersection Treatments) restrict through motor vehicle movements while providing a refuge for bicyclists to cross in two stages.

- Street closures create a "T" that blocks motor vehicles from continuing on a bicycle boulevard, while bicycle travel can continue unimpeded. Full closures can accommodate emergency vehicles with the use of mountable curbs (maximum of six inches high).



Partial Closure



Diagonal Diverter



Median Diverter



Full Closure

### Discussion

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

### Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

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

Alta Planning + Design and IBPI. *Bicycle Boulevard Planning and Design Handbook*. 2009.

### Materials and Maintenance

Depending on the diverter type, these treatments can be challenging to keep clear of snow and debris. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

# Minor Intersection Treatments

## Description

Treatments at minor roadway intersections are designed to improve the visibility of a bicycle boulevard, raise awareness of motorists on the cross-street that they are likely to encounter bicyclists, and enhance safety for all road users.

## Guidance

- On the bicycle boulevard, the majority of intersections with minor roadways should stop-control cross traffic to minimize bicyclist delay. This will maximize bicycling efficiency.

Traffic circles are a type of horizontal traffic calming that can be used at minor street intersections. Traffic circles reduce conflict potential and severity while providing traffic calming to the corridor.

- If a stop sign is present on the bicycle boulevard, a second stop bar for bicyclists can be placed closer to the centerline of the cross street than the motorists' stop bar to increase the visibility of bicyclists waiting to cross the street.
- Curb extensions can be used to move bicyclists closer to the centerline to improve visibility and encourage motorists to let them cross.



Stop Signs on Cross-Street



Traffic Circles



Bicycle Forward Stop Bar



Curb Extension

## Discussion

Stop signs increase bicycling time and energy expenditure, frequently leading to non-compliance by bicyclists and motorists, and/or use of other less desirable routes. Bicycle boulevards should have fewer stops or delays than other local streets. A typical bicycle trip of 30 minutes can increase to 40 minutes if there is a STOP sign at every block (*Berkeley Bicycle Boulevard Design Tools and Guidelines*). If several stop signs are turned along a corridor, speeds should be monitored and traffic-calming treatments used to reduce excessive vehicle speeds on the bicycle boulevard.

## Additional References and Guidelines

Transportation Research Board. *Improving Pedestrian Safety at Unsignalized Crossings*. NCHRP Report 562. 2006.

## Materials and Maintenance

Vegetation in traffic circles and curb extensions should be regularly trimmed to maintain visibility and attractiveness. Repaint bicycle stop bars as needed.

## Major Intersection Treatments

### Description

The quality of treatments at major street crossings can significantly affect a bicyclist's choice to use a bicycle boulevard, as opposed to another road that provides a crossing treatment.

### Guidance

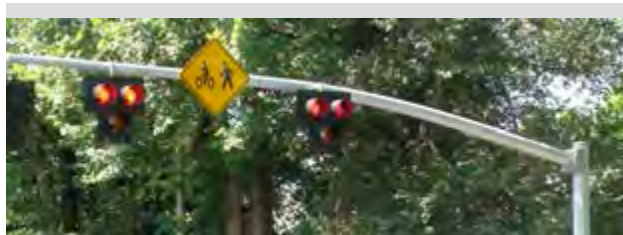
- Bike boxes increase bicyclist visibility to motorists and reduce the danger of right "hooks" by providing a space for bicyclists to wait at signalized intersections.
- Median islands provided at uncontrolled intersections of bicycle boulevards and major streets allow bicyclists to cross one direction of traffic at a time as gaps in traffic occur.
- Hybrid beacons, active warning beacons and bicycle signals can facilitate bicyclists crossing a busy street on which cross-traffic does not stop.
- Select treatments based on engineering judgment; see National Cooperative Highway Research Program (NCHRP) Report # 562 *Improving Pedestrian Safety at Unsignalized Crossings* (2006) for guidance on appropriate use of crossing treatments. Treatments are designed to improve visibility and encourage motorists to stop for pedestrians; with engineering judgement many of the same treatments are appropriate for use along bicycle boulevards.



Bike Box



Median Island



Hybrid Beacon (HAWK)



Rectangular Rapid Flash Beacon (RRFB)

### Discussion

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.

### Additional References and Guidelines

Transportation Research Board. *Improving Pedestrian Safety at Unsignalized Crossings*. NCHRP Report 562. 2006.

Federal Highway Administration. *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*. 2004.

NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Maintain signs, markings, and other treatments and replace as needed. Monitor intersections for bicyclist delay to determine if additional treatments are warranted.



# Offset Intersection Treatments

## Description

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

## Guidance

- Appropriate treatments depend on volume of traffic including turning volumes, traffic speeds and the type of bicyclist using the crossing.
- Contraflow bike lanes allow bicyclists to travel against the flow of traffic on a one-way street and can improve bicycle boulevard connectivity.
- Bicycle left-turn lanes can be painted where a bicycle boulevard is offset to the right on a street that has sufficient traffic gaps. Bicyclists cross one direction of traffic and wait in a protected space for a gap in the other direction. The bike turn pockets should be at least 4 feet wide, with a total of 11 feet for both turn pockets and center striping.
- Short bike lanes on the cross street assist with accessing a bicycle boulevard that jogs to the left. Crossing treatments should be provided on both sides to minimize wrong-way riding.
- A protected bike lane can be provided on one side of a busy street. Bicyclists enter the protected bike lane from the bicycle boulevard to reach the connecting segment of the bicycle boulevard. This maneuver may be signaled on one side.



Contraflow Bike Lane



Left Turn Bike Lanes



Short Bike Lanes on the Cross Street



Protected bike lane Connection

## Discussion

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

## Additional References and Guidelines

Hendrix, Michael. *Responding to the Challenges of Bicycle Crossings at Offset Intersections*. Third Urban Street Symposium. 2007.  
NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Facilities should be cleared of snow through routine snow removal operations.

## SEPARATED BIKEWAYS

Designated exclusively for bicycle travel, separated bikeways are segregated from vehicle travel lanes by striping, and can include pavement stencils and other treatments. Separated bikeways are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation.

Separated bikeways can increase safety and promote proper riding by:

- Defining road space for bicyclists and motorists, reducing the possibility that motorists will stray into the bicyclists' path.
- Discouraging bicyclists from riding on the sidewalk.
- Reducing the incidence of wrong way riding.
- Reminding motorists that bicyclists have a right to the road.

### *Protected Bike Lanes*

Protected bike lanes are a special type of separated bikeway. These facilities use physical barriers, such as bollards, curbs or parking to separate bicyclists from moving cars. These facilities require a high attention to detail, and have been provided an independent section within these guidelines.



**Conventional Bicycle Lanes**



**Bike Lanes and Diagonal Parking**



**Buffered Bike Lanes**



**Protected Bike Lanes**

# Conventional Bicycle Lanes

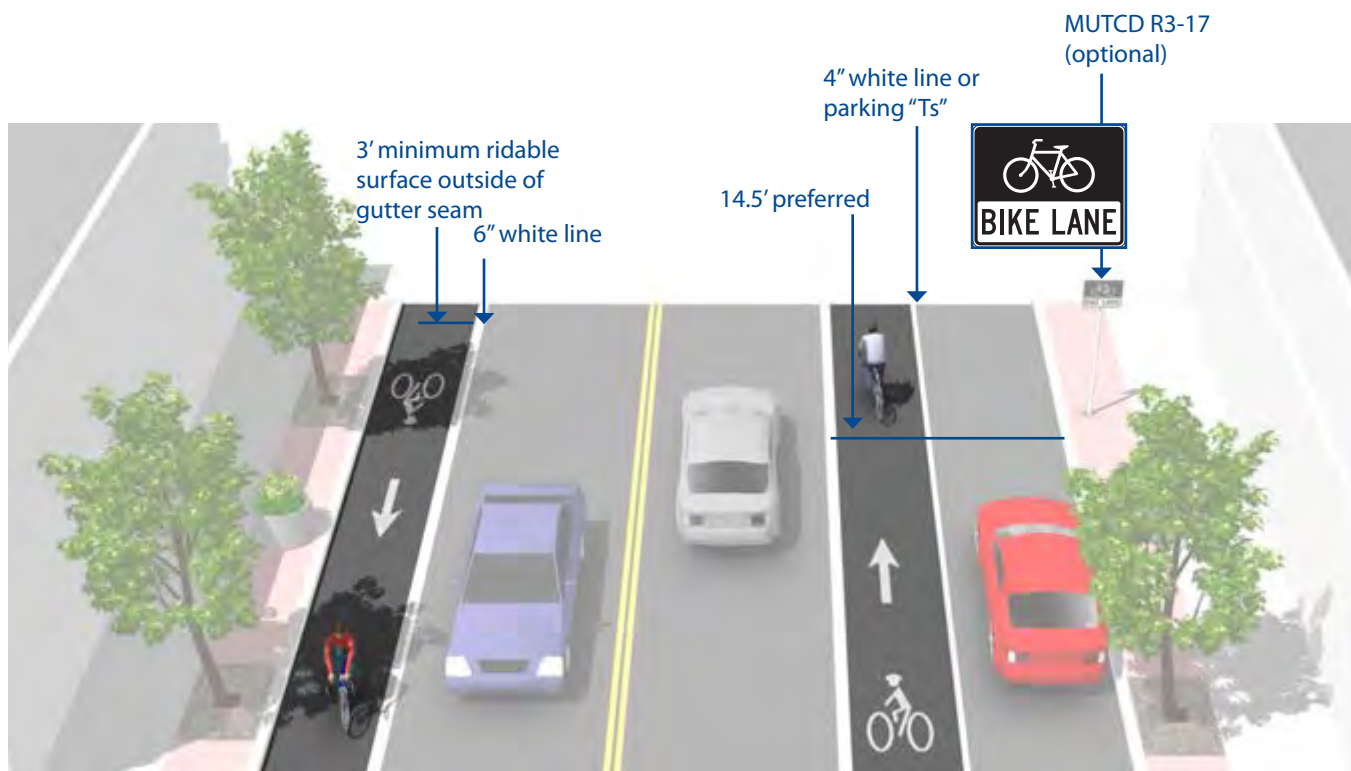
## Description

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is located 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.

Many bicyclists, particularly less experienced riders, are more comfortable riding on a busy street if it has a striped and signed bikeway than if they are expected to share a lane with vehicles.

## Guidance

- 4 foot minimum when no curb and gutter is present.
- 5 foot minimum when adjacent to curb and gutter or 3 feet more than the gutter pan width if the gutter pan is wider than 2 feet.
- When adjacent to parallel parking, 14.5 foot preferred from curb face to edge of bike lane.
- 7 foot maximum width for use adjacent to arterials with high travel speeds. Greater widths may encourage motor vehicle use of bike lane.



## Discussion

Wider bicycle lanes are desirable in certain situations such as on higher speed arterials (45 mph+) where use of a wider bicycle lane would increase separation between passing vehicles and bicyclists. Appropriate signing and stenciling is important with wide bicycle lanes to ensure motorists do not mistake the lane for a vehicle lane or parking lane. Consider buffered bike lanes when further separation is desired.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

# Bike Lanes and Diagonal Parking

## Description

In certain areas with high parking demand such as urban commercial areas, diagonal parking can be used to increase parking supply.

Back-in diagonal parking improves sight distances between drivers and bicyclists when compared to conventional head-in diagonal parking. Back-in parking is best paired with a dedicated bicycle lane.

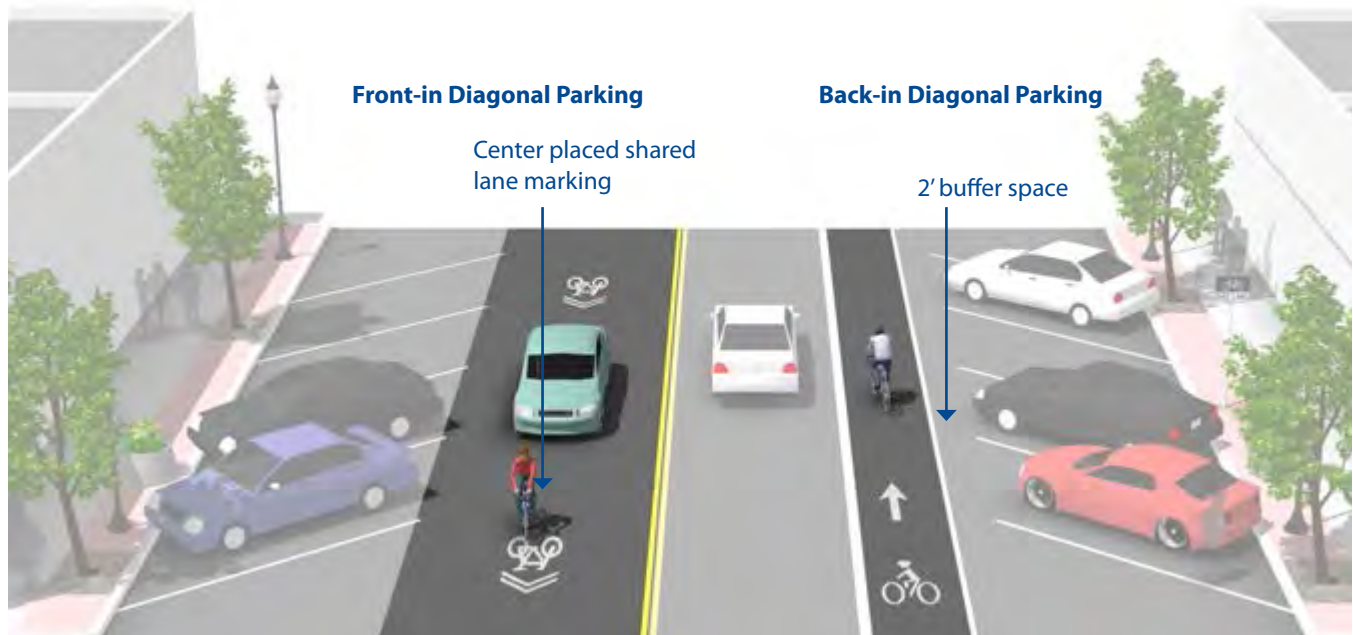
## Guidance

### Front-in Diagonal Parking

- Shared lane markings are the preferred facility with front-in diagonal parking. Position markings in the center of the adjacent travel lane.

### Back-in Diagonal Parking

- 5 foot minimum marked width of bike lane
- Parking bays are sufficiently long to accommodate most vehicles (so vehicles do not block bike lane)



## Discussion

Conventional front-in diagonal parking is not compatible or recommended with the provision of bike lanes, as drivers backing out of conventional diagonal parking have limited visibility of approaching bicyclists. Under these conditions, shared lane markings should be used to guide bicyclists away from reversing automobiles.

## Additional References and Guidelines

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

## Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

# Buffered Bike Lanes

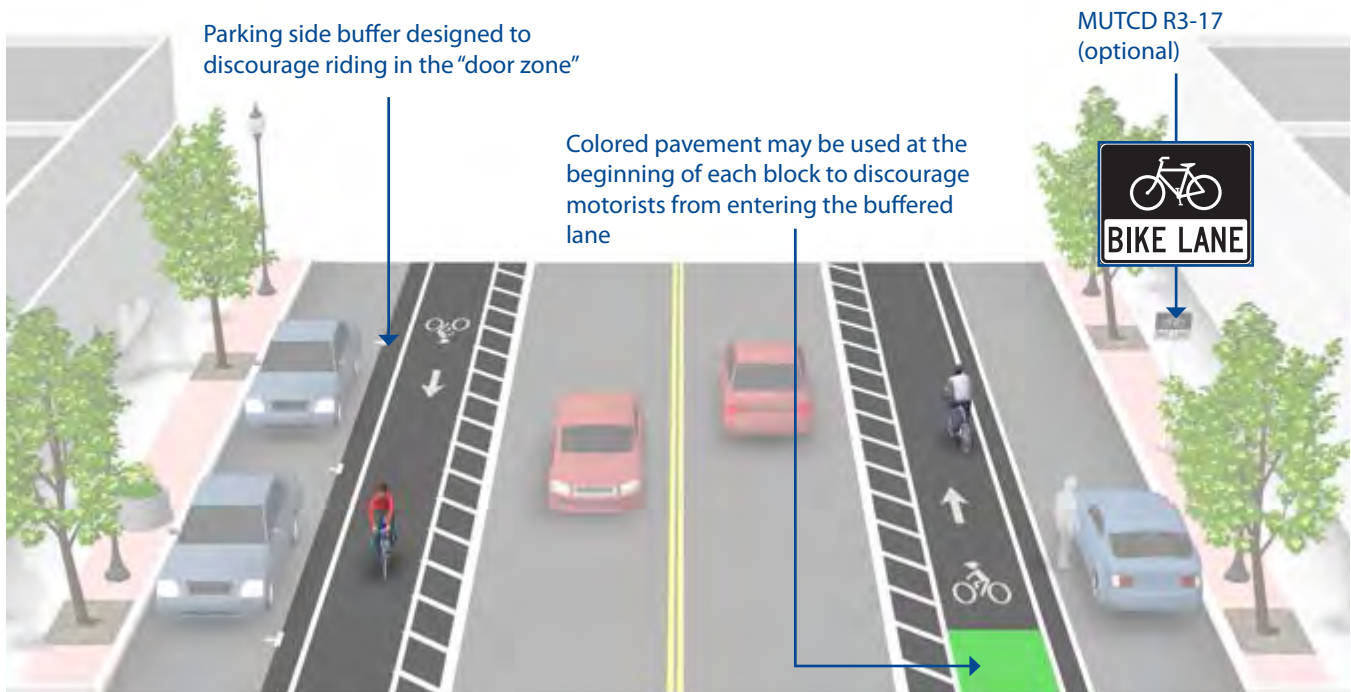
## Description

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. Buffered bike lanes follow general guidance for buffered preferential vehicle lanes as per MUTCD guidelines (section 3D-01).

