CITY OF COLUMBIA ENGINEERING REGULATIONS
PART 9: PEDESTRIAN, BICYCLE, AND COMPLETE STREETS DESIGN GUIDELINES

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PART 9: PEDESTRIAN, BICYCLE, AND COMPLETE STREETS DESIGN GUIDELINES

9.1 Introduction

This technical handbook is intended to assist the City of Columbia in the selection and design of pedestrian, bicycle, transit facilities. The following sections pull together best practices by facility type from public agencies and municipalities nation¬wide. Within the design sections, treatments are covered within a single sheet tabular format relaying important design information and discussion, example photos, schematics (if applicable), and existing summary guidance from current or upcoming draft standards. Existing standards are referenced throughout and should be the first source of information when seeking to implement any of the treatments featured here.

9.1.1 National Standards

9.1.1.1 The Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD) defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic. The MUTCD is the primary source for guidance on lane striping requirements, signal warrants, and recommended signage and pavement markings.

The National Committed on Traffic Control Devices (NUTCD) has submitted draft language for consideration in future editions of the MUTCD to include contemporary bicycle facilities. Guidance for these treatments are evolving, and practitioners should reference future editions of national guidance to understand current best practice.

To further clarify the MUTCD, the FHWA created a table of contemporary bicycle facilities that lists various bicycle-related signs, markings, signals, and other treatments and identifies their official status (e.g., can be implemented, currently experimental). See Bicycle Facilities and the Manual on Uniform Traffic Control Devices.[1]

Bikeway treatments not explicitly covered by the MUTCD are often subject to experiments, interpretations and official rulings by the FHWA. The MUTCD Official Rulings is a resource that allows website visitors to obtain information about these supplemen- tary materials. Copies of various documents (such as incoming request letters, response letters from the FHWA, progress reports, and final reports) are available on this website.[2]

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 standards and guidelines presented by AASHTO provide basic information, such as minimum sidewalk widths,

1 Bicycle Facilities and the Manual on Uniform Traffic Control Devices. (2011). FHWA. http://www.fhwa.dot.gov/environment/bikeped/mutcd_bike.htm

2 MUTCD Official Rulings. FHWA. http://mutcd.fhwa.dot.gov/orsearch.asp

bicycle lane dimensions, detailed striping requirements and recommended signage and pavement markings.

The National Association of City Transportation Officials' (NACTO[3]) Urban Bikeway Design Guide and Urban Streets Design Guide is the newest publication of nationally recognized street design guidelines, and offers guidance on the current state

of the practice designs. The NACTO Urban Bikeway Design Guide is based on current practices in the best cycling cities in the world. The intent of the guide is to offer substantive guidance for cities seeking to improve bicycle transportation in places where competing demands for the use of the right of way present unique challenges. All of the NACTO Urban Bikeway Design Guide treatments are in use internationally and in many cities around the US.

Offering similar guidance for pedestrian design, the 2004 AASHTO Guide for the Planning, Design and Operation of Pedes- trian Facilities provides comprehensive guidance on planning and designing for people on foot.

Some of these treatments are not directly referenced in the current versions of the AASHTO Guide or the MUTCD, although many of the elements of these treatments are found within these documents. In all cases, engineering judgment is recommended to ensure that the application makes sense for the context of each treatment, given the many complexities of urban

9.1.2 Local Standards

9.1.2.1 The South Carolina Department of Transportation has published a variety of additional resources for designing bicycle and pedestrian facilities. These include the SCDOT Highway Design Manual, SCDOT Traffic Calming Design Guidelines, SCDOT Traffic Signal Design Guidelines and SCDOT Access and Roadside Management Standards. In recent years, SCDOT has also issued several Traffic Engineering Guidelines, and Engineering Directive Memorandums for such treatments as pedestrian hybrid beacons, shared lane markings, rumble strips and other complete streets treatments.

9.1.3 Additional US Federal Guidelines

9.1.3.1 Meeting the requirements of the Americans with Disabilities Act (ADA) is an important part of any bicycle and pedestrian facility project. The United States Access Board's proposed Public Rights-of-Way Accessibility Guidelines[4] (PROWAG) and the 2010 ADA Standards for Accessible Design[5] (2010 Standards) contain standards and guidance for the construction of accessible facilities. This includes requirements for sidewalk curb ramps, slope requirements, and pedestrian railings along stairs.

3 http://nacto.org/

4 http://www.access-board.gov/prowac/

5 http://www.ada.gov/2010ADAstandards_index.htm

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

9.2 Pedestrian Facilities

9.2.1 Design Needs of Pedestrians

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

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

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

9.2.1.2 Pedestrian Characteristics by Age[6]

Table 9-1. *Pedestrian Characteristics by Age*

Age	Characteristics
0-4	Learning to walk Requires constant adult supervision Developing peripheral vision and depth perception
5-8	Increasing independence, but still requires supervision Poor depth perception
9-13	Susceptible to "darting out" in roadways Insufficient judgment Sense of invulnerability
14-18	Improved awareness of traffic environment Insufficient judgment
19-40	Active, aware of traffic environment
41-65	Slowing of reflexes

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

Age	Characteristics
65+	Difficulty crossing street Difficulty hearing vehicles approaching from behind Vision loss

9.2.1.3 Pedestrian Space Usage

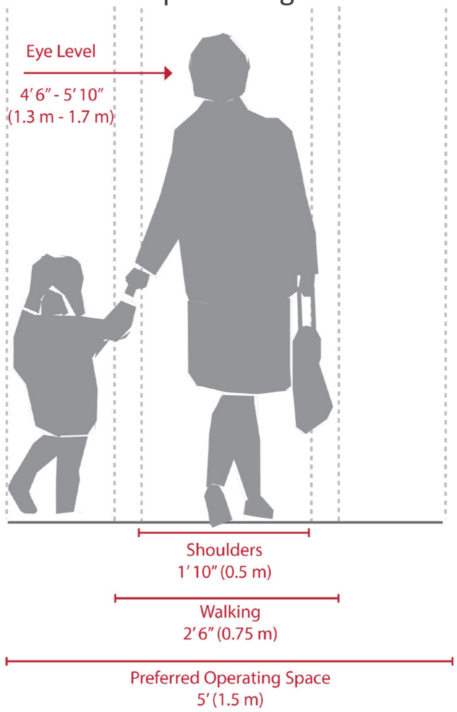


Figure 9-1. *Pedestrian Space Usage*

9.2.1.4 Disabled Pedestrian Design Considerations

Table 9-2. *Disabled Pedestrian Design Considerations*

Impairment	Effect on Mobility	Design Solution
Wheelchair and Scooter Users	Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
	Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
	Require wider path of travel.	Sufficient width and maneuvering space.
Walking Aid Users	Difficulty negotiating steep grades and cross slopes; decreased stability.	Smooth, non-slipperly travel surface.
	Slower walking speed and reduced endurance; reduced ability to react.	Longer pedestrian signal cycles, shorter crossing distances, median refuges, and street furniture.

Impairment	Effect on Mobility	Design Solution
Hearing Impairment	Less able to detect oncoming hazards at locations with limited sight lines (e.g. driveways, angled inter- sections, channelized right turn lanes) and complex intersections.	Longer pedestrian signal cycles, clear sight distances, highly visible pedestrian signals and markings.
Vision Impairment	Limited perception of path ahead and obstacles; reliance on memory; reliance on non-visual indicators (e.g. sound and texture).	Accessible text (larger print and raised text), accessible pedestrian signals (APS), guide strips and detectable warning surfaces, safety barriers, and lighting.
Cognitive Impairment	Varies greatly. Can affect ability to perceive, recognize, understand, interpret, and respond to information.	Signs with pictures, universal symbols, and colors, rather than text.

9.2.2 Design Needs of Wheelchair Users - As the American population ages, the number of people using mobility assistive devices (such as manual wheel¬chairs, powered wheelchairs) increases.

Manual wheelchairs are self-propelled devices. Users propel themselves using push rims attached to the rear wheels. Braking is done through resisting wheel movement with the hands or arm. Alternatively, a second individual can control the wheelchair using handles attached to the back of the chair.

Power wheelchairs user battery power to move the wheelchair. The size and weight of power wheelchairs limit their ability to negotiate obstacles without a ramp.

Maneuvering around a turn requires additional space for wheelchair devices. Providing adequate space for 180 degree turns at appropriate locations is an important element for accessible design.

ADA inadequacies should be inventoried in an ADA transition plan and addressed in a systematic fashion.

9.2.2.1 Wheelchair User Typical Speed

Table 9-3. *Wheelchair User Typical Speed*

User	Typical Speed
Manual Wheelchair	3.6 mph
Power Wheelchair	6.8 mph

9.2.2.2 Wheelchair User Design Considerations

Table 9-4. *Wheelchair User Design Considerations*

Effect on Mobility	Design Solution
Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
Pavement lip over 1/4” due to settling or root buckling.	Grind down pavement or replace sidewalk section.
Ramp slope difficult for wheelchair users to climb.	Ensure 8.3% ramp slope.

9.2.2.3 Wheelchair Space Usage

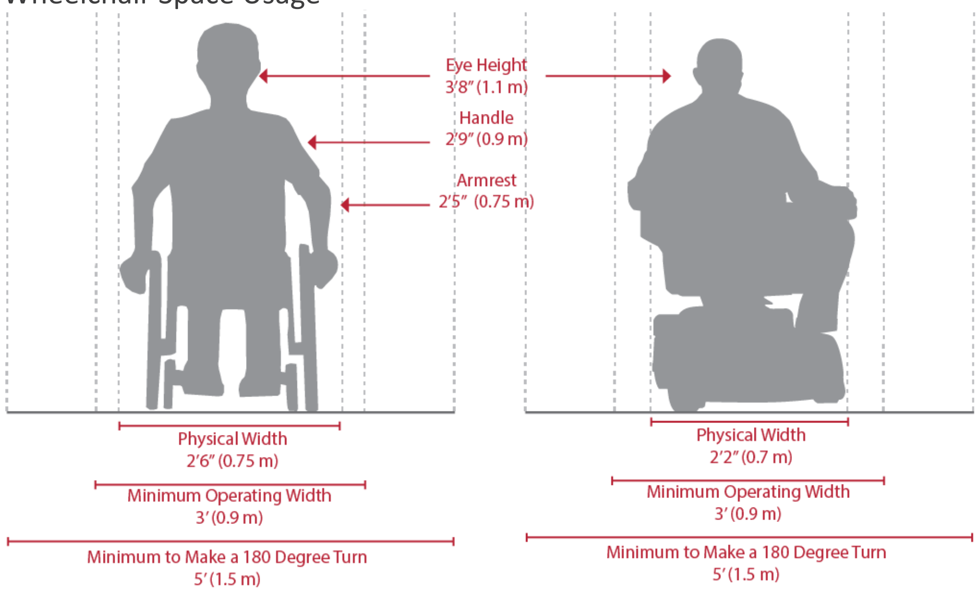


Figure 9-2. *Wheelchair Space Usage*

9.2.3 Design Needs of Runners - Running is an important recreation and fitness activity commonly performed on shared use paths. Many runners prefer softer surfaces (such as rubber, bare earth or crushed rock) to reduce impact. Runners can change their speed and direction frequently. If high volumes are expected, controlled interaction or separation of different types of users should be considered.

9.2.3.1 Runner Typical Speed

Table 9-5. *Runner Typical Speed*

User	Typical Speed
Runner	6.2 mph

9.2.4 Runner Space Usage

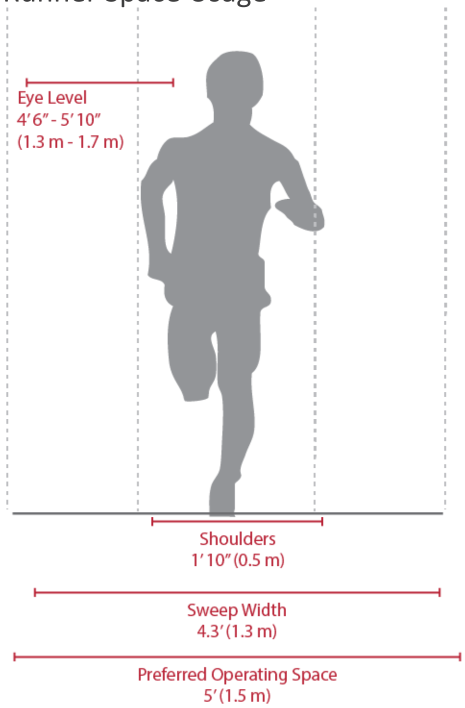


Figure 9-3. *Runner Space Usage*

9.3 Sidewalks

9.3.1 Zones In The Sidewalk Corridor

Parking Lane/ Enhancement Zone	Edge Zone*	Furnishing Zone	Pedestrian Through Zone	Frontage Zone
The parking lane can act as a flexible space to further buffer the sidewalk from moving traffic. Curb extensions and bike corrals may occupy this space where appropriate. * In the edge zone there should be a 6 inch wide curb		The furnishing zone buffers pedestrians from the adjacent roadway, and is also the area where elements such as street trees, signal poles, signs, and other street furniture are properly located.	The through zone is the area intended for pedestrian travel. This zone should be entirely free of permanent and temporary objects. Wide through zones are needed in downtown areas or where pedestrian flows are high.	The Frontage Zone allows pedestrians a comfortable “shy” distance from the building fronts. It provides opportunities for window shopping, to place signs, planters, or chairs. Not applicable if adjacent to a landscaped space.

Figure 9-4. *Zones In The Sidewalk Corridor*

9.3.1.1 Description - Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel separated from vehicle traffic. A variety of con- siderations are important in sidewalk design. Providing adequate and accessible facilities can lead to increased numbers of people walking, improved safety, and the creation of social space.

9.3.1.2 Discussion - Sidewalks should be more than areas to travel; they should provide places for people to interact. There should be places for standing, visiting, and sitting. Sidewalks should contribute to the character of neighborhoods and business districts, strengthen their identity, and be an area where adults and children can safely participate in public life.

9.3.1.3 Materials and Maintenance - Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped space. Colored, patterned, or stamped concrete can add distinctive visual appeal.

9.3.1.4 Additional References and Guidelines

9.3.1.4.1 USDOJ. ADA Standards for Accessible Design. 2010.

9.3.1.4.2 United States Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG). 2011. AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.3.1.4.3 NACTO. Urban Street Design Guide. 2013. SCDOT. Highway Design Manual. 2003.

9.3.2 Sidewalk Widths

Table 9-6. *Sidewalk Widths*

Street Classification	Parking Lane/ Enhancement Zone	Furnishing Zone*	Pedestrian Through Zone+	Frontage Zone	Total
Local Streets	Varies	2 - 8 feet	4 - 6 feet	N/A	6 - 14 feet
Commercial/ Downtown Areas	Varies	4 - 8 feet	6 - 12 feet	2.5 - 10 feet	11 - 30 feet
Arterials and Collectors	Varies	2 - 8 feet	4 - 8 feet	2.5 - 5 feet	8 -21 feet
* Furnishing Zone - Seating for outdoor dining is most common and functional in furnishing zones of 6 ft, although narrower configurations are possible.					
+ Pedestrian Through Zone - Six feet enables two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably					

9.3.2.1 Description - The width and design of sidewalks will vary depending on street context, functional classification, and pedestrian demand. Below are preferred widths of each sidewalk zone according to general street type. Standardizing sidewalk guidelines for different areas of the city, dependent on the above listed factors, ensures a minimum level of quality for all sidewalks.

9.3.2.2 Guidance - Sidewalk width should be determined based on desired user comfort. While a 3 foot wide through zone may accommodate a single person walking, it is inadequate for two people to walk side-by-side or comfortably pass other users. Designers should strive for sidewalk conditions that allow for side-by-side walking and comfortable passing.

9.3.2.3 Discussion - It is important to provide adequate width along a sidewalk corridor. Two people should be able to walk side-by-side and pass a third comfortably. In areas of high demand, sidewalks should contain adequate width to accommodate the high volumes and different walking speeds of pedestrians. The Americans with Disabilities Act requires a 4 foot clear width in the pedestrian zone plus 5 foot passing areas every 200 feet.

9.3.2.4 Materials and Maintenance - Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Surfaces must be firm, stable, and slip resistant.

9.3.2.5 Additional References and Guidelines

9.3.2.5.1 USDOJ. ADA Standards for Accessible Design. 2010.

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

9.3.2.5.3 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.3.2.5.4 NACTO. Urban Street Design Guide. 2013.

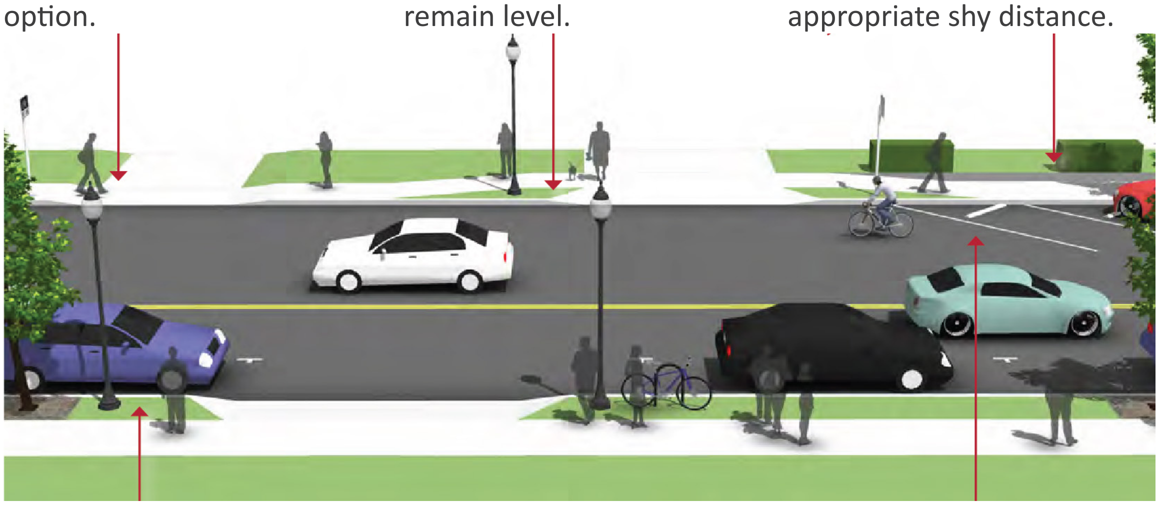
9.3.2.5.5 SCDOT. Highway Design Manual. 2003.

9.3.3 Sidewalk Obstructions And Driveway Ramps

Dipping the entire sidewalk at the driveway approaches keeps the crossslope at a constant grade. This is the least-preferred driveway option.

Where constraints preclude a planter strip, wrapping the sidewalk around the driveway allows the sidewalk to still remain level.

When sidewalks abut hedges, fences, or buildings, an additional two feet of lateral clearance should be added to provide appropriate shy distance.



Planter strips allow sidewalks to remain level, with the driveway grade change occurring within the planter strip.

When sidewalks abut angled on-street parking, wheel stops should be used to prevent vehicles from overhanging in the sidewalk.

Figure 9-5. *Sidewalk Obstructions And Driveway Ramps*

9.3.3.1 Description - Obstructions to pedestrian travel in the sidewalk corridor typically include driveway ramps, curb ramps, sign posts, utility and signal poles, mailboxes, fire hydrants and street furniture.

9.3.3.2 Guidance - Reducing the number of accesses reduces the need for special provisions. This strategy should be pursued first.

Obstructions should be placed between the sidewalk and the roadway to create a buffer for increased pedestrian comfort.

9.3.3.3 Discussion - Driveways are a common sidewalk obstruction, especially for wheelchair users. When constraints only allow curb-tight sidewalks, dipping the entire sidewalk at the driveway approaches keeps the cross-slope at a constant grade. However, this may be uncomfortable for pedestrians and could create drainage problems behind the sidewalk.

9.3.3.4 Materials and Maintenance - Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped space. Surfaces must be firm, stable, and slip resistant.

9.3.3.5 Additional References and Guidelines

9.3.3.5.1 USDOJ. ADA Standards for Accessible Design. 2010.

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

9.3.3.5.3 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.3.3.5.4 SCDOT. Highway Design Manual. 2003.

9.3.4 Pedestrian Amenities

9.3.4.1 Description - A variety of streetscape elements can define the pedestrian realm, offer protection from moving vehicles, and enhance the walking experience. Key features are presented below.

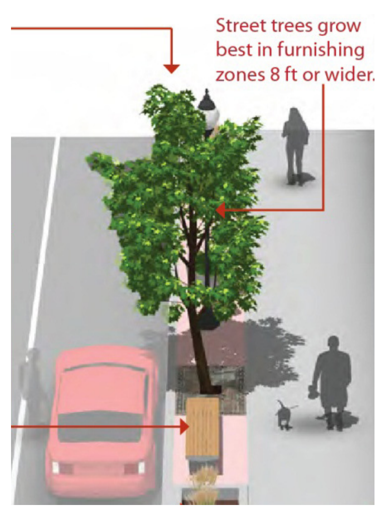


Figure 9-6. *Street Trees and Street Furniture*

9.3.4.1.1 Street Trees - In addition to their aesthetic and environmental value, street trees can slow traffic and improve safety for pedestrians. Trees add visual interest to streets and narrow the street's visual corridor, which may cause drivers to slow down. It is important that trees do not block light or the vision triangle.

9.3.4.1.2 Street Furniture - Providing benches at key rest areas and viewpoints encourages people of all ages to use the walkways by ensuring that they have a place to rest along the way. Benches should be 20" tall to accommodate elderly pedestrians comfortably. Benches can be simple (e.g., wood slats) or more ornate (e.g., stone, wrought iron, concrete). If alongside a parking zone, street furniture should be placed to minimize interference with passenger loading

9.3.4.1.3 Green Features - Green stormwater strategies may include bioretention swales, rain gardens, tree box filters, and pervious pavements (pervious concrete, asphalt and pavers).

Bioswales are natural landscape elements that manage water runoff from a paved surface. Plants in the swale trap pollutants and silt from entering a river system.

9.3.4.1.4 Lighting - Pedestrian scale lighting improves visibility for both pedestrians and motorists - particularly at intersections. Pedestrian scale lighting can provide a vertical buffer between the sidewalk and the street, defining pedestrian areas.

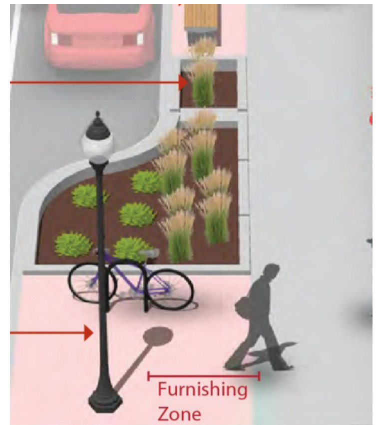


Figure 9-7. *Green Features and Lighting*

9.3.4.2 Discussion - Additional pedestrian amenities such as banners, public art, special paving, along with historical elements and cultural references, promote a sense of place. Public activities should be encouraged and commercial activities such as dining, vending and advertising may be permitted when they do not interfere with safety and accessibility.

Pedestrian amenities should be placed in the furnishing zone on a sidewalk corridor. See Zones in the Sidewalk Corridor for a discussion of the functional parts of a sidewalk. Signs, meters, tree wells should go between parking spaces.

9.3.4.3 Materials and Maintenance - Establishing and caring for your young street trees is essential to their health. Green features may require routine maintenance, including sediment and trash removal, and clearing curb openings and overflow drains.

9.3.4.4 Additional References and Guidelines

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

9.3.4.4.2 NACTO. Urban Street Design Guide. 2013.

9.3.5 Accessible Bus Stop Design

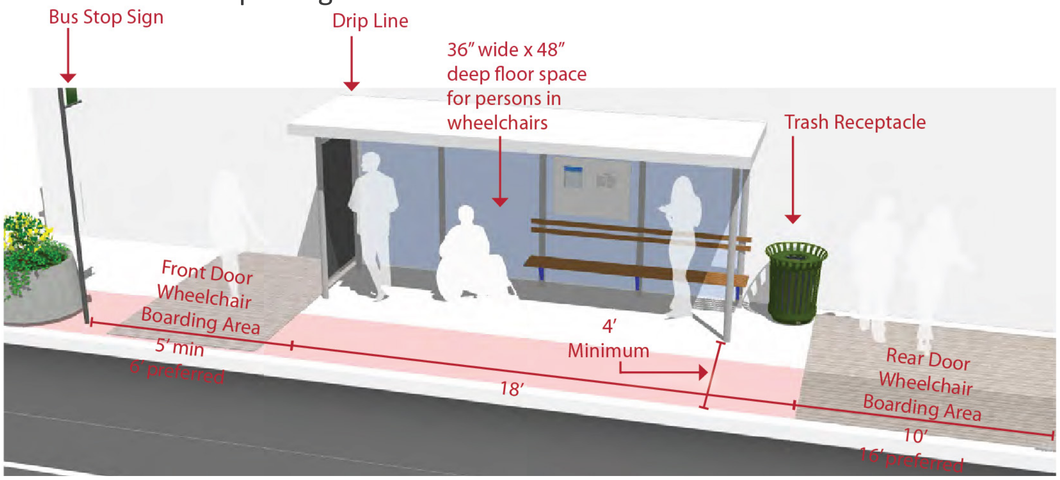


Figure 9-8. *Accessible Bus Stop Design*

9.3.5.1 Description - Bus stops should be connected to a continuous sidewalk and be located with adequate right of way to provide amenities such as shelters, benches and bike racks for users. The bus stop should offer direct pedestrian connectivity to adjacent destinations. Bus stops should be placed in a conspicuous, well-lit location to improve safety and reduce vandalism.

Bus stops should be designed to accomadate all users through the Americans with Disabilities Act accessibility requirements.

9.3.5.2 Guidance - Successful stop design provides good pedestrian traffic flow and thoughtful placement of amenities while meeting ADA accessibility requirements.

9.3.5.2.1 Site fixtures should be placed at the back of the site, allowing for pedestrian flow adjacent to the street.

9.3.5.2.2 A 5’ minimum clear area should be maintained between any site fixtures and the street.

9.3.5.2.3 The boarding and alighting areas should also be kept clear of obstacles. This includes benches, trash receptacles, trees, utility poles, newsracks, etc.

9.3.5.2.4 The space for front door boarding and alighting should be a minimum of 5’ wide (6’ preferred) and the space for each of the rear doors should be a minimum of 10’ wide (16’ preferred).

9.3.5.3 Discussion - Far-side bus stops have been shown to offer advantages for pedestrians and motorists – by improving visibility of pedestrians at crosswalks and not disrupting motor vehicle turning movements. For bus stops located at intersections, far-side bus stops should be utilized wherever possible.

9.3.5.4 Materials and Maintenance - Regularly inspect transit stops and keep clear of debris and trash.

9.3.5.5 Additional References and Guidelines

9.3.5.5.1 USDOJ. ADA Standards for Accessible Design. 2010.

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

9.3.5.5.3 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4 Pedestrians at Intersections

9.4.1 Marked Crosswalks

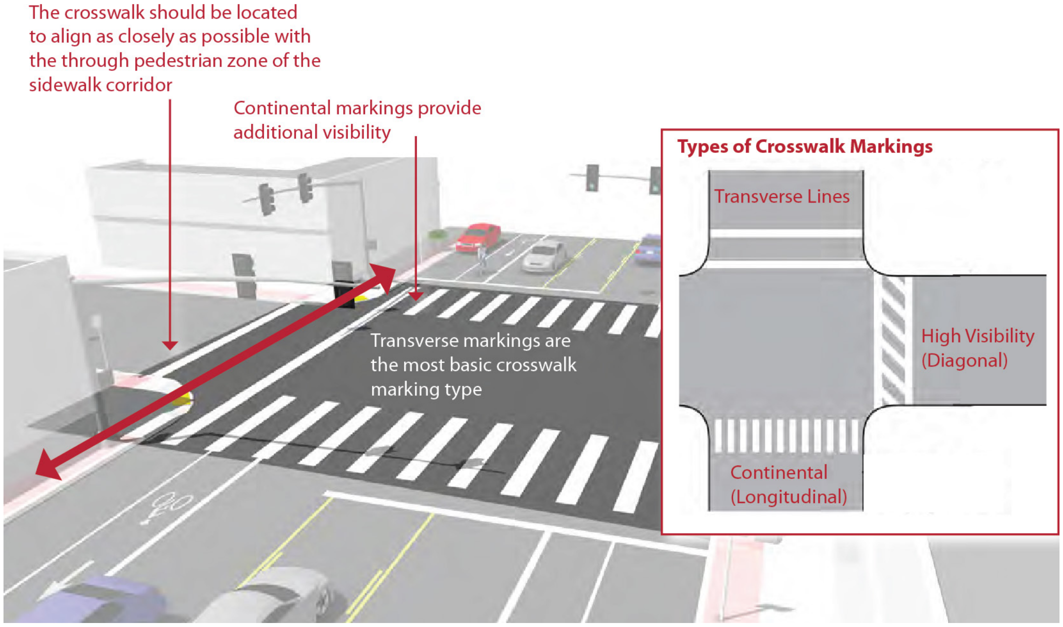


Figure 9-9. *Marked Crosswalks*

9.4.1.1 Description - A marked crosswalk signals to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer especially on multi-lane roadways.
At mid-block locations, crosswalks can be marked where there is a demand for crossing and there are no nearby marked crosswalks.

