BIKERALEIGH

that's how we roll

DRAFT

BikeRaleigh Plan Update
Design Guidelines

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TABLE OF CONTENTS

Context DG-5

Separated Bikeways DG-7

Shared Use Paths. DG-11

Neighborhood Bikeways. DG-14

On-Street Bike Lanes DG-22

Shared Roadways DG-26

Intersection Treatments DG-29

Shared Use Path Crossings DG-41

Bicycles on Bridges. DG-45

Retrofitting Streets DG-49

Bicycle Signing & Wayfinding DG-55

Bicycle Parking and Operations DG-59

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CONTEXT

CONTEXT

GUIDANCE BASIS

The sections that follow serve as an inventory of bicycle design treatments and provide guidelines for their development. The guidelines are not, however, a substitute for a more thorough evaluation by a landscape architect or engineer upon implementation of facility improvements. The following standards and guidelines are referred to in this guide.

NATIONAL GUIDANCE

American Association of State Highway and Transportation Officials **(AASHTO) Guide for the Development of Bicycle Facilities (2013)**, updated in June 2014 provides guidance on dimensions, use, and layout of specific bicycle facilities.

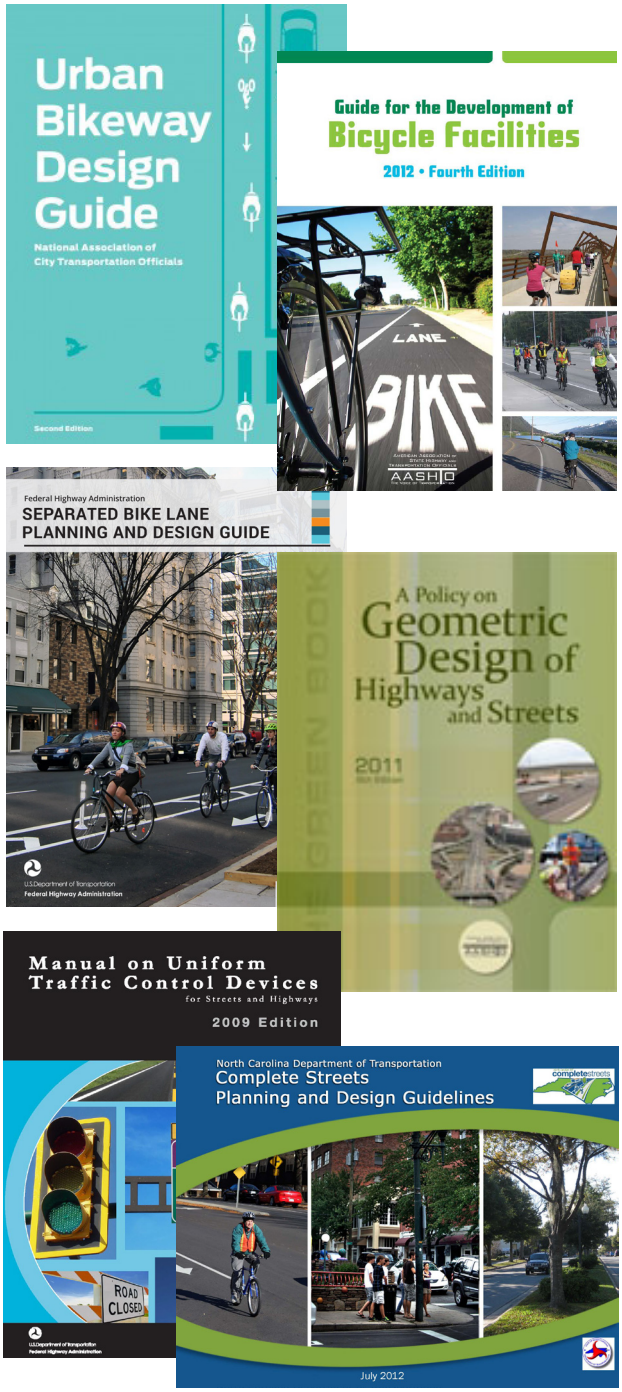
The National Association of City Transportation Officials' **(NACTO) Urban Bikeway Design Guide (2012)** is a nationally recognized bikeway design standards, and offers guidance on the current state of the practice designs.

The Federal Highway Administration's (FHWA) **Separated Bike Lane Planning and Design Guide (2015)** provides federal endorsement of physically separated bike lanes and preferred design standards.

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

FHWA's **Manual on Uniform Traffic Control Devices (MUTCD) (2009)** 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.