Buffered bike lanes are designed to increase the space between the bike lane and the travel lane and/or parked cars. This treatment is appropriate for bike lanes on roadways with high motor vehicle traffic volumes and speed, adjacent to parking lanes, or a high volume of truck or oversized vehicle traffic.

## Guidance

- The minimum bicycle travel area (not including buffer) is 5 feet wide.
- Buffers should be at least 2 feet wide. If 3 feet or wider, mark with diagonal or chevron hatching. For clarity at driveways or minor street crossings, consider a dotted line for the inside buffer boundary where cars are expected to cross.
- Buffered bike lanes can buffer the travel lane only, or parking lane only depending on available space and the objectives of the design.



## Discussion

Frequency of right turns by motor vehicles at major intersections should determine whether continuous or truncated buffer striping should be used approaching the intersection. Commonly configured as a buffer between the bicycle lane and motor vehicle travel lane, a parking side buffer may also be provided to help bicyclists avoid the 'door zone' of parked cars.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. (3D-01). 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

## PROTECTED BIKE LANES (ALSO CALLED CYCLE TRACKS)

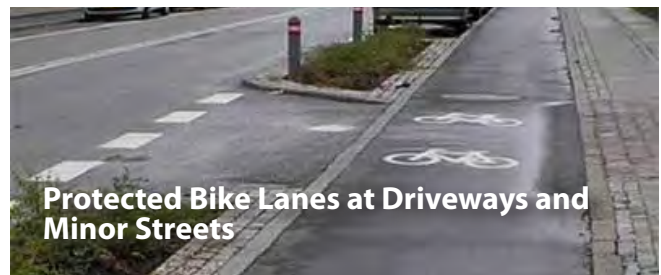
A protected bike lane is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A protected bike lane is physically separated from motor traffic and distinct from the sidewalk. Protected bike lanes have different forms but all share common elements—they provide space that is intended to be exclusively or primarily used by bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In situations where on-street parking is allowed, protected bike lanes are located to the curb-side of the parking (in contrast to bike lanes).

Protected bike lanes may be one-way or two-way, and may be at street level, sidewalk level or at an intermediate level. If at sidewalk level, a curb or median separates them from motor traffic, while different pavement color/texture separates the protected bike lane from the sidewalk. If at street level, they can be separated from motor traffic by raised medians, on-street parking or bollards.

A two-way protected bike lane is desirable when more destinations are on one side of a street (therefore preventing additional crossings), if the facility connects to a path or other bicycle facility on one side of the street, or if there is not enough room for a protected bike lane on both sides of the road.

By separating bicyclists from motor traffic, protected bike lanes can offer a higher level of comfort than bike lanes and are attractive to a wider spectrum of the public.

Intersections and approaches must be carefully designed to promote safety and facilitate left-turns from the right side of the street.



# Protected Bike Lane Separation and Placement

## Description

Protection is provided through physical barriers and can include bollards, parking, a planter strip, an extruded curb, or on-street parking. Protected bike lanes using these buffer elements typically share the same elevation as adjacent travel lanes.

Raised protected bike lanes may be at the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk to separate the protected bike lane from the pedestrian area.

## Guidance

- Protected bike lanes should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles. Protected bike lanes located on one-way streets have fewer potential conflict areas than those on two-way streets.
- In situations where on-street parking is allowed, protected bike lanes shall be located between the parking lane and the sidewalk (in contrast to bike lanes).



## Discussion

Sidewalks or other pedestrian facilities should not be narrowed to accommodate the protected bike lane as pedestrians will likely walk on the protected bike lane if sidewalk capacity is reduced. Visual and physical cues (e.g., pavement markings & signage) should be used to make it clear where bicyclists and pedestrians should be travelling. If possible, separate the protected bike lane and pedestrian zone with a furnishing zone.

## Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

In cities with winter climates, barrier separated and raised protected bike lanes may require special equipment for snow removal.

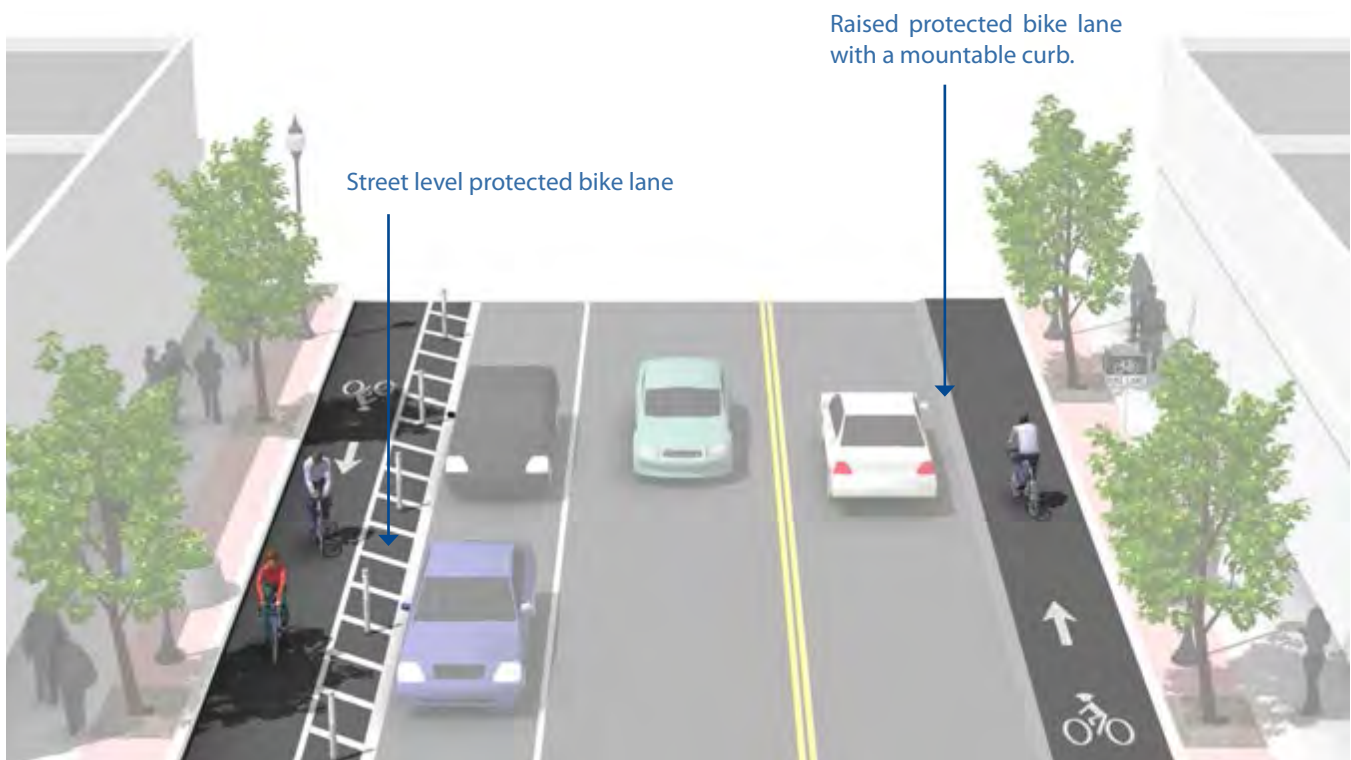
# One-Way Protected Bike Lanes

## Description

One-way protected bike lanes are physically separated from motor traffic and distinct from the sidewalk. Protected bike lanes are either raised or at street level and use a variety of elements for physical protection from passing traffic.

## Guidance

- 7 foot recommended minimum to allow passing.
- 5 foot minimum width in constrained locations.
- When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.
- When placed adjacent to a travel lane, one-way raised protected bike lanes may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes.



## Discussion

Special consideration should be given at transit stops to manage bicycle and pedestrian interactions. Driveways and minor street crossings are unique challenges to protected bike lane design. Parking should be prohibited within 30 feet of the intersection to improve visibility. Color, yield markings and “Yield to Bikes” signage should be used to identify the conflict area and make it clear that the protected bike lane has priority over entering and exiting traffic. If configured as a raised protected bike lane, the crossing should be raised so that the sidewalk and protected bike lane maintain their elevation through the crossing.

## Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

In cities with winter climates, barrier separated and raised protected bike lanes may require special equipment for snow removal.



## Two-Way Protected Bike Lanes

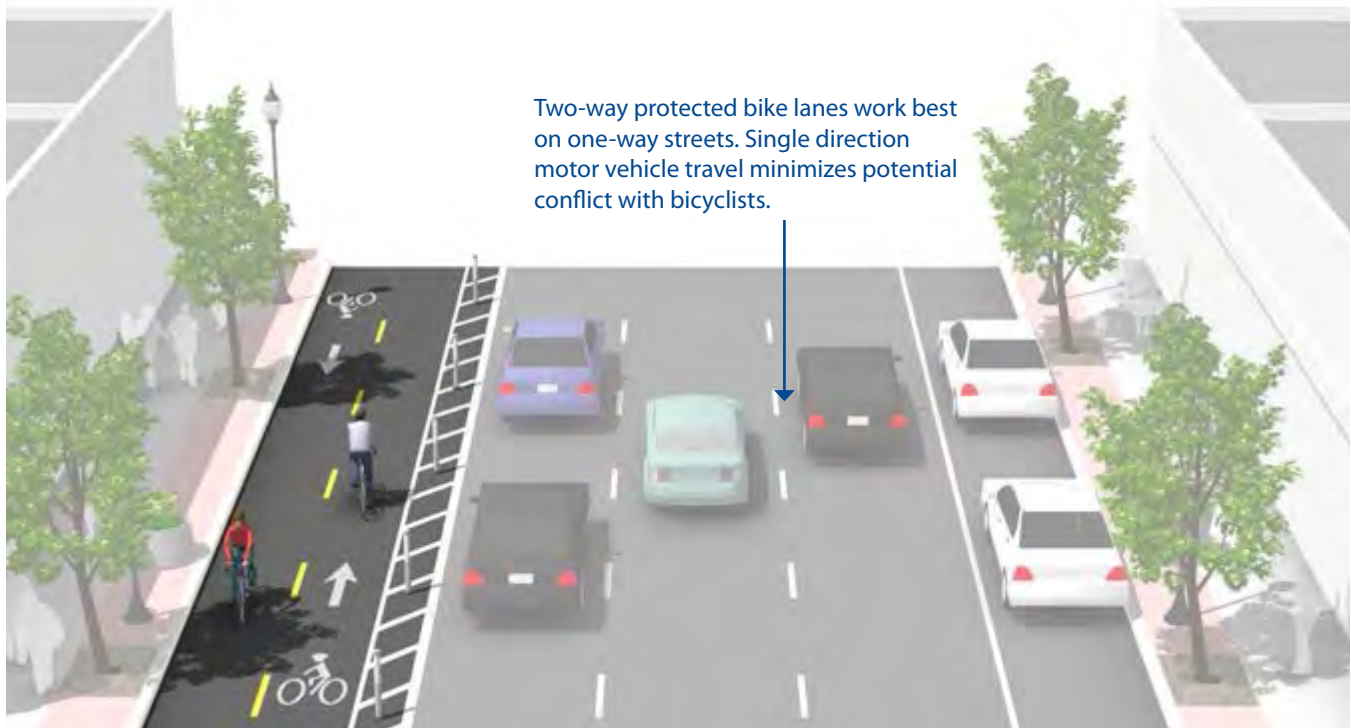
### Description

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

A two-way protected bike lane may be configured as a protected bike lane at street level with a parking lane or other barrier between the protected bike lane and the motor vehicle travel lane and/or as a raised protected bike lane to provide vertical separation from the adjacent motor vehicle lane.

### Guidance

- 12 foot recommended minimum for two-way facility
- 8 foot minimum in constrained locations
- When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.



### Discussion

Two-way protected bike lanes require a higher level of control at intersections to allow for a variety of turning movements. These movements should be guided by separated signals for bicycles and motor vehicles. Transitions into and out of two-way protected bike lanes should be simple and easy to use to deter bicyclists from continuing to ride against the flow of traffic.

### Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

In cities with winter climates barrier, separated and raised protected bike lanes may require special equipment for snow removal.

# Protected Bike Lanes at Driveways and Minor Streets

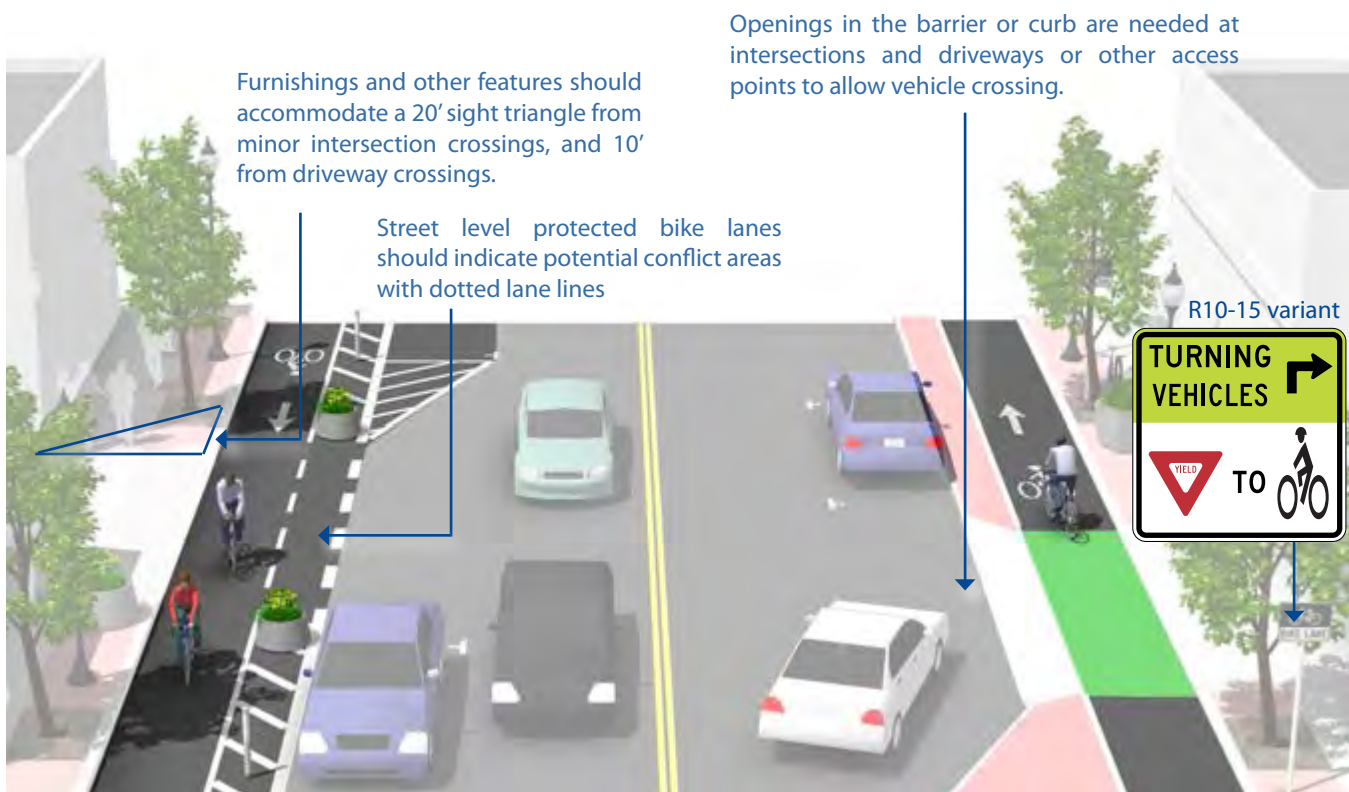
## Description

The added separation provided by protected bike lanes creates additional considerations at intersections that should be addressed.

At driveways and crossings of minor streets a smaller fraction of automobiles will cross the protected bike lane. Bicyclists should not be expected to stop at these minor intersections if the major street does not stop.

## Guidance

- If raised, maintain the height of the protected bike lane through the crossing, requiring automobiles to cross over.
- Remove parking 30 feet prior the intersection.
- Use colored pavement markings, shared lane markings or other markings through the conflict area.
- Place warning signage to identify the crossing.



## Discussion

At these locations, bicyclist visibility is important, as a buffer of parked cars or vegetation can reduce the visibility of a bicyclist traveling in the protected bike lane. Markings and signage should be present that make it easy to understand where bicyclists and pedestrians should be travelling. Access management should be used to reduce the number of crossings of driveways on a protected bike lane. Driveway consolidations and restrictions on motorized traffic movements reduce the potential for conflict.

## Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

In cities with winter climates, barrier separated and raised protected bike lanes may require special equipment for snow removal.