9.4.1.2 Guidance - At signalized intersections, all crosswalks should be marked. At un-signalized intersections, crosswalks may be marked under the following conditions:

9.4.1.2.1 At a complex intersection, to orient pedestrians in finding their way across.

9.4.1.2.2 At an offset intersection, to show pedestrians the shortest route across traffic with the least exposure to vehicular traffic and traffic conflicts.

9.4.1.2.3 At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.

9.4.1.2.4 At an intersection within a school zone on a walking route.

9.4.1.3 Discussion - Continental crosswalk markings should be used at crossings with high pedestrian use or where vulnerable pedestrians are expected, including: school crossings, across arterial streets for pedestrian-only signals, at mid-block crosswalks, and at intersections where there is expected high pedestrian use and the crossing is not controlled by signals or stop signs.

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

9.4.1.5 Additional References and Guidelines

9.4.1.5.1 FHWA. Manual on Uniform Traffic Control Devices. (3B.18). 2009.

9.4.1.5.2 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4.1.5.3 FHWA. Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations. 2005.

9.4.1.5.4 FHWA. Crosswalk Marking Field Visibility Study. 2010.

9.4.1.5.5 NACTO. Urban Street Design Guide. 2013.

9.4.2 Median Refuge Islands

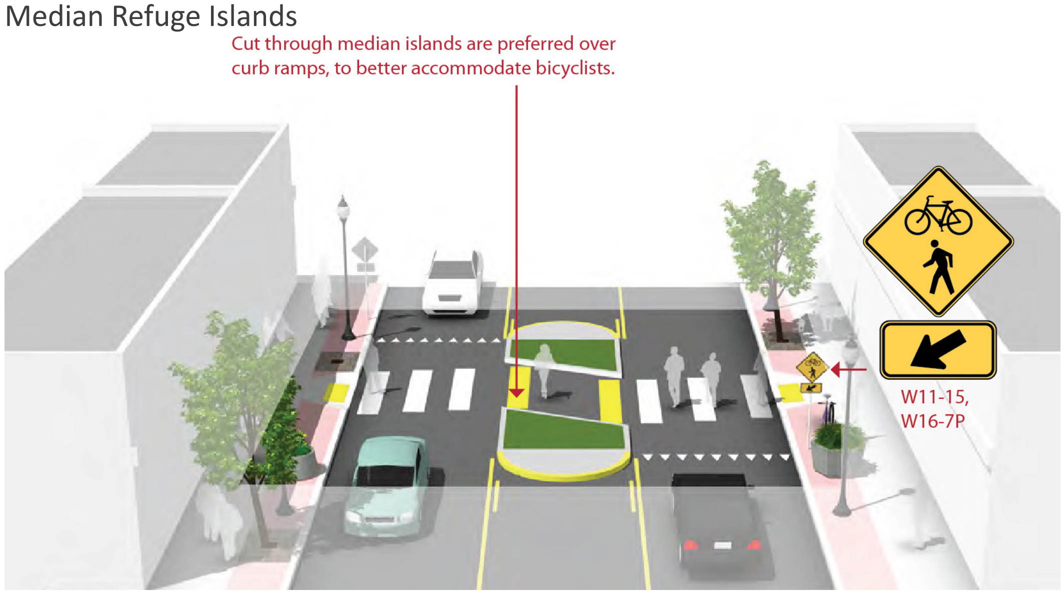


Figure 9-10. *Median Refuge Islands*

9.4.2.1 Description - Median refuge islands are located at the mid-point of a marked crossing and help improve pedestrian safety by allowing pedestrians to cross one direction of traffic at a time. Refuge islands minimize pedestrian exposure by shortening crossing distance and increasing the number of available gaps for crossing.

9.4.2.2 Guidance

9.4.2.2.1 Can be applied on any roadway with a left turn center lane or median that is at least 6' wide.

9.4.2.2.2 Appropriate at signalized or unsignalized crosswalks

9.4.2.2.3 The refuge island must be accessible, preferably with an at-grade passage through the island rather than ramps and landings.

9.4.2.2.4 The island should be at least 6' wide between travel lanes (to accommodate bikes with trailers and wheelchair users) and at least 20' long.

9.4.2.2.5 On streets with speeds higher than 25 mph there should also be double centerline marking, reflectors, and "KEEP RIGHT" signage.

9.4.2.3 Discussion - If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Shrubs and ground plantings should be no higher than 1 ft 6 in.

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

9.4.2.4 Materials and Maintenance - Refuge islands may collect road debris and may require somewhat frequent maintenance. Refuge islands should be visible to snow plow crews and should be kept free of snow berms that block access.

9.4.2.5 Additional References and Guidelines

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

9.4.2.7 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4.2.8 NACTO. Urban Bikeway Design Guide. 2012.

9.4.2.9 NACTO. Urban Street Design Guide. 2013.

9.4.2.10 SCDOT. Traffic Calming Guidelines. 2006.

9.4.3 Minimizing Curb Radii

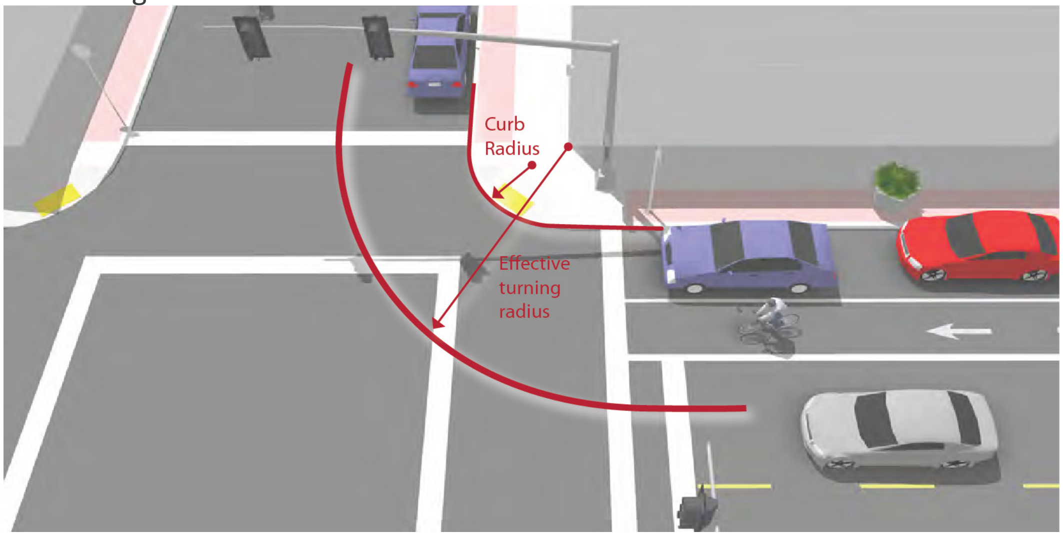


Figure 9-11. *Minimizing Curb Radii*

9.4.3.1 Description - The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crossing distance and requires vehicles to slow more on the intersection approach. During the design phase, the chosen radius should be the smallest possible for the circumstances.

9.4.3.2 Guidance

9.4.3.2.1 The radius may be as small as 3 ft where there are no turning movements, or 5 ft where there are turning movements, adequate street width, and a larger effective turning radius created by parking or bike lanes.

9.4.3.2.2 The designer should differentiate between two types of vehicles:

9.4.3.2.2.1 The Design Vehicle: the frequent user that should be able to make a turn at the intersection with ease.

9.4.3.2.2.2 The Intersection Check Vehicle, the infrequent user that must be able to accomplish the turn, but may involve occupying adjacent or opposing lanes temporarily during the maneuver.

9.4.3.3 Discussion - Several factors govern the choice of curb radius in any given location. These include the desired pedestrian area of the corner, traffic turning movements, street classifications, design vehicle turning radius, intersection geometry, and whether there is parking or a bike lane (or both) between the travel lane and the curb.

9.4.3.4 Materials and Maintenance - Improperly designed curb radii at corners may be subject to damage by large trucks.

9.4.3.5 Additional References and Guidelines

9.4.3.6 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4.3.7 AASHTO. A Policy on Geometric Design of Highways and Streets. 2004.

9.4.3.8 NACTO. Urban Street Design Guide. 2013.

9.4.4 Curb Extensions

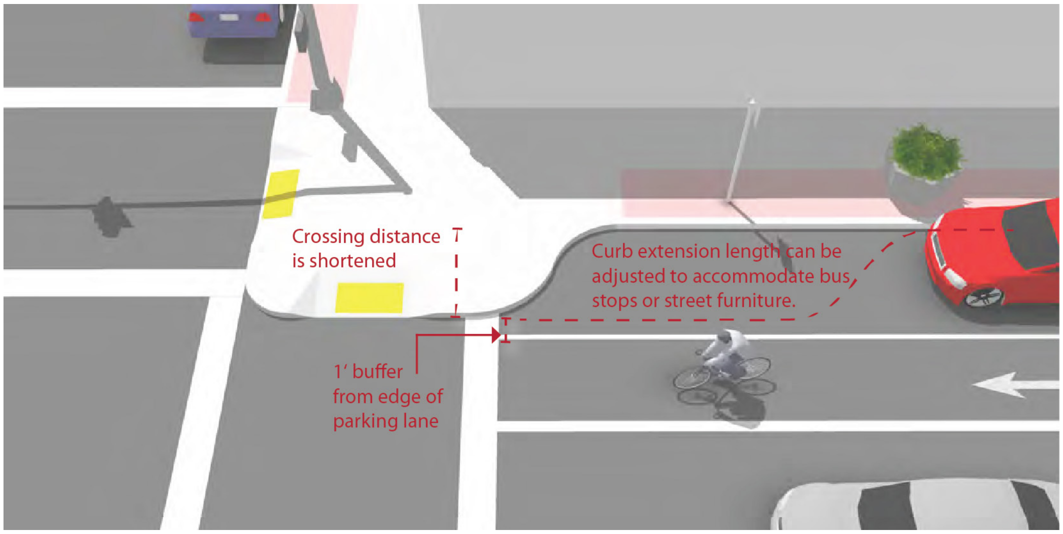


Figure 9-12. *Curb Extensions*

9.4.4.1 Description - Curb extensions minimize pedestrian exposure during crossing by shortening crossing distance and giving pedestrians a better chance to see and be seen before committing to crossing. They are appropriate for any crosswalk where it is desirable to shorten the crossing distance and there is a parking lane adjacent to the curb.

9.4.4.2 Guidance

9.4.4.2.1 In most cases, the curb extensions should be designed to transition between the extended curb and the running curb in the shortest practicable distance.

9.4.4.2.2 For purposes of efficient street sweeping, the minimum radius for the reverse curves of the transition is 10 ft and the two radii should be balanced to be nearly equal.

9.4.4.2.3 Curb extensions should terminate one foot short of the parking lane to maximize bicyclist safety.

9.4.4.3 Discussion - If there is no parking lane, adding curb extensions may be a problem for bicycle travel and truck or bus turning movements.

9.4.4.4 Materials and Maintenance - Planted curb extensions may be designed as a bioswale, a vegetated system for stormwater management.

9.4.4.5 Additional References and Guidelines

9.4.4.5.1 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4.4.5.2 AASHTO. A Policy on Geometric Design of Highways and Streets. 2004.

9.4.4.5.3 NACTO. Urban Street Design Guide. 2013.

9.4.5 Advanced Yield Line or Stop Bar

Figure 9-13. *Advanced Yield Line or Stop Bar*

9.4.5.1 Description - Advance stop bars and yield lines increase pedestrian comfort and safety by stopping motor vehicles well in advance of marked crosswalks, allowing vehicle operators a better line of sight of pedestrians and giving inner lane motor vehicle traffic time to stop for pedestrians.

9.4.5.2 Guidance

9.4.5.2.1 On streets with at least two travel lanes in each direction.

9.4.5.2.2 Prior to a marked crosswalk

9.4.5.2.3 In one or both directions of motor vehicle travel

9.4.5.2.4 Recommended 15-50 feet or more in advance of the crosswalk

9.4.5.2.5 A “Stop Here for Pedestrians” sign should accompany the advance stop bar

9.4.5.3 Discussion - If a bicycle lane is present, mark the advance stop bar or yield line to permit bicyclists to stop at the crosswalk ahead of the stop bar.

9.4.5.4 Materials and Maintenance - Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

9.4.5.5 Additional References and Guidelines

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

9.4.6 Parking Control

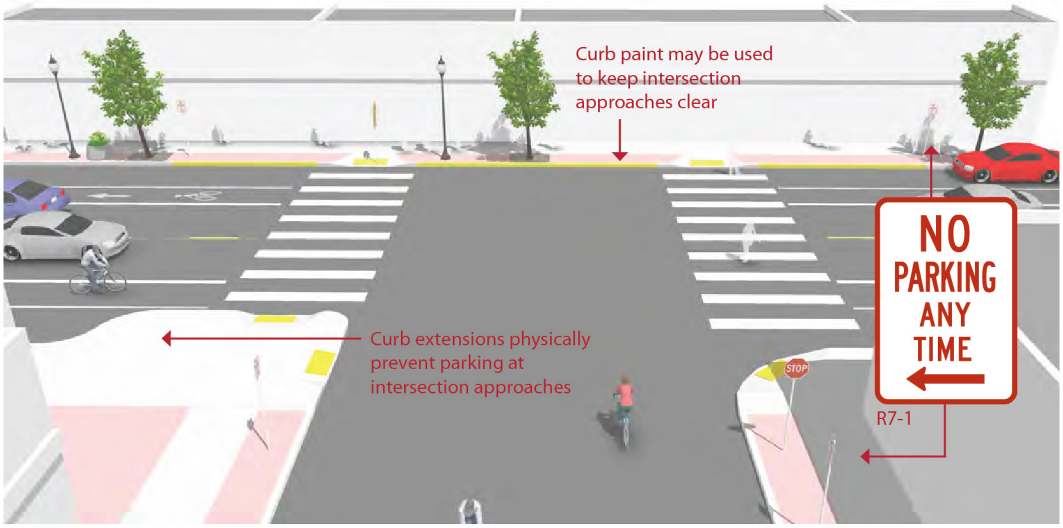


Figure 9-14. *Parking Control*

9.4.6.1 Description - Parking control involves restricting or reducing on-street parking near intersections or other locations with high pedestrian activity, such as bus stops, driveways, bridge or tunnel entrances, and school zones. Locating parking away from the intersection improves motorist's visibility on the approach to the intersection and crosswalk. Improved sight lines at intersections reduces conflicts between motorists and pedestrians.

9.4.6.2 Guidance - Curb extensions, NO PARKING signage, or curb paint can be used to keep the approach to intersections clear of parked vehicles.

At "T" and offset intersections, where the boundaries of the intersection may not be obvious, this prohibition should be made clear with signage.

Parking should not be allowed within any type of intersection adjacent to schools, school crosswalks, and parks. This includes "T" and offset intersections.

SCDOT Access and Roadside Management Standards recommend a minimum 20 foot clearance from signalized intersections, 30 feet from stop-controlled intersections, and 50 feet from railway or highway crossings.

9.4.6.3 Discussion - In areas where there is high parking demand parking compact vehicles may be allowed within "T" or offset intersections and on either side of the crosswalk. At these locations, signs will be placed to prohibit parking within the designated crosswalk areas, and additional enforcement should be provided, particularly when the treatment is new.

9.4.6.4 Materials and Maintenance - Signage and striping require routine maintenance.

9.4.6.5 Additional References and Guidelines

9.4.6.5.1 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.4.6.5.2 AASHTO. A Policy on Geometric Design of Highways and Streets. 2004.

9.4.6.5.3 SCDOT. Access and Roadside Management Standards. 2012.

9.4.7 ADA Compliant Curb Ramps

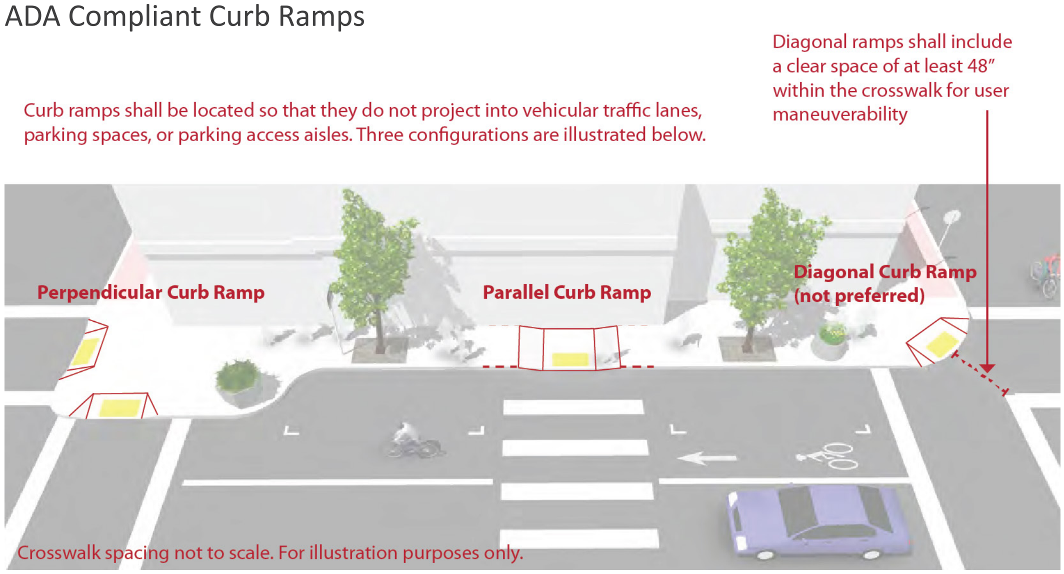


Figure 9-15. *ADA Compliant Curb Ramps*

9.4.7.1 Description - Curb ramps are the design elements that allow all users to make the transition from the street to the sidewalk. There are a number of factors to be considered in the design and placement of curb ramps at corners. Properly designed curb ramps ensure that the sidewalk is accessible from the roadway. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access.

Although diagonal curb ramps might save money, they create potential safety and mobility problems for pedestrians,including reduced maneuverability and increased interaction with turning vehicles, particularly in areas with high traffic volumes. Diagonal curb ramp configurations are the least preferred of all options.

9.4.7.2 Guidance

9.4.7.2.1 The landing at the top of a ramp shall be at least 4 feet long and at least the same width as the ramp itself.

9.4.7.2.2 The ramp shall slope no more than 1:12 , with a maximum cross slope of 2.0%.

9.4.7.2.3 If the ramp runs directly into a crosswalk, the landing at the bottom will be in the roadway.

9.4.7.2.4 If the ramp lands on a dropped landing within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 5’-0” long and at least as wide as the ramp, although a width of 5’-0” is preferred.

9.4.7.3 Discussion - The edge of an ADA compliant curb ramp may be marked with a tactile warning device (also known as truncated domes) to alert people with visual impairments to changes in the pedestrian environment. Contrast between the raised tactile device and the surrounding infrastructure is important so that the change is readily evident. These devices are most effective when adjacent to smooth pavement so the difference is easily detected. The devices should provide color contrast so partially sighted people can see them.

9.4.7.4 Materials and Maintenance - It is critical that the interface between a curb ramp and the street be maintained adequately. Asphalt street sections can develop potholes at the foot of the ramp, which can catch the front wheels of a wheelchair.

9.4.7.5 Additional References and Guidelines

9.4.7.5.1 United States Access Board. Accessibility Guidelines for Buildings and Facilities. 2002.

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

9.4.7.5.3 USDOJ. ADA Standards for Accessible Design. 2010.

9.4.7.5.4 SCDOT. Highway Design Manual. 2003.

9.4.8 Pedestrians at Railroad Grade Crossings

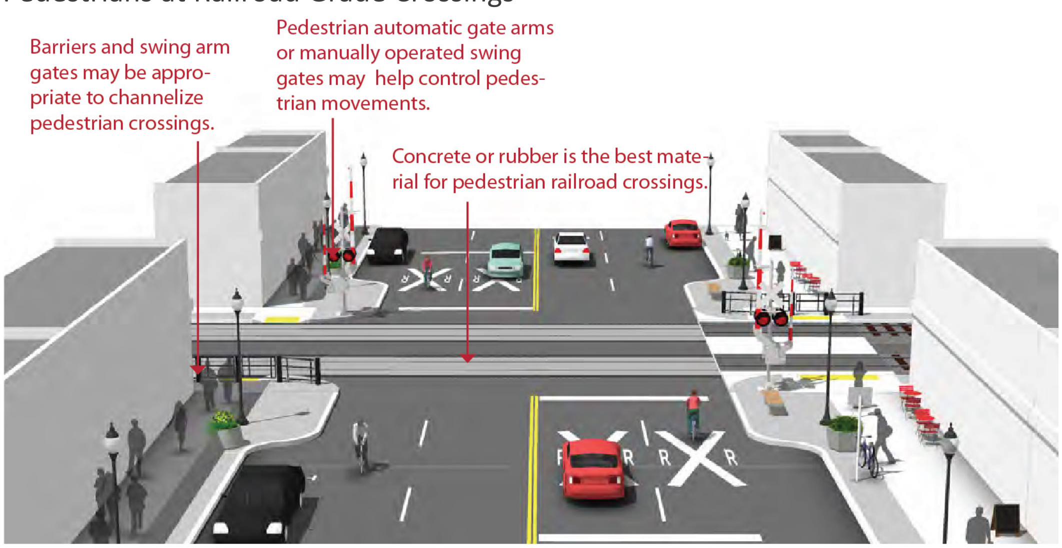


Figure 9-16. *Pedestrians at Railroad Grade Crossings*

9.4.8.1 Description - Locations where sidewalks must cross railroad tracks are problematic for pedestrians, particularly for those with mobility or vision impairments.

Wheelchair and scooter casters can easily get caught in the flangeway gap, and slippery surfaces, degraded rough materials, or elevated track height can cause tripping hazards for all pedestrians.

Angled track crossings also limit sight triangles, impacting the ability to see oncoming trains.

9.4.8.2 Guidance

9.4.8.2.1 Bells or other audible warning devices may be included in the flashing-light signal assembly to provide additional warning for pedestrians and bicyclists.

9.4.8.2.2 Pedestrians need clear communication and warning to know that they may encounter a train and when a train is coming. Provide clear definition of where the safest place to cross is.

9.4.8.2.3 The crossing should be as close as practical to perpendicular with tracks. Ensure clear lines of sign and good visibility so that pedestrians can see approaching trains

9.4.8.2.4 The crossing must be level and flush with the top of the rail at the outer edge and between the rails.

9.4.8.2.5 Flangeway gaps should not exceed 2.5 in (3.0 in for tracks that carry freight.)

9.4.8.3 Discussion - Crossing design and implementation is a collaboration between the railroad company and highway agency. The railroad company is responsible for the crossbucks, flashing lights and gate mechanisms, and the highway agency is responsible for advance warning markings and signs. Warning devices should be recommended for each specific situation by a qualified engineer based on various factors including train frequency and speed, path and trail usage and sight distances.

9.4.8.4 Materials and Maintenance - Surfaces must be firm, stable, and slip resistant. Concrete or rubber are the preferred materials for use at railroad crossings. Rubber may become slippery when wet and degrade over time. (AASHTO 2012)

9.4.8.5 Additional References and Guidelines

9.4.8.5.1 AASHTO. Planning, Design, and Operation of Ped. Facilities. 2004.

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

9.4.8.5.3 FHWA. Railroad-Highway Grade Crossing Handbook. 2007.

9.4.8.5.4 TRB. TCRP 17: Integration of Light Rail Transit into City Streets. 1996.

9.4.8.5.5 Rails-to-Trails Conservancy. Rails-with-Trails: A Preliminary Assessment of Safety and Grade Crossings. 2005.

9.5 Crossings, Beacons and Signals for Pedestrians

9.5.1 Accommodating Pedestrians at Signalized Crossings

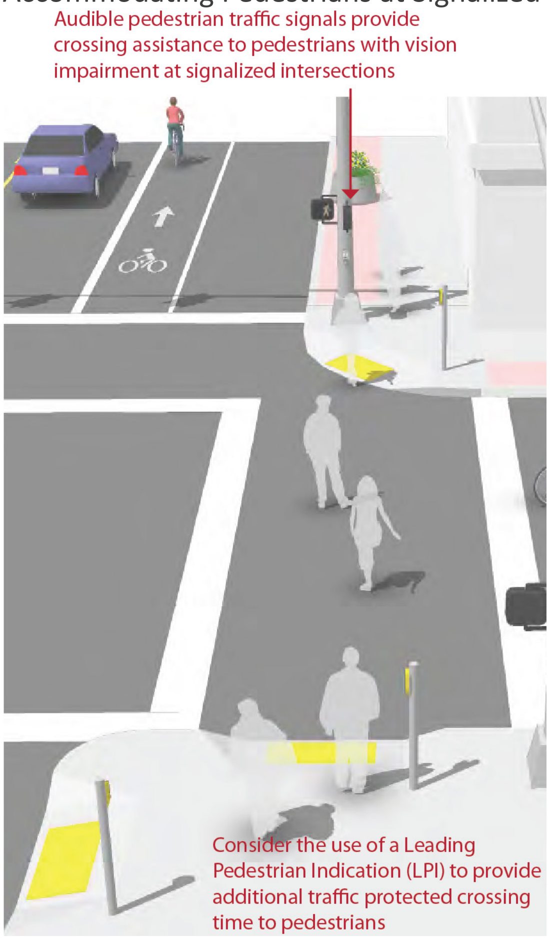


Figure 9-17. *Accommodating Pedestrians at Signalized Crossings*

9.5.1.1 Description

9.5.1.1.1 Pedestrian Signal Head - Pedestrian signal indicators demonstrate to pedestrians when to cross at a signalized crosswalk. All traffic signals should be equipped with pedestrian signal indications except where pedestrian crossing is prohibited by signage. An Accessible Pedestrian Signal (APS) using audible and/or vibrotactile indication should be provided for pedestrians upon detection/actuation.

Countdown pedestrian signals are particularly valuable for pedestrians, as they indicate whether a pedestrian has time to cross the street before the signal phase ends. Countdown signals should be used at all signalized intersections.

9.5.1.1.2 Signal Timing - Providing adequate pedestrian crossing time is a critical element of the walking environment at signalized intersections. The MUTCD recommends traffic signal timing to assume a pedestrian walking speed of 4’ per second, meaning that the length of a signal phase with parallel pedestrian movements should provide sufficient time for a pedestrian to safely cross the adjacent street.

At crossings where older pedestrians or pedestrians with disabilities are expected, crossing speeds as low as 3’ per second may be assumed. Special pedestrian phases can be used to provide greater visibility or more crossing time for pedestrians at certain intersections.

In busy pedestrian areas such as downtowns, the pedestrian signal indication should be built into each signal phase, eliminating the requirement for a pedestrian to actuate the signal by pushing a button.

9.5.1.2 Discussion - When push buttons are used, they should be located so that someone in a wheelchair can reach the button from a level area of the sidewalk without deviating significantly from the natural line of travel into the crosswalk, and marked (for example, with arrows) so that it is clear which signal is affected.

In new construction, APS should be installed wherever pedestrian signals are installed. New accessible signals should be prioritized where insufficient acoustic information exists — at all times — to permit safe crossing at a particular intersection or crosswalk. See http://www.apsguide.org/ for more information.

9.5.1.3 Materials and Maintenance - It is important to repair or replace traffic control equipment before it fails. Consider semi-annual inspections of controller and signal equipment, intersection hardware, and loop detectors.

9.5.1.4 Additional References and Guidelines

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

9.5.1.4.2 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.5.1.4.3 NACTO. Urban Street Design Guide. 2013.