NCDOT's Complete Streets Planning & Design Guidelines, released in 2012, provides NCDOT and municipality staff with detailed information on the processes, street types, and recommendations for creating complete streets in North Carolina.



CONTEXT

BICYCLIST USER TYPE

The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs Transportation) and on the level of comfort and skill of the rider (Casual vs Experienced). An alternate framework for understanding the US population's relationship to transportation focused bicycling is illustrated in the figure below. Developed by planners in Portland, OR[1] and supported by research[2], this classification identifies four categories to address varying attitudes towards bicycling in the US.

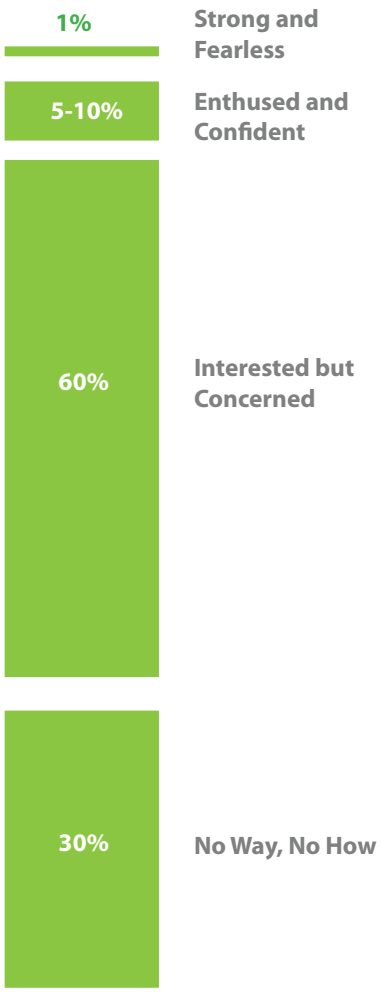
FOUR TYPES OF TRANSPORTATION BICYCLISTS

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.

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.

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.

No Way, No How (approximately 30% of population) – Persons in this category are not bicyclists, and perceive severe safety issues with riding in traffic. Some people in this group may eventually become more regular cyclists with time and education. A significant portion of these people will not ride a bicycle under any circumstances.



Typical Distribution of Bicyclist Types

1 Roger Geller, City of Portland Bureau of Transportation. Four Types of Cyclists. http://www.portlandonline.com/transportation/index.cfm?&a=237507. 2009.
2 Dill, J., McNeil, N. Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential. 2012.