## Protected Bike Lanes at Major Street Crossings

### Description

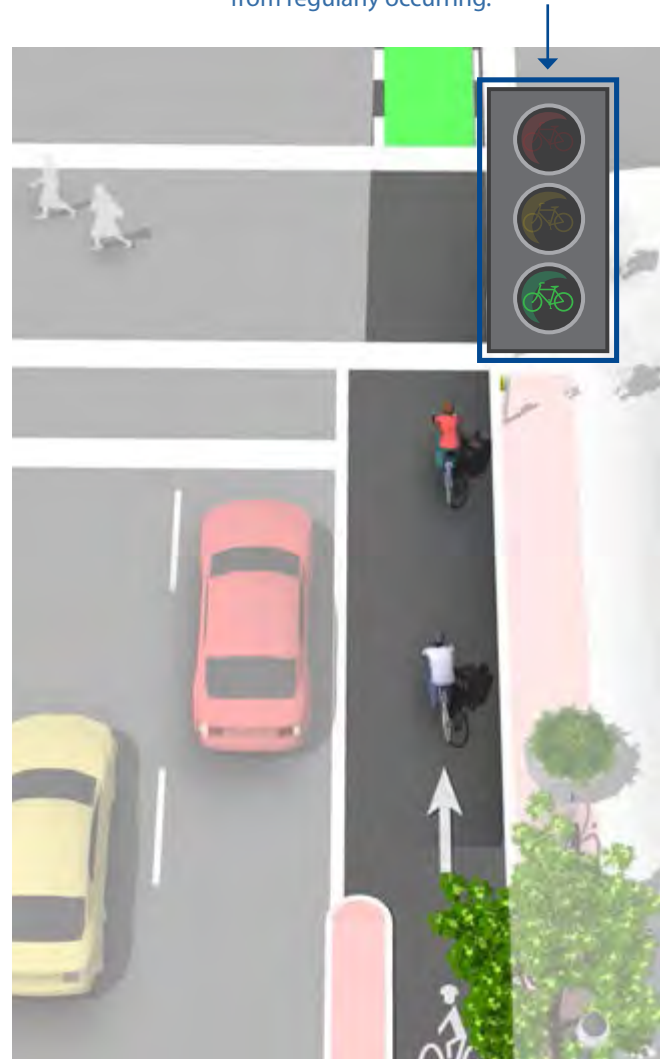
Protected bike lanes approaching major intersections must minimize and mitigate potential conflicts and provide connections to intersecting facility types.

Protected bike lane crossings of signalized intersections can also 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.

### Guidance

- Drop protected bike lane buffer and transition to bike lane 16' in advance of the intersection.
- Remove parking 16'-50' in advance of the buffer termination.
- Use a bike box or advanced stop line treatment to place bicyclists in front of traffic.
- Use colored pavement markings through the conflict area.
- Provide for left-turning movements with two-stage turn boxes.
- Consider using a protected phase bicycle signal to isolate conflicts between bicyclists and motor vehicle traffic.
- In constrained conditions with right turn only lanes, consider transitioning to a shared bike lane/turn lane.

Demand-only bicycle signals can be implemented to reduce vehicle delay and to prevent an empty signal phase from regularly occurring.



### Discussion

Signalization utilizing a bicycle signal head can also be set to provide protected bike lane users a green phase in advance of vehicle phases. The length of the signal phase will depend on the width of the intersection.

The same conflicts exist at unsignalized intersections. Warning signs, special markings and the removal of on-street parking in advance of the intersection can raise visibility and awareness of bicyclists.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

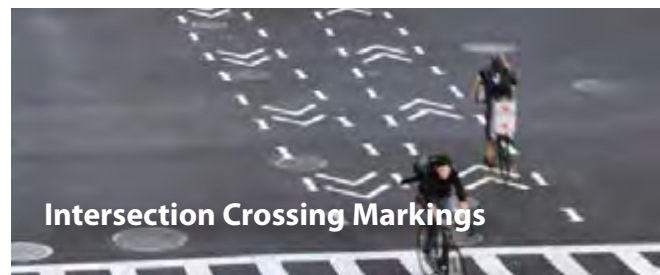
### Materials and Maintenance

In cities with winter climates, barrier separated and raised protected bike lanes may require special equipment for snow removal.

## SEPARATED BIKEWAYS AT INTERSECTIONS

Intersections are junctions at which different modes of transportation meet and facilities overlap. An intersection facilitates the interchange between bicyclists, motorists, pedestrians and other modes in order to advance traffic flow in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflict between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes. Intersection treatments can improve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.

The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort. The level of treatment required for bicyclists at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, and the adjacent street function and land use.



# Bike Lanes at Right Turn Only Lanes

## Description

The appropriate treatment at right-turn lanes is to place the bike lane between the right-turn lane and the right-most through lane or, where right-of-way is insufficient, to use a shared bike lane/turn lane.

The design (right) illustrates a bike lane pocket, with signage indicating that motorists should yield to bicyclists through the conflict area.

## Guidance

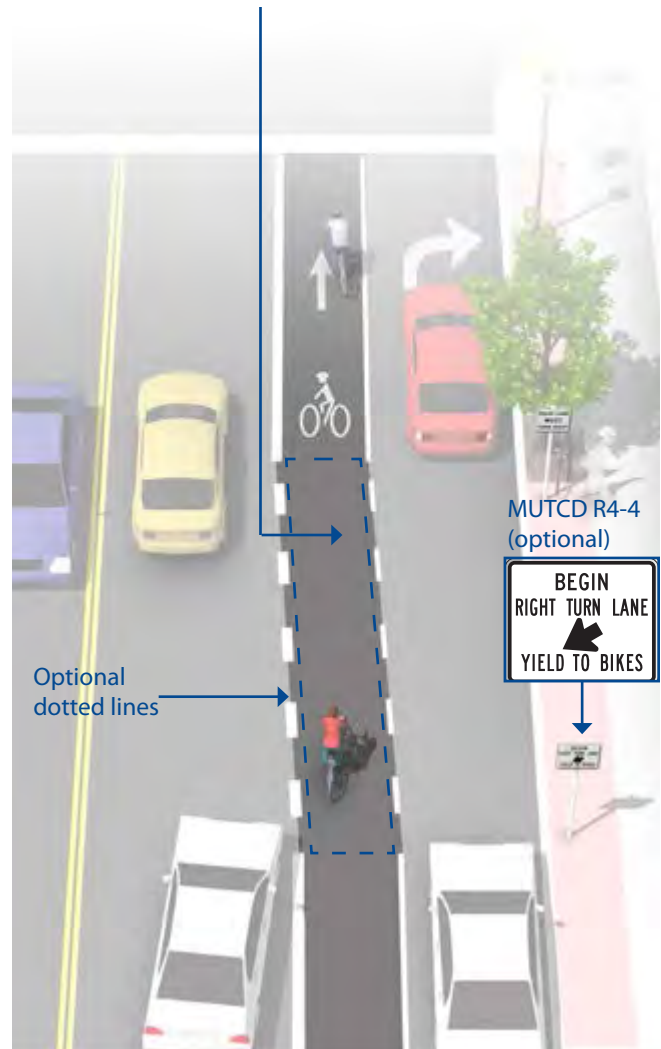
### At auxiliary right turn only lanes (add lane):

- Continue existing bike lane width; standard width of 5 to 6 feet or 4 feet in constrained locations.
- Use signage to indicate that motorists should yield to bicyclists through the conflict area.
- Consider using colored conflict areas to promote visibility of the mixing zone.

### Where a through lane becomes a right turn only lane:

- Do not define a dotted line merging path for bicyclists.
- Drop the bicycle lane in advance of the merge area.
- Use shared lane markings to indicate shared use of the lane in the merging zone.

Colored pavement may be used in the weaving area to increase visibility and awareness of potential conflict



## Discussion

For other potential approaches to providing accommodations for bicyclists at intersections with turn lanes, please see guidance on shared bike lane/turn lane, bicycle signals, and colored bike facilities.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

## Colored Bike Lanes in Conflict Areas

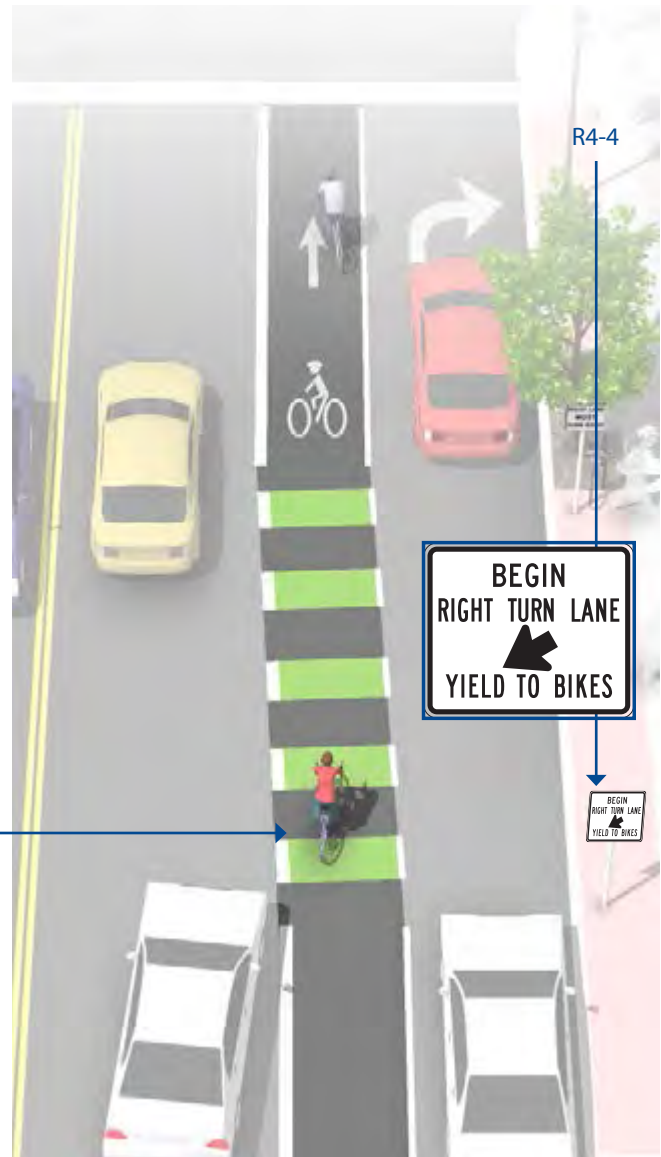
### Description

Colored pavement within a bicycle lane increases the visibility of the facility and reinforces priority of bicyclists in conflict areas.

### Guidance

- Green colored pavement was given interim approval by the Federal Highways Administration in March 2011. See interim approval for specific colored pavement standards.
- The colored surface should be skid resistant and retro-reflective.
- A “Yield to Bikes” sign should be used at intersections or driveway crossings to reinforce that bicyclists have the right-of-way in colored bike lane areas.

Normal white dotted edge lines should define colored space



### Discussion

Evaluations performed in Portland, OR, St. Petersburg, FL and Austin, TX found that significantly more motorists yielded to bicyclists and slowed or stopped before entering the conflict area after the application of the colored pavement when compared with an uncolored treatment.

### Additional References and Guidelines

FHWA. Interim Approval (IA-14) has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10. 2011. NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

## Combined Bike Lane / Turn Lane

### Description

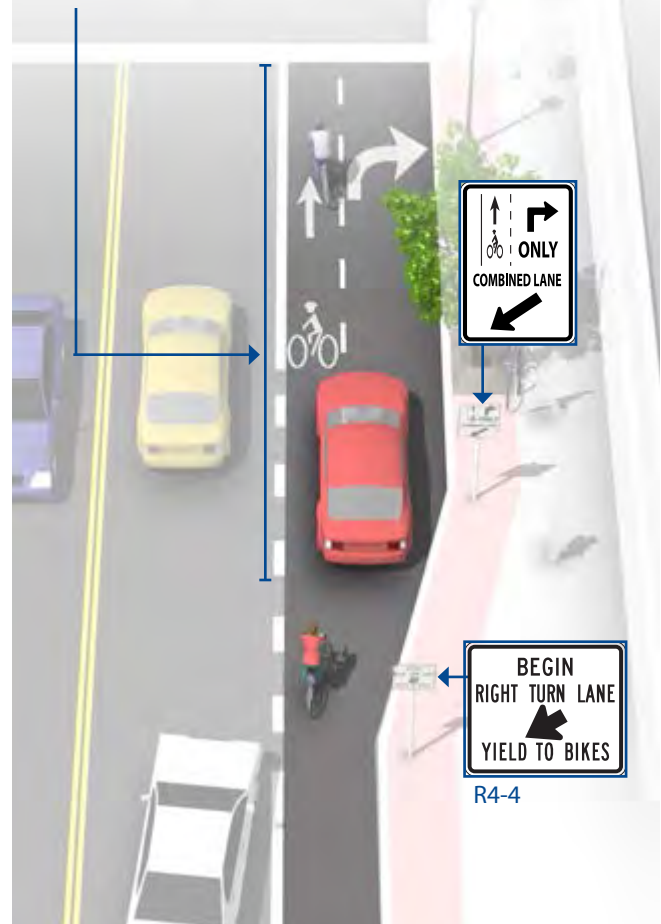
The combined bike lane/turn lane places a standard-width bike lane on the left side of a dedicated right turn lane. A dotted line delineates the space for bicyclists and motorists within the shared lane. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane.

This treatment is recommended at intersections lacking sufficient space to accommodate both a standard through bike lane and right turn lane.

### Guidance

- Maximum shared turn lane width is 13 feet; narrower is preferable.
- Bike Lane pocket should have a minimum width of 4 feet with 5 feet preferred.
- A dotted 4 inch line and bicycle lane marking should be used to clarify bicyclist positioning within the combined lane, without excluding cars from the suggested bicycle area.
- A "Right Turn Only" sign with an "Except Bicycles" plaque may be needed to make it legal for through bicyclists to use a right turn lane.

Short length turn pockets encourage slower motor vehicle speeds



### Discussion

Case studies cited by the Pedestrian and Bicycle Information Center indicate that this treatment works best on streets with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less). 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.

### Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Locate markings out of tire tread to minimize wear. Because the effectiveness of markings depends on their visibility, maintaining markings should be a high priority.

# Intersection Crossing Markings

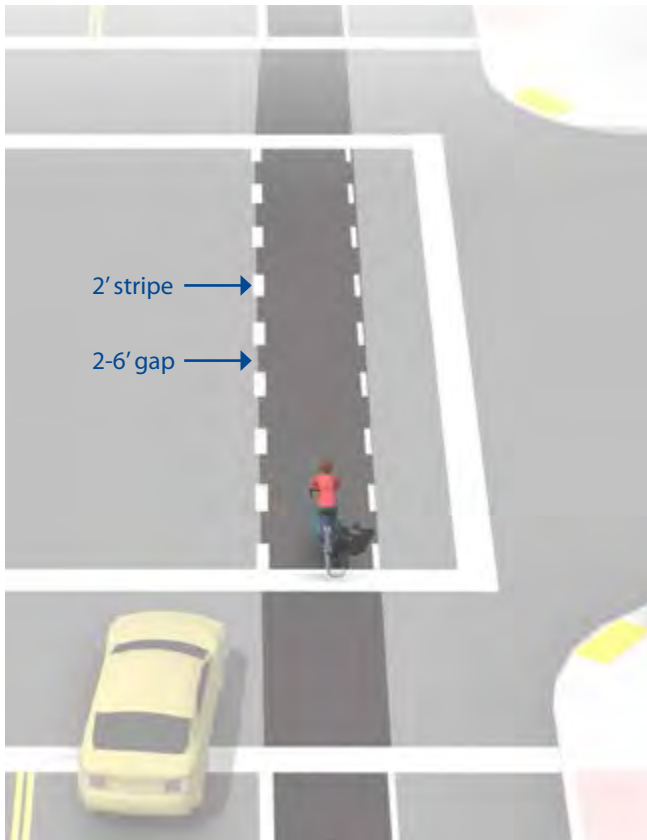
## Description

Bicycle pavement markings through intersections indicate the intended path of bicyclists through an intersection or across a driveway or ramp. They guide bicyclists on a safe and direct path through the intersection and provide a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane.

## Guidance

- See MUTCD Section 3B.08: “dotted line extensions”
- Crossing striping shall be at least six inches wide when adjacent to motor vehicle travel lanes. Dotted lines should be two-foot lines spaced two to six feet apart.

Dotted Line Extension



Colored Conflict Area



Colored pavement may be marked through the intersection to indicate where a potential conflict point is per FHWA Interim Approval IA-14.

## Discussion

The use of colored pavement is recommended to identify where permissive right turns might lead to conflicts with through bicyclists. Common applications in the US use either solid or dashed striping though the intersection or conflict area. Additional markings such as chevrons, shared lane markings, or colored bike lanes in conflict areas are strategies currently in use in the United States and Canada. Cities considering the implementation of markings through intersections should standardize future designs to avoid confusion.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. (3A.06). 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.



## Two-Stage Turn Boxes

### Description

Two-stage turn queue boxes offer bicyclists a safe way to make left turns at multi-lane signalized intersections from a right side protected bike lane or bike lane.

On right side protected bike lanes, bicyclists are often unable to merge into traffic to turn left due to physical separation, making the provision of two-stage left turn boxes critical. Design guidance for two-stage turns apply to both bike lanes and protected bike lanes.

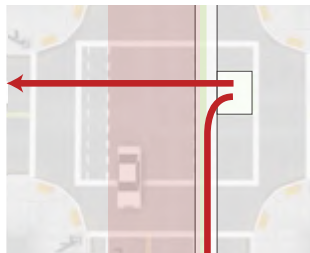
### Guidance

- The queue box shall be placed in a protected area. Typically this is within an on-street parking lane or protected bike lane buffer area.
- 6' minimum depth of bicycle storage area
- Bicycle stencil and turn arrow pavement markings shall be used to indicate proper bicycle direction and positioning.
- A "No Turn on Red" (MUTCD R10-11) sign shall be installed on the cross street to prevent vehicles from entering the turn box.