9.5.2 Active Warning Beacons (RRFB)

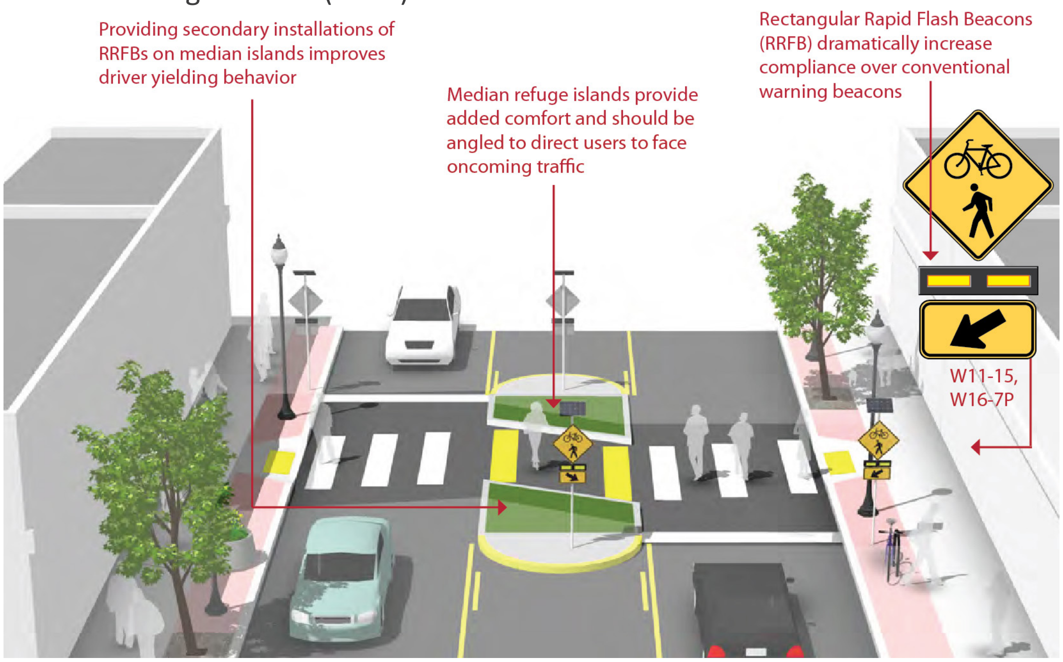


Figure 9-18. *Active Warning Beacons (RRFB)*

9.5.2.1 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.

9.5.2.2 Guidance - Guidance for marked/unsignalized crossings applies.

9.5.2.2.1 Warning beacons shall not be used at crosswalks controlled by YIELD signs, STOP signs, or traffic control signals.

9.5.2.2.2 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.

9.5.2.3 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%. Additional studies of long term installations show little to no decrease in yielding behavior over time.

9.5.2.4 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.

9.5.2.5 Additional References and Guidelines

9.5.2.5.1 NACTO. Urban Bikeway Design Guide. 2012.

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

9.5.2.5.3 FHWA. MUTCD - Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11). 2008.

9.5.2.5.4 SCDOT. Traffic Engineering Guideline TG-33: Rectangular Rapid Flash Beacons.

9.5.3 Hybrid Warning Beacon (HAWK) For Mid-Block Crossing

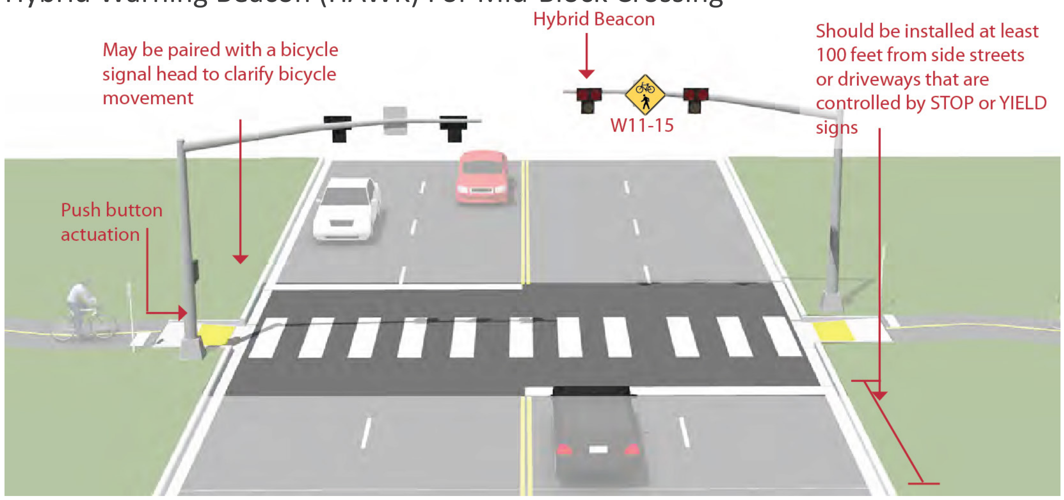


Figure 9-19. *Hybrid Warning Beacon (HAWK) For Mid-Block Crossing*

9.5.3.1 Description - Pedestrian hybrid beacons provide a high level of comfort for crossing users through the use of a red-signal indication to stop conflicting motor vehicle traffic.

Hybrid beacon installation faces only cross motor vehicle traffic, stays dark when inactive, and uses a unique 'wigwag' signal phase to indicate activation. Vehicles have the option to proceed after stopping during the final flashing red phase, which can reduce motor vehicle delay when compared to a full signal installation.

9.5.3.2 Guidance - Hybrid beacons (illustrated here) may be installed without meeting traffic signal control warrants if roadway speed and volumes are excessive for comfortable path crossings.

FHWA does not allow bicycle signals to be used with Hybrid beacons, though some cities have done so successfully.

To maximize safety when used for bicycle crossings, the flashing 'wig-wag' phase should be very short and occur after the pedestrian signal head has changed to a solid "DON'T WALK" indication as bicyclists can enter an intersection quickly.

9.5.3.3 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.

9.5.3.4 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.

9.5.3.5 Additional References and Guidelines

9.5.3.5.1 SCDOT. Traffic Guideline TG-26: Pedestrian Hybrid Beacon Guideline

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

9.5.3.5.3 NACTO. Urban Bikeway Design Guide. 2012.

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

9.5.4 Route Users To Signalized Crossings

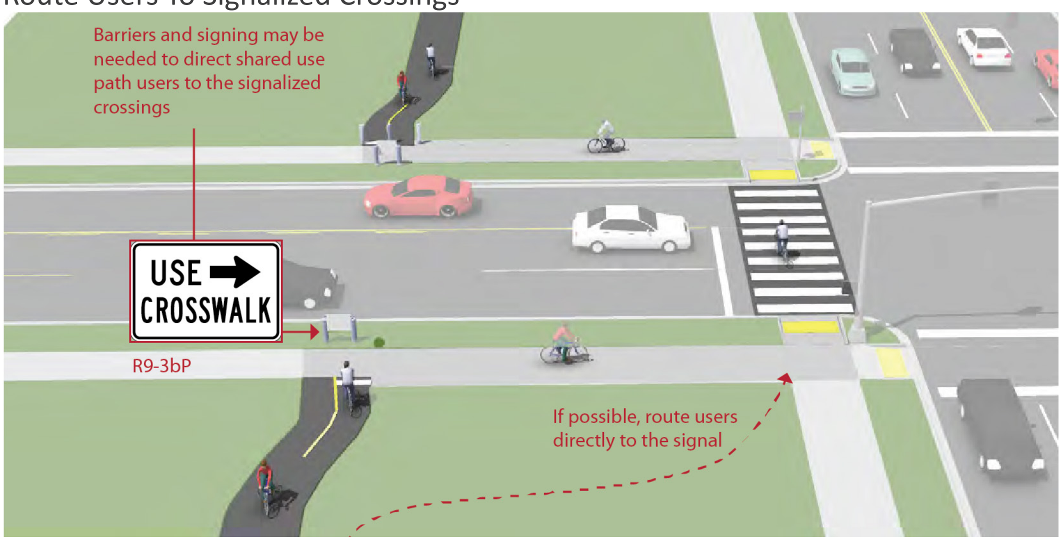


Figure 9-20. *Route Users To Signalized Crossings*

9.5.4.1 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.

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

9.5.4.3 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.

9.5.4.4 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.

9.5.4.5 Additional References and Guidelines

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

9.5.4.5.2 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.6 Shared Use Paths and Off Street Facilities

9.6.1 General Design Practice

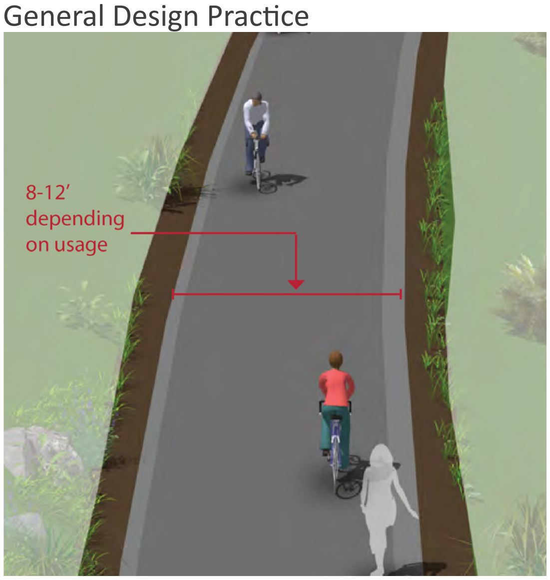


Figure 9-21. *General Design Practice*

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

9.6.1.2 Guidance

9.6.1.2.1 Width

9.6.1.2.1.1 10 feet is recommended in most situations and will be adequate for most usage levels.

9.6.1.2.1.2 12 feet is recommended for heavy use situations with high concentrations of multiple users. A separate track (5’ minimum) can be provided for pedestrian use.

9.6.1.2.1.3 In constrained conditions for short distances, 8 foot width may be acceptable.

9.6.1.2.2 Lateral Clearance

9.6.1.2.2.1 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.

9.6.1.2.2.2 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.

9.6.1.2.3 Overhead Clearance

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

9.6.1.2.4 Striping

9.6.1.2.4.1 When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.

9.6.1.2.4.2 Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.

9.6.1.3 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.

9.6.1.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.1.5 Additional References and Guidelines

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

9.6.1.5.2 FHWA. Manual on Uniform Traffic Control Devices. 2009.Flink, C. Greenways: A Guide To Planning Design And Development. 1993.

9.6.2 Greenways In River And Utility Corridors

9.6.2.1 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.

9.6.2.2 Guidance

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

9.6.2.2.2 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.

9.6.2.2.3 Path Closure - Public access to the shared use path may be prohibited during the following events:

9.6.2.2.3.1 Canal/flood control channel or other utility maintenance activities

9.6.2.2.3.2 Inclement weather or the prediction of storm conditions

9.6.2.3 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.

9.6.2.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.2.5 Additional References and Guidelines

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

9.6.2.5.2 FHWA. Manual on Uniform Traffic Control Devices. 2009.Flink, C. Greenways: A Guide To Planning Design And Development. 1993.

9.6.3 Greenways In Abandoned Rail Corridors

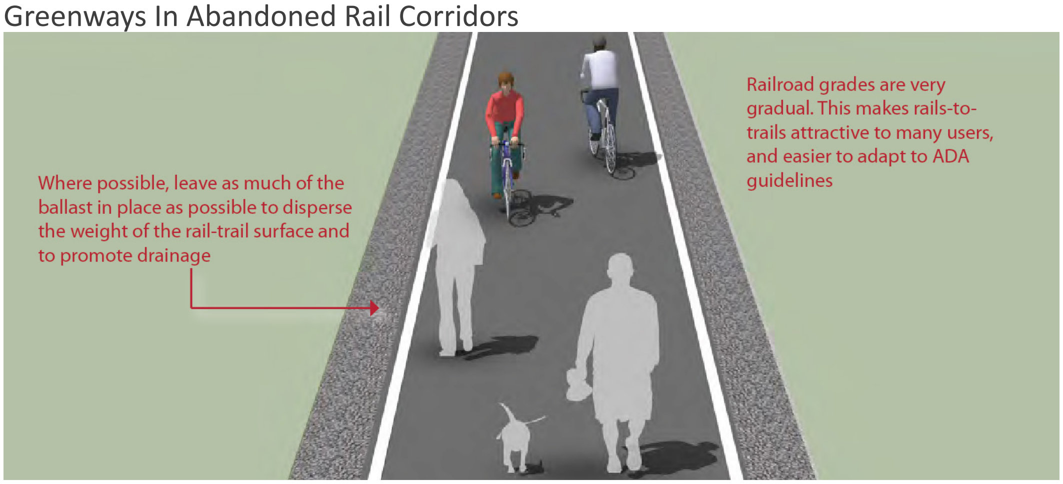


Figure 9-22. *Greenways In Abandoned Rail Corridors*

9.6.3.1 Description - Commonly referred to as Rails-to-Trails or Rail-Trails, these projects convert vacated rail corridors into off-street paths. Rail corridors offer several advantages, including relatively direct routes between major destinations and generally flat terrain.

In some cases, rail owners may rail-bank their corridors as an alternative to a complete abandonment of the line, thus preserving the rail corridor for possible future use.

The railroad may form an agreement with any person, public or private, who would like to use the banked rail line as a trail or linear park until it is again needed for rail use. Municipalities should acquire abandoned rail rights-of-way whenever possible to preserve the opportunity for trail development.

9.6.3.2 Guidance - Shared use paths in abandoned rail corridors should meet or exceed general design practices. If additional width allows, wider paths, and landscaping are desirable.

In full conversions of abandoned rail corridors, the subbase, superstructure, drainage, bridges, and crossings are already established. Design becomes a matter of working with the existing infrastructure to meet the needs of a rail-trail.

If converting a rail bed adjacent to an active rail line, see Shared Use Paths in Active Rail Corridors.

9.6.3.3 Discussion - It is often impractical and costly to add material to existing railroad bed fill slopes. This results in trails that meet minimum path widths, but often lack preferred shoulder and lateral clearance widths.

Rail-to-trails can involve many challenges including the acquisition of the right of way, cleanup and removal of toxic substances, and rehabilitation of tunnels, trestles and culverts. A structural engineer should evaluate existing railroad bridges for structural integrity to ensure they are capable of carrying the appropriate design loads.

9.6.3.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.3.5 Additional References and Guidelines

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

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

9.6.3.5.3 Flink, C. Greenways: A Guide To Planning Design And Development. 1993.

9.6.4 Greenways In Active Rail Corridors

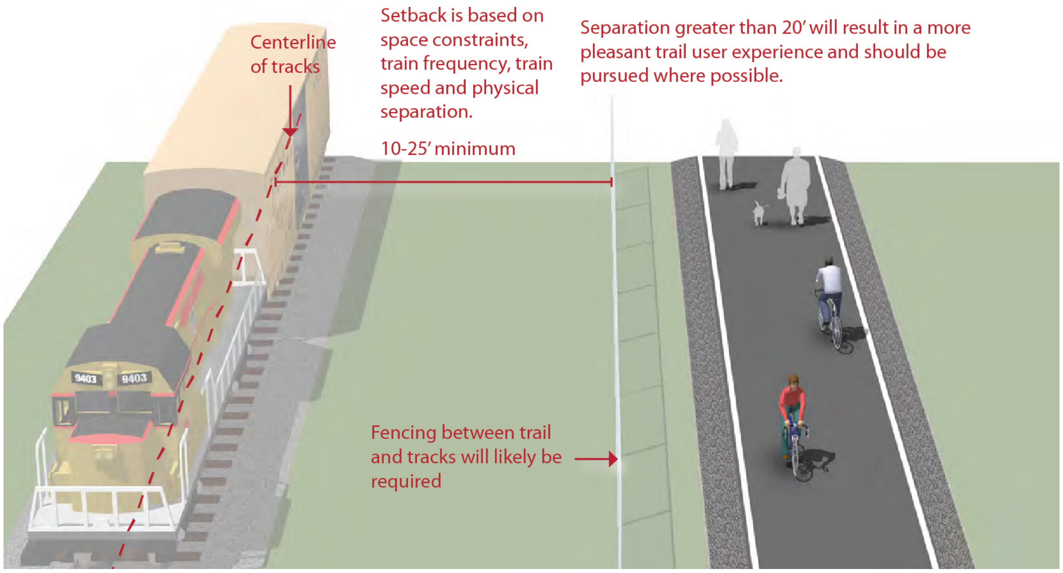


Figure 9-23. *Greenways In Active Rail Corridors*

9.6.4.1 Description - Rails-with-Trails projects typically consist of paths adjacent to active railroads. It should be noted that some constraints could impact the feasibility of rail-with-trail projects. In some cases, space needs to be preserved for future planned freight, transit or commuter rail service. In other cases, limited right-of-way width, inadequate setbacks, concerns about safety/trespassing, and numerous crossings may affect a project's feasibility.

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

If required, fencing should be a minimum of 5 feet in height with higher fencing than usual next to sensitive areas such as switching yards. Setbacks from the active rail line will vary depending on the speed and frequency of trains, and available right-of-way.

9.6.4.3 Discussion - Railroads may require fencing with rail-with-trail projects. Concerns with trespassing and security can vary with the volume and speed of train traffic on the adjacent rail line and the setting of the shared use path, i.e. whether the section of track is in an urban or rural setting.

9.6.4.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.4.5 Additional References and Guidelines

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

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

9.6.4.5.3 FHWA. Rails-with-Trails: Lessons Learned. 2002.

9.6.5 Local Neighborhood Accessways

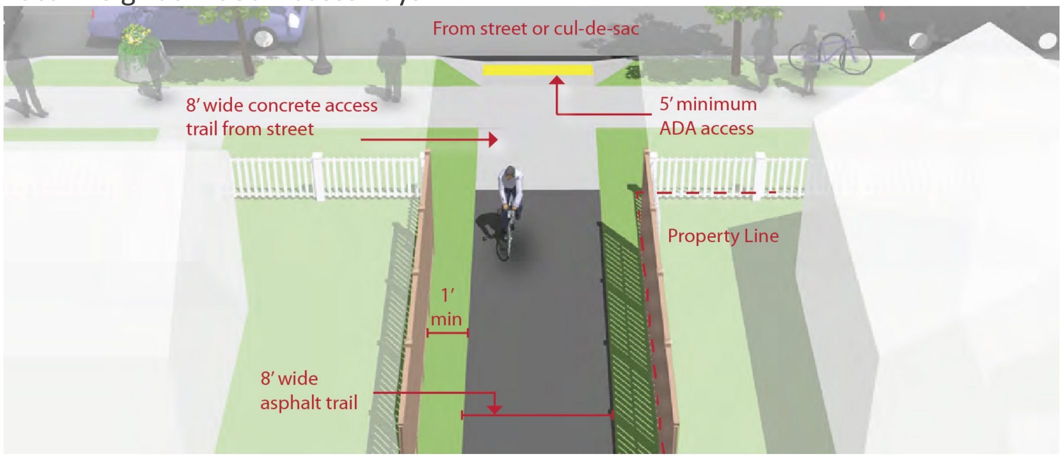


Figure 9-24. *Local Neighborhood Accessways*

9.6.5.1 Description - Neighborhood accessways provide residential areas with direct bicycle and pedestrian access to parks, trails, greenspaces, and other recreational areas. They most often serve as small trail connections to and from the larger trail network, typically having their own rights-of-way and easements.

Additionally, these smaller trails can be used to provide bicycle and pedestrian connections between dead-end streets, cul-de-sacs, and access to nearby destinations not provided by the street network.

9.6.5.2 Guidance

9.6.5.2.1 Neighborhood accessways should remain open to the public.

9.6.5.2.2 Trail pavement shall be at least 8' wide to accommodate emergency and maintenance vehicles, meet ADA requirements and be considered suitable for multi-use.

9.6.5.2.3 Trail widths should be designed to be less than 8' wide only when necessary to protect large mature native trees over 18" in caliper, wetlands or other ecologically sensitive areas.

9.6.5.2.4 Access trails should slightly meander whenever possible.

9.6.5.3 Discussion - Neighborhood accessways should be designed into new subdivisions at every opportunity and should be required by City/County subdivision regulations.

For existing subdivisions, Neighborhood and homeowner association groups are encouraged to identify locations where such connects would be desirable. Nearby residents and adjacent property owners should be invited to provide landscape design input.

9.6.5.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.5.5 Additional References and Guidelines

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

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

9.6.5.5.3 FHWA. Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 19: Greenways and Shared Use Paths. 2006.

9.6.5.5.4 NACTO. Urban Street Design Guide. 2013.

9.6.6 Shared Use Paths Along Roadways

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

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.

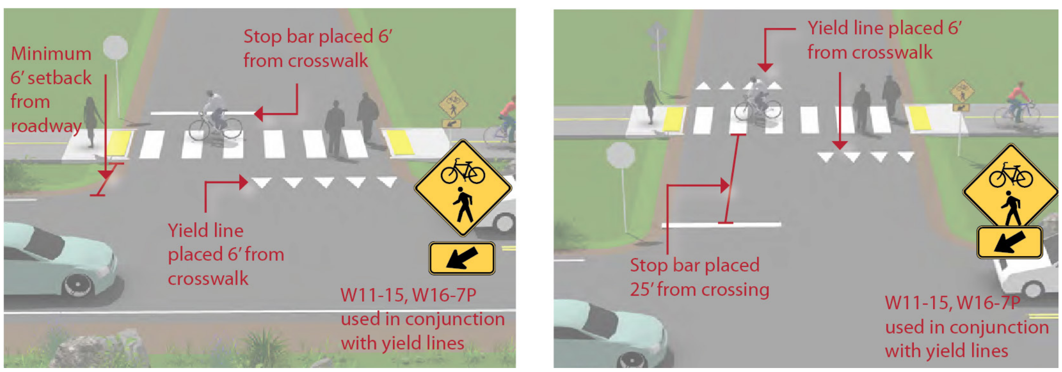


Figure 9-25. *Shared Use Paths Along Roadways*

9.6.6.1 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.

9.6.6.2 Guidance

9.6.6.2.1 Guidance for sidepaths should follow that for general design practises of shared use paths.

9.6.6.2.2 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.

9.6.6.2.3 Where a sidepath terminates special consideration should be given to transitions so as not to encourage unsafe wrong-way riding by bicyclists.

9.6.6.2.4 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.

9.6.6.3 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.

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

9.6.6.4 Materials and Maintenance - Asphalt is the most common surface for bicycle 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.

9.6.6.5 Additional References and Guidelines

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

9.6.6.5.2 NACTO. Urban Bikeway Design Guide. See entry on Raised Cycle Tracks. 2012.

9.7 Path/ Roadway Crossing Types

9.7.1 Marked/Unsignalized Crossings

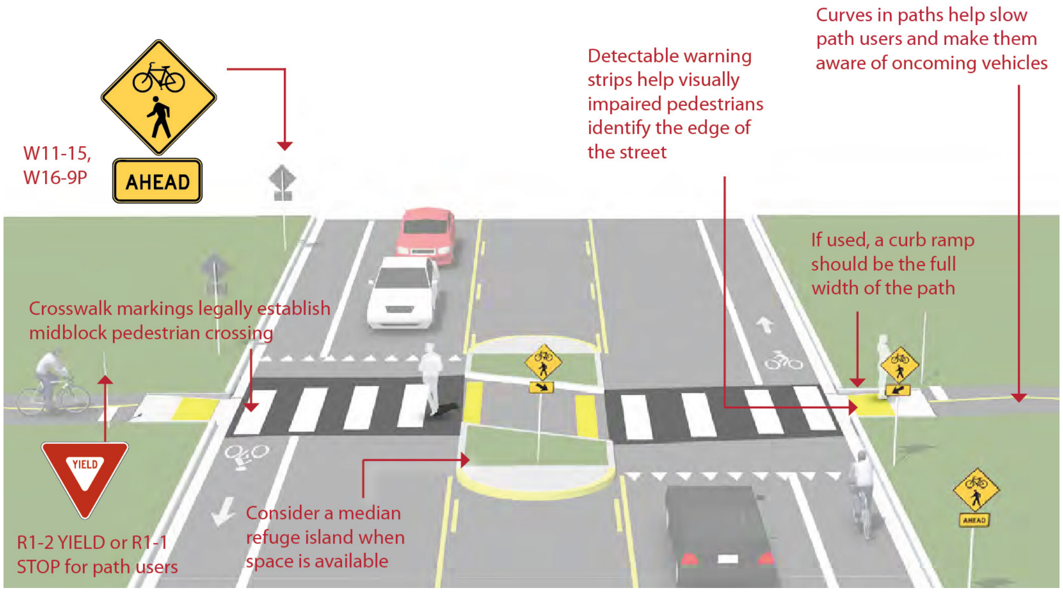


Figure 9-26. *Marked/Unsignalized Crossings*

9.7.1.1 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.

See Active Warning Beacons (RRFB) and Hybrid Warning Beacons (HAWK) for more information on enhanced bicycle and pedestrian crossing treatments at unsignalized crossings locations.

9.7.1.2 Guidance

9.7.1.2.1 Maximum traffic volumes

9.7.1.2.1.1 ≤9,000-12,000 Average Daily Traffic (ADT) volume

9.7.1.2.1.2 Up to 15,000 ADT on two-lane roads, preferably with a median

9.7.1.2.1.3 Up to 12,000 ADT on four-lane roads with median

9.7.1.2.2 Maximum travel speed

9.7.1.2.2.1 35 MPH

9.7.1.2.3 Minimum line of sight

9.7.1.2.3.1 25 MPH zone: 155 feet

9.7.1.2.3.2 35 MPH zone: 250 feet

9.7.1.2.3.3 45 MPH zone: 360 feet

9.7.1.3 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.

9.7.1.4 Materials and Maintenance - Locate markings out of wheel tread when possible to minimize wear and maintenance costs.

9.7.1.5 Additional References and Guidelines

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

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

9.7.2 Full Traffic Signal Crossings

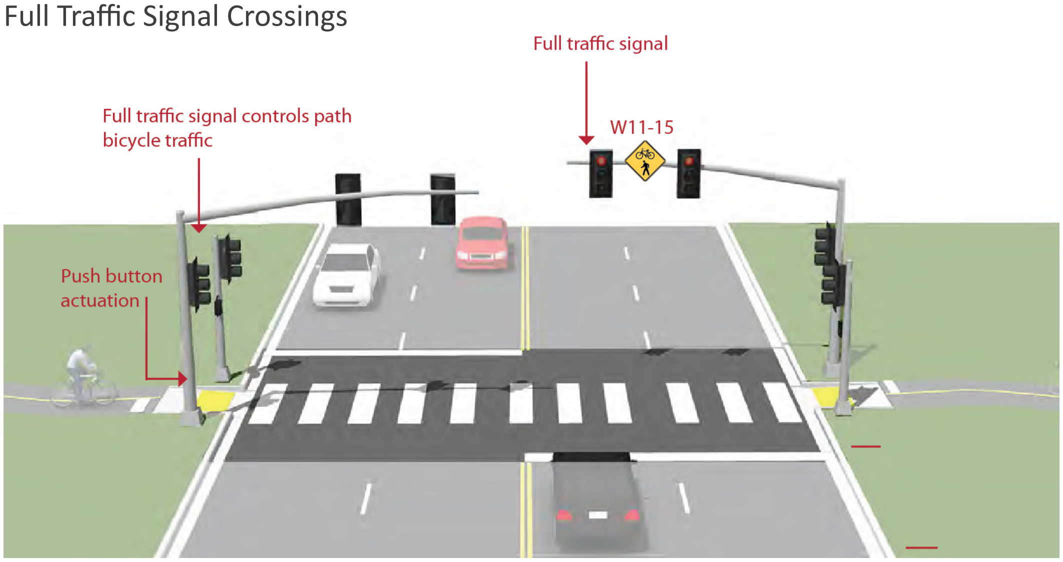


Figure 9-27. *Full Traffic Signal Crossings*

9.7.2.1 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.

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

9.7.2.2.1 Located more than 300 feet from an existing signalized intersection

9.7.2.2.2 Roadway travel speeds of 40 MPH and above

9.7.2.2.3 Roadway ADT exceeds 15,000 vehicles

9.7.2.3 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.

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

9.7.2.5 Additional References and Guidelines

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

9.7.2.5.2 NACTO. Urban Bikeway Design Guide. 2012.

9.7.3 Undercrossings

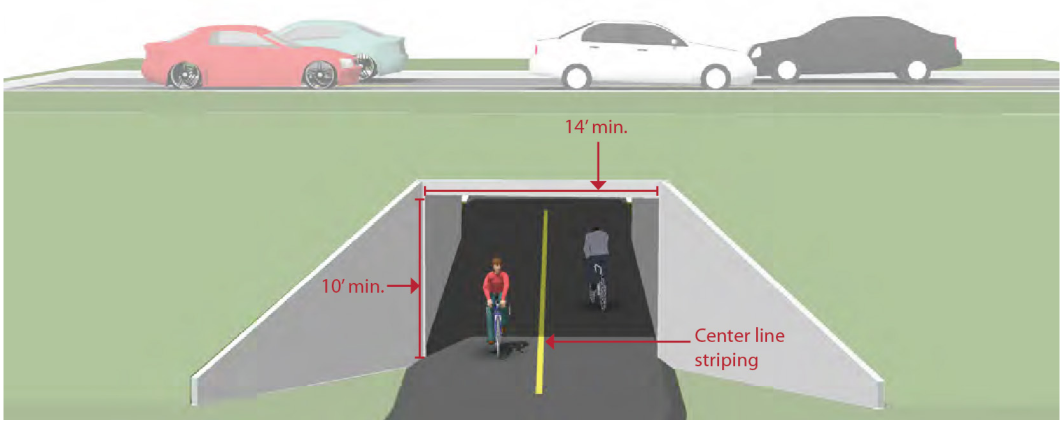


Figure 9-28. *Undercrossings*

9.7.3.1 Description - Bicycle/pedestrian undercrossings provide critical non-motorized system links by joining areas separated by barriers such as railroads and highway corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.