CONTEXT

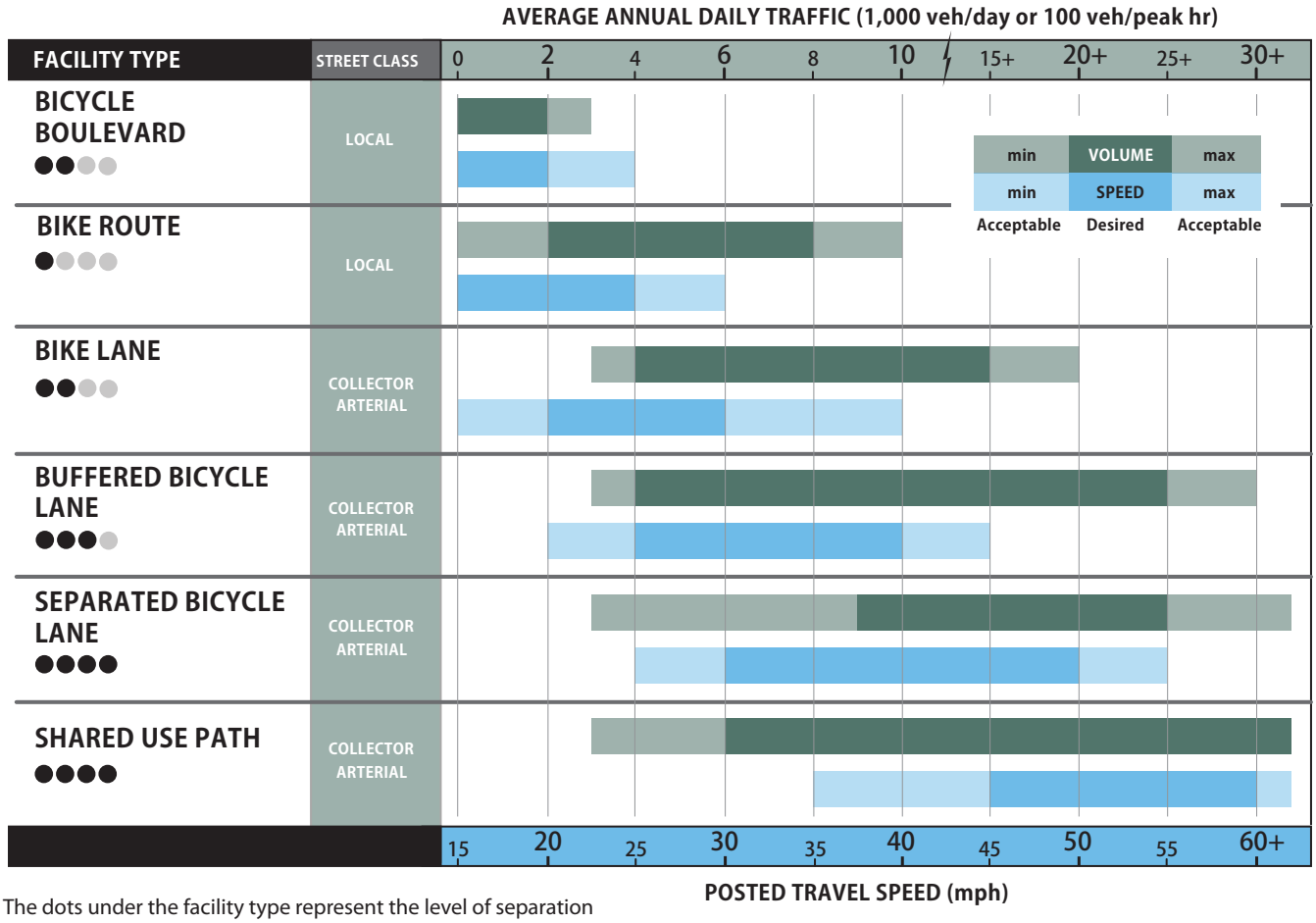
FACILITY SELECTION

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

FACILITY SELECTION TABLE

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

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



The dots under the facility type represent the level of separation from motor vehicle traffic each facility type offers.

CONTEXT

USER DESIGN DIMENSIONS

The purpose of this section is to provide the facility designer with an understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers.

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

BICYCLE AS A DESIGN VEHICLE

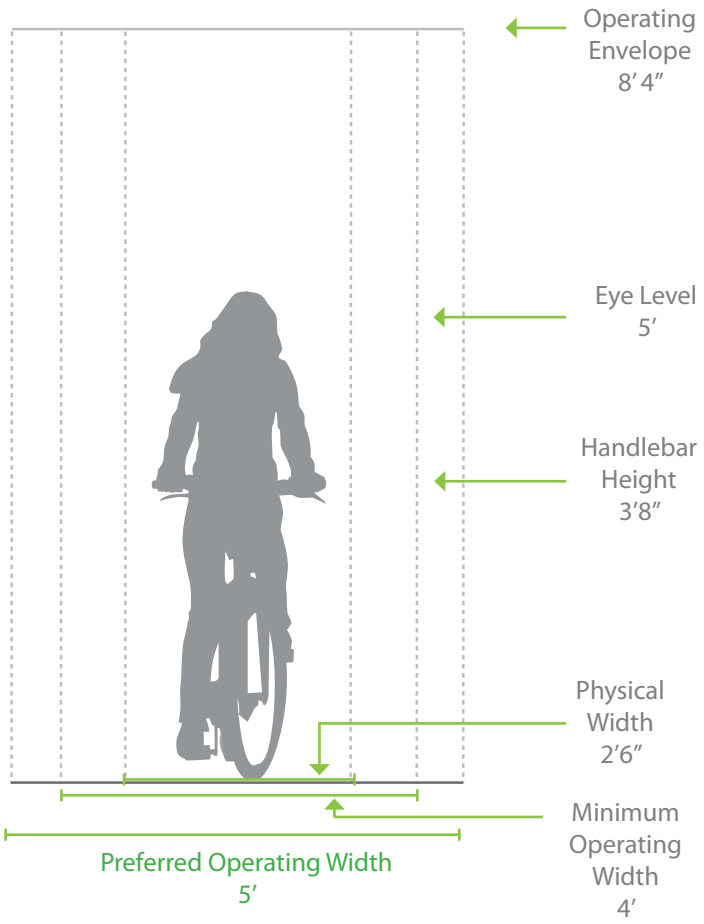
Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The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

The figure to the right illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist.