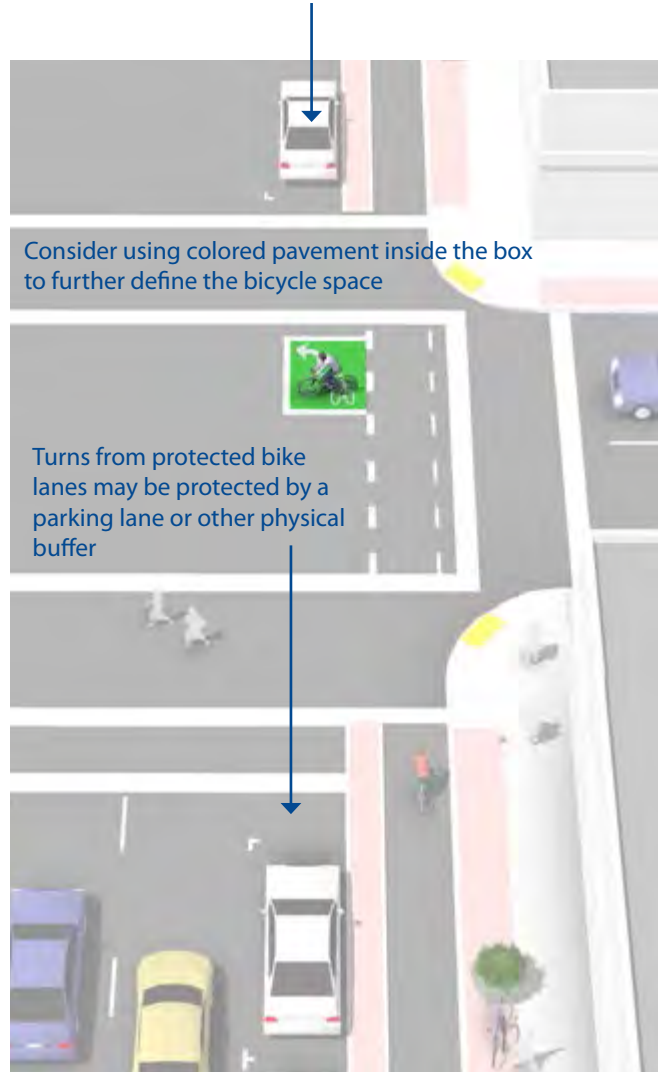
Protected bike lane  
turn box protected by  
physical buffer:



Bike lane turn  
box protected by  
parking lane:



Turns from a bicycle lane may be protected by an adjacent parking lane or crosswalk setback space



Consider using colored pavement inside the box to further define the bicycle space

Turns from protected bike lanes may be protected by a parking lane or other physical buffer

### Discussion

Two-Stage Turn boxes are considered experimental by FHWA.

While two stage turns may increase bicyclist comfort in many locations, this configuration will typically result in higher average signal delay for bicyclists due to the need to receive two separate green signal indications (one for the through street, followed by one for the cross street) before proceeding.

### Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.

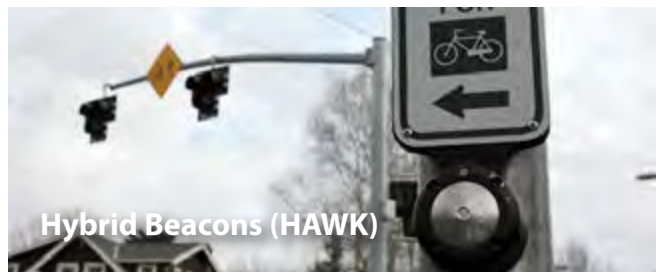
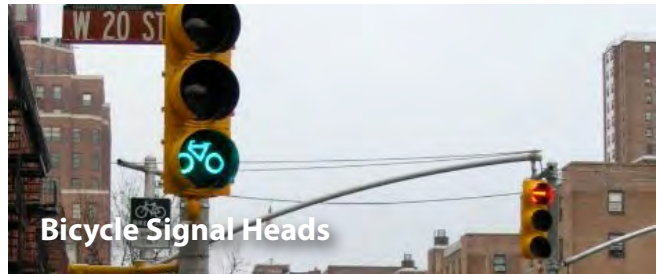
### Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates.

## SIGNALIZATION

Bicycle signals and beacons facilitate bicyclist crossings of roadways. Bicycle signals make crossing intersections safer for bicyclists by clarifying when to enter an intersection and by restricting conflicting vehicle movements. Bicycle signals are traditional three lens signal heads with green, yellow and red bicycle stenciled lenses that can be employed at standard signalized intersections. Flashing amber warning beacons can be utilized at unsignalized intersection crossings. Push buttons, signage, and pavement markings may be used to supplement these facilities for both bicyclists and motorists.

Determining which type of signal or beacon to use for a particular intersection depends on a variety of factors. These include speed limits, Average Daily Traffic (ADT), anticipated bicycle crossing traffic, and the configuration of planned or existing bicycle facilities. Signals may be necessary as part of the construction of a protected bicycle facility such as a protected bike lane with potential turning conflicts, or to decrease vehicle or pedestrian conflicts at major crossings. An intersection with bicycle signals may reduce stress and delays for a crossing bicyclist, and discourage illegal and unsafe crossing maneuvers.



# Bicycle Detection and Actuation

## Description

### Push Button Actuation

User-activated button mounted on a pole facing the street.

### Loop Detectors

Bicycle-activated loop detectors are installed within the roadway to allow the presence of a bicycle to trigger a change in the traffic signal. This allows the bicyclist to stay within the lane of travel without having to maneuver to the side of the road to trigger a push button.

Loops that are sensitive enough to detect bicycles should be supplemented with pavement markings to instruct bicyclists how to trip them.

### Video Detection Cameras

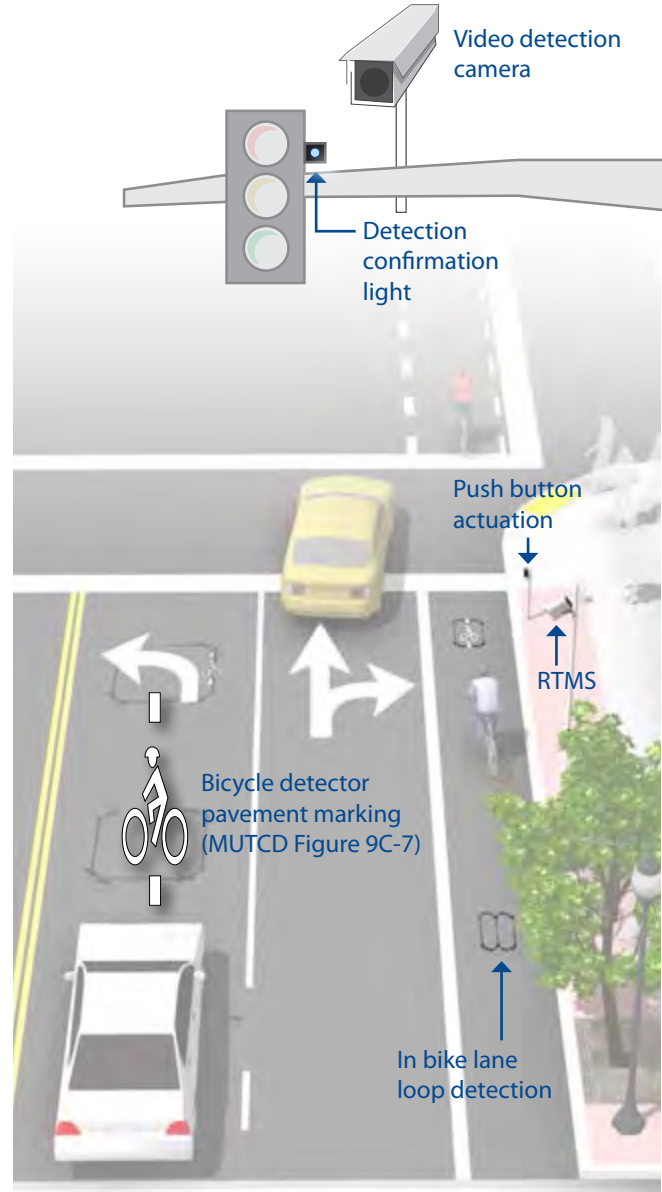
Video detection systems use digital image processing to detect a change in the image at a location. These systems can be calibrated to detect bicycles. Video camera system costs range from \$20,000 to \$25,000 per intersection.

### Remote Traffic Microwave Sensor Detection (RTMS)

RTMS is a system which uses frequency modulated continuous wave radio signals to detect objects in the roadway. This method marks the detected object with a time code to determine its distance from the sensor. The RTMS system is unaffected by temperature and lighting, which can affect standard video detection.

### Detection Confirmation Light

A detection confirmation light is a small, bright light directed at bicyclists to identify when a user is triggering the loop detector.



## Discussion

Proper bicycle detection should meet two primary criteria: 1) accurately detects bicyclists and 2) provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand).

Bicycle loops and other detection mechanisms can also provide bicyclists with an extended green time before the light turns yellow so that bicyclists of all abilities can reach the far side of the intersection.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Signal detection and actuation for bicyclists should be maintained with other traffic signal detection and roadway pavement markings.

# Bicycle Signal Heads

## Description

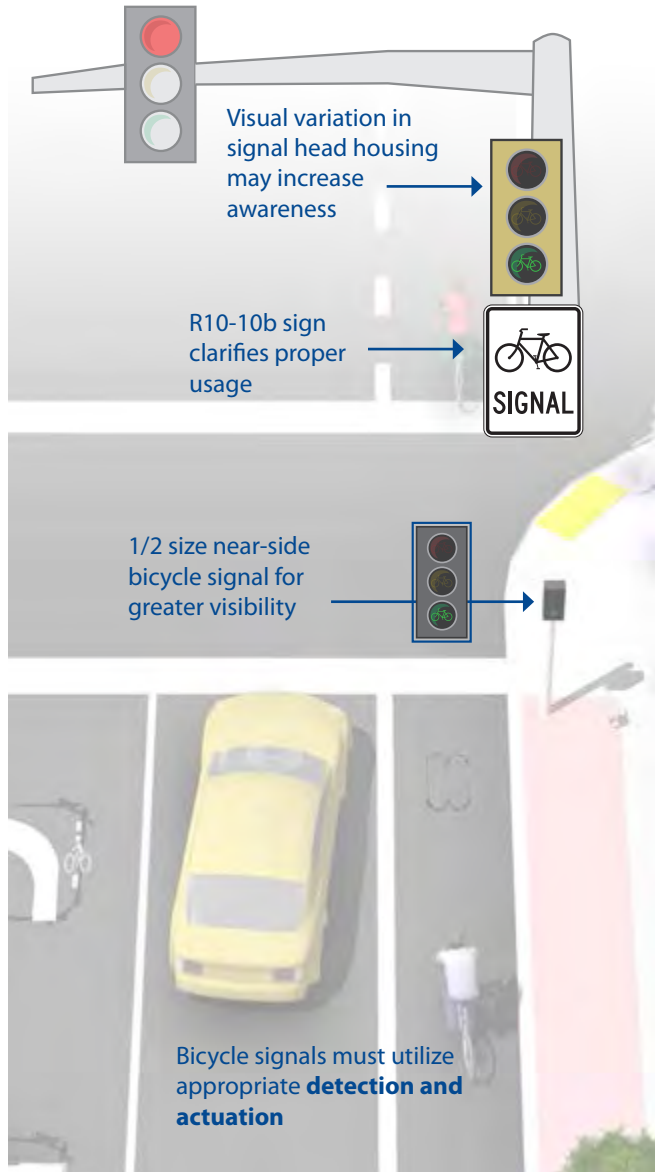
A bicycle signal is an electrically powered traffic control device that should only be used in combination with an existing traffic signal. Bicycle signals are typically used to improve identified safety or operational problems involving bicycle facilities. Bicycle signal heads may be installed at signalized intersections to indicate bicycle signal phases and other bicycle-specific timing strategies. Bicycle signals can be actuated with bicycle sensitive loop detectors, video detection, or push buttons.

Bicycle signals are typically used to provide guidance for bicyclists at intersections where they may have different needs from other road users (e.g., bicycle-only movements).

## Guidance

Specific locations where bicycle signals have had a demonstrated positive effect include:

- Those with high volume of bicyclists at peak hours
- Those with high numbers of bicycle/motor vehicle crashes, especially those caused by turning vehicle movements
- At T-intersections with major bicycle movement along the top of the "T"
- At the confluence of an off-street bike path and a roadway intersection
- Where separated bike paths run parallel to arterial streets
- On two-way cycle tracks at intersections



## Discussion

Local municipal code should be checked or modified to clarify that at intersections with bicycle signals, bicyclists should only obey the bicycle signal heads. For improved visibility, smaller (4 inch lens) near-sided bicycle signals should be considered to supplement far-side signals.

## Additional References and Guidelines

FHWA. *MUTCD - Interim Approval for Optional Use of a Bicycle Signal Face (IA-16)*. 2013.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Bicycle signal heads require the same maintenance as standard traffic signal heads, such as replacing bulbs and responding to power outages.

## Hybrid Beacons

### Description

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.

### Guidance

Hybrid beacons may be installed without meeting traffic control signal warrants if roadway speed and volumes are excessive for comfortable user crossing.

- 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.



### Discussion

The hybrid beacon can significantly improve the operation of a bicycle route, particularly along bicycle boulevard corridors. Because of the low traffic volumes on these facilities, intersections with major roadways are often unsignalized, creating difficult and potentially unsafe crossing conditions for bicyclists.

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.

### Additional References and Guidelines

FHWA. *Pedestrian Hybrid Beacon Guide - Recommendations and Case Study*. 2014.

NACTO. *Urban Bikeway Design Guide*. 2012.

FHWA. *Manual on Uniform Traffic Control Devices*. 2009.

### Materials and Maintenance

Hybrid beacons are subject to the same maintenance needs and requirements as standard traffic signals. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

## BIKEWAY SIGNING

The ability to navigate through a city is informed by landmarks, natural features and other visual cues. Signs throughout the city should indicate to bicyclists:

- Direction of travel
- Location of destinations
- Travel time/distance to those destinations

These signs will increase users' comfort and accessibility to the bicycle systems.

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the bicycle network
- Helping users identify the best routes to destinations
- Helping to address misperceptions about time and distance
- Helping overcome a "barrier to entry" for people who are not frequent bicyclists (e.g., "interested but concerned" bicyclists)

A community-wide bicycle wayfinding signage plan would identify:

- Sign locations
- Sign type – what information should be included and design features
- Destinations to be highlighted on each sign – key destinations for bicyclists
- Approximate distance and travel time to each destination

Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists rather than per vehicle signage standards.



Wayfinding Sign Types



Wayfinding Sign Placement

# Wayfinding Sign Types

## Description

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. There are three functional types of wayfinding signs:

### Confirmation Signs

Alternative Bike Route Guide (D11-1c) signs are used to indicate to bicyclists that they are on a designated bikeway and make motorists aware of the bicycle route. The use of the D11-1c sign (which includes a destination or route name) is preferred whenever practical, as it provides the reader with more useful information than the D11-1.



D11-1c

### Turn Signs

A Bicycle Destination Sign (D1-1) with one or more destinations in a single direction indicates where a bike route turns from one street onto another street. This signage can be used with pavement markings, and includes destinations and arrows.



D1-1

### Decisions Signs

Decision sign assemblies are a combination of D11-1c and D1-3a signs used to mark the junction of two or more bikeways and inform bicyclists of the designated bike route to access key destinations. Commonly includes destinations and arrows and distances.



D11-1/D1-3a

### Numbered Bicycle Route Signs

Numbered Bicycle Route (M1-8, M1-8a) signs are used to establish a unique identification of state or local bicycle routes. U.S. Bicycle Route (M1-9) signs shall contain the AASHTO designated route number.



M1-8



M1-9

## Discussion

Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MUTCD.

While not included in the MUTCD, some jurisdictions include travel time on Bicycle Destination Signs to help communicate and inform users of realistic bicycle travel times based on a 10 mph travel speed.

### Additional References and Guidelines

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
- NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.

# Wayfinding Sign Placement

## Guidance

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

### Decisions Signs

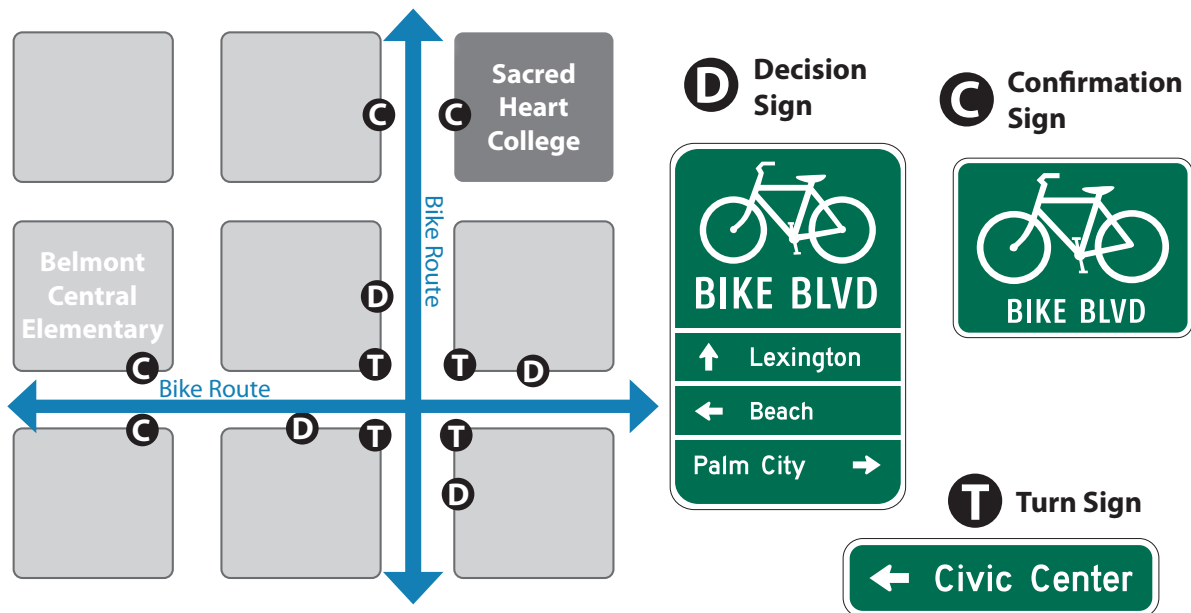
Near-side of intersections in advance of a junction with another bicycle route, and along a route to indicate a nearby destination.