9.7.3.2 Guidance

9.7.3.2.1 14 foot minimum width, greater widths preferred for lengths over 60 feet.

9.7.3.2.2 10 foot minimum height.

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

9.7.3.2.4 Lighting should be considered during the design process for any undercrossing with high anticipated use or in culverts and tunnels.

9.7.3.3 Discussion - Safety is a major concern with undercrossings. Shared use path users may be temporarily out of sight from public view and may experience poor visibility themselves. To mitigate safety concerns, an undercrossing should be designed to be spacious, well-lit, equipped with emergency call boxes at each end and completely visible for its entire length from end to end.

9.7.3.4 Materials and Maintenance - 14 foot width allows for maintenance vehicle access.

Potential problems include conflicts with utilities, drainage, flood control and vandalism.

9.7.3.5 Additional References and Guidelines

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

9.7.3.5.2 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.7.4 Overcrossings

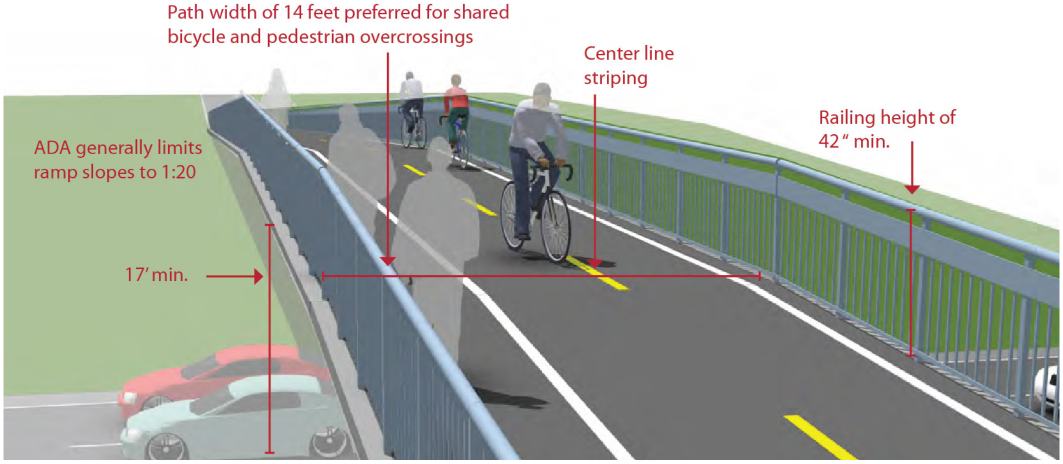


Figure 9-29. *Overcrossings*

9.7.4.1 Description - Bicycle/pedestrian overcrossings provide critical non-motorized system links by joining areas separated by barriers such as deep canyons, waterways or major transportation corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.

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

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

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

Roadway: 17 feet

Freeway: 18.5 feet

Heavy Rail Line: 23 feet

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

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

Overcrossings pose potential concerns about visual impact and functional appeal, as well as space requirements necessary to meet ADA guidelines for slope.

9.7.4.4 Materials and Maintenance - Potential issues with vandalism.

Overcrossings can be more difficult to clear of snow than undercrossings.

9.7.4.5 Additional References and Guidelines

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

9.7.4.5.2 AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.

9.8 Bicycle Facilities[7]

9.8.1 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.

9.8.1.1 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.

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.

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

9.8.1.2 Standard Bicycle Rider Dimensions

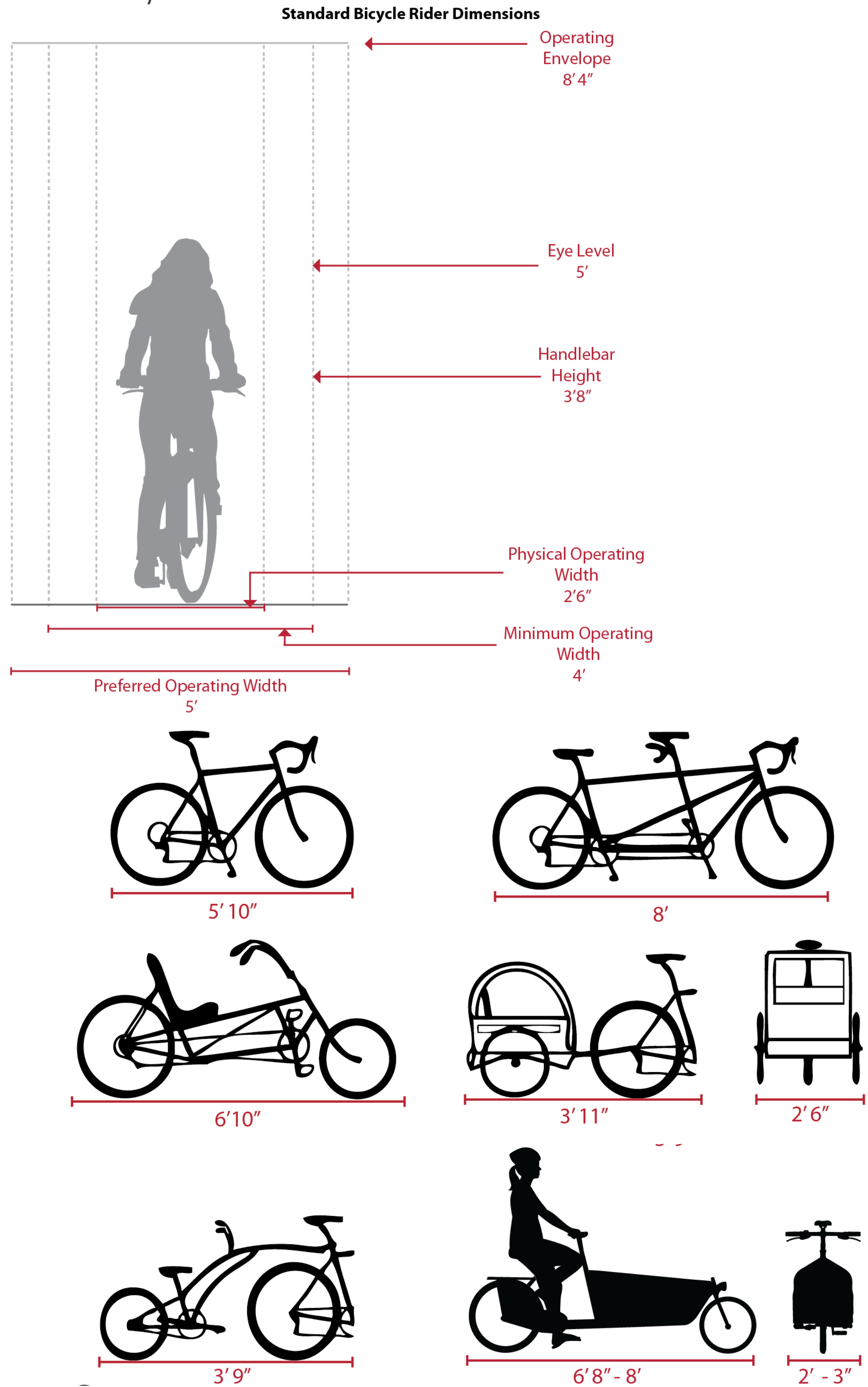


Figure 9-30. *Standard Bicycle Rider Dimensions*

9.8.1.3 Bicycle as Design Vehicle - Typical Dimensions

Table 9-7. *Bicycle as Design Vehicle - Typical Dimensions*

Bicycle Type	Feature	Typical Dimensions
Upright Adult Bicyclist	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
Recumbent Bicyclist	Physical length	8 ft
	Eye height	3 ft 10 in
Tandem Bicyclist	Physical length	8 ft
Bicyclist with child trailer	Physical length	10 ft
	Physical width	2 ft 6 in

9.8.1.4 Bicycle as Design Vehicle - Typical Speed

Table 9-8. *Bicycle as Design Vehicle - Typical Speed*

Bicycle Type	Feature	Typical Speed
Upright Adult Bicyclist	Paved level surfacing	15 mph
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph
*Tandem bicycles and bicyclists with trailers have typical speeds equal to or less than upright adult bicyclists.		

9.8.1.5 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.

9.8.1.6 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[8] and supported by research[9], this classification provides the following alternative categories to address varying attitudes towards bicycling in the US:

9.8.1.6.1 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.

9.8.1.6.2 Enthused 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.

9.8.1.6.3 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 "Enthused & Confident" with encouragement, education and experience.

9.8.1.6.4 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.

9.8.2 Bicycle Facility Selection Guidelines

9.8.2.1 The specific bicycle facility type that should be provided depends on the surrounding environment (e.g. auto speed and volume, topography, and adjacent land use) and expected bicyclist needs (e.g. bicyclists commuting on a highway versus students riding to school on residential streets).

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

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

9.8.2.2 Facility Selection Guidelines - There are no 'hard and fast' rules for determining the most appropriate type of bicycle facility for a particular location – roadway speeds, volumes, right-of-way width, presence of parking, adjacent land uses, and expected bicycle user types are all critical elements of this decision. Studies find that the most significant factors influencing bicycle use are motor vehicle traffic volumes and speeds. Additionally, most bicyclists prefer facilities separated from motor vehicle traffic or located on local roads with low motor vehicle traffic speeds and volumes. Because off-street pathways are physically separated from the roadway, they are perceived as safe and attractive routes for bicyclists who prefer to avoid motor vehicle traffic. Consistent use of treatments and application of bikeway facilities allow users to anticipate whether they would feel comfortable riding on a particular facility, and plan their trips accordingly. This section provides guidance on various factors that affect the type of facilities that should be provided.

9.8.3 Facility Classification

9.8.3.1 Description - Consistent with bicycle facility classifications throughout the nation, these Bicycle Facility Design Guidelines identify the following classes of facilities by degree of separation from motor vehicle traffic.

Figure 9-31. *Shared Roadways*

9.8.3.1.1 Shared Roadways are bikeways where bicyclists and cars operate within the same travel lane, either side by side or in single file depending on roadway configuration. The most basic type of bikeway is a signed shared roadway. This facility provides continuity with other bicycle facilities (usually bike lanes), or designates preferred routes through high-demand corridors.

Shared Roadways may also be designated by pavement markings, signage and other treatments including directional signage, traffic diverters, chicanes, chokers and /or other traffic calming devices to reduce vehicle speeds or volumes. Such treatments often are associated with Neighborhood Greenways.

Figure 9-32. *Separated Bikeways*

Figure 9-33. *Cycle Tracks*

9.8.3.1.2 Separated Bikeways, such as bike lanes, use signage and striping to delineate the right-of-way assigned to bicyclists and motorists. Bike lanes encourage predictable movements by both bicyclists and motorists.

Figure 9-34. *Shared Use Paths*

9.8.3.1.3 Cycle Tracks are exclusive bike facilities that combine the user experience of a separated path with the on-street infrastructure of conventional bike lanes.

9.8.3.1.4 Shared Use Paths are facilities separated from roadways for use by bicyclists and pedestrians.

9.8.4 Facility Continua - The following continua illustrate the range of bicycle facilities applicable to various roadway environments, based on the roadway type and desired degree of separation. Engineering judgment, traffic studies, previous municipal planning efforts, community input and local context should be used to refine criteria when developing bicycle facility recommendations for a particular street. In some corridors, it may be desirable to construct facilities to a higher level of treatment than those recommended in relevant planning documents in order to enhance user safety and comfort. In other cases, existing and/ or future motor vehicle speeds and volumes may not justify the recommended level of separation, and a less intensive treatment may be acceptable.

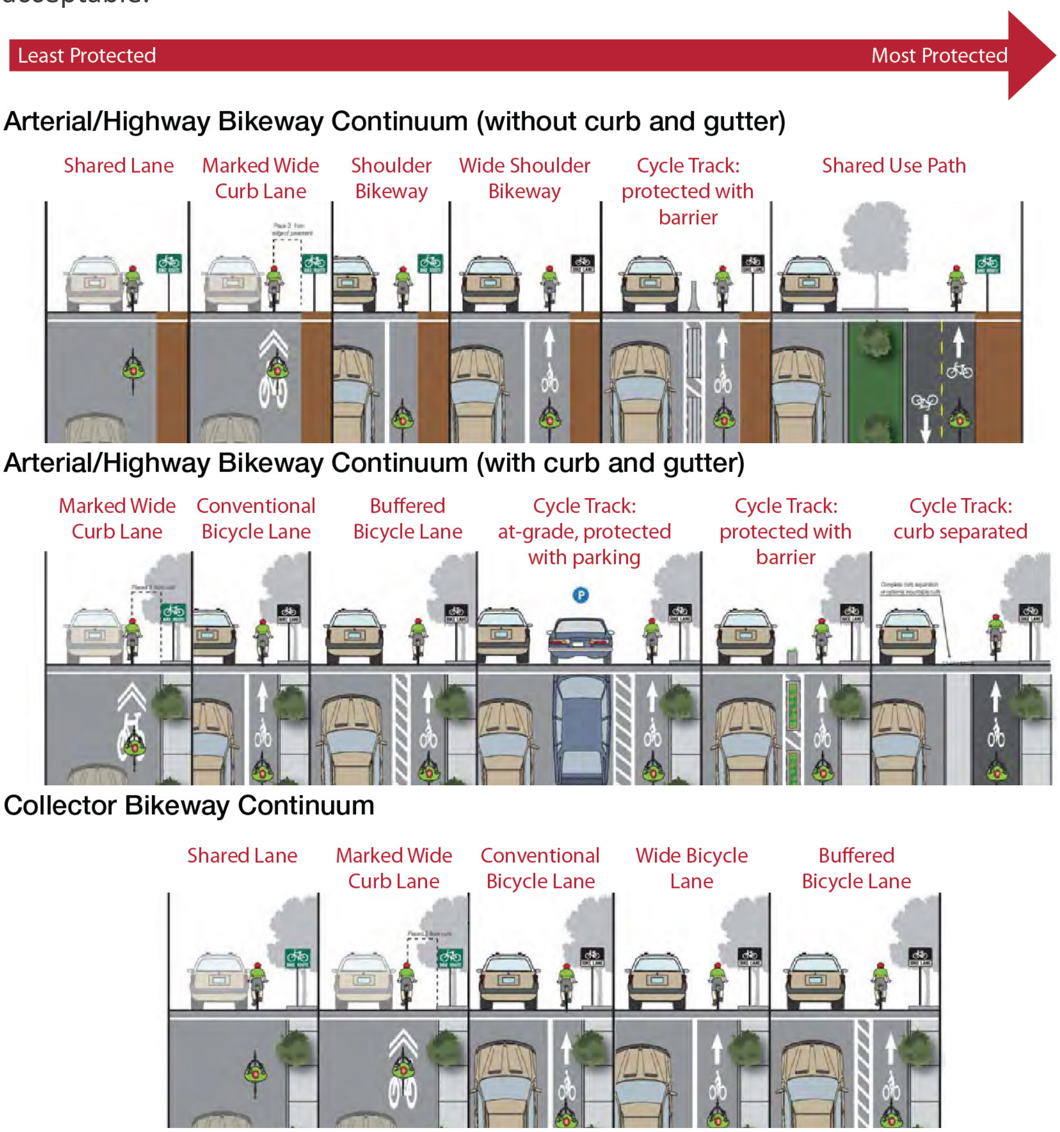


Figure 9-35. *Facility Continua*

9.9 Shared Roadways

9.9.1 Signed Shared Roadways

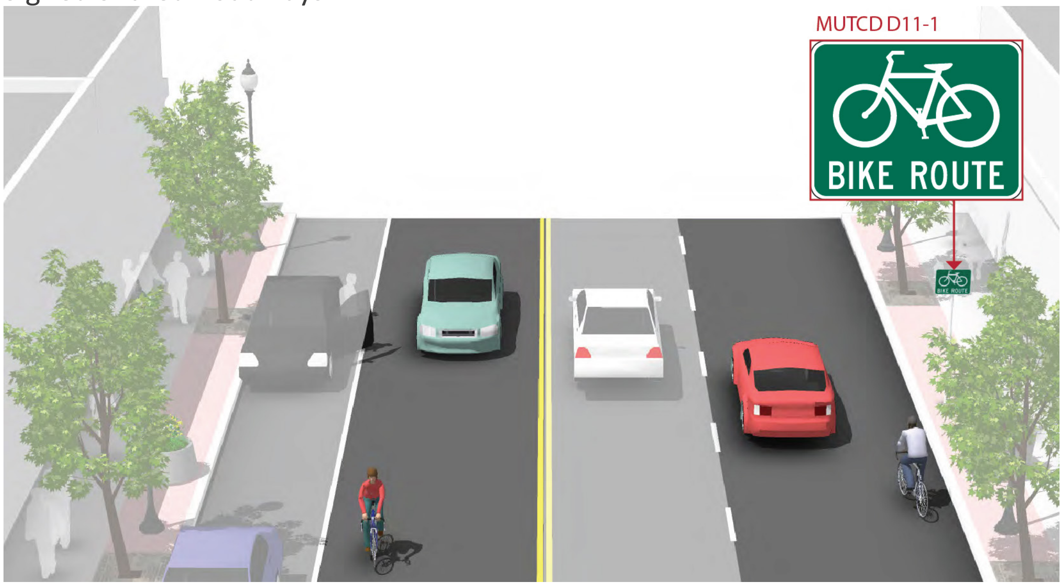


Figure 9-36. *Signed Shared Roadways*

9.9.1.1 Description - Signed shared roadways are facilities shared with motor vehicles. They are typically used on roads with low speeds and traffic volumes, however 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.

9.9.1.2 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:

9.9.1.2.1 Beginning or end of Bicycle Route.

9.9.1.2.2 At major changes in direction or at intersections with other bicycle routes.

9.9.1.2.3 At intervals along bicycle routes not to exceed ½ mile.

9.9.1.3 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 neighborhood greenway 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.

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

9.9.1.5 Additional References and Guidelines

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

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

9.9.2 Marked Shared Roadways

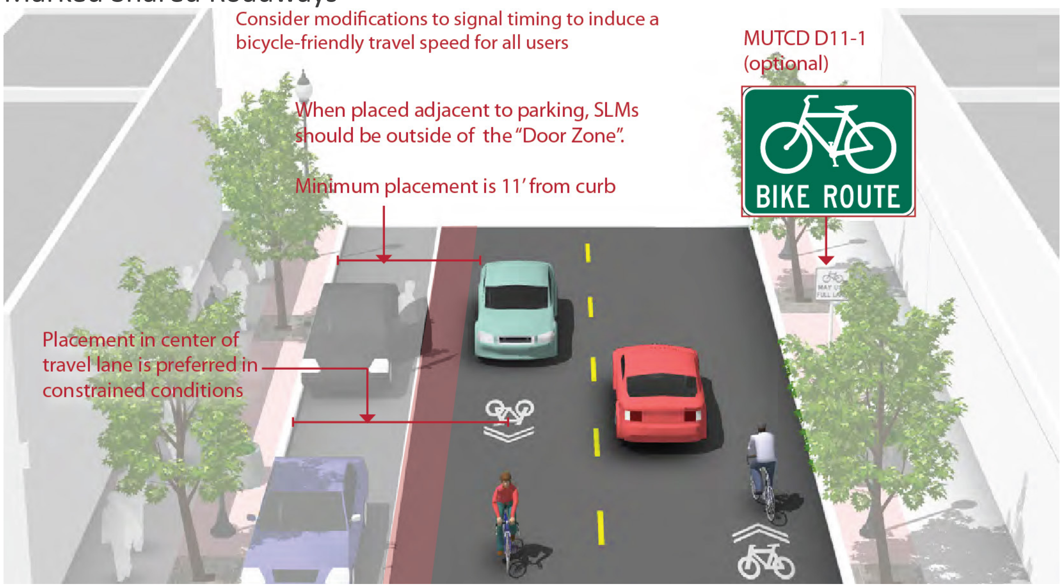


Figure 9-37. *Marked Shared Roadways*

9.9.2.1 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.

9.9.2.2 Guidance

9.9.2.2.1 May be used on streets with a speed limit of 35 mph or under. Lower than 30 mph speed limit preferred.

9.9.2.2.2 In constrained conditions, preferred placement is in the center of the travel lane to minimize wear and promote single file travel.

9.9.2.2.3 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.

9.9.2.3 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)

9.9.2.4 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.

9.9.2.5 Additional References and Guidelines

9.9.2.5.1 SCDOT. TG-24: Use of Shared Lane Marking Symbols.

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

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

9.9.2.5.4 NACTO. Urban Bikeway Design Guide. 2012.

9.9.3 Bicycle Boulevards

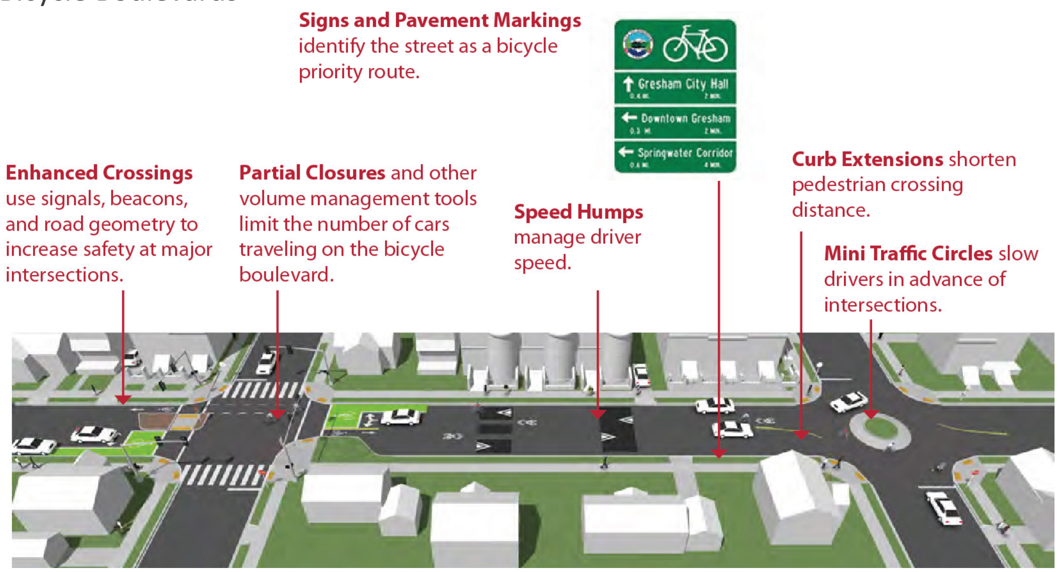


Figure 9-38. *Bicycle Boulevards*

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

9.9.3.2 Guidance

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

9.9.3.2.2 Bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.

9.9.3.2.3 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.

9.9.3.2.4 Intersection crossings should be designed to enhance safety and minimize delay for bicyclists.

9.9.3.3 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.

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

9.9.3.4 Materials and Maintenance - Vegetation should be regularly trimmed to maintain visibility and attractiveness.

9.9.3.5 Additional References and Guidelines

9.9.3.5.1 Alta Planning + Design and IBPI. Bicycle Boulevard Planning and Design Handbook. 2009. BikeSafe. Bicycle countermeasure selection system.

9.9.3.5.2 Ewing, Reid. Traffic Calming: State of the Practice. 1999.

9.9.3.5.3 Ewing, Reid and Brown, Steven. U.S. Traffic Calming Manual. 2009.

9.9.4 Advisory Bike Lane

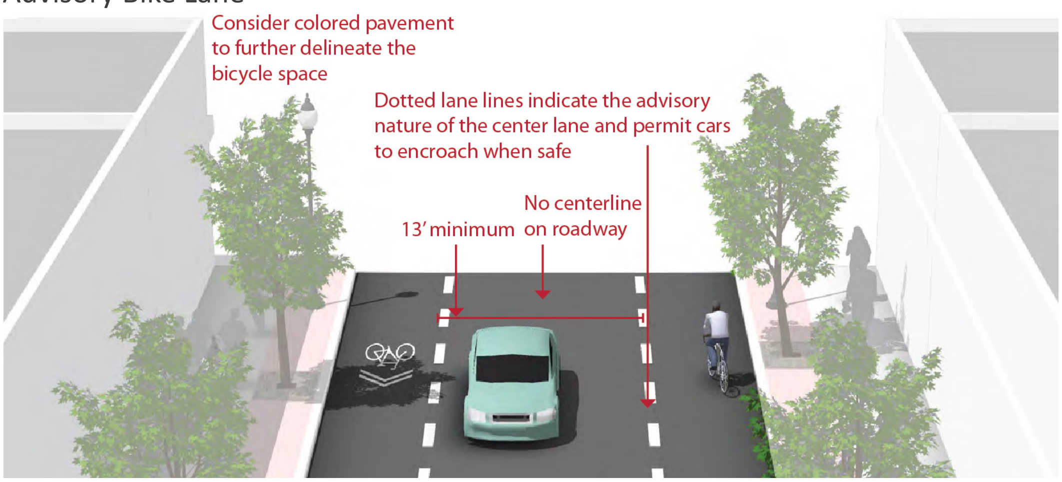


Figure 9-39. *Advisory Bike Lane*

9.9.4.1 Description - Advisory bike lanes are bicycle priority areas delineated by dotted white lines, separated from a narrow automobile travel area. The automobile zone should be configured narrowly enough so that two cars cannot pass each other in both directions without crossing the advisory lane line.

Motorists may only enter the bicycle zone when no bicycles are present. Motorists must overtake with caution due to potential oncoming traffic.

9.9.4.2 Guidance - Advisory bike lanes can be used on roadways where the following conditions exist:

9.9.4.2.1 Motor vehicle traffic is <4000 motor vehicles per day (<2000 preferred).

9.9.4.2.2 Advisory bike lane width of 5 to 7 ft.

9.9.4.2.3 Minimum 2-way motor vehicle travel lane width of 13-18 feet.

9.9.4.2.4 No centerline on roadway.

9.9.4.3 Discussion - Most appropriate when roadways are straight with few bends, inclines or sightline obstructions. Consider the use of colored pavement within the bicycle priority area to discourage unnecessary encroachment by motorists or parked vehicles. This treatment requires a request to experiment to be implemented on roadways funded with federal transportation dollars.

9.9.4.4 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.

9.9.4.5 Additional References and Guidelines

9.9.4.5.1 City of Minneapolis. Request To Experiment. July 2010.

9.10 Separated Bikeways

9.10.1 Shoulder Bikeways

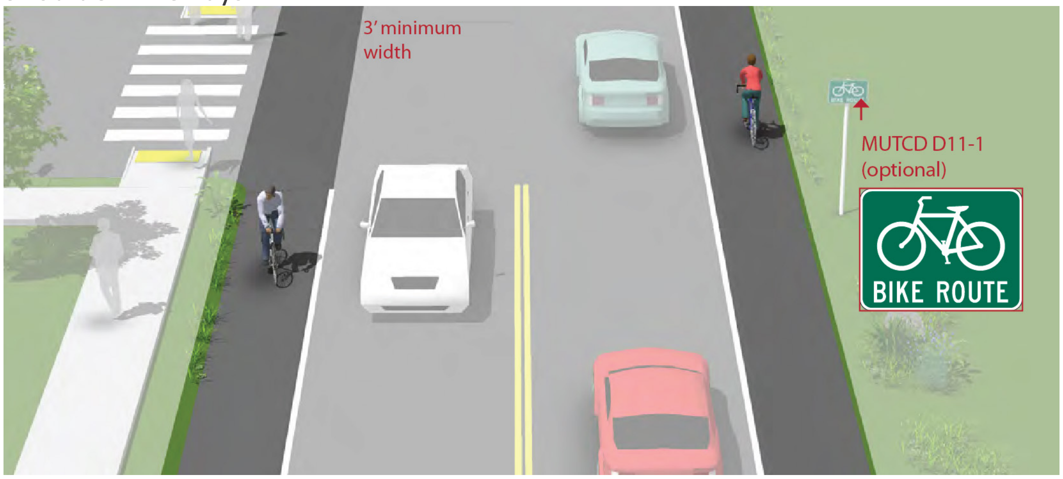


Figure 9-40. *Shoulder Bikeways*

9.10.1.1 Description - Typically found in less-dense areas, shoulder bikeways are paved roadways with striped shoulders (4'+) wide enough for bicycle travel. Shoulder bikeways often, but not always, include signage alerting motorists to expect bicycle travel along the roadway. Shoulder bikeways should be considered a temporary treatment, with full bike lanes planned for construction when the roadway is widened or completed with curb and gutter. This type of treatment is not typical in urban areas and should only be used where constraints exist.

9.10.1.2 Guidance - If 4 feet or more is available for bicycle travel, the full bike lane treatment of signs, legends, and an 8" bike lane line would be provided.

9.10.1.2.1 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.

9.10.1.2.2 Rumble strips are not recommended on shoulders used by bicyclists unless there is a minimum 4 foot clear path. 12 foot gaps every 40-60 feet should be provided to allow access as needed.