### Confirmation Signs

Every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along on-street bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign). Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

### Turn Signs

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



## Discussion

It can be useful to classify a list of destinations for inclusion on the signs based on their relative importance to users throughout the area. A particular destination’s ranking in the hierarchy can be used to determine the physical distance from which the locations are signed. For example, primary destinations (such as the downtown area) may be included on signage up to 5 miles away. Secondary destinations (such as a transit station) may be included on signage up to two miles away. Tertiary destinations (such as a park) may be included on signage up to one mile away.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

### Materials and Maintenance

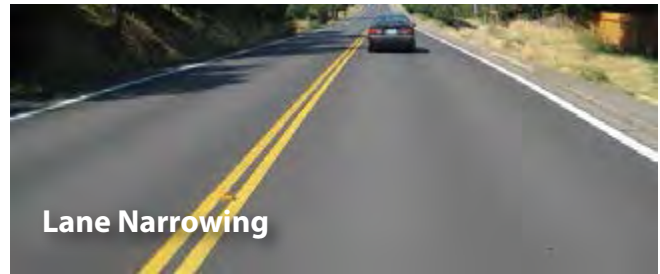
Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.



## RETROFITTING EXISTING STREETS TO ADD BIKEWAYS

Most major streets are characterized by conditions (e.g., high vehicle speeds and/or volumes) for which dedicated bike lanes are the most appropriate facility to accommodate safe and comfortable riding. Although opportunities to add bike lanes through roadway widening may exist in some locations, many major streets have physical and other constraints that would require street retrofit measures within existing curb-to-curb widths. As a result, much of the guidance provided in this section focuses on effectively reallocating existing street width through striping modifications to accommodate dedicated bike lanes.

Although largely intended for major streets, these measures may be appropriate for any roadway where bike lanes would be the best accommodation for bicyclists.



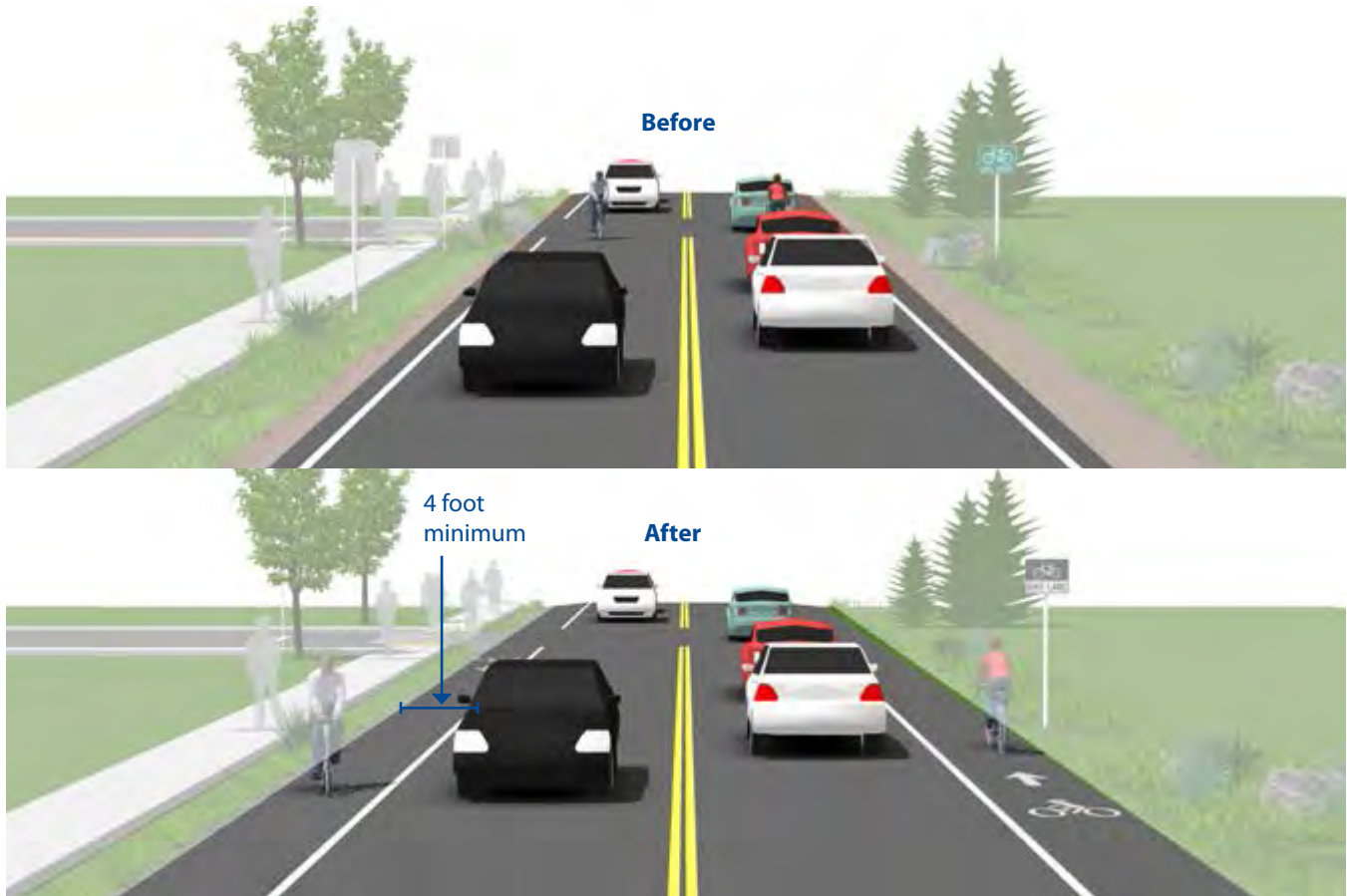
# Roadway Widening

## Description

Bike lanes can be accommodated on streets with excess right-of-way through shoulder widening. Although roadway widening incurs higher expenses compared with re-striping projects, bike lanes can be added to streets currently lacking curbs, gutters and sidewalks without the high costs of major infrastructure reconstruction.

## Guidance

- Guidance on bicycle lanes applies to this treatment.
- 4 foot minimum width when no curb and gutter is present.
- 6 foot width preferred.



## Discussion

Roadway widening is most appropriate on roads lacking curbs, gutters and sidewalks.

If it is not possible to meet minimum bicycle lane dimensions, a reduced width paved shoulder can still improve conditions for bicyclists on constrained roadways. In these situations, a minimum of 3 feet of operating space should be provided.

## Additional References and Guidelines

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

## Materials and Maintenance

The extended bicycle area should not contain any rough joints where bicyclists ride. Saw or grind a clean cut at the edge of the travel lane, or feather with a fine mix in a non-ridable area of the roadway.

# Lane Narrowing

## Description

Lane narrowing utilizes roadway space that exceeds minimum standards to provide the needed space for bike lanes. Many roadways have existing travel lanes that are wider than those prescribed in local and national roadway design standards, or which are not marked. Most standards allow for the use of 11 foot and sometimes 10 foot wide travel lanes to create space for bike lanes.

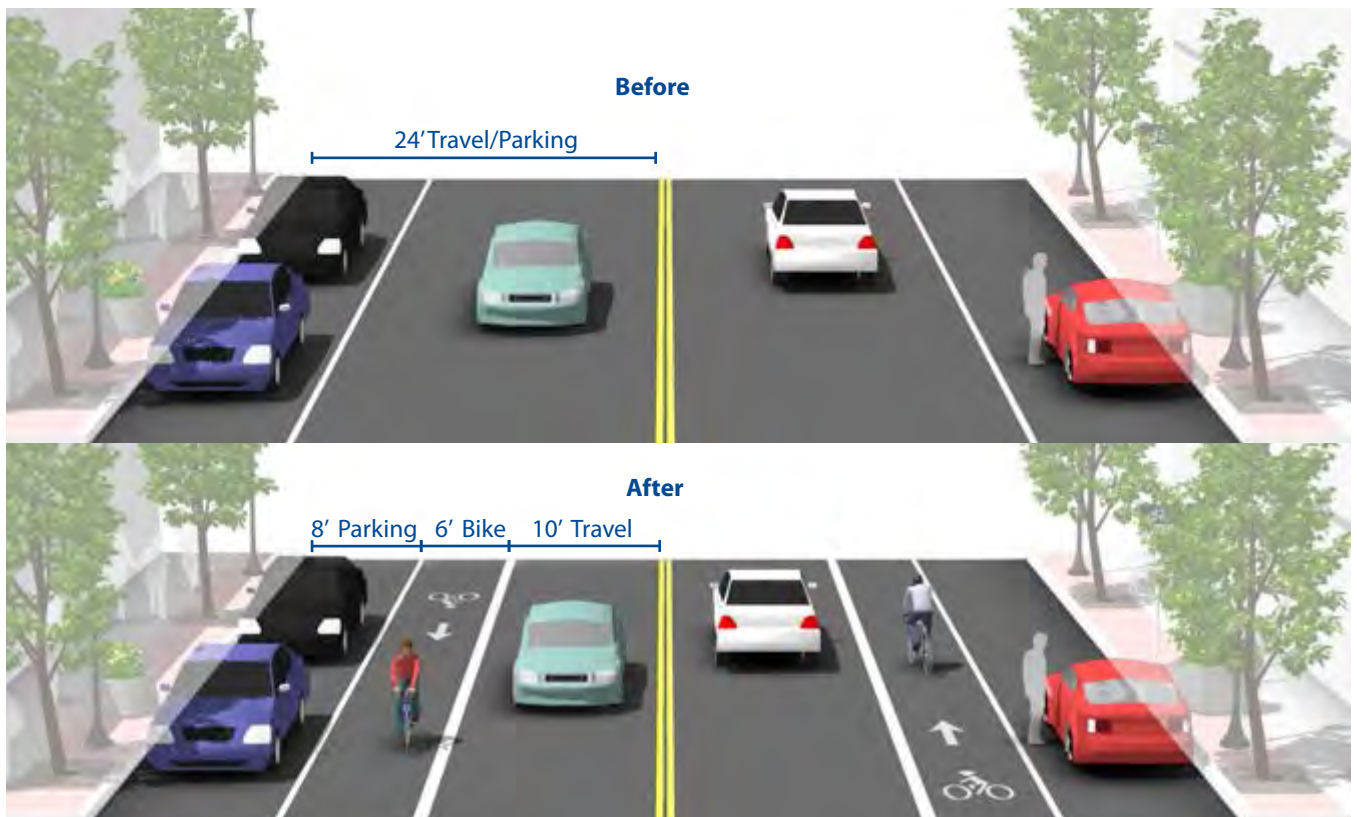
## Guidance

### Vehicle lane width:

- Before: 10-15 feet
- After: 10-11 feet

### Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.



## Discussion

Special consideration should be given to the amount of heavy vehicle traffic and horizontal curvature before the decision is made to narrow travel lanes. Center turn lanes can also be narrowed in some situations to free up pavement space for bike lanes.

AASHTO supports reduced width lanes in *A Policy on Geometric Design of Highways and Streets*: "On interrupted-flow operation conditions at low speeds (45 mph or less), narrow lane widths are normally adequate and have some advantages."

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 AASHTO. *A Policy on Geometric Design of Highways and Streets*. 2004.  
 NACTO. *Urban Street Design Guide*. 2013.

## Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

## Lane Reconfiguration

### Description

The removal of a single travel lane will generally provide sufficient space for bike lanes on both sides of a street. Streets with excess vehicle capacity provide opportunities for bike lane retrofit projects.

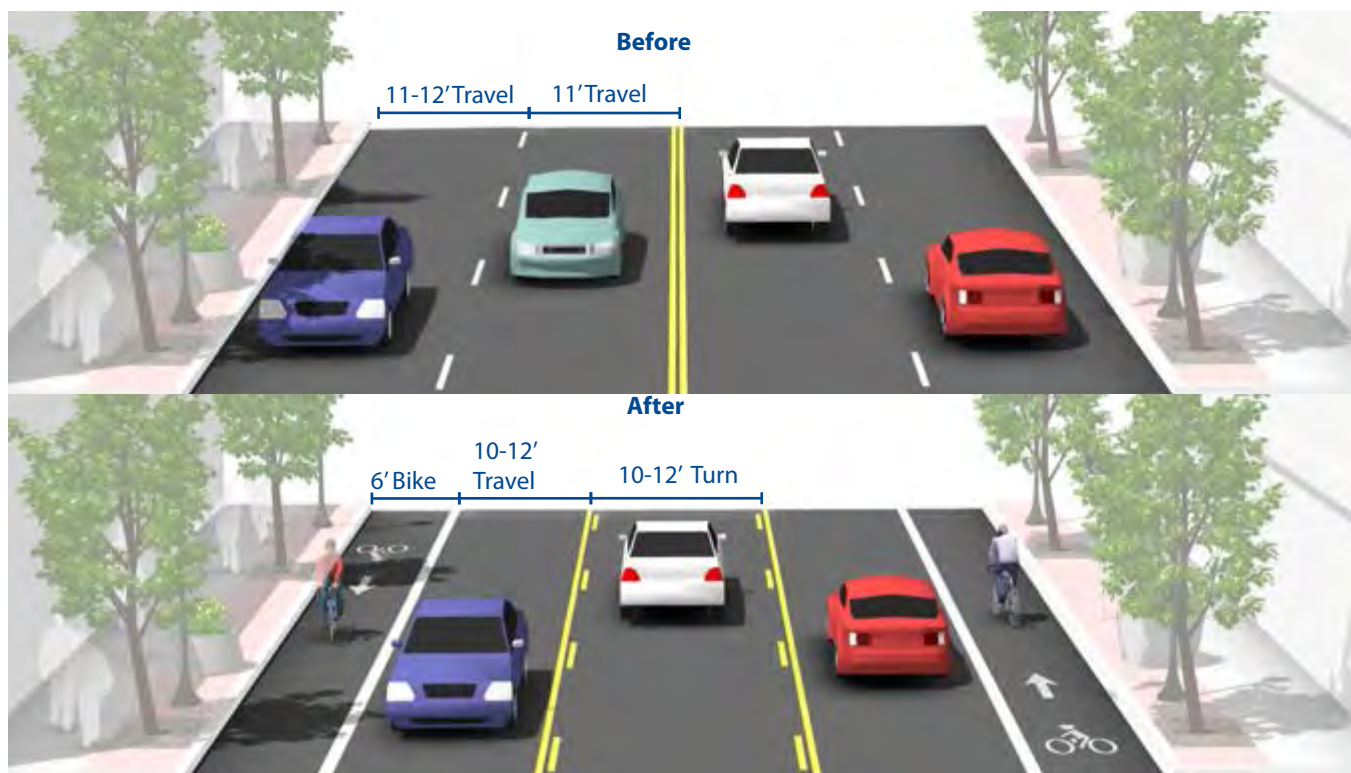
### Guidance

#### Vehicle lane width:

- Width depends on project. No narrowing may be needed if a lane is removed.

#### Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.



### Discussion

Depending on a street's existing configuration, traffic operations, user needs and safety concerns, various lane reduction configurations may apply. For instance, a four-lane street (with two travel lanes in each direction) could be modified to provide one travel lane in each direction, a center turn lane, and bike lanes. Prior to implementing this measure, a traffic analysis should identify potential impacts.

### Additional References and Guidelines

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Evaluation of Lane Reduction "Road Diet" Measures on Crashes*. Publication Number: FHWA-HRT-10-053. 2010.
- NACTO. *Urban Street Design Guide*. 2013.

### Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

## Parking Reduction

### Description

Bike lanes can replace one or more on-street parking lanes on streets where excess parking exists and/or the importance of bike lanes outweighs parking needs. For example, parking may be needed on only one side of a street. Eliminating or reducing on-street parking also improves sight distance for bicyclists in bike lanes and for motorists on approaching side streets and driveways.

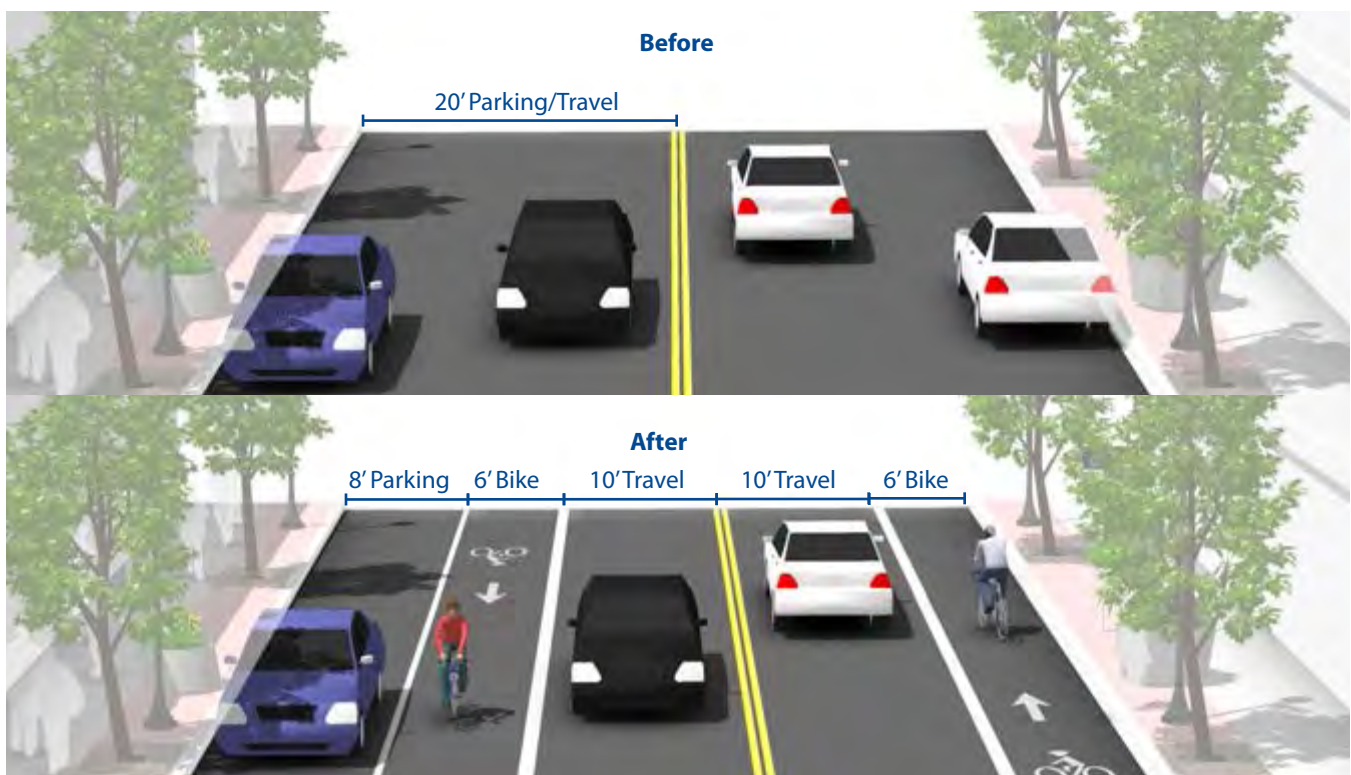
### Guidance

#### Vehicle lane width:

- Parking lane width depends on project. No travel lane narrowing may be required depending on the width of the parking lanes.

#### Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.



### Discussion

Removing or reducing on-street parking to install bike lanes requires comprehensive outreach to the affected businesses and residents. Prior to reallocating on-street parking for other uses, a parking study should be performed to gauge demand and to evaluate impacts to people with disabilities.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 AASHTO. *A Policy on Geometric Design of Highways and Streets*. 2004.

### Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement

## SHARED USE PATHS

A shared use path allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles. Shared use paths may also be configured along roadways, separated from traffic by a curb or landscaping.

Path facilities can also include amenities such as lighting, signage, and fencing (where appropriate).

Key features of shared use paths include:

- Frequent access points from the local road network.
- Directional signs to direct users to and from the path.
- A limited number of at-grade crossings with streets or driveways (except sidepaths).
- Terminating the path where it is easily accessible to and from the street system.
- Separate treads for pedestrians and bicyclists when heavy use is expected.



# General Design Practices

## Description

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

## Guidance

### Width

- 8 feet is the minimum allowed for a two-way shared use path and is only recommended for low traffic situations.
- 10 feet is recommended in most situations and will be adequate for moderate to heavy use.
- 12 feet is recommended for heavy use situations with high concentrations of multiple users.

### Lateral Clearance

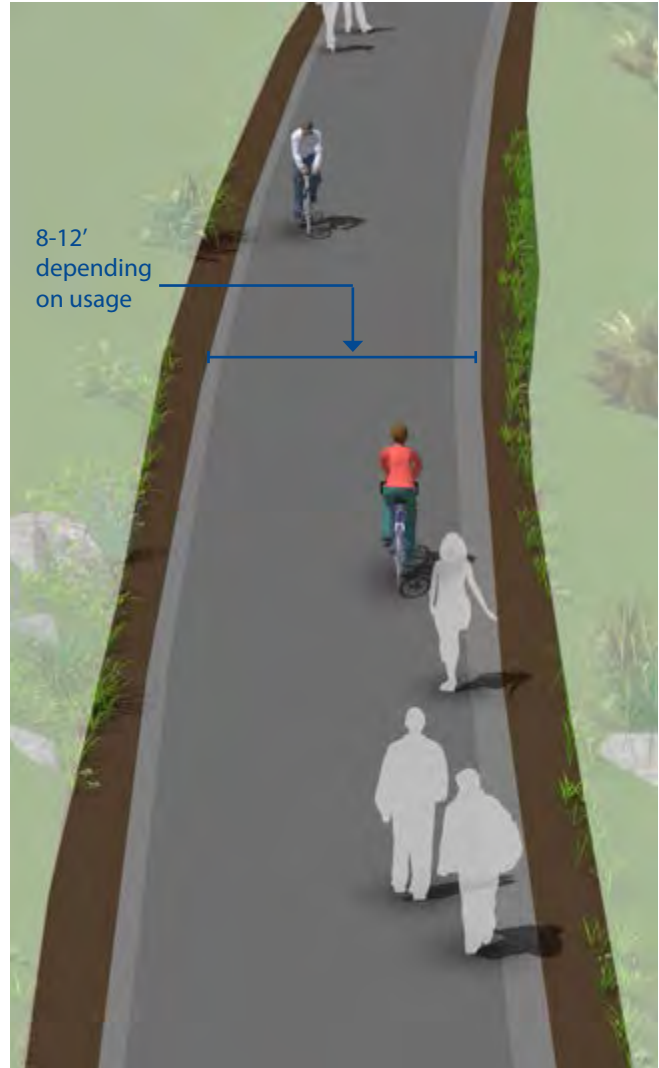
- A 2 foot or greater shoulder on both sides of the path should be provided. An additional foot of lateral clearance (total of 3') is required by the MUTCD for the installation of signage or other furnishings.
- If bollards are used at intersections and access points, they should be colored brightly and/or supplemented with reflective materials to be visible at night.

### Overhead Clearance

- Clearance to overhead obstructions should be 8 feet minimum, with 10 feet recommended.

### Striping

- When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.
- Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.



## Discussion

Terminate the path where it is easily accessible to and from the street system, preferably at a controlled intersection or at the beginning of a dead-end street.

With heavy volumes, consider providing a separate track (5' minimum) for exclusive pedestrian use.

## Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 Flink, C. *Greenways: A Guide To Planning Design And Development*. 1993.

## Materials and Maintenance

Asphalt is the most common surface for shared use paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

## Shared Use Paths in River/Utility Corridors - Off Street Trails

### Description

Utility and waterway corridors often offer excellent shared use path development and bikeway gap closure opportunities. Utility corridors typically include powerline and sewer corridors, while waterway corridors include canals, drainage ditches, rivers, and beaches. These corridors offer excellent transportation and recreation opportunities for bicyclists of all ages and skills.

### Guidance

Shared use paths in utility corridors should meet or exceed general design practices. If additional width allows, wider paths, and landscaping are desirable.

#### Access Points

Any access point to the path should be well-defined with appropriate signage designating the pathway as a bicycle facility and prohibiting motor vehicles.

#### Path Closure

Public access to the shared use path may be prohibited during the following events:

- Canal/flood control channel or other utility maintenance activities
- Inclement weather or the prediction of storm conditions



### Discussion

Similar to railroads, public access to flood control channels or canals may be undesirable. Hazardous materials, deep water or swift current, steep, slippery slopes, and debris all may constitute risks for public access. Appropriate fencing may be desired to keep path users within the designated travel way. Creative design of fencing is encouraged to make the path facility feel welcoming to the user.

### Additional References and Guidelines

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
- Flink, C. *Greenways: A Guide To Planning Design And Development*. 1993.

### Materials and Maintenance

Asphalt is the most common surface for shared use paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.



## Shared-Use Paths Along Roadways - Sidepath

### Description

Shared Use Paths along roadways, also called Sidepaths, are a type of path that run adjacent to a street.

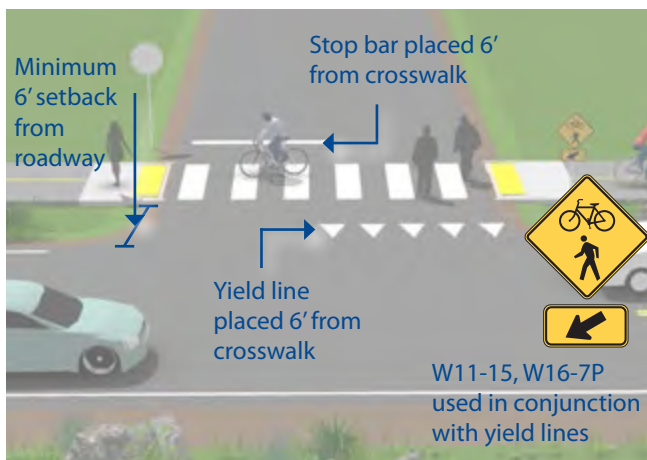
Because of operational concerns it is generally preferable to place paths within independent rights-of-way away from roadways. However, there are situations where existing roads provide the only corridors available.

Along roadways, these facilities create a situation where a portion of the bicycle traffic rides against the normal flow of motor vehicle traffic and can result in wrong-way riding where bicyclists enter or leave the path.

The AASHTO Guide for the Development of Bicycle Facilities cautions practitioners of the use of two-way sidepaths on urban or suburban streets with many driveways and street crossings.

In general, there are two approaches to crossings: adjacent crossings and setback crossings, illustrated below.

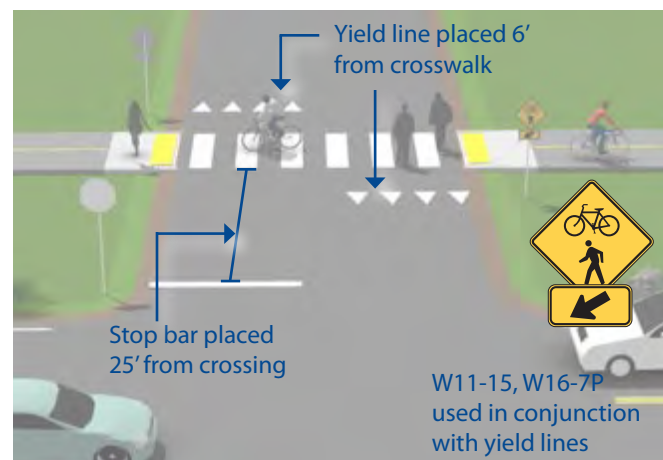
**Adjacent Crossing** - A separation of 6 feet emphasizes the conspicuity of riders at the approach to the crossing.



### Guidance

- Guidance for sidepaths should follow that for general design practices of shared use paths.
- A high number of driveway crossings and intersections create potential conflicts with turning traffic. Consider alternatives to sidepaths on streets with a high frequency of intersections or heavily used driveways.
- Where a sidepath terminates, special consideration should be given to transitions so as not to encourage unsafe wrong-way riding by bicyclists.
- Crossing design should emphasize visibility of users and clarity of expected yielding behavior. Crossings may be STOP or YIELD controlled depending on sight lines and bicycle motor vehicle volumes and speeds.

**Setback Crossing** - A set back of 25 feet separates the path crossing from merging/turning movements that may be competing for a driver's attention.



### Discussion

The provision of a shared use path adjacent to a road is not a substitute for the provision of on-road accommodation such as paved shoulders or bike lanes, but may be considered in some locations in addition to on-road bicycle facilities. Sidepaths should only be considered as a sole bicycle facility in constrained corridors.

To reduce potential conflicts in some situations, it may be better to place one-way sidepaths on both sides of the street.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
NACTO. *Urban Bikeway Design Guide*. See entry on Raised Protected bike lanes. 2012.

### Materials and Maintenance

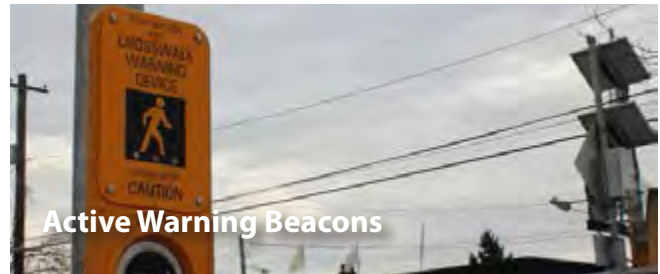
Asphalt is the most common surface for shared use paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

## SHARED USE PATH/ROAD CROSSINGS

At-grade roadway crossings can create potential conflicts between path users and motorists, however, well-designed crossings can mitigate many operational issues and provide a higher degree of safety and comfort for path users. This is evidenced by the thousands of successful facilities around the United States with at-grade crossings. In most cases, at-grade path crossings can be properly designed to provide a reasonable degree of safety and can meet existing traffic and safety standards. Path facilities that cater to bicyclists can require additional considerations due to the higher travel speed of bicyclists versus pedestrians.

Consideration must be given to adequate warning distance based on vehicle speeds and line of sight, with the visibility of any signs absolutely critical. Directing the active attention of motorists to roadway signs may require additional alerting devices such as a flashing beacon, roadway striping or changes in pavement texture. Signing for path users may include a standard "STOP" or "YIELD" sign and pavement markings, possibly combined with other features such as bollards or a bend in the pathway to slow bicyclists. Care must be taken not to place too many signs at crossings lest they begin to lose their visual impact.

A number of striping patterns have emerged over the years to delineate path crossings. A median stripe on the path approach will help to organize and warn path users. Crosswalk striping is typically a matter of local preference, and may be accompanied by pavement treatments to help warn and slow motorists. In areas where motorists do not typically yield to crosswalk users, additional measures may be required to increase compliance.



# Marked/Unsignalized Crossings

## Description

A marked/unsignalized crossing typically consists of a marked crossing area, signage and other markings to slow or stop traffic. The approach to designing crossings at mid-block locations 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.

When space is available, using a median refuge island can improve user safety by providing pedestrians and bicyclists space to perform the safe crossing of one side of the street at a time.

## Guidance

Maximum traffic volumes

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

Maximum travel speed

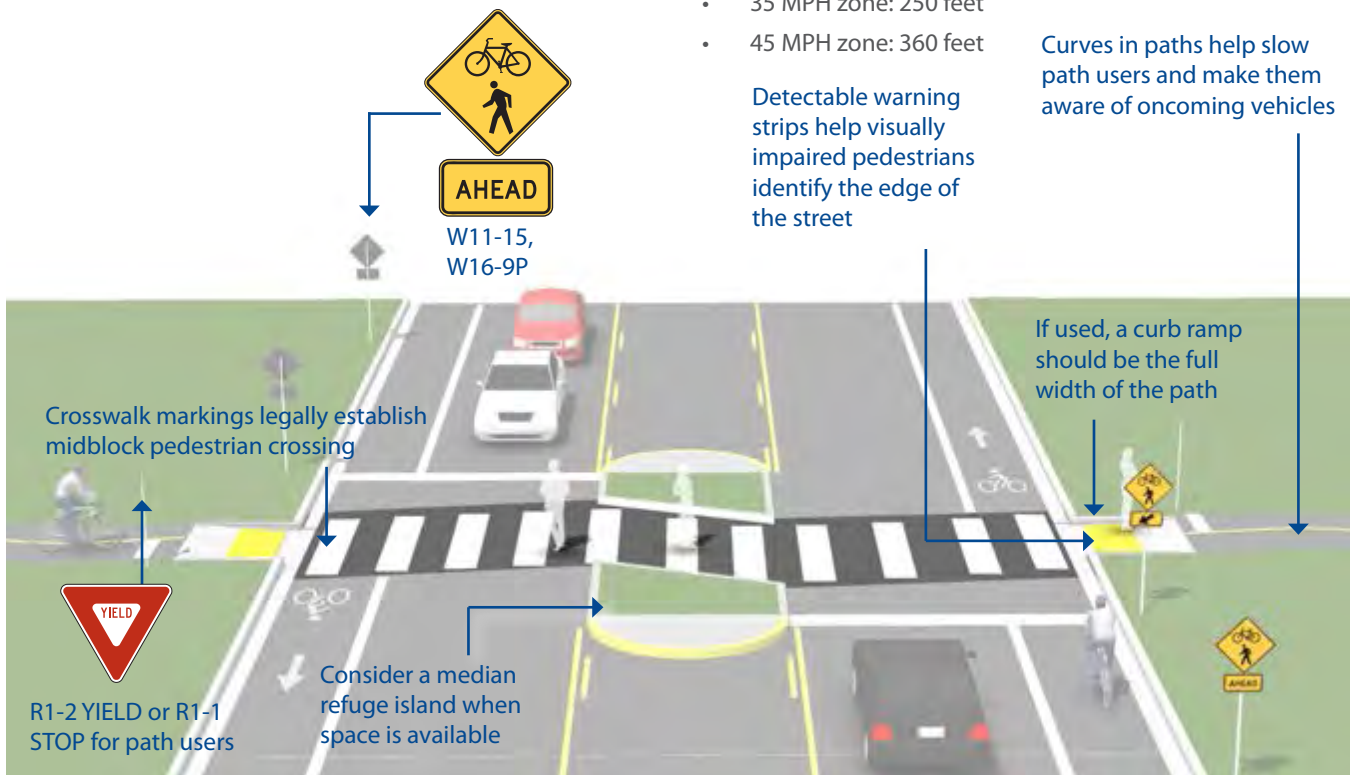
- 35 MPH

Minimum line of sight

- 25 MPH zone: 155 feet
- 35 MPH zone: 250 feet
- 45 MPH zone: 360 feet

Detectable warning strips help visually impaired pedestrians identify the edge of the street

Curves in paths help slow path users and make them aware of oncoming vehicles



## Discussion

Unsignalized crossings of multi-lane arterials over 15,000 ADT may be possible with features such as sufficient crossing gaps (more than 60 per hour), median refuges, and/or active warning devices like rectangular rapid flash beacons or in-pavement flashers, and excellent sight distance. For more information see the discussion of active warning beacons.