9.10.1.3 Discussion - A wide outside lane may be sufficient accommodation for bicyclists on streets with insufficient width for bike lanes but which do have space available to provide a wider (14'-16') outside travel lane. Consider configuring as a marked shared roadway in these locations.

9.10.1.4 Materials and Maintenance - Paint can wear more quickly in high traffic areas or in winter climates. Shoulder bikeways should be cleared of snow through routine snow removal operations.

9.10.1.5 Additional References and Guidelines

9.10.1.5.1 SCDOT. EDM 53: Installation of Rumble Strips.

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

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

9.10.2 Conventional Bike Lane

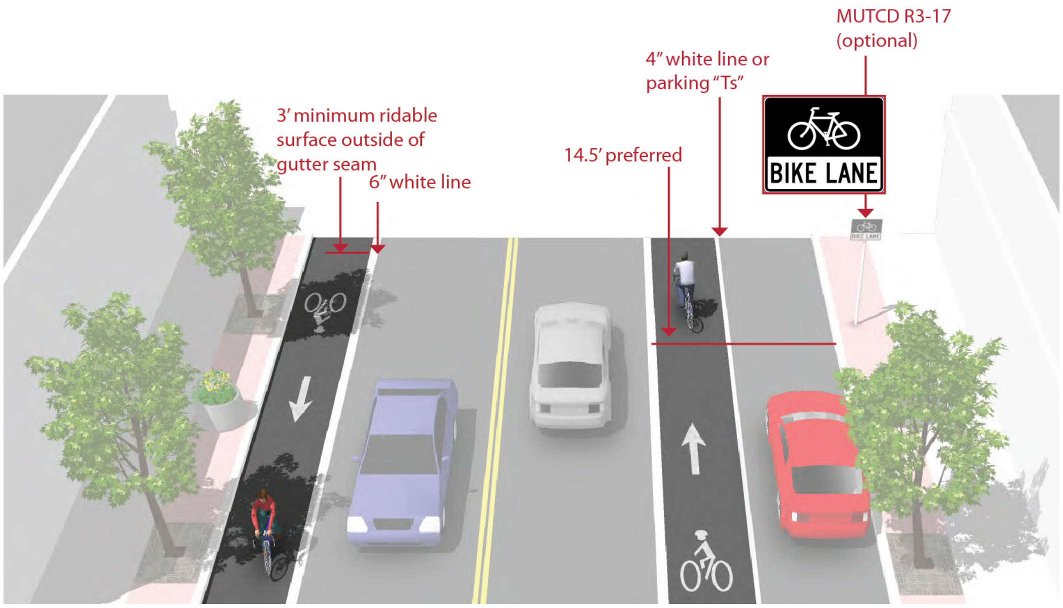


Figure 9-41. *Conventional Bike Lane*

9.10.2.1 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.

9.10.2.2 Guidance

9.10.2.2.1 4 foot minimum when no curb and gutter is present.

9.10.2.2.2 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.

9.10.2.2.3 14.5 foot preferred from curb face to edge of bike lane. (12 foot minimum).

9.10.2.2.4 7 foot maximum width for use adjacent to arterials with high travel speeds. Greater widths may encourage motor vehicle use of bike lane.

9.10.2.3 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.

9.10.2.4 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.

9.10.2.5 Additional References and Guidelines

9.10.2.5.1 SCDOT. EDM 22: Considerations for Bicycle Facilities.

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

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

9.10.2.5.4 NACTO. Urban Bikeway Design Guide. 2012.

9.10.3 Bike Lane Adjacent To On-Street Parking

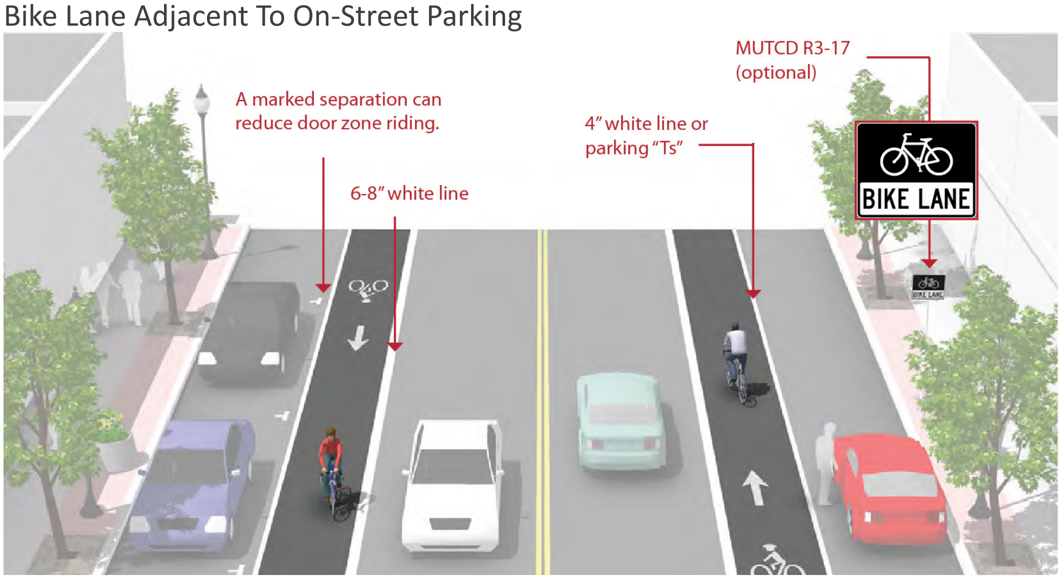


Figure 9-42. *Bike Lane Adjacent To On-Street Parking*

9.10.3.1 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.

9.10.3.2 Guidance

9.10.3.2.1 12 foot minimum from curb face to edge of bike lane.

9.10.3.2.2 14.5 foot preferred from curb face to edge of bike lane.

9.10.3.2.3 7 foot maximum for marked width of bike lane. Greater widths may encourage vehicle loading in bike lane. Configure as buffered bicycle lanes when a wider facility is desired.

9.10.3.3 Discussion - Bike lanes adjacent to on-street parallel parking require special treatment in order to avoid crashes caused by an open vehicle door. The bike lane should have sufficient width to allow bicyclists to stay out of the door zone while not encroaching into the adjacent vehicular lane. Parking stall markings, such as parking "Ts" and double white lines create a parking side buffer that encourages bicyclists to ride farther away from the door zone.

9.10.3.4 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.

9.10.3.5 Additional References and Guidelines

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

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

9.10.3.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.10.4 Bikeways And Diagonal Parking

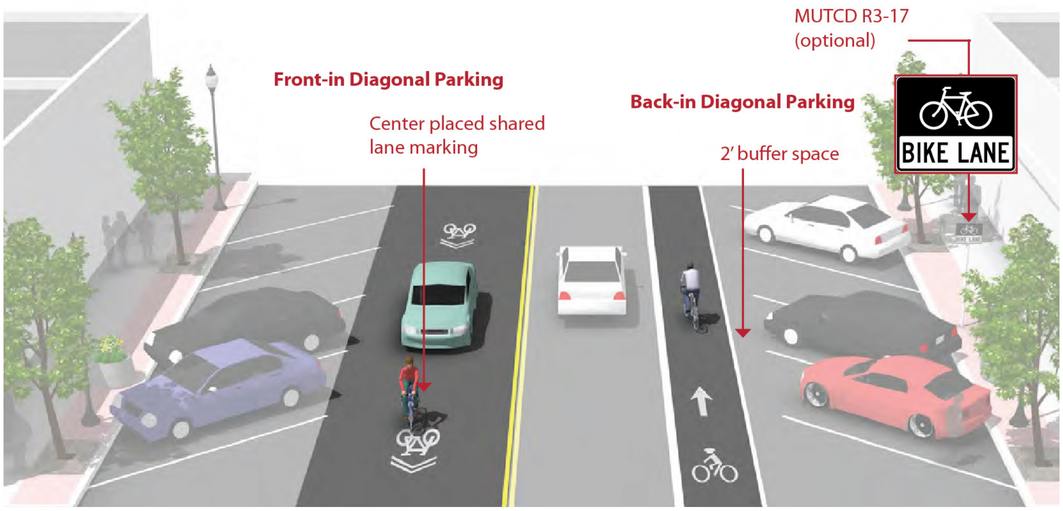


Figure 9-43. *Bikeways And Diagonal Parking*

9.10.4.1 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.

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.

9.10.4.2 Guidance

9.10.4.2.1 Front-in Diagonal Parking

9.10.4.2.1.1 Shared lane markings are the preferred facility with front-in diagonal parking

9.10.4.2.2 Back-in Diagonal Parking

9.10.4.2.2.1 5 foot minimum marked width of bike lane

9.10.4.2.2.2 Parking bays are sufficiently long to accommodate most vehicles (so vehicles do not block bike lane)

9.10.4.3 Discussion - Back-in diagonal parking provides other benefits including loading and unloading of the trunk at the curb rather than in the street, passengers (including children) are directed by open doors towards the curb and there is no door conflict with bicyclists. While there may be a learning curve for some drivers, back-in diagonal parking is typically an easier maneuver than conventional parallel parking.

9.10.4.4 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.

9.10.4.5 Additional References and Guidelines

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

9.10.5 Left Side Bike Lane

Figure 9-44. *Left Side Bike Lane*

9.10.5.1 Description - Left-side bike lanes are conventional bike lanes placed on the left side of one-way streets or two-way median divided streets.

Left-side bike lanes offer advantages on streets with heavy delivery or transit use, frequent parking turnover on the right side or other potential conflicts that could be associated with right-side bicycle lanes.

9.10.5.2 Guidance - Follow guidance for conventional bike lanes.

Signage should accompany left-side bicycle lanes to clarify proper use by bicyclists to reduce wrong-way riding.

Bicycle through lanes should be provided to the right of vehicle left turn pockets to reduce conflicts at intersections.

9.10.5.3 Discussion - Intersection treatments such as bike boxes and bike signals should be considered to assist in the transition from left-side bike lanes to right-side bike lanes.

9.10.5.4 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.

9.10.5.5 Additional References and Guidelines

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

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

9.10.5.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.10.6 Contra Flow Bike Lane

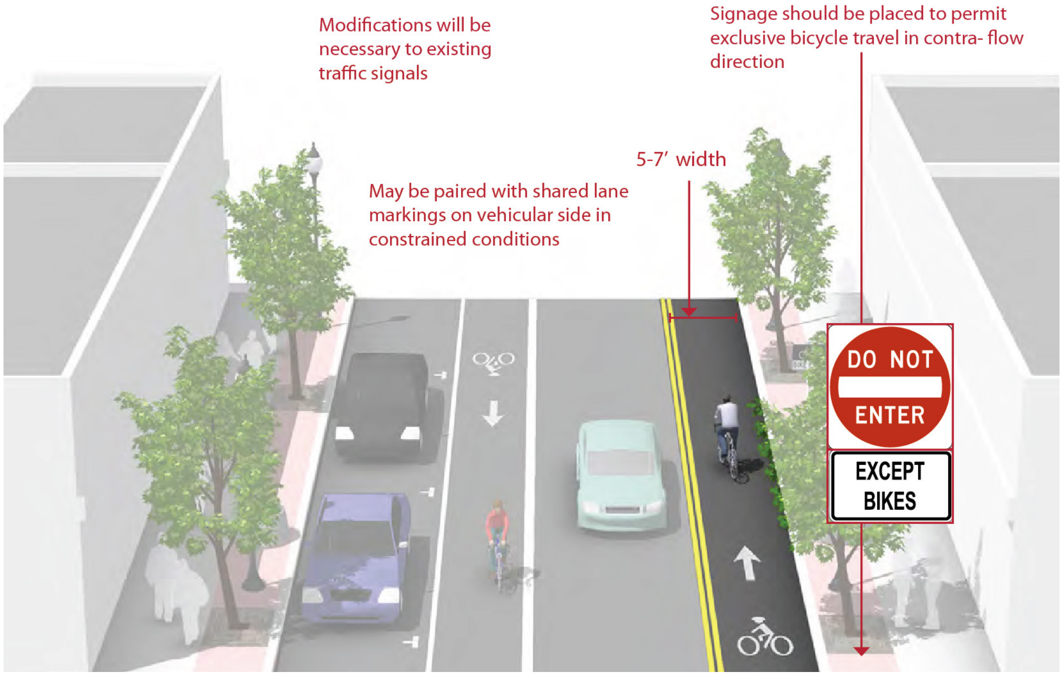


Figure 9-45. *Contra Flow Bike Lane*

9.10.6.1 Description - Contra-flow bike lanes provide bidirectional bicycle access on a roadway that is one-way for motor vehicle traffic. This treatment can provide direct access and connectivity for bicyclists and reducing travel distances. Contra-flow bike lanes can also be used to convert two-way motor vehicle traffic to one-way to reduce traffic volumes where desired.

9.10.6.2 Guidance

9.10.6.2.1 The contra-flow bike lane should be 5-7 feet wide and marked with a solid double yellow line and appropriate signage. Bike lane markings should be clearly visible to ensure that the contra-flow lane is exclusively for bicycles. Coloration should be considered in the bike lane.

9.10.6.2.2 Signage specifically allowing bicycles at the entrance of the contra flow lane is recommended.

9.10.6.3 Discussion - Because of the opposing direction of travel, contra-flow bike lanes increase the speed differential between bicyclists and motor vehicles in the adjacent travel lane. If space permits consider a buffered bike lane or cycle track configuration to provide additional separation.

9.10.6.4 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.

9.10.6.5 Additional References and Guidelines

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

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

9.10.6.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.10.7 Buffered Bike Lane

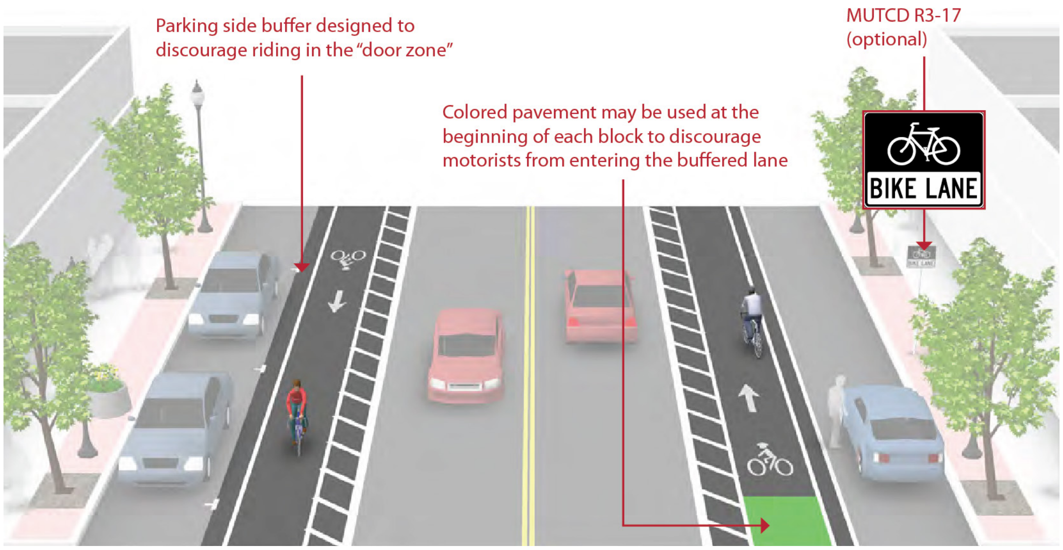


Figure 9-46. *Buffered Bike Lane*

9.10.7.1 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.

9.10.7.2 Guidance

9.10.7.2.1 The minimum bicycle travel area (not including buffer) is 5 feet wide.

9.10.7.2.2 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.

9.10.7.2.3 Buffered bike lanes can buffer the travel lane only, or parking lane only depending on available space and the objectives of the design.

9.10.7.3 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.

9.10.7.4 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.

9.10.7.5 Additional References and Guidelines

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

9.10.7.5.2 FHWA. Manual on Uniform Traffic Control Devices. (3D-01). 2009.

9.10.7.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.10.8 Uphill Bicycle Climbing Lane

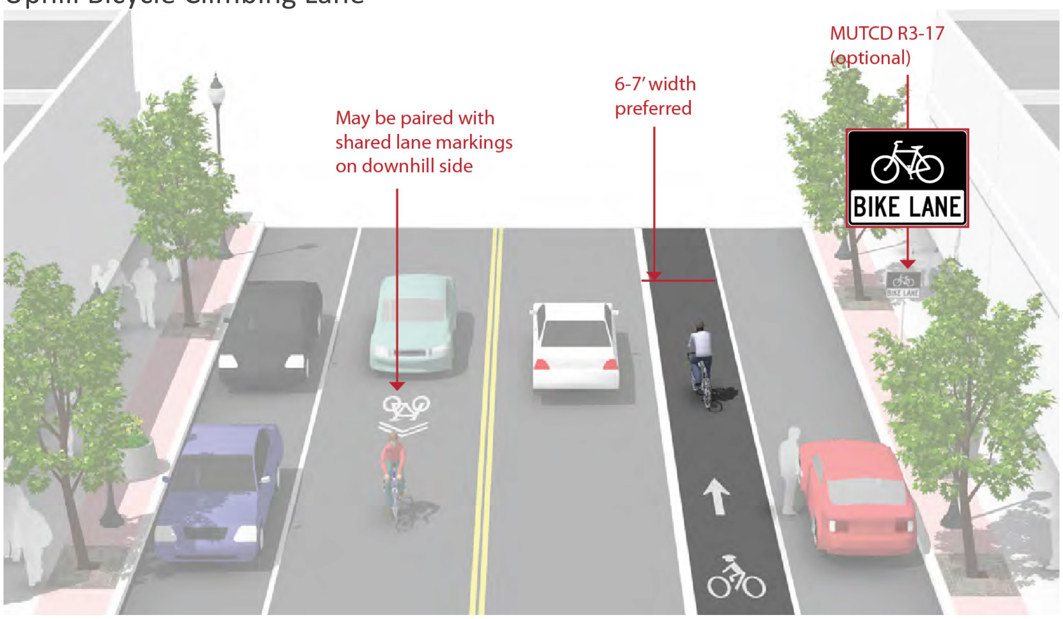


Figure 9-47. *Uphill Bicycle Climbing Lane*

9.10.8.1 Description - Uphill bike lanes (also known as "climbing lanes") enable motorists to safely pass slower-speed bicyclists, thereby improving conditions for both travel modes.

9.10.8.2 Guidance

9.10.8.2.1 Uphill bike lanes should be 6-7 feet wide (wider lanes are preferred because extra maneuvering room on steep grades can benefit bicyclists).

9.10.8.2.2 Can be combined with shared lane markings for downhill bicyclists who can more closely match prevailing traffic speeds.

9.10.8.3 Discussion - This treatment is typically found on retrofit projects as newly constructed roads should provide adequate space for bicycle lanes in both directions of travel.

Accommodating an uphill bicycle lane often includes delineating on-street parking (if provided), narrowing travel lanes and/or shifting the centerline if necessary.

9.10.8.4 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.

9.10.8.5 Additional References and Guidelines

9.10.8.5.1 NACTO. Urban Bikeway Design Guide. 2012.

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

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

9.11 Protected Bike Lanes

9.11.1 Cycle Track Separation And Placement

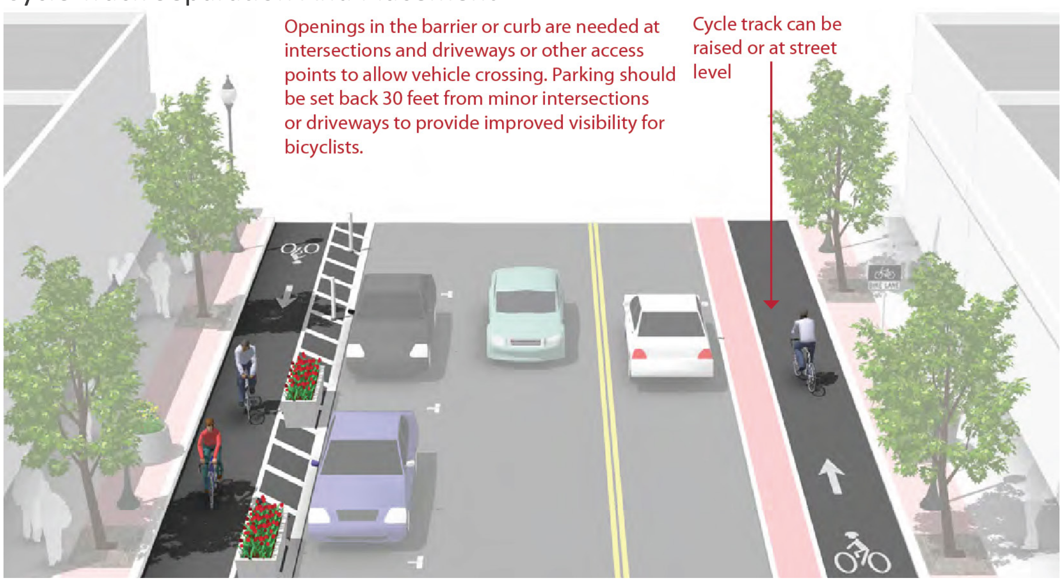


Figure 9-48. *Cycle Track Separation And Placement*

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

Raised cycle tracks may be at the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk to separate the cycle track from the pedestrian area.

9.11.1.2 Guidance

9.11.1.2.1 Cycle tracks should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles. Cycle tracks located on one-way streets have fewer potential conflict areas than those on two-way streets.

9.11.1.2.2 In situations where on-street parking is allowed, cycle tracks shall be located between the parking lane and the sidewalk (in contrast to bike lanes).

9.11.1.3 Discussion - Sidewalks or other pedestrian facilities should not be narrowed to accommodate the cycle track as pedestrians will likely walk on the cycle track 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 cycle track and pedestrian zone with a furnishing zone.

9.11.1.4 Materials and Maintenance - In cities with winter climates, barrier separated and raised cycle tracks may require special equipment for snow removal.

9.11.1.5 Additional References and Guidelines

9.11.1.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.11.2 One-Way Cycle Tracks

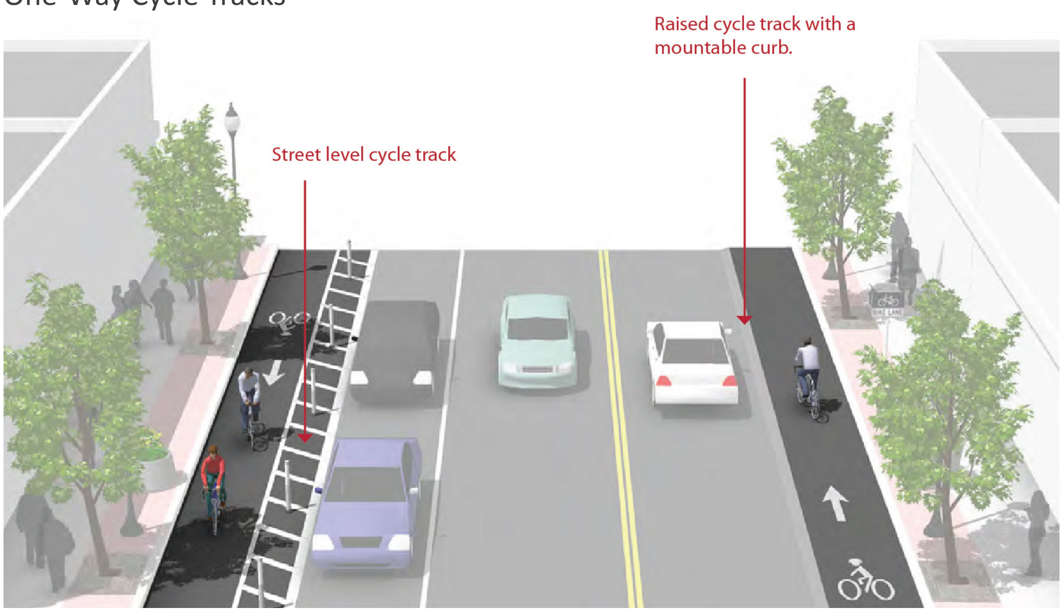


Figure 9-49. *One-Way Cycle Tracks*

9.11.2.1 Description - One-way cycle tracks are physically separated from motor traffic and distinct from the sidewalk. Cycle tracks are either raised or at street level and use a variety of elements for physical protection from passing traffic.

9.11.2.2 Guidance

9.11.2.2.1 7 foot recommended minimum to allow passing.

9.11.2.2.2 5 foot minimum width in constrained locations.

9.11.2.2.3 When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.

9.11.2.2.4 When placed adjacent to a travel lane, one-way raised cycle tracks 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.

9.11.2.3 Discussion - Special consideration should be given at transit stops to manage bicycle and pedestrian interactions. Driveways and minor street crossings are unique challenges to cycle track 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 cycle track has priority over entering and exiting traffic. If configured as a raised cycle track, the crossing should be raised so that the sidewalk and cycle track maintain their elevation through the crossing.

9.11.2.4 Materials and Maintenance - In cities with winter climates, barrier separated and raised cycle tracks may require special equipment for snow removal.

9.11.2.5 Additional References and Guidelines

9.11.2.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.11.3 Two Way Cycle Tracks

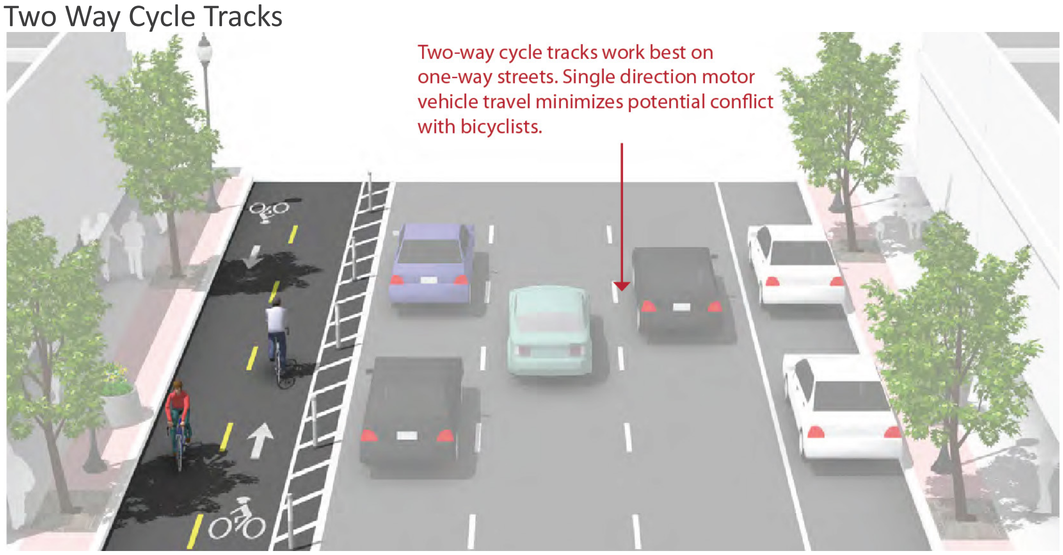


Figure 9-50. *Two Way Cycle Tracks*

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

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

9.11.3.2 Guidance

9.11.3.2.1 12 foot recommended minimum for two-way facility

9.11.3.2.2 8 foot minimum in constrained locations

9.11.3.2.3 When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.

9.11.3.3 Discussion - Cycle tracks will require careful assessment of intersection traffic operation, including traffic signal control, to ensure safe and efficient travel is maintained. Turning movements should be guided by separated signals for bicycles and conflicting motor vehicles. Transitions into and out of two-way cycle tracks should be simple and easy to use to deter bicyclists from continuing to ride against the flow of traffic.

At driveways and minor intersections, bicyclists riding against roadway traffic in two-way cycle tracks may surprise pedestrians and drivers not expecting bidirectional travel. Appropriate signage is recommended.

9.11.3.4 Materials and Maintenance - In cities with winter climates barrier, separated and raised cycle tracks may require special equipment for snow removal.

9.11.3.5 Additional References and Guidelines

9.11.3.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.11.3.5.2 ITE. Separated Bikeways. 2013.