On roadways with low to moderate traffic volumes (<12,000 ADT) and a need to control traffic speeds, a raised crosswalk may be the most appropriate crossing design to improve pedestrian visibility and safety.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
FHWA. *Manual on Uniform Traffic Control Devices*. 2009.

### Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs.

# Active Warning Beacons

## Description

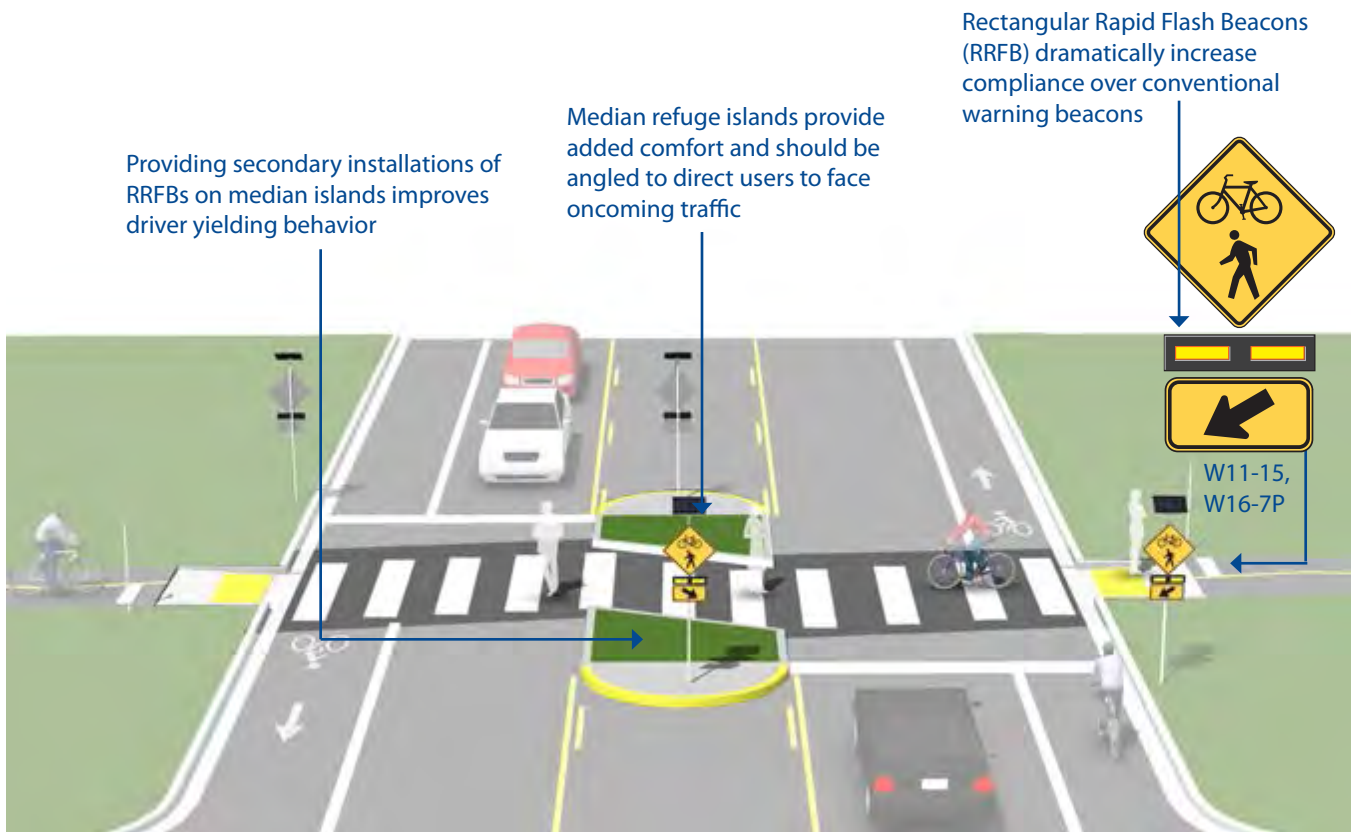
Enhanced marked crossings are unsignalized crossings with additional treatments designed to increase motor vehicle yielding compliance on multi-lane or high volume roadways.

These enhancements include pathway user or sensor actuated warning beacons, Rectangular Rapid Flash Beacons (RRFB) shown below, or in-roadway warning lights.

## Guidance

Guidance for marked/unsignalized crossings applies.

- Warning beacons shall not be used at crosswalks controlled by YIELD signs, STOP signs, or traffic control signals.
- Warning beacons shall initiate operation based on user actuation and shall cease operation at a predetermined time after the user actuation or, with passive detection, after the user clears the crosswalk.



## Discussion

Rectangular rapid flash beacons show the most increased compliance of all the warning beacon enhancement options.

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 arrangement raised compliance to 88 percent. Additional studies of long term installations show little to no decrease in yielding behavior over time.

## Additional References and Guidelines

NACTO. *Urban Bikeway Design Guide*. 2012.  
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 FHWA. *MUTCD - Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11)*. 2008.

## Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

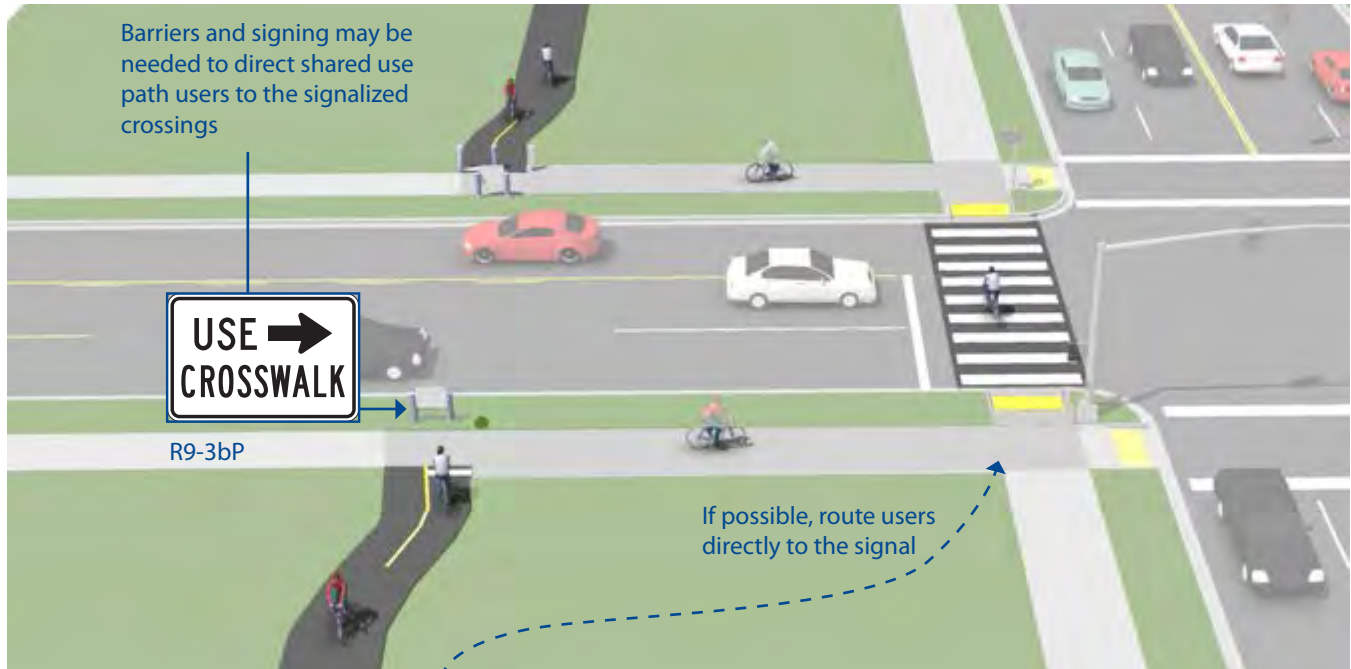
## Route Users to Signalized Crossings

### Description

Path crossings within approximately 400 feet of an existing signalized intersection with pedestrian crosswalks are typically diverted to the signalized intersection to avoid traffic operation problems when located so close to an existing signal. For this restriction to be effective, barriers and signing may be needed to direct path users to the signalized crossing. If no pedestrian crossing exists at the signal, modifications should be made.

### Guidance

Path crossings should not be provided within approximately 400 feet of an existing signalized intersection. If possible, route path directly to the signal.



### Discussion

In the US, the minimum distance a marked crossing can be from an existing signalized intersection varies from approximately 250 to 660 feet. Engineering judgement and the context of the location should be taken into account when choosing the appropriate allowable setback. Pedestrians are particularly sensitive to out of direction travel and undesired mid-block crossing may become prevalent if the distance is too great.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.

### Materials and Maintenance

If a sidewalk is used for crossing access, it should be kept clear of snow and debris and the surface should be level for wheeled users.

# Full Traffic Signal Crossings

## Description

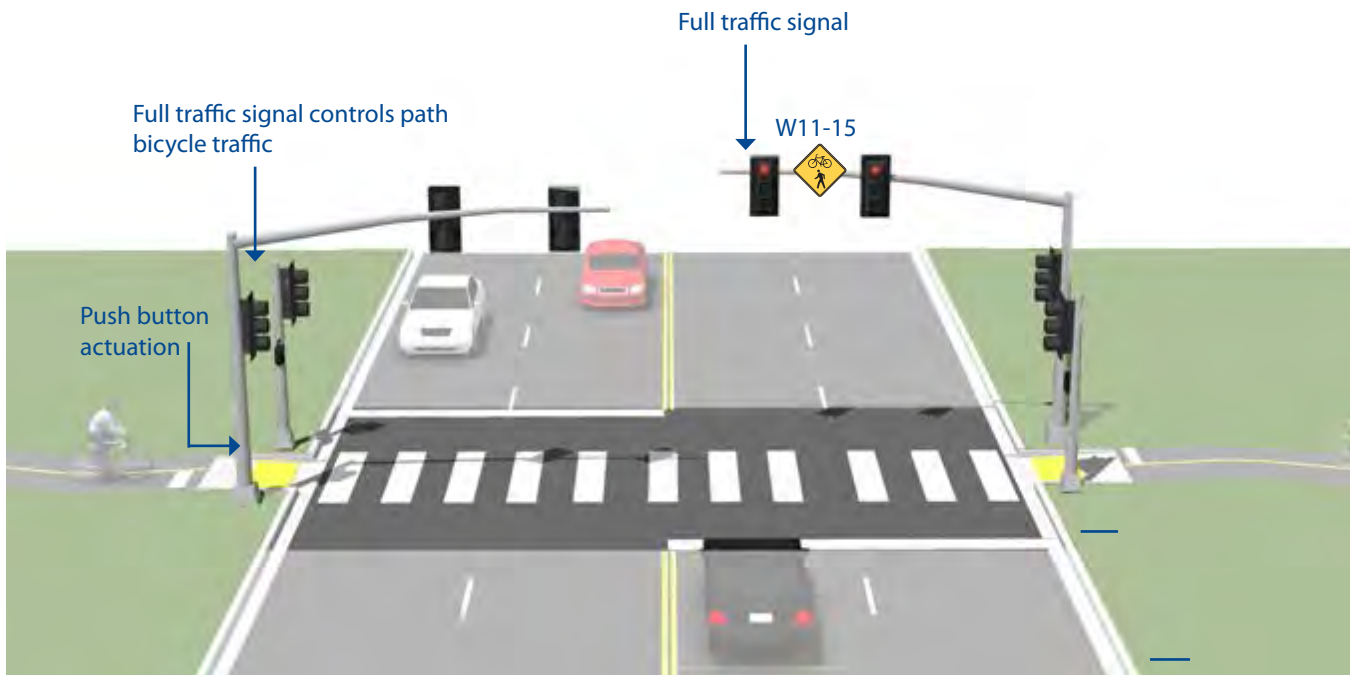
Signalized crossings provide the most protection for crossing path users through the use of a red-signal indication to stop conflicting motor vehicle traffic.

A full traffic signal installation treats the path crossing as a conventional 4-way intersection and provides standard red-yellow-green traffic signal heads for all legs of the intersection.

## Guidance

Full traffic signal installations must meet MUTCD pedestrian, school or modified warrants. Additional guidance for signalized crossings:

- Located more than 300 feet from an existing signalized intersection
- Roadway travel speeds of 40 MPH and above
- Roadway ADT exceeds 15,000 vehicles



## Discussion

Shared use path signals are normally activated by push buttons but may also be triggered by embedded loop, 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.

## Additional References and Guidelines

FHWA. *Manual on Uniform Traffic Control Devices*. 2009.  
 NACTO. *Urban Bikeway Design Guide*. 2012.

## Materials and Maintenance

Traffic signals require routine maintenance. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

## BICYCLE PARKING

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



# Bicycle Racks

## Description

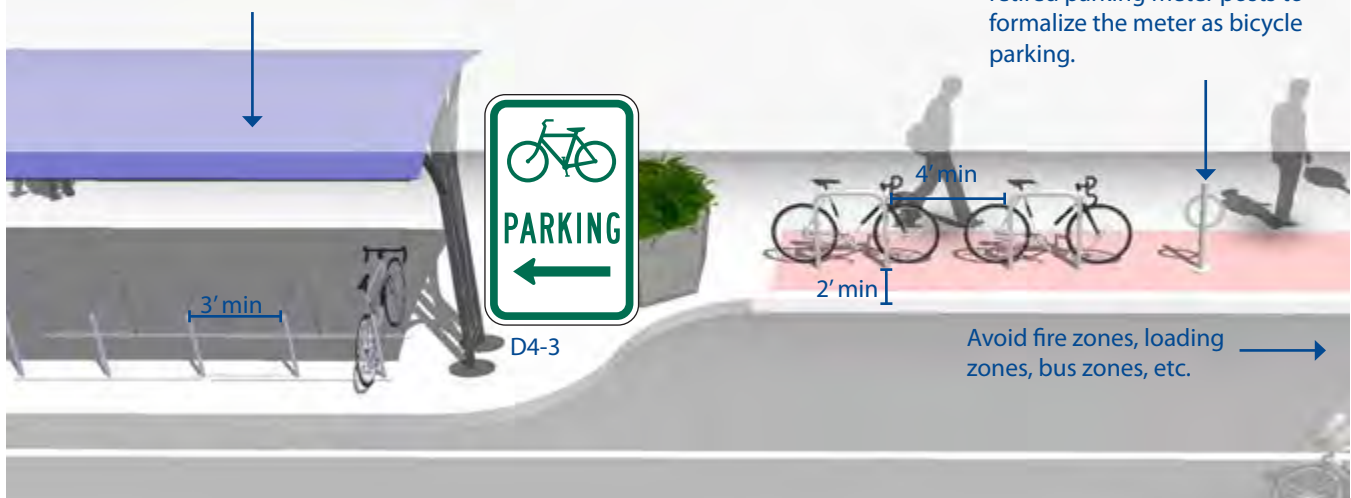
Short-term bicycle parking is meant to accommodate visitors, customers, and others expected to depart within two hours. It should have an approved standard rack, appropriate location and placement, and weather protection. The Association for Pedestrian and Bicycle Professionals (APBP) recommends selecting a bicycle rack that:

- Supports the bicycle in at least two places, preventing it from falling over.
- Allows locking of the frame and one or both wheels with a U-lock.
- Is securely anchored to ground.
- Resists cutting, rusting and bending or deformation.

## Guidance

- 2' minimum from the curb face to avoid 'dooring'
- Close to destinations; 50' maximum distance from main building entrance.
- Minimum clear distance of 6' should be provided between the bicycle rack and the property line.
- Should be highly visible from adjacent bicycle routes and pedestrian traffic.
- Locate racks in areas that cyclists are most likely to travel.
- In areas with uncomfortable weather conditions, covered bike parking and be an attractive way to improve conditions for bicyclists.

Bicycle shelters consist of bicycle racks grouped together within structures with a roof that provides weather protection.



## Discussion

Where the placement of racks on sidewalks is not possible (due to narrow sidewalk width, sidewalk obstructions, street trees, etc.), bicycle parking can be provided in the street where on-street vehicle parking is allowed in the form of on-street bicycle corrals.

Some types of bicycle racks may meet design criteria, but are discouraged except in limited situations. This includes undulating "wave" racks, schoolyard "wheel bender" racks, and spiral racks.

## Additional References and Guidelines

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- APBP. *Bicycle Parking Guide 2nd Edition*. 2010.

## Materials and Maintenance

Use of proper anchors will prevent vandalism and theft. Racks and anchors should be regularly inspected for damage. Educate snow removal crews to avoid burying racks during winter months.