9.11.4 Driveways And Minor Street Crossings

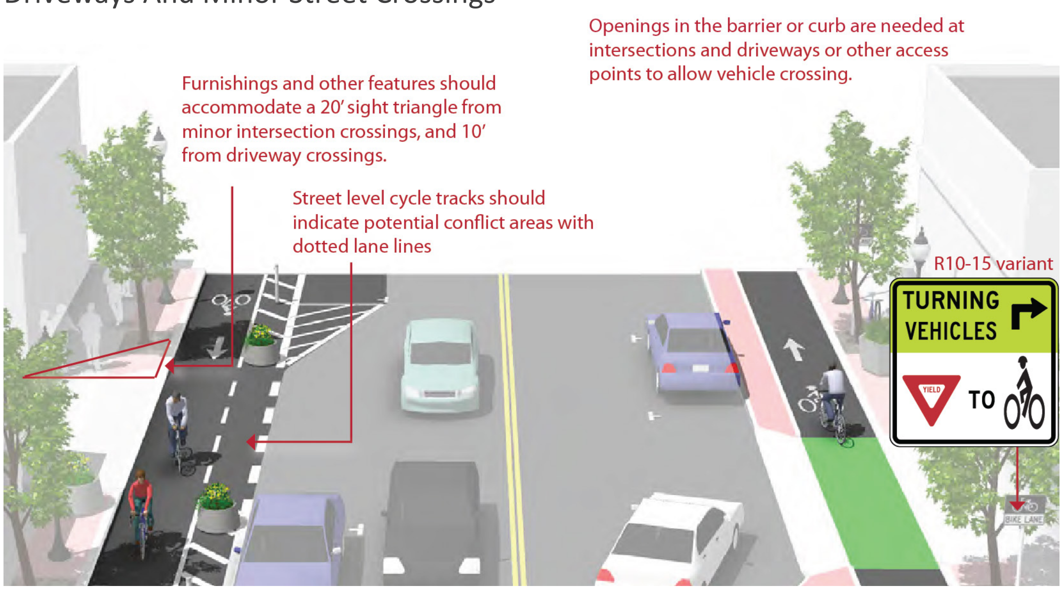


Figure 9-51. *Driveways And Minor Street Crossings*

9.11.4.1 Description - The added separation provided by cycle tracks creates additional considerations at intersections that should be addressed.

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

9.11.4.2 Guidance

9.11.4.2.1 If raised, maintain the height of the cycle track through the crossing, requiring automobiles to cross over.

9.11.4.2.2 Remove parking 30 feet prior the intersection.

9.11.4.2.3 Use colored pavement markings and/or shared lane markings through the conflict area.

9.11.4.2.4 Place warning signage to identify the crossing.

9.11.4.3 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 cycle track. 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 cycle track. Driveway consolidations and restrictions on motorized traffic movements reduce the potential for conflict.

9.11.4.4 Materials and Maintenance - In cities with winter climates, barrier separated and raised cycle tracks may require special equipment for snow removal.

9.11.4.5 Additional References and Guidelines

9.11.4.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.11.5 Major Street Crossings

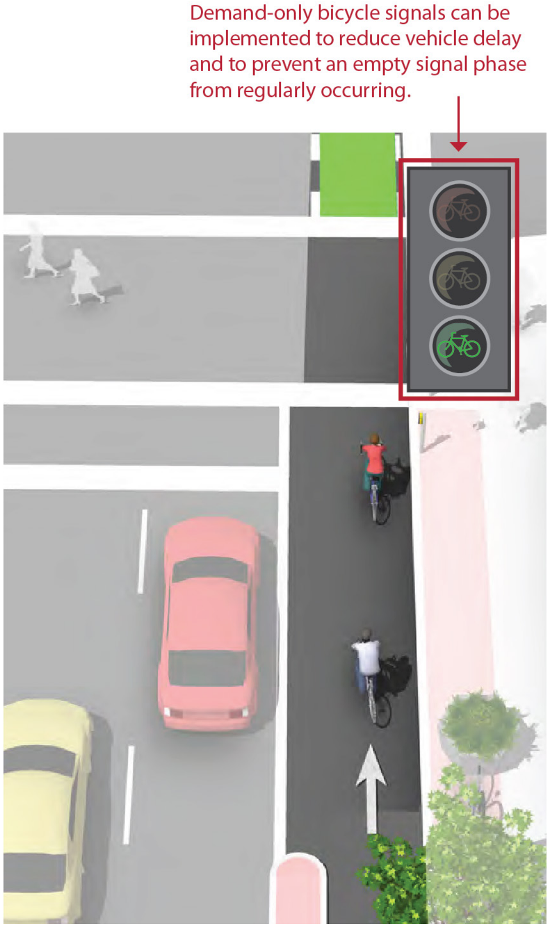


Figure 9-52. *Major Street Crossings*

9.11.5.1 Description - Cycle tracks approaching major intersections must minimize and mitigate potential conflicts and provide connections to intersecting facility types.

Cycle track 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.

9.11.5.2 Guidance

9.11.5.2.1 Drop cycle track buffer and transition to bike lane 16’ in advance of the intersection.

9.11.5.2.2 Remove parking 16’ -50’ in advance of the buffer termination.

9.11.5.2.3 Use a bike box or advanced stop line treatment to place bicyclists in front of traffic.

9.11.5.2.4 Use colored pavement markings through the conflict area.

9.11.5.2.5 Provide for left-turning movements with two-stage turn boxes.

9.11.5.2.6 Consider using a protected phase bicycle signal to isolate conflicts between bicyclists and motor vehicle traffic.

9.11.5.2.7 In constrained conditions with right turn only lanes, consider transitioning to a shared bike lane/turn lane.

9.11.5.3 Discussion - Signalization utilizing a bicycle signal head can also be set to provide cycle track 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 non-signalized intersections. Warning signs, special markings and the removal of on-street parking in advance of the intersection can raise visibility and awareness of bicyclists.

9.11.5.4 Materials and Maintenance - In cities with winter climates, barrier separated and raised cycle tracks may require special equipment for snow removal.

9.11.5.5 Additional References and Guidelines

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

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

9.11.5.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.11.6 Bicycle Transit Bypass

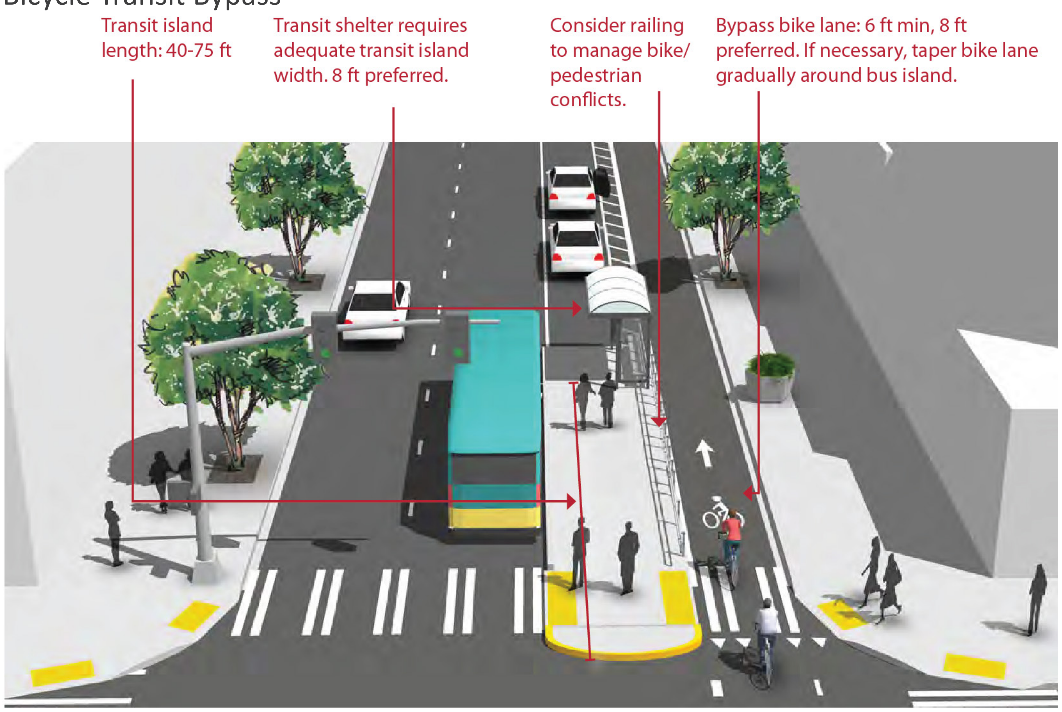


Figure 9-53. *Bicycle Transit Bypass*

9.11.6.1 Description - The bicycle lane transit bypass is a channelized lane for bicycles designed to allow bicyclists to pass stopped buses, and prevent conflicts with buses pulling to the curb. This is particularly helpful on corridors with high volumes of transit vehicles and bicyclists, where “leapfrogging” may occur.

9.11.6.2 Guidance

9.11.6.2.1 Appropriate in areas with high volumes of buses and bicyclists.

9.11.6.2.2 6 foot minimum width bypass lane.

9.11.6.2.3 Transit island should be wide enough to hold all waiting transit riders.

9.11.6.3 Discussion - Ensure an adequate width bicycle lane where the bypass lane rejoins the roadway so that bicyclists do not encroach into adjacent lanes.

Conflicts with pedestrians may be increased over conventional bus stop designs. Consider railings to direct pedestrians to a single location where they may cross to the sidewalk.

9.11.6.4 Materials and Maintenance - The channelized bicycle lane may require additional sweeping to maintain free of debris.

9.11.6.5 Additional References and Guidelines

9.11.6.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.11.6.5.2 NACTO. Urban Street Design Guide. 2013.

9.12 Bikeways at Intersections

9.12.1 Bike Box

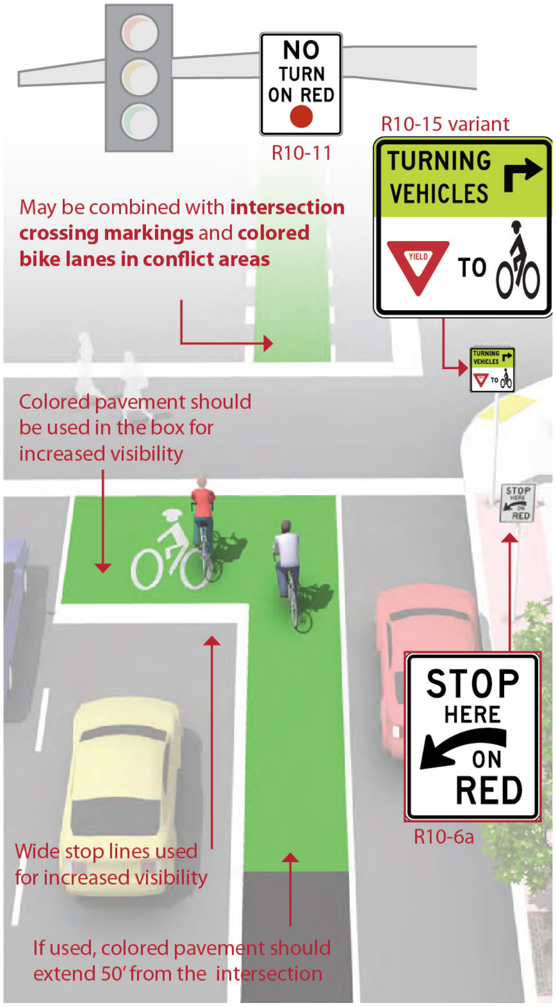


Figure 9-54. *Bike Box*

9.12.1.1 Description - A bike box is a designated area located at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible space to get in front of queuing motorized traffic during the red signal phase. Motor vehicles must queue behind the white stop line at the rear of the bike box.

At locations with downhill grades or high speed bicycle travel, intersections will require additional safety measures to prevent conflicts between bicyclists proceeding straight and motorists turning right. Potential enhancements include designing the intersection to include a separate right turn lane, prohibiting all vehice right turns, and/or providing an exclusive signal phase for bicycles.

9.12.1.2 Guidance

9.12.1.2.1 14’ minimum depth

9.12.1.2.2 A “No Turn on Red” (MUTCD R10-11) sign shall be installed overhead to prevent vehicles from entering the Bike Box.

9.12.1.2.3 A “Stop Here on Red” sign should be post-mounted at the stop line to reinforce observance of the stop line.

9.12.1.2.4 A “Yield to Bikes” sign should be post-mounted in advance of and in conjunction with an egress lane to reinforce that bicyclists have the right-of-way going through the intersection.

9.12.1.2.5 An ingress lane should be used to provide access to the box.

9.12.1.2.6 A supplemental “Wait Here” legend can be provided in advance of the stop bar to increase clarity to motorists.

9.12.1.3 Discussion - Bike boxes are considered experimental by the FHWA. Bike boxes should be placed only at signalized intersections, and right turns on red shall be prohibited for motor vehicles. Bike boxes should be used in locations that have a large volume of bicyclists and are best utilized in central areas where traffic is usually moving more slowly. Prohibiting right turns on red improves safety for bicyclists yet does not significantly impede motor vehicle travel.

9.12.1.4 Materials and Maintenance - Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

9.12.1.5 Additional References and Guidelines

9.12.1.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.12.1.5.2 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.

9.12.2 Bike Lanes at Right Turn Only Lanes

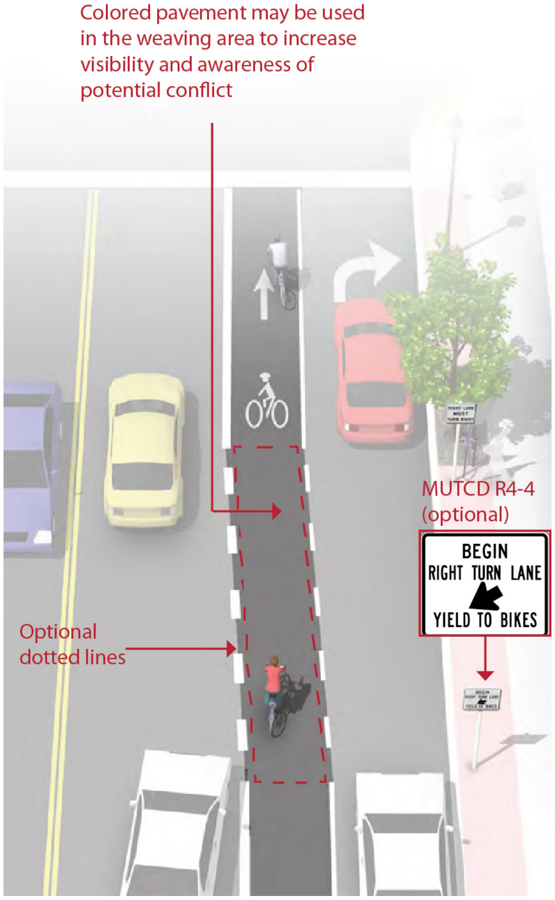


Figure 9-55. *Bike Lanes at Right Turn Only Lanes*

9.12.2.1 Description - The appropriate treatment at right-turn lanes is to place the bike lane between the right-turn lane and the rightmost 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.

9.12.2.2 Guidance

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

9.12.2.2.1.1 Continue existing bike lane width; standard width of 5 to 6 feet or 4 feet in constrained locations.

9.12.2.2.1.2 Use signage to indicate that motorists should yield to bicyclists through the conflict area.

9.12.2.2.1.3 Consider using colored conflict areas to promote visibility of the mixing zone.

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

9.12.2.2.2.1 Do not define a dotted line merging path for bicyclists.

9.12.2.2.2.2 Drop the bicycle lane in advance of the merge area.

9.12.2.2.2.3 Use shared lane markings to indicate shared use of the lane in the merging zone.

9.12.2.3 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.

9.12.2.4 Materials and Maintenance - Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

9.12.2.5 Additional References and Guidelines

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

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

9.12.2.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.12.3 Colored Bike Lanes In Conflict Areas

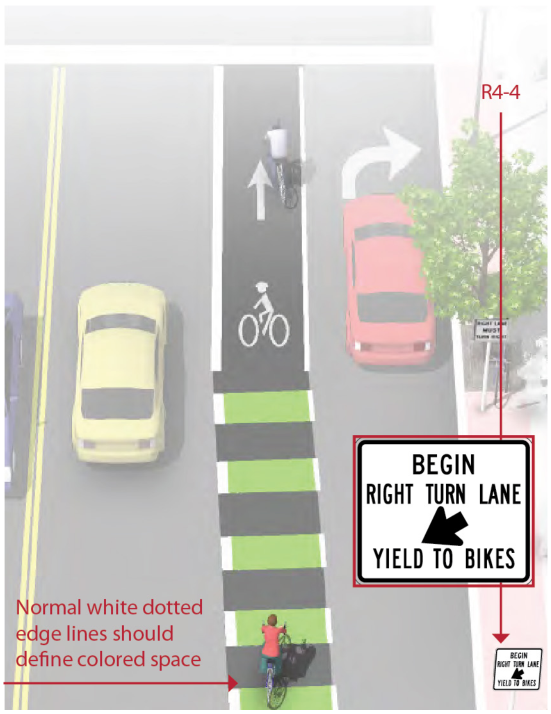


Figure 9-56. *Colored Bike Lanes In Conflict Areas*

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

9.12.3.2 Guidance

9.12.3.2.1 Green colored pavement was given interim approval by the Federal Highways Administration in March 2011. See interim approval for specific colored pavement standards.

9.12.3.2.2 The colored surface should be skid resistant and retro-reflective.

9.12.3.2.3 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.

9.12.3.3 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.

9.12.3.4 Materials and Maintenance - Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

9.12.3.5 Additional References and Guidelines

9.12.3.5.1 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.

9.12.3.5.2 NACTO. Urban Bikeway Design Guide. 2012.

9.12.4 Combined Bike Lane/Turn Lane

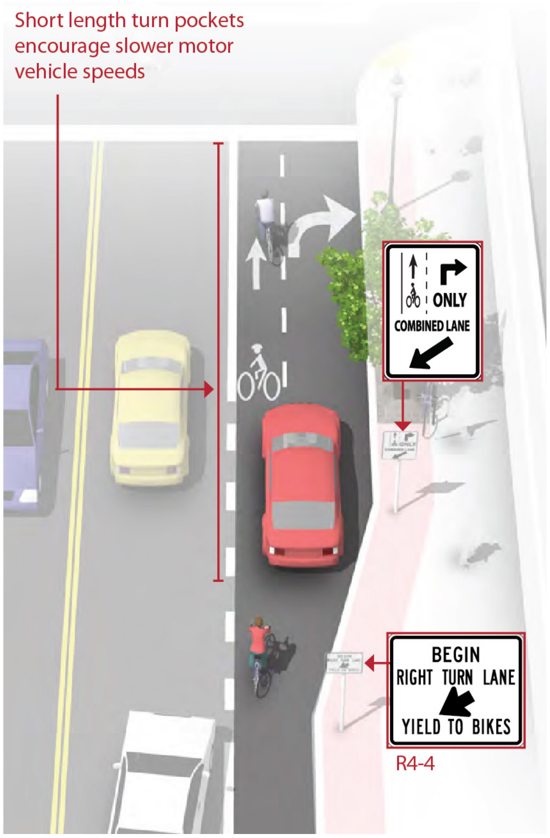


Figure 9-57. *Combined Bike Lane/Turn Lane*

9.12.4.1 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.

9.12.4.2 Guidance

9.12.4.2.1 Maximum shared turn lane width is 13 feet; narrower is preferable.

9.12.4.2.2 Bike Lane pocket should have a minimum width of 4 feet with 5 feet preferred.

9.12.4.2.3 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.

9.12.4.2.4 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.

9.12.4.3 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.

9.12.4.4 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.

9.12.4.5 Additional References and Guidelines

9.12.4.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.12.5 Intersection Crossing Markings

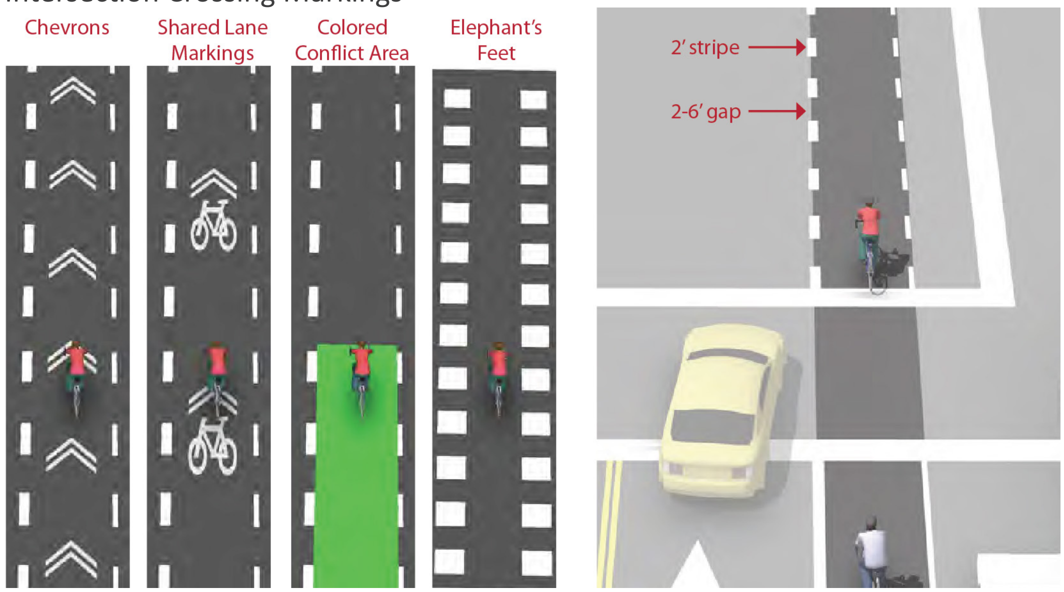


Figure 9-58. *Intersection Crossing Markings*

9.12.5.1 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.

9.12.5.2 Guidance

9.12.5.2.1 See MUTCD Section 3B.08: "dotted line extensions"

9.12.5.2.2 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.

9.12.5.2.3 Chevrons, shared lane markings, or colored bike lanes in conflict areas may be used to increase visibility within conflict areas or across entire intersections. Elephant's Feet markings are common in Europe and Canada.

9.12.5.3 Discussion - 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.

9.12.5.4 Materials and Maintenance - Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.

9.12.5.5 Additional References and Guidelines

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

9.12.5.5.2 FHWA. Manual on Uniform Traffic Control Devices. (3A.06). 2009.

9.12.5.5.3 NACTO. Urban Bikeway Design Guide. 2012.

9.12.6 Two-Stage Turn Box

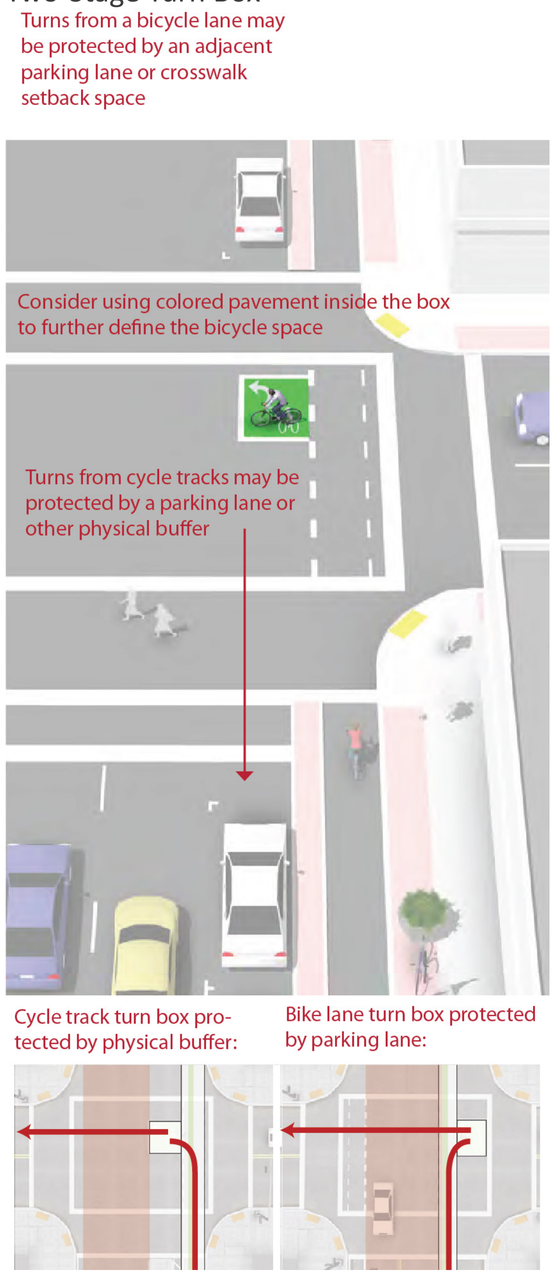


Figure 9-59. *Two-Stage Turn Box*

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

On right side cycle tracks, 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 cycle tracks.

9.12.6.2 Guidance

9.12.6.2.1 The queue box shall be placed in a protected area. Typically this is within an on-street parking lane or cycle track buffer area.

9.12.6.2.2 6’ minimum depth of bicycle storage area

9.12.6.2.3 Bicycle stencil and turn arrow pavement markings shall be used to indicate proper bicycle direction and positioning.

9.12.6.2.4 A “No Turn on Red” (MUTCD R10-11) sign shall be installed on the cross street to prevent vehicles from entering the turn box.

9.12.6.3 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.

9.12.6.4 Materials and Maintenance - Paint can wear more quickly in high traffic areas or in winter climates.

9.12.6.5 Additional References and Guidelines

9.12.6.5.1 NACTO. Urban Bikeway Design Guide. 2012.

9.12.7 Bicyclists at Single Lane Roundabouts

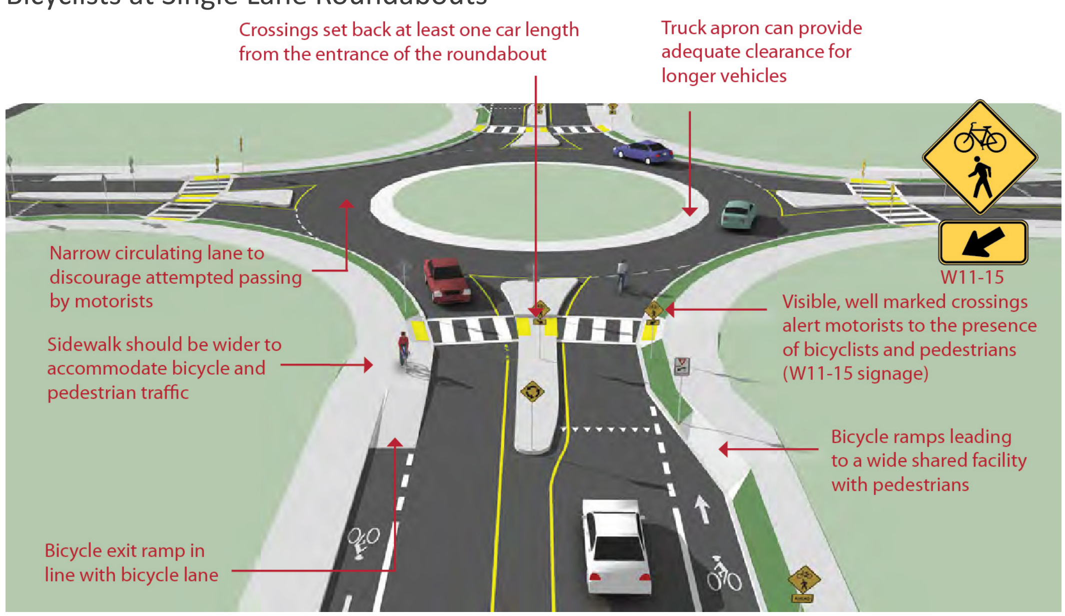


Figure 9-60. *Bicyclists at Single Lane Roundabouts*

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

9.12.7.2 Guidelines

9.12.7.2.1 25 mph maximum circulating design speed.

9.12.7.2.2 Design approaches/exits to the lowest speeds possible.

9.12.7.2.3 Encourage bicyclists navigating the roundabout like motor vehicles to "take the lane."

9.12.7.2.4 Maximize yielding rate of motorists to pedestrians and bicyclists at crosswalks.

9.12.7.2.5 Provide separated facilities for bicyclists who prefer not to navigate the roundabout on the roadway.

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

9.12.7.4 Materials and Maintenance - Signage and striping require routine maintenance.

9.12.7.5 Additional References and Guidelines

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

9.12.7.5.2 FHWA. Roundabouts: An Informational Guide. 2000.

9.12.7.5.3 TRB. Roundabouts: An Informational Guide, Second Edition. NCHRP 672. 2010.

9.12.8 Bike Lanes at High Speed Interchanges

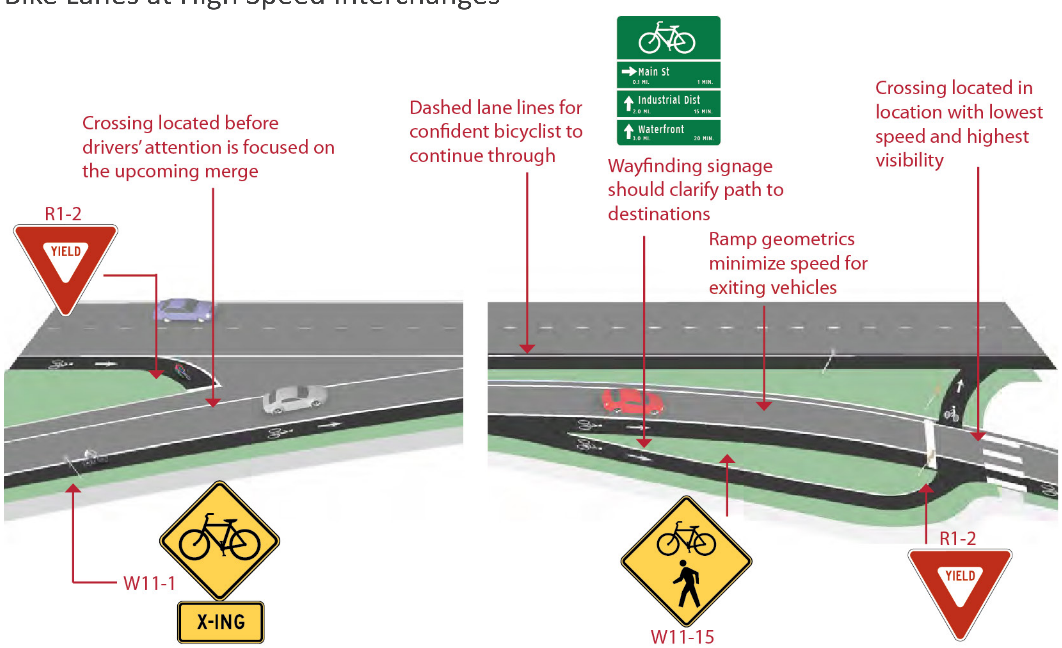


Figure 9-61. *Bike Lanes at High Speed Interchanges*

9.12.8.1 Description - Some arterials may contain high speed freeway-style designs such as merge lanes and exit ramps, which can create difficulties for bicyclists. The entrance and exit lanes typically have intrinsic visibility problems because of low approach angles and feature high speed differentials between bicyclists and motor vehicles.

Strategies to improve safety focus on increasing sight distances, creating formal crossings, and minimizing crossing distances.

9.12.8.2 Guidance

9.12.8.2.1 Entrance Ramps: Angle the bike lane to increase the approach angle with entering traffic. Position crossing before drivers' attention is focused on the upcoming merge.

9.12.8.2.2 Exit Ramps: Use a jug handle turn to bring bicyclists to increase the approach angle with exiting traffic, and add yield striping and signage to the bicycle approach.

9.12.8.3 Discussion - While the jug-handle approach is the preferred configuration at exit ramps, provide the option for through bicyclists to perform a vehicular merge and proceed straight through under safe conditions.

9.12.8.4 Materials and Maintenance - Locate crossing markings out of wheel tread when possible to minimize wear and maintenance costs.

9.12.8.5 Additional References and Guidelines

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

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

9.12.8.5.3 FHWA. Bicycle and Pedestrian Transportation. Lesson 15: Bicycle Lanes. 2006.

9.12.9 Bike/Ped Facilities at Diverging Diamond Interchanges

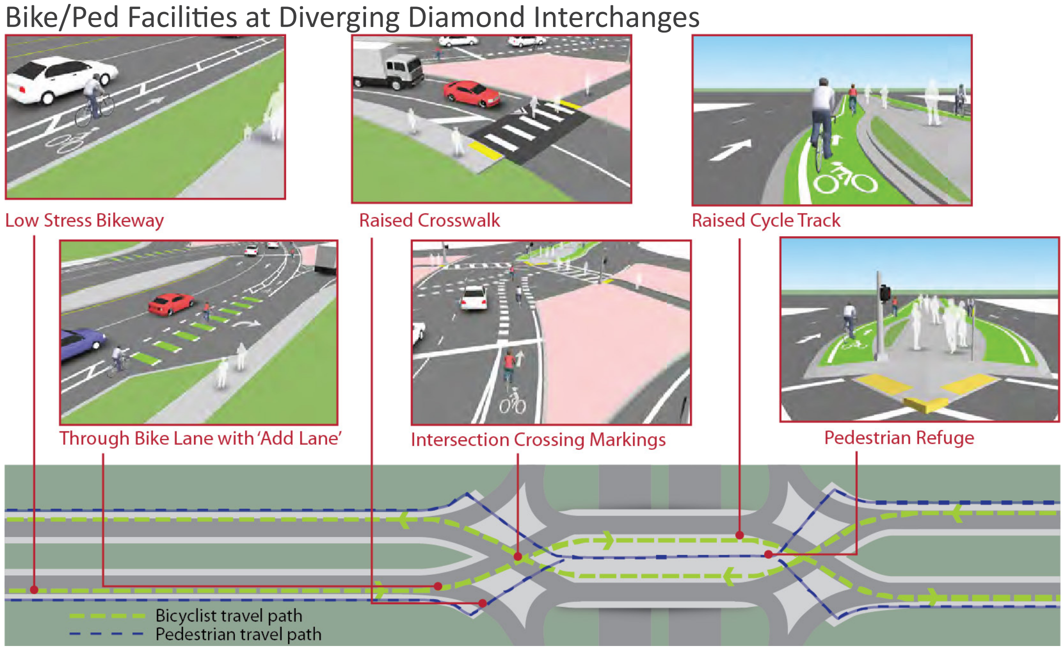


Figure 9-62. *Bike/Ped Facilities at Diverging Diamond Interchanges*

9.12.9.1 Description - The Diverging Diamond Interchange (DDI) is a modern interchange configuration designed to reduce conflict points and improve safety and performance for automobile users.

Highway interchanges are not typically comfortable for bicyclists or pedestrians due to the high speed and volume of motor vehicle traffic. Key design features at conflict areas in DDIs should be included to improve the experience for vulnerable road users such as bicyclists and pedestrians.

9.12.9.2 Guidance

9.12.9.2.1 A buffered bike lane or cycle track approaching the interchange offers a lower stress approach for bicyclists.

9.12.9.2.2 Through bike lane striping provides clear priority for bicyclists at right turn ‘add lane’ on-ramps.

9.12.9.2.3 Raised crosswalks increase yielding compliance at the channelized right turn on- and off- ramps.

9.12.9.2.4 A raised bike lane provides separation from moving traffic, and provides an added buffer for pedestrians.

9.12.9.2.5 Median island offers a safe refuge from moving traffic.

9.12.9.3 Discussion - The on-ramps should be configured as a right-turn-only “add lane” to assert through bicyclist priority. The center running island may provide a physical barrier between the auto lanes and the cycle track or pedestrian way to provide additional protection. Elephant’s feet markings (shown) offer more visibility through the intersection than conventional dotted line extensions.

9.12.9.4 Materials and Maintenance - Maintenance issues of DDIs are very similar to other types of interchanges.

9.12.9.5 Additional References and Guidelines

9.12.9.5.1 TRB. NCHRP 674: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities. 2011.

9.12.9.5.2 Missouri DOT. Engineering Policy Guide. 234.6 Diverging Diamond Interchanges. 2012.

9.12.10 Bikeways at Railroad Grade Crossings

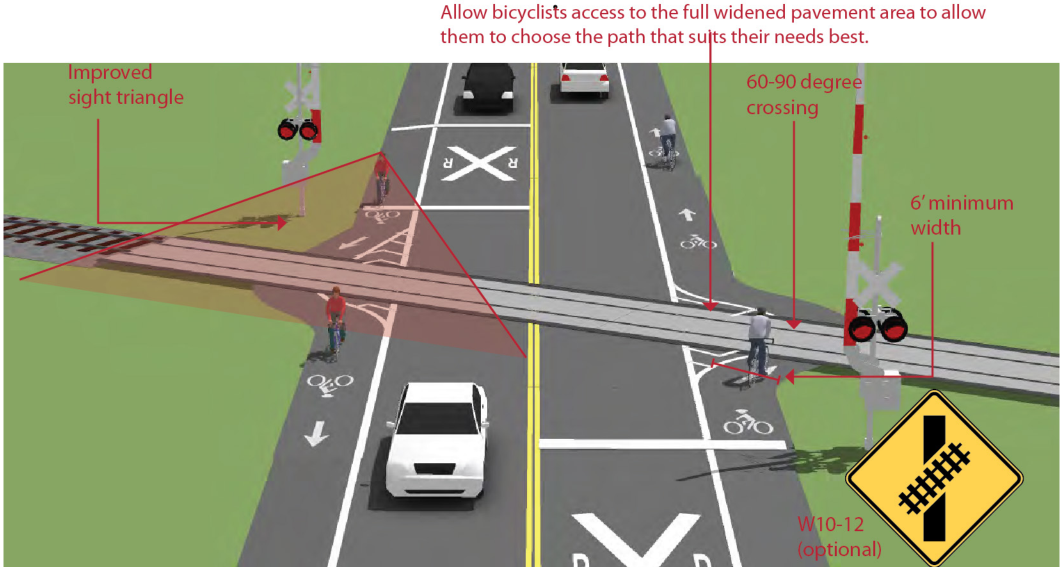


Figure 9-63. *Bikeways at Railroad Grade Crossings*

9.12.10.1 Description - Bikeways that cross railroad tracks at a diagonal may cause steering difficulties or loss of control for bicyclists due to slippery surfaces, degraded rough materials, and the size of the flangeway gaps.

Angled track crossings also limit sight triangles, impacting the ability to see oncoming trains.

Bicyclist crashes at railroad tracks are often sudden and unexpected. Improvements to track placement, surface quality, flangeway opening width and crossing angle can minimize risks to people riding.

9.12.10.2 Guidance

9.12.10.2.1 6 ft minimum shoulder/bike lane width.

9.12.10.2.2 If the skew angle is less than 45 degrees, special attention should be given to the sidewalk and bicycle alignment to improve the approach angle to at least 60 degrees (90 degrees preferred where possible).

9.12.10.2.3 Consider posting W-10 or W-12 signs to alert bicyclists.

9.12.10.2.4 Sight triangles of 50 feet by 100 feet will be provided at the railroad and street right of way. (Sight triangles are measured from the centerline of the railroad track.

9.12.10.3 Discussion - Crossing design and implementation is a collaboration between the railroad company and highway agency. The railroad company is responsible for the crossbucks, flashing lights and gate mechanisms, and the highway agency is responsible for advance warning markings and signs. Warning devices should be recommended for each specific situation by a qualified engineer based on various factors including train frequency and speed, path and trail usage and sight distances.

9.12.10.4 Materials and Maintenance - Concrete is the preferred material for use at bikeway railroad crossings. Rubber crossings are ridable when new and dry, but become slippery when wet and degrade over time. (AASHTO 2012)

9.12.10.5 Additional References and Guidelines

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

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

9.12.10.5.3 TRB. TCRP 17: Integration of Light Rail Transit into City Streets. 1996.

9.12.10.5.4 FHWA. Railroad-Highway Grade Crossing Handbook. 2007.

9.12.10.5.5 Rails-to-Trails Conservancy. Rails-with-Trails: A Preliminary Assessment of Safety and Grade Crossings. 2005.

9.13 Crossing Beacons and Signals for Bicycles

9.13.1 Active Warning Beacons

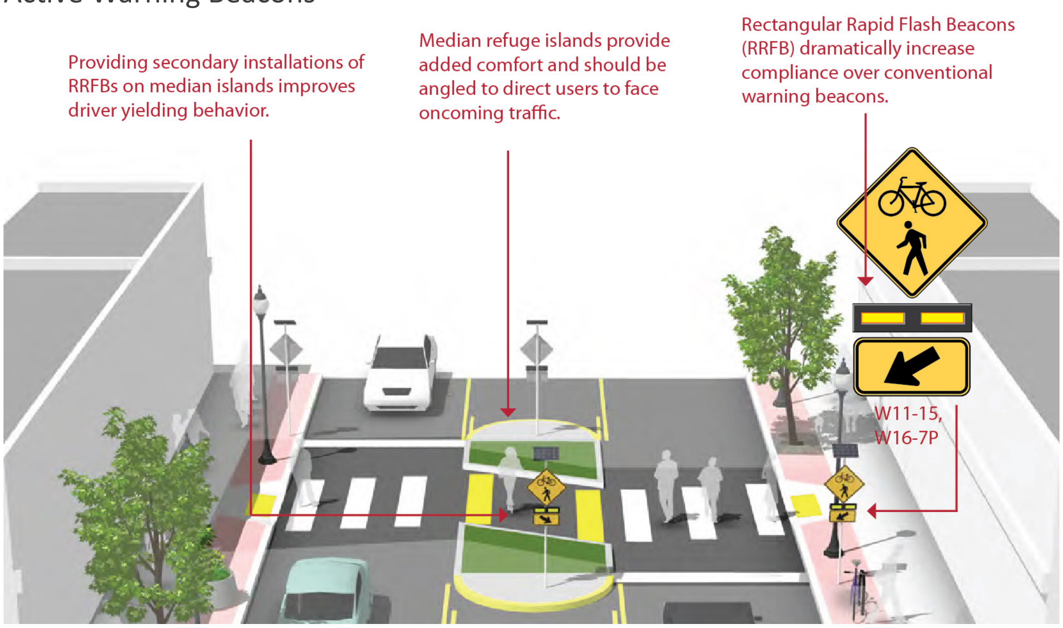


Figure 9-64. *Active Warning Beacons*

9.13.1.1 Description - Active warning beacons are user actuated illuminated devices designed to increase motor vehicle yielding compliance at crossings of multi lane or high volume roadways.

Types of active warning beacons include conventional circular yellow flashing beacons, in-roadway warning lights, or Rectangular Rapid Flash Beacons (RRFB).

9.13.1.2 Guidance - Warning beacons shall not be used at crosswalks controlled by YIELD signs, STOP signs or traffic signals.

Warning beacons shall initiate operation based on pedestrian or bicyclist actuation and shall cease operation at a predetermined time after actuation or, with passive detection, after the pedestrian or bicyclist clears the crosswalk.

9.13.1.3 Discussion - Rectangular rapid flash beacons have the highest 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 over long term installations show little to no decrease in yielding behavior over time.

9.13.1.4 Materials and Maintenance - Depending on power supply, maintenance can be minimal. If solar power is used, RRFBs can run for years without issue.

9.13.1.5 Additional References and Guidelines

9.13.1.5.1 NACTO. Urban Bikeway Design Guide. 2012.

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

9.13.1.5.3 FHWA. MUTCD - Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11). 2008.

9.13.1.5.4 SCDOT. Traffic Engineering Guideline TG-33: Rectangular Rapid Flash Beacons.

9.13.2 Hybrid Warning Beacon (HAWK) for Bicycle Route Crossing

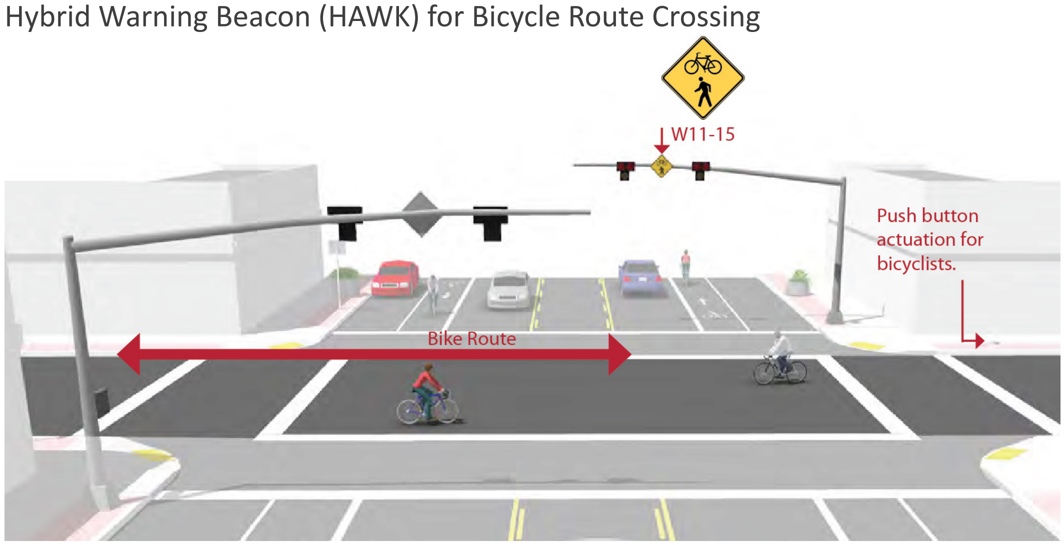


Figure 9-65. *Hybrid Warning Beacon (HAWK) for Bicycle Route Crossing*

9.13.2.1 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.

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

9.13.2.2.1 If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals.

9.13.2.2.2 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.

9.13.2.3 Discussion - The hybrid beacon can significantly improve the operation of a bicycle route, particularly along neighborhood greenway 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.

9.13.2.4 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.

9.13.2.5 Additional References and Guidelines

9.13.2.5.1 FHWA. Pedestrian Hybrid Beacon Guide. 2014.

9.13.2.5.2 SCDOT. TG-26: Pedestrian Hybrid Beacon Guideline.

9.13.2.5.3 NACTO. Urban Bikeway Design Guide. 2012.

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

9.13.3 Bicycle Detection and Actuation

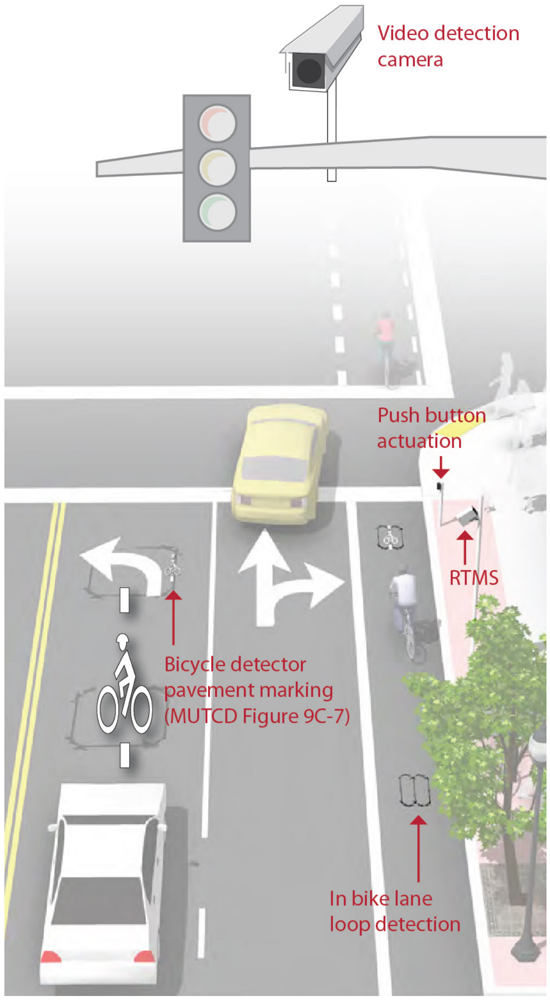


Figure 9-66. *Bicycle Detection and Actuation*

9.13.3.1 Description

9.13.3.1.1 Push Button Actuation - User-activated button mounted on a pole facing the street.

9.13.3.1.2 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.

9.13.3.1.3 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.

9.13.3.1.4 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.

9.13.3.2 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.

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

9.13.3.4 Additional References and Guidelines

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

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

9.13.3.4.3 NACTO. Urban Bikeway Design Guide. 2012.

9.13.4 Bicycle Signal Heads

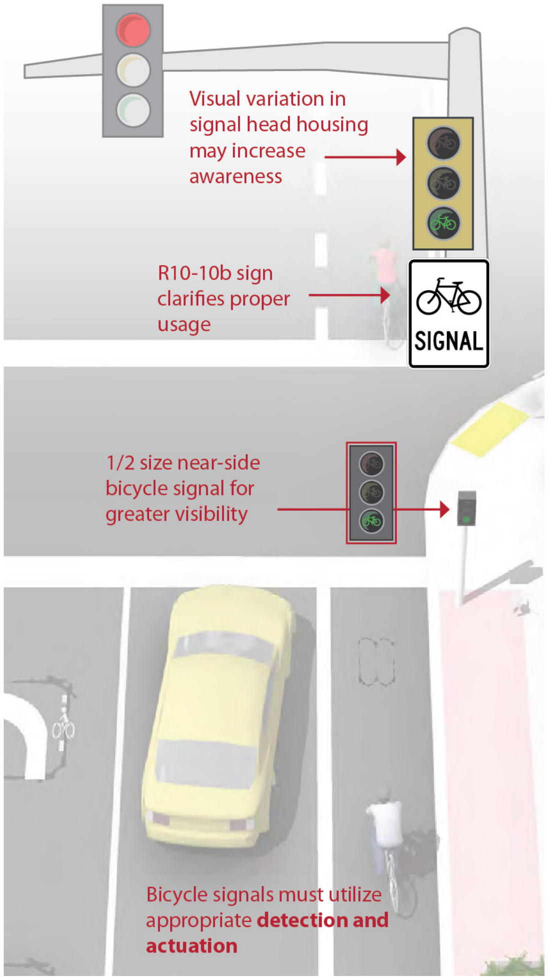


Figure 9-67. *Bicycle Signal Heads*

9.13.4.1 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).

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

9.13.4.2.1 Those with high volume of bicyclists at peak hours

9.13.4.2.2 Those with high numbers of bicycle/motor vehicle crashes, especially those caused by turning vehicle movements

9.13.4.2.3 At T-intersections with major bicycle movement along the top of the "T."

9.13.4.2.4 At the confluence of an off-street bike path and a roadway intersection

9.13.4.2.5 Where separated bike paths run parallel to arterial Streets

9.13.4.3 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.

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

9.13.4.5 Additional References and Guidelines

9.13.4.5.1 FHWA. MUTCD - Interim Approval for Optional Use of a Bicycle Signal Face (IA-16). 2013.

9.13.4.5.2 NACTO. Urban Bikeway Design Guide. 2012.

9.14 Retrofitting Streets to Add Bikeways

9.14.1 Roadway Widening

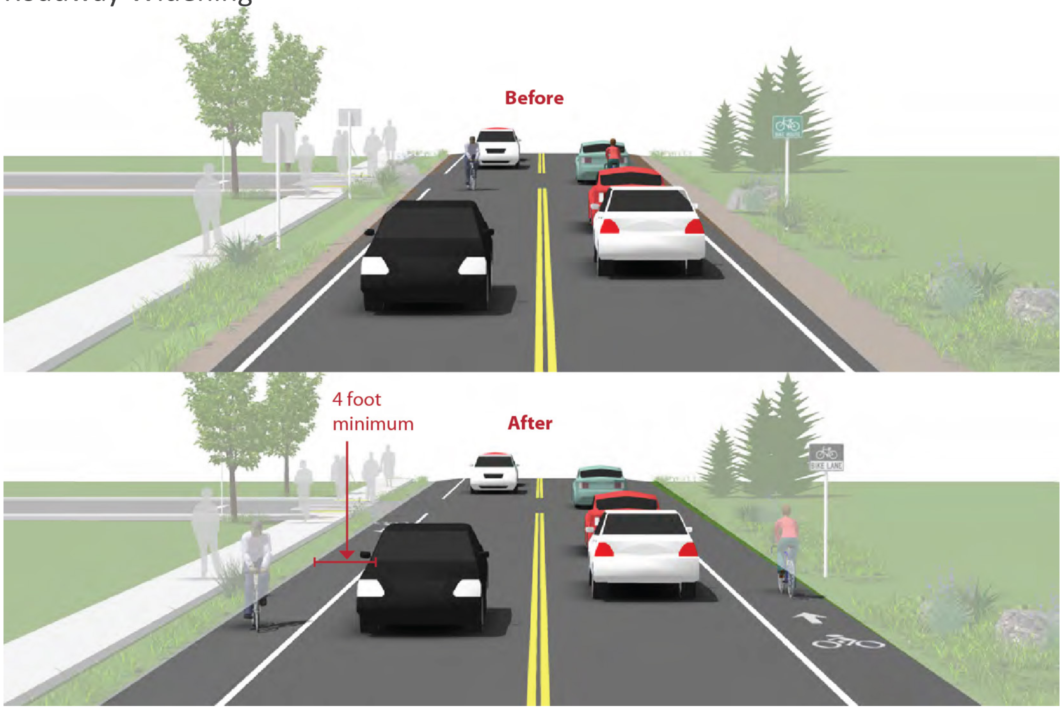


Figure 9-68. *Roadway Widening*

9.14.1.1 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.

9.14.1.2 Guidance

9.14.1.2.1 Guidance on bicycle lanes applies to this treatment.

9.14.1.2.2 4 foot minimum width when no curb and gutter is present.

9.14.1.2.3 6 foot width preferred.

9.14.1.3 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.

9.14.1.4 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.

9.14.1.5 Additional References and Guidelines

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

9.14.2 Lane Narrowing

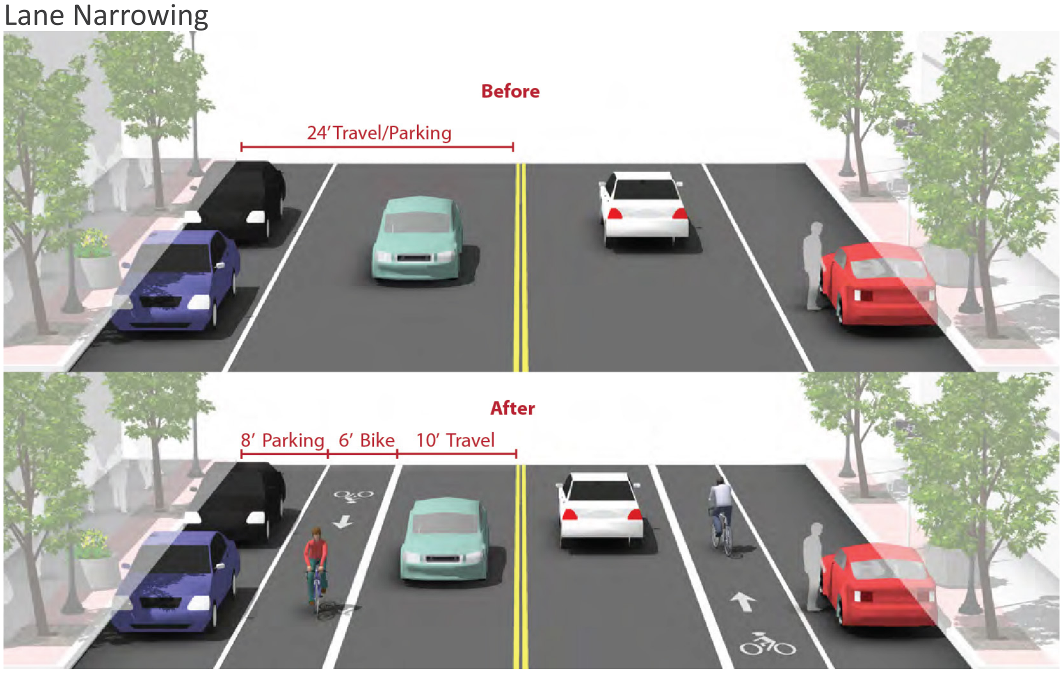


Figure 9-69. *Lane Narrowing*

9.14.2.1 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.

9.14.2.2 Guidance

9.14.2.2.1 Vehicle lane width:

9.14.2.2.1.1 Before: 10-15 feet

9.14.2.2.1.2 After: 10-11 feet

9.14.2.2.2 Bicycle lane width:

9.14.2.2.2.1 Guidance on bicycle lanes applies to this treatment.

9.14.2.3 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.”

9.14.2.4 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.

9.14.2.5 Additional References and Guidelines

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

9.14.2.5.2 SCDOT. EDM 22: Considerations for Bicycle Facilities.

9.14.2.5.3 NACTO. Urban Street Design Guide. 2013.

9.14.2.5.4 SCDOT. Traffic Calming Guidelines. 2006.

9.14.3 Lane Reconfiguration

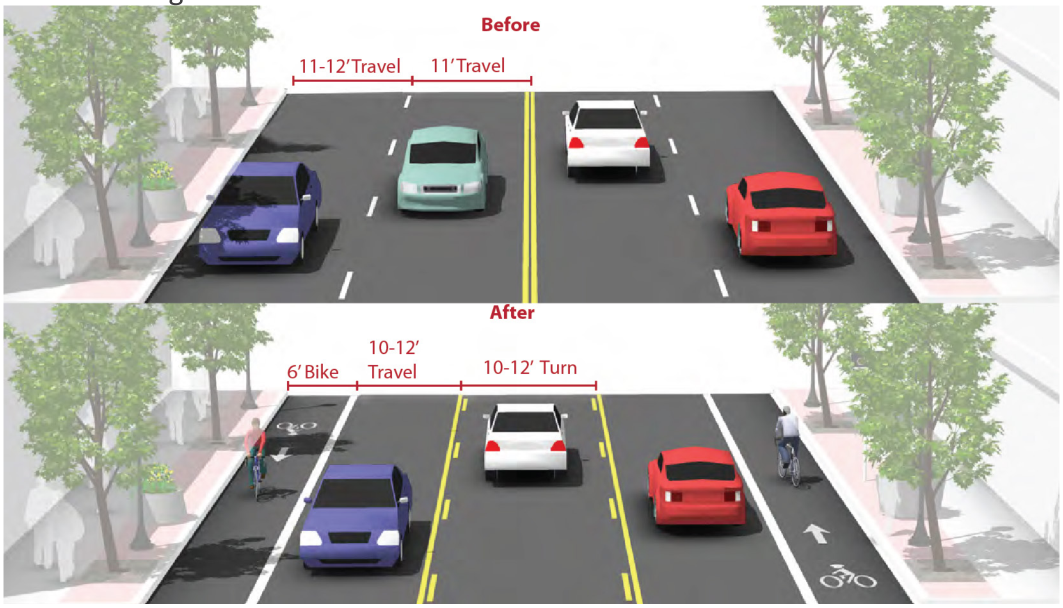


Figure 9-70. *Lane Reconfiguration*

9.14.3.1 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.