## On-Street Bicycle Corral

### Description

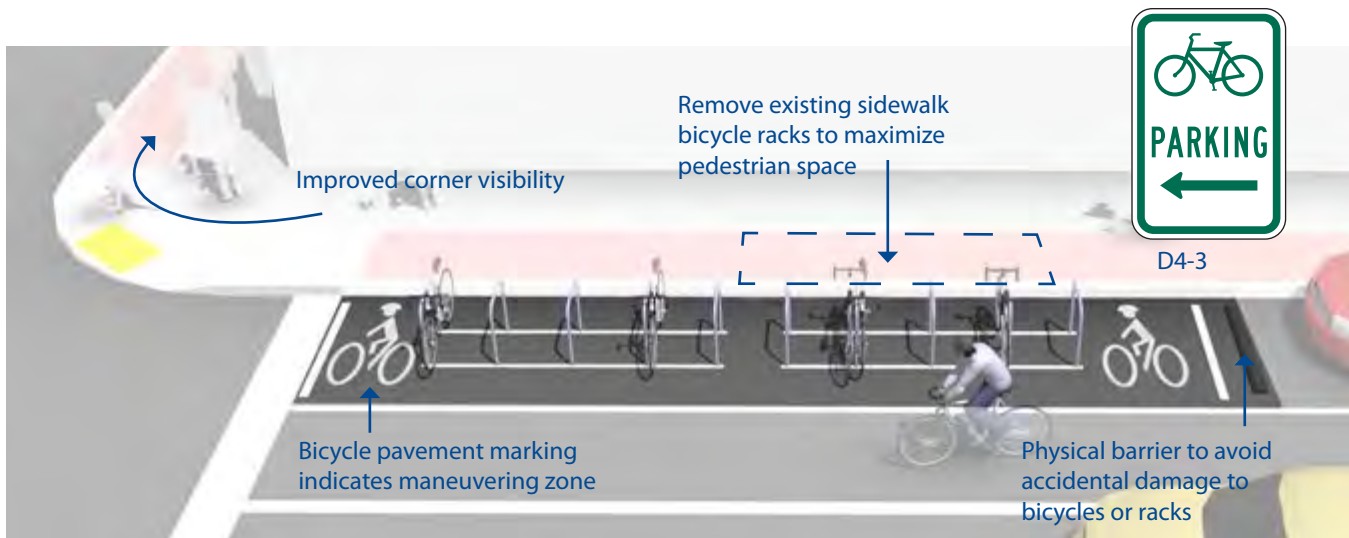
Bicycle corrals (also known as on-street bicycle parking) consist of bicycle racks grouped together in a common area within the street traditionally used for automobile parking. Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking. Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces.

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

### Guidance

See guidelines for sidewalk bicycle rack placement and clear zones.

- Bicyclists should have an entrance width from the roadway of 5' – 6'.
- Can be used with parallel or angled parking.
- Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.



### Discussion

In many communities, the installation of bicycle corrals is driven by requests from adjacent businesses, and is not a city-driven initiative. In such cases, the city does not remove motor vehicle parking unless it is explicitly requested. In other areas, the city provides the facility and business associations take responsibility for the maintenance of the facility. Communities can establish maintenance agreements with the requesting business. Bicycle corrals can be especially effective in areas with high bicycle parking demand or along street frontages with narrow sidewalks where parked bicycles would be detrimental to the pedestrian environment.

### Additional References and Guidelines

APBP. *Bicycle Parking Guide 2nd Edition*. 2010.

### Materials and Maintenance

Physical barriers may obstruct drainage and collect debris. Establish a maintenance agreement with neighboring businesses. In snowy climates the bicycle corral may need to be removed during the winter months.

## Bicycle Lockers

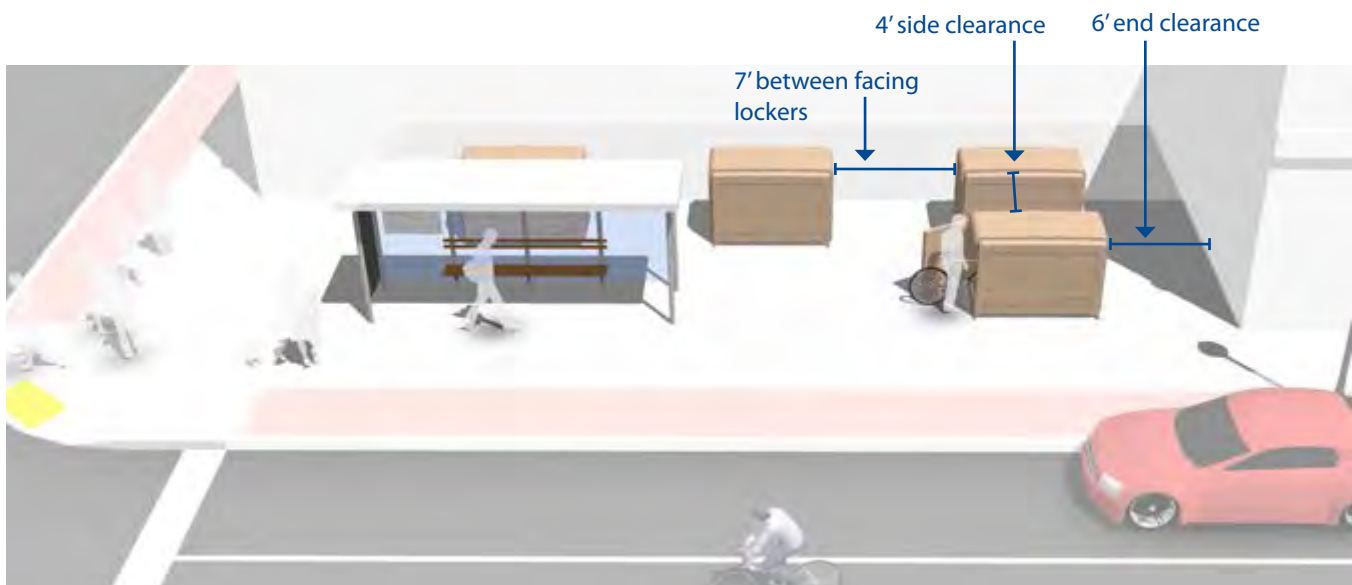
### Description

Bicycle lockers are intended to provide long-term bicycle storage for employees, students, residents, commuters, and others expected to park more than two hours. Long-term facilities protect the entire bicycle, its components and accessories against theft and against inclement weather, including snow and wind-driven rain.

Bicycle lockers provide space to store a few accessories or rain gear in addition to containing the bicycle. Some lockers allow access to two users - a partition separating the two bicycles can help users feel their bike is secure. Lockers can also be stacked, reducing the footprint of the area, although that makes them more difficult to use.

### Guidance

- Minimum dimensions: width (opening) 2.5'; height 4'; depth 6'.
- 4 foot side clearance and 6 foot end clearance.
- 7 foot minimum distance between facing lockers.
- Locker designs that allow visibility and inspection of contents are recommended for increased security.
- Access is controlled by a key or access code.



### Discussion

Long-term parking facilities are more expensive to provide than short-term facilities, but are also significantly more secure. Although many bicycle commuters would be willing to pay a nominal fee to guarantee the safety of their bicycle, long-term bicycle parking should be free wherever automobile parking is free. Potential locations for long-term bicycle parking include transit stations, large employers, and institutions where people use their bikes for commuting and not consistently throughout the day.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
 APBP. *Bicycle Parking Guide 2nd Edition*. 2010.

### Materials and Maintenance

Regularly inspect the functioning of moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

## Secure Parking Areas (SPA)

### Description

A Secure Parking Area for bicycles, also known as a BikeSPA or Bike & Ride (when located at transit stations), is a semi-enclosed space that offers a higher level of security than ordinary bike racks. Accessible via key-card, combination locks, or keys, BikeSPAs provide high-capacity parking for 10 to 100 or more bicycles. Increased security measures create an additional transportation option for those whose biggest concern is theft and vulnerability.

### Guidance

#### Key features may include:

- Closed-circuit television monitoring.
- Double high racks & cargo bike spaces.
- Bike repair station with bench.
- Bike tube and maintenance item vending machine.
- Bike lock “hitching post” – allows people to leave bike locks.
- Secure access for users.

Double-height racks help take advantage of the vertical space, further maximizing the parking capacity.

In the space formerly used for seven cars, a BikeSPA can comfortably park 80 bikes with room for future expansion.



Additional covered short term parking.

### Discussion

Long-term parking facilities are more expensive to provide than short-term facilities, but are also significantly more secure. Although many bicycle commuters would be willing to pay a nominal fee to guarantee the safety of their bicycle, long-term bicycle parking should be free wherever automobile parking is free. BikeSPAs are ideal for transit centers, airports, train stations, or wherever large numbers of people might arrive by bicycle and need a secure place to park while away.

### Additional References and Guidelines

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.  
APBP. *Bicycle Parking Guide 2nd Edition*. 2010.

### Materials and Maintenance

Regularly inspect the functioning of moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

## BIKEWAY MAINTENANCE

Regular bicycle facility maintenance includes sweeping, maintaining a smooth roadway, ensuring that the gutter-to-pavement transition remains relatively flush, and installing bicycle-friendly drainage grates. Pavement overlays are a good opportunity to improve bicycle facilities. The following recommendations provide a menu of options to consider to enhance a maintenance regimen.

### Recommended Walkway and Bikeway Maintenance Activities

Maintenance Activity	Frequency
<b>Inspections</b>	Seasonal – at beginning and end of Summer
<b>Pavement sweeping/blowing</b>	As needed, with higher frequency in the early Spring and Fall
<b>Pavement sealing</b>	5 - 15 years
<b>Pothole repair</b>	1 week – 1 month after report
<b>Culvert and drainage grate inspection</b>	Before Winter and after major storms
<b>Pavement markings replacement</b>	As needed
<b>Signage replacement</b>	As needed
<b>Shoulder plant trimming (weeds, trees, brambles)</b>	Twice a year; middle of growing season and early Fall
<b>Tree and shrub plantings, trimming</b>	1 – 3 years
<b>Major damage response (washouts, fallen trees, flooding)</b>	As soon as possible



Sweeping



Roadway Surface



Gutter to Pavement Transition



Drainage Grates



Landscaping



Maintenance Management Plan

## Sweeping

### Description

Bicyclists often avoid shoulders and bike lanes filled with gravel, broken glass and other debris; they will ride in the roadway to avoid these hazards, potentially causing conflicts with motorists. Debris from the roadway should not be swept onto sidewalks (pedestrians need a clean walking surface), nor should debris be swept from the sidewalk onto the roadway. A regularly scheduled inspection and maintenance program helps ensure that roadway debris is regularly picked up or swept.



### Guidance

- Establish a seasonal sweeping schedule that prioritizes roadways with major bicycle routes.
- Sweep walkways and bikeways whenever there is an accumulation of debris on the facility.
- In curbed sections, sweepers should pick up debris; on open shoulders, debris can be swept onto gravel shoulders.
- Pave gravel driveway approaches to minimize loose gravel on paved roadway shoulders.
- Perform additional sweeping in the Spring to remove debris from the Winter.
- Perform additional sweeping in the Fall in areas where leaves accumulate .

## Signage

### Description

Bike lanes, shared shoulders, Bicycle Boulevards and paths all have different signage types for wayfinding and regulations. Such signage is vulnerable to vandalism or wear, and requires periodic maintenance and replacement as needed.

### Guidance

- Perform a regularly-scheduled check on the status of signage with follow-up as necessary. Check for signs of vandalism, graffiti, or normal wear.
- Replace signage along the bikeway network as-needed.
- Create a Maintenance Management Plan.



## Roadway Surface

### Description

Bicycles are much more sensitive to subtle changes in roadway surface than are motor vehicles. Various materials are used to pave roadways, and some are smoother than others. Compaction is also an important issue after trenches and other construction holes are filled. Uneven settlement after trenching can affect the roadway surface nearest the curb where bicycles travel. Sometimes compaction is not achieved to a satisfactory level, and an uneven pavement surface can result due to settling over the course of days or weeks. When resurfacing streets, use the smallest chip size and ensure that the surface is as smooth as possible to improve safety and comfort for bicyclists.



### Guidance

- Maintain a smooth pothole-free surface.
- Ensure that on new roadway construction, the finished surface on bikeways does not vary more than ¼".
- Maintain pavement so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- If chip sealing is to be performed, use the smallest possible chip on bike lanes and shoulders. Sweep loose chips regularly following application.
- During chip seal maintenance projects, if the pavement condition of the bike lane is satisfactory, it may be appropriate to chip seal the travel lanes only. However, use caution when doing this so as not to create an unacceptable ridge between the bike lane and travel lane.

## Pavement Overlays

### Description

Pavement overlays represent good opportunities to improve conditions for bicyclists if done carefully. A ridge should not be left in the area where bicyclists ride (this occurs where an overlay extends part-way into a shoulder bikeway or bike lane). Overlay projects also offer opportunities to widen a roadway, or to re-stripe a roadway with bike lanes.



### Guidance

- Extend the overlay over the entire roadway surface to avoid leaving an abrupt edge.
- If the shoulder or bike lane pavement is of good quality, it may be appropriate to end the overlay at the shoulder or bike lane stripe provided no abrupt ridge remains.
- Ensure that inlet grates, manhole and valve covers are within ¼ inch of the finished pavement surface and are made or treated with slip resistant materials.
- Pave gravel driveways to property lines to prevent gravel from being tracked onto shoulders or bike lanes.

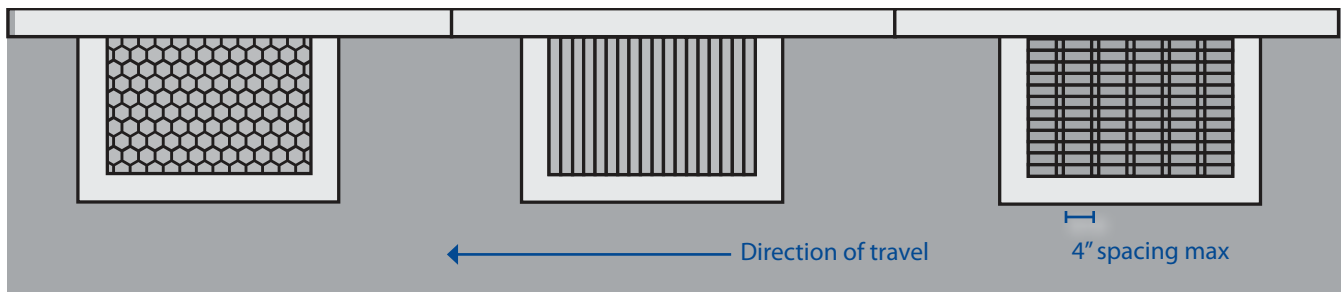
## Drainage Grates

### Description

Drainage grates are typically located in the gutter area near the curb of a roadway. Drainage grates typically have slots through which water drains into the municipal storm sewer system. Many older grates were designed with linear parallel bars spread wide enough for a tire to become caught so that if a bicyclist were to ride on them, the front tire could become caught in the slot. This would cause the bicyclist to tumble over the handlebars and sustain potentially serious injuries.

### Guidance

- Require all new drainage grates be bicycle-friendly, including grates that have horizontal slats on them so that bicycle tires and assistive devices do not fall through the vertical slats.
- Create a program to inventory all existing drainage grates, and replace hazardous grates as necessary – temporary modifications such as installing rebar horizontally across the grate should not be an acceptable alternative to replacement.

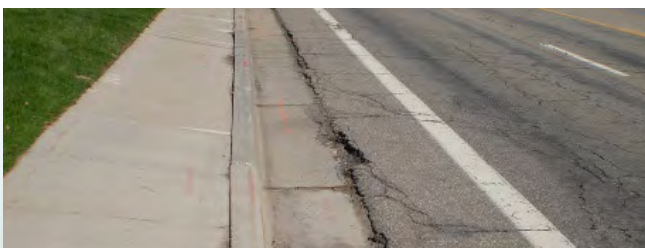


## Gutter to Pavement Transition

### Description

On streets with concrete curbs and gutters, 1 to 2 feet of the curbside area is typically devoted to the gutter pan, where water collects and drains into catch basins. On many streets, the bikeway is situated near the transition between the gutter pan and the pavement edge. This transition can be susceptible to erosion, creating potholes and a rough surface for travel.

The pavement on many streets is not flush with the gutter, creating a vertical transition between these segments. This area can buckle over time, creating a hazardous condition for bicyclists.



### Guidance

- Ensure that gutter-to-pavement transitions have no more than a ¼" vertical transition.
- Examine pavement transitions during every roadway project for new construction, maintenance activities, and construction project activities that occur in streets.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- Provide at least 3 feet of pavement outside of the gutter seam.

## Landscaping

### Description

Bikeways can become inaccessible due to overgrown vegetation. All landscaping needs to be designed and maintained to ensure compatibility with the use of the bikeways. After a flood or major storm, bikeways should be checked along with other roads, and fallen trees or other debris should be removed promptly.



### Guidance

- Ensure that shoulder plants do not hang into or impede passage along bikeways
- After major damage incidents, remove fallen trees or other debris from bikeways as quickly as possible

## Maintenance Management Plan

### Description

Bikeway users need accommodation during construction and maintenance activities when bikeways may be closed or unavailable. Users must be warned of bikeway closures and given adequate detour information to bypass the closed section. Users should be warned through the use of standard signing approaching each affected section (e.g., "Bike Lane Closed," "Trail Closed"), including information on alternate routes and dates of closure. Alternate routes should provide reasonable directness, equivalent traffic characteristics, and be signed.



### Guidance

- Provide fire and police departments with map of system, along with access points to gates/bollards
- Enforce speed limits and other rules of the road
- Enforce all trespassing laws for people attempting to enter adjacent private properties