9.14.3.2 Guidance

9.14.3.2.1 Vehicle lane width: Width depends on project. No narrowing may be needed if a lane is removed.

9.14.3.2.2 Bicycle lane width: Guidance on bicycle lanes applies to this treatment.

9.14.3.3 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.

9.14.3.4 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.

9.14.3.5 Additional References and Guidelines

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

9.14.3.5.2 FHWA. Evaluation of Lane Reduction “Road Diet” Measures on Crashes. Publication Number: FHWA-HRT-10-053. 2010.

9.14.3.5.3 NACTO. Urban Street Design Guide. 2013.

9.14.4 Parking Reduction

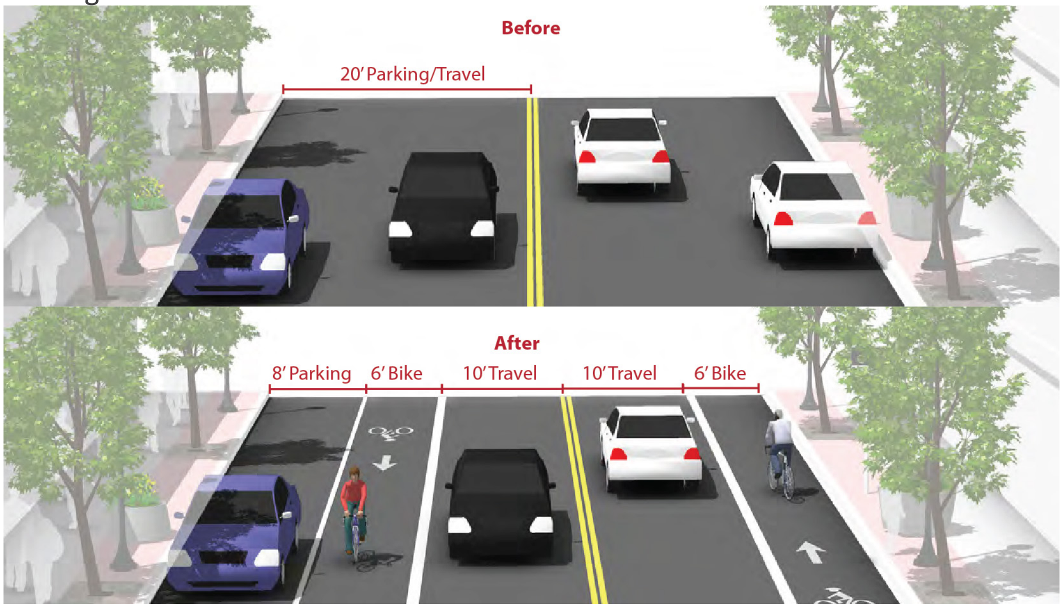


Figure 9-71. *Parking Reduction*

9.14.4.1 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.

9.14.4.2 Guidance

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

9.14.4.2.2 Bicycle lane width: Guidance on bicycle lanes applies to this treatment.

9.14.4.3 Discussion - The City of Columbia has bonds issued against future parking revenue which requires any paid parking removed from the street be relocated elsewhere. 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.

9.14.4.4 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

9.14.4.5 Additional References and Guidelines

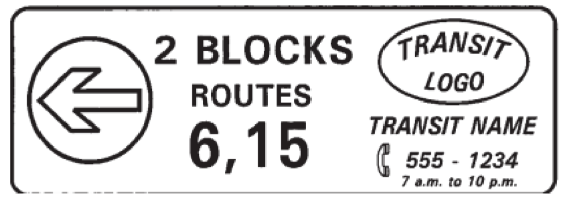
9.14.4.5.1 AASHTO. Guide for the Development of Bicycle Facilities. 2012.

9.14.4.5.2 AASHTO. A Policy on Geometric Design of Highways and Streets. 2004.

9.15 Transit and Bicycle Wayfinding

9.15.1 Transit Wayfinding

Supplemental information can be included to assist in decision making and increase the convenience for passengers and may include:
- Hours of operation
- Route frequency and/or timetables
- Diagrammatic route maps
- System maps
- Distances, directions and travel times to popular destinations



A "Trailblazer sign" can be used along or nearby routes to direct people to stops within close proximity. Such signage is also helpful guiding transit users between two nearby stops

Figure 9-72. *Transit Wayfinding*

9.15.1.1 Description - Transit wayfinding is important primarily for informing the public on where to access transit, and to assist users in making educated route plans to reach their destinations. Well planned and designed transit wayfinding can encourage people to use transit – likewise, poorly designed transit wayfinding can discourage transit use. Taking trips with transit involves several important steps that can be generalized into three phases:

9.15.1.1.1 Trip planning – locating a destination and deciding what mode or modes to utilize for the trip.

9.15.1.1.2 Trip segment assessment – understanding the necessary steps required to successfully reach a destination.

9.15.1.1.3 En route decision points – successfully judging options and navigating transfers between transit routes or modes within the trip.

9.15.1.2 Guidance - There are several media for providing wayfinding information to transit users - most often oral communication, signage (static and dynamic), pamphlets and digital communication are used. All can be effective means of conveying wayfinding information, and typically a combination of all should be considered. For the purposes of these Design Guidelines, we will be focusing on information conveyance through wayfinding signage.

9.15.1.2.1 Signs should be mounted to be conspicuous against other signs, advertising, and other visual clutter. Consideration must also be given to local ordinances and protection against vandalism.

9.15.1.2.2 Sign must be visible to bus passengers inside bus when bus is at stop.

9.15.1.2.3 Consider use of duplicate sign with 3-in. raised letters/symbols in location suitable for approach to within 3 in., with Grade II Braille under each character.

9.15.1.2.4 Bus stop signage should include the transit system logo/name, transit information telephone number, names of streets and landmarks where bus stop is located, and route number(s) serving the bus stop.

9.15.1.3 Discussion - Signage siting is an important aspect of transit wayfinding. In order to be noticed and effective, information must be perceived at or shortly before the decision point. Signage site characteristics to consider include light levels, density of people using the facility, ceiling heights and corridor widths. (from TCRP Report 12: Guidelines for Transit Facility Signing and Graphics)

9.15.1.4 Materials and Maintenance - Maintenance needs for transit wayfinding signs are similar to other signs and will need periodic replacement due to wear.

9.15.1.5 Additional References and Guidelines

9.15.1.5.1 OCTA. Bus Stop Safety and Design Guidelines. 2004. TCRP. Report 12: Guidelines for Transit Facility Signing and Graphics. 1996.

9.15.2 Bikeway Wayfinding Sign Types

9.15.2.1 Description - A bicycle wayfinding system consists of compreh pavement markings to guide bicyclists to their destinations along preferred bicycle routes. There are three general types of wayfinding signs:

Figure 9-73. *Confirmation Signs*

9.15.2.1.1 Confirmation Signs - Indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route.

Can include destinations and distance/time. Do not include arrows.

Figure 9-74. *Turn Signs*

9.15.2.1.2 Turn Signs - Indicate where a bikeway turns from one street onto another street. Can be used with pavement markings.

Include destinations and arrows.

Figure 9-75. *Decisions Signs*

9.15.2.1.3 Decisions Signs - Mark the junction of two or more bikeways.

Inform bicyclists of the designated bike route to access key destinations. Includes destinations and arrows and distances.

Travel times are optional but recommended.

9.15.2.2 Discussion - There is no standard color for bicycle wayfinding signage. Section 1A.12 of the MUTCD establishes the general meaning for signage colors. 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.

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

9.15.2.4 Additional References and Guidelines

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

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

9.15.2.4.3 NACTO. Urban Bikeway Design Guide. 2012.

9.15.3 Bikeway Wayfinding Sign Placement

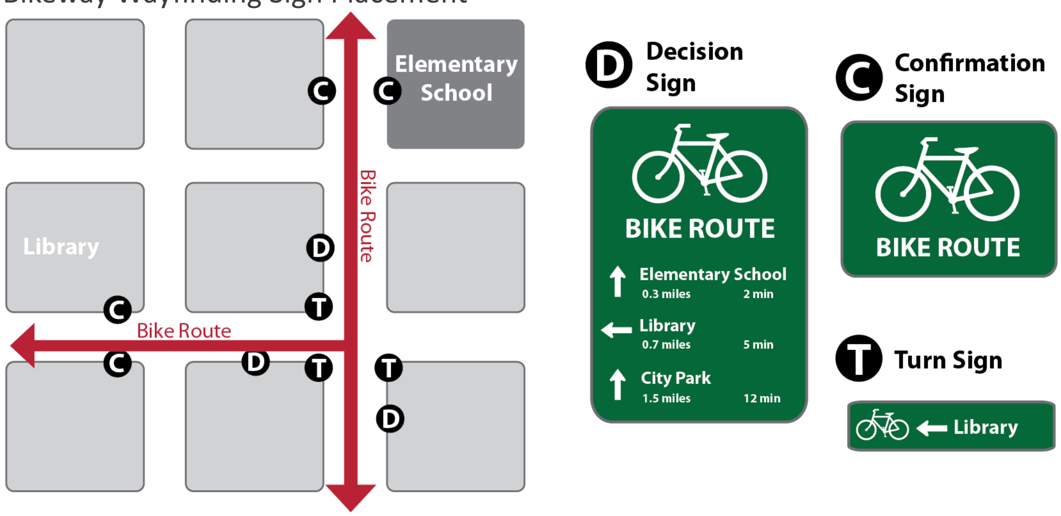


Figure 9-76. *Bikeway Wayfinding Sign Placement*

9.15.3.1 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.

9.15.3.1.1 Decisions Signs - Near-side of intersections in advance of a junction with another bicycle route.

Along a route to indicate a nearby destination.

9.15.3.1.2 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.

9.15.3.1.3 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.

9.15.3.2 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.

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

9.15.3.4 Additional References and Guidelines

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

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

9.15.3.4.3 NACTO. Urban Bikeway Design Guide. 2012.

9.16 Bicycle Support Facilities

9.16.1 Bicycle Racks

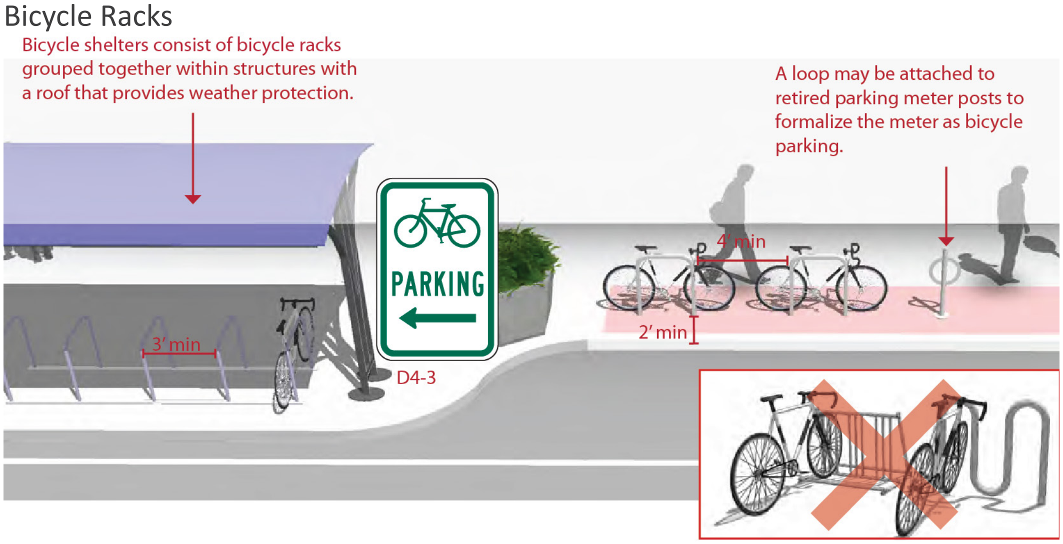


Figure 9-77. *Bicycle Racks*

9.16.1.1 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:

9.16.1.1.1 Supports the bicycle in at least two places, preventing it from falling over.

9.16.1.1.2 Allows locking of the frame and one or both wheels with a U-lock.

9.16.1.1.3 Is securely anchored to ground.

9.16.1.1.4 Resists cutting, rusting and bending or deformation.

9.16.1.2 Guidance

9.16.1.2.1 2’ minimum from the curb face to avoid ‘dooring.’

9.16.1.2.2 Close to destinations; 50’ maximum distance from main building entrance.

9.16.1.2.3 Minimum clear distance of 6’ should be provided between the bicycle rack and the property line.

9.16.1.2.4 Should be highly visible from adjacent bicycle routes and pedestrian traffic.

9.16.1.2.5 Locate racks in areas that cyclists are most likely to travel.

9.16.1.2.6 Post signage that clearly indicates mopeds and motorcycles are prohibited from parking at bike racks. Direct mopeds/motorcycles to designated moped/ motorcycle parking areas.

9.16.1.3 Discussion - 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. (See illustration above).

Decorative racks may enhance the aesthetic nature of a streetscape, but the custom design should not interfere with the functionality of the rack. Standard “U” racks are preferred over decorative racks in most regular installations, but decorative racks may be preferred in special districts or in areas with space constraints.

9.16.1.4 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.

9.16.1.5 Additional References and Guidelines

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

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

9.16.2 On-Street Bicycle Corral

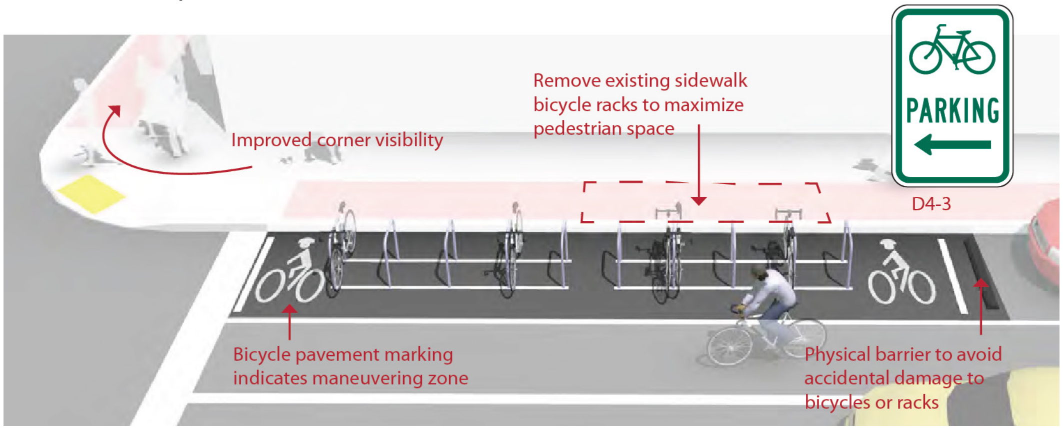


Figure 9-78. *On-Street Bicycle Corral*

9.16.2.1 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.

9.16.2.2 Guidance - See guidelines for sidewalk bicycle rack placement and clear zones.

9.16.2.2.1 Bicyclists should have an entrance width from the roadway of 5' – 6'.

9.16.2.2.2 Can be used with parallel or angled parking.

9.16.2.2.3 Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.

9.16.2.3 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.

9.16.2.4 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.

9.16.2.5 Additional References and Guidelines

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

9.16.3 Bicycle Lockers

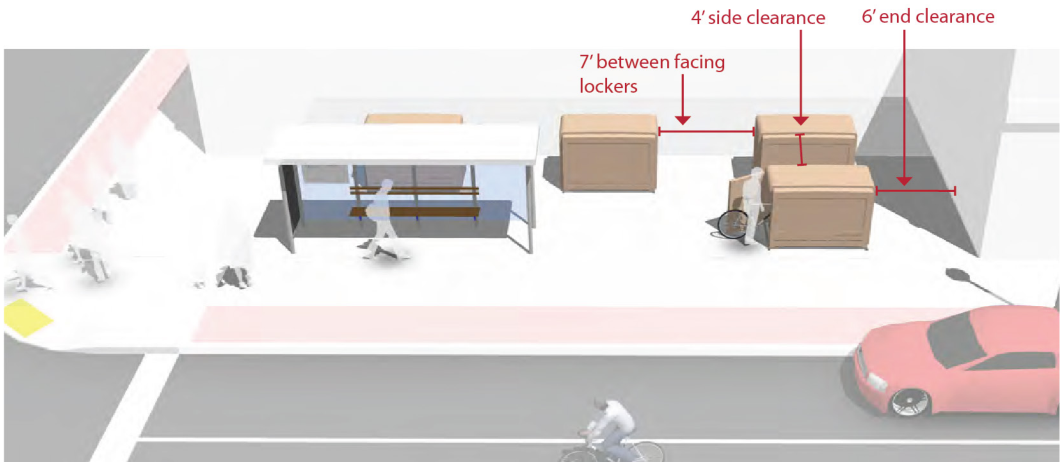


Figure 9-79. *Bicycle Lockers*

9.16.3.1 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.

9.16.3.2 Guidance

9.16.3.2.1 Minimum dimensions: width (opening) 2.5'; height 4'; depth 6'.

9.16.3.2.2 4 foot side clearance and 6 foot end clearance.

9.16.3.2.3 7 foot minimum distance between facing lockers.

9.16.3.2.4 Locker designs that allow visibility and inspection of contents are recommended for increased security.

9.16.3.2.5 Access is controlled by a key or access code.

9.16.3.3 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.

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

9.16.3.5 Additional References and Guidelines

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

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

9.16.4 Secure Parking Area (SPA)

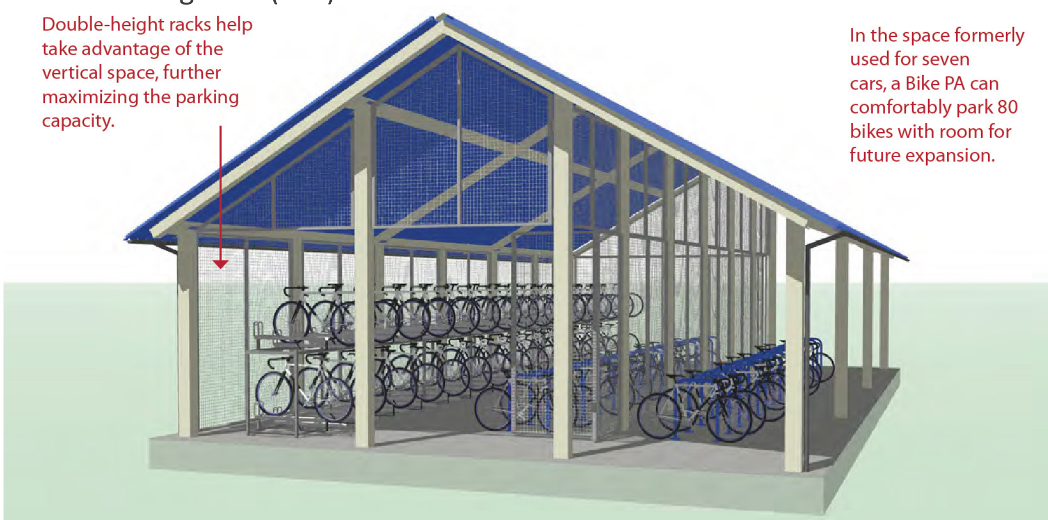


Figure 9-80. *Secure Parking Area (SPA)*

9.16.4.1 Description - A Secure Parking Area for bicycles, also known as a Bike SPA 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, Bike SPAs 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.

9.16.4.2 Guidance - Bike SPAs may be stand alone or integrated into the ground floor of parking garage structure. Key features may include:

9.16.4.2.1 Closed-circuit television monitoring.

9.16.4.2.2 Double high racks & cargo bike spaces.

9.16.4.2.3 Bike repair station with bench.

9.16.4.2.4 Bike tube and maintenance item vending machine.

9.16.4.2.5 Bike lock "hitching post" – allows people to leave bike locks.

9.16.4.2.6 Secure access for users.

9.16.4.3 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. Bike SPAs 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.

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

9.16.4.5 Additional References and Guidelines

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

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

9.16.5 Bicycle Parking at Transit

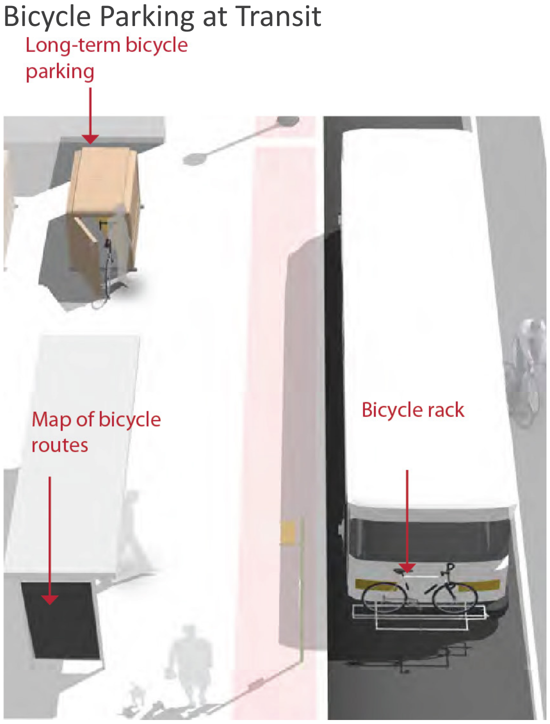


Figure 9-81. *Bicycle Parking at Transit*

9.16.5.1 Description - Bicycle parking facilities, such as securement devices (bike racks and storage lockers), may be provided at bus stops by local jurisdictions or adjacent property owners for the convenience of bicyclists using transit.

Bicycle parking facilities discourage the practice of locking bicycles onto bus facilities or onto adjacent property. By confining bicycles to one area, securement devices can reduce visual clutter and maintain appropriate pedestrian clearances. Below are guidelines for the placement of bicycle parking facilities.

9.16.5.2 Guidance

9.16.5.2.1 Locate securement devices or bicycle lockers away from other pedestrian or bus patron activities to improve safety and reduce congestion.

9.16.5.2.2 Coordinate the location of bicycle parking facilities with existing on-site or street lighting.

9.16.5.2.3 Ensure parked bikes are visible at all times. Do not locate bicycle parking where views are restricted by a bus shelter, landscaping, or existing site elements, such as walls.

9.16.5.2.4 Design and placement of bicycle parking facilities should complement other transit furniture at bus stop.

9.16.5.2.5 Covered or weather protected parking locations is an important bonus to bicyclists.

9.16.5.3 Discussion - There are two bicycle locker facilities avaible for secure parking at transit stops. A key based locker is a long term rental, typically provided by the transit agency. A key based system allows access to only one individual. An alternative bicycle locker is a code or combo based system. These lockers allow users to rent the locker on a need-only basis.

9.16.5.3.1 Materials and Maintenance - Regularly inspect the functioning of long-term parking moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

9.16.5.4 Additional References and Guidelines

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

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

9.16.5.4.3 FHWA. Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 18: Bicycle and Pedestrian Connections to Transit. 2006.

9.16.6 Bike Share Station Placement

An 11 dock bike sharing station will require an approximate space of 32 feet wide and 10-12 feet deep for infrastructure and access.

Figure 9-82. *Bike Share Station Placement*

9.16.6.1 Description - Bike sharing is a nonmotorized transportation service, typically structured to provide users point-to-point transportation for short distance trips. Users pick up a bicycle at self-serve bike sharing stations and return it to the same or other station at the end of their trip.

Bike sharing stations holds the automated customer kiosk and bicycle docks.

9.16.6.2 Guidance - Bike sharing station should be placed in safe, convenient and highly visible locations. If they are intended to support transit stations, they should be visible from the entrance/exit of the station. Placement:

9.16.6.2.1 On-street stations are placed within the parking lane of a street. On-street stations are accessible from within the street. These stations are typically located adjacent to on-street bicycle facilities such as bike lanes.

9.16.6.2.2 Sidewalk stations are located on the furnishing or frontage zone of a wide sidewalk.

9.16.6.2.3 Public space stations are located in plazas or parks. These locations may be privately owned.

9.16.6.3 Discussion - Two-sided stations may be provided in locations with adequate access from both sides, and offer the potential for increased station capacity given a certain footprint.

Solar powered stations should be placed in locations with access to sunlight for a portion of the day, and have 11 ft vertical clearance.

9.16.6.4 Materials and Maintenance - Provide a 1 ft gap between on-street stations and the curb of the sidewalk to allow for water drainage and debris removal.

9.16.6.5 Additional References and Guidelines

9.16.6.5.1 FHWA. Bike Sharing in The United States: State of the Practice and Guide to Implementation. 2012.

9.17 Bikeway Maintenance

9.17.1 Sweeping

9.17.1.1 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.

9.17.1.2 Guidance

9.17.1.2.1 Establish a seasonal sweeping schedule that prioritizes roadways with major bicycle routes.

9.17.1.2.2 Sweep walkways and bikeways whenever there is an accumulation of debris on the facility.

9.17.1.2.3 In curbed sections, sweepers should pick up debris; on open shoulders, debris can be swept onto gravel shoulders.

9.17.1.2.4 Pave gravel driveway approaches to minimize loose gravel on paved roadway shoulders.

9.17.1.2.5 Perform additional sweeping in the Spring to remove debris from the Winter.

9.17.1.2.6 Perform additional sweeping in the Fall in areas where leaves accumulate.

9.17.2 Signage

9.17.2.1 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.

9.17.2.2 Guidance

9.17.2.2.1 Check regulatory and wayfinding signage along bikeways for signs of vandalism, graffiti, or normal wear.

9.17.2.2.2 Replace signage along the bikeway network as-needed.

9.17.2.2.3 Perform a regularly-scheduled check on the status of signage with follow-up as necessary.

9.17.2.2.4 Create a Maintenance Management Plan.

9.17.3 Roadway Surface

9.17.3.1 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.

9.17.3.2 Guidance

9.17.3.2.1 Maintain a smooth pothole-free surface.

9.17.3.2.2 Ensure that on new roadway construction, the finished surface on bikeways does not vary more than ¼”.

9.17.3.2.3 Maintain pavement so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.

9.17.3.2.4 Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.

9.17.3.2.5 If chip sealing is to be performed, use the smallest possible chip on bike lanes and shoulders. Sweep loose chips regularly following application.

9.17.3.2.6 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.

9.17.4 Pavement Overlays

9.17.4.1 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.

9.17.4.2 Guidance

9.17.4.2.1 Extend the overlay over the entire roadway surface to avoid leaving an abrupt edge.

9.17.4.2.2 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.

9.17.4.2.3 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.

9.17.4.2.4 Pave gravel driveways to property lines to prevent gravel from being tracked onto shoulders or bike lanes.

9.17.5 Drainage Grates

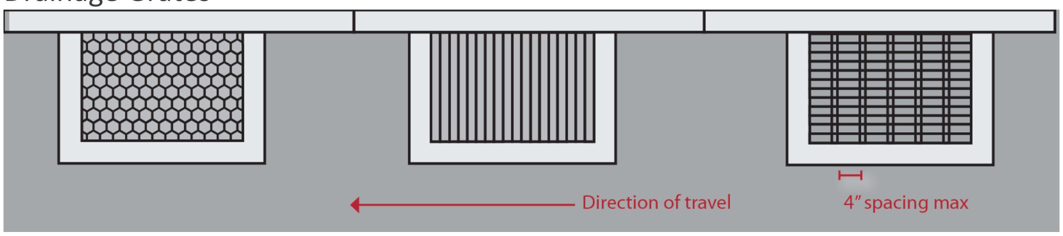


Figure 9-83. *Drainage Grates*

9.17.5.1 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.

9.17.5.2 Guidance

9.17.5.2.1 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.

9.17.5.2.2 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.

9.17.6 Gutter To Pavement Transition

9.17.6.1 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.

9.17.6.2 Guidance

9.17.6.2.1 Ensure that gutter-to-pavement transitions have no more than a ¼” vertical transition.

9.17.6.2.2 Examine pavement transitions during every roadway project for new construction, maintenance activities, and construction project activities that occur in streets.

9.17.6.2.3 Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.

9.17.6.2.4 Provide at least 3 feet of pavement outside of the gutter seam.

9.17.7 Landscaping

9.17.7.1 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

9.17.7.2 Guidance

9.17.7.2.1 Ensure that shoulder plants do not hang into or impede passage along bikeways

9.17.7.2.2 After major damage incidents, remove fallen trees or other debris from bikeways as quickly as possible

9.17.8 Maintenance Management Plan

9.17.8.1 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.

9.17.8.2 Guidance

9.17.8.2.1 Provide fire and police departments with map of system, along with access points to gates/bollards

9.17.8.2.2 Enforce speed limits and other rules of the road

9.17.8.2.3 Enforce all trespassing laws for people attempting to enter adjacent private properties