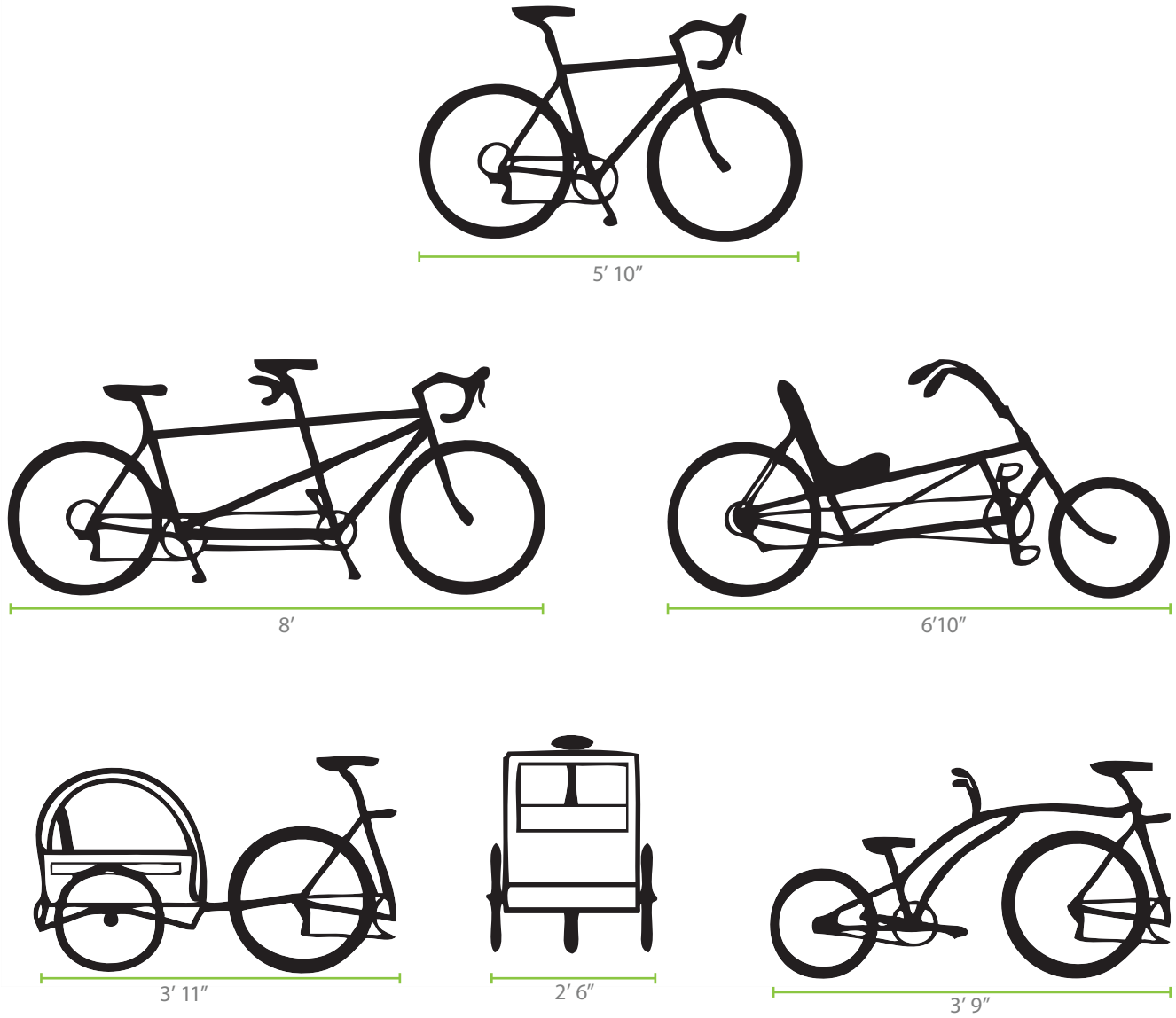
Bicyclists prefer five feet or more operating width, although four feet may be minimally acceptable.

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

Bicycle Rider - Typical Dimensions



Bicycle Design Vehicle - Typical Dimensions



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

DESIGN SPEED EXPECTATIONS

Bicycle as Design Vehicle - Design Speed Expectations

Bicycle Type	Feature	Typical Speed
Upright Adult Bicyclist	Paved level surfacing	8-12 mph*
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

* Typical speed for causal riders per AASHTO 2013.

SEPARATED BIKEWAYS

PHYSICAL SEPARATION MATTERS

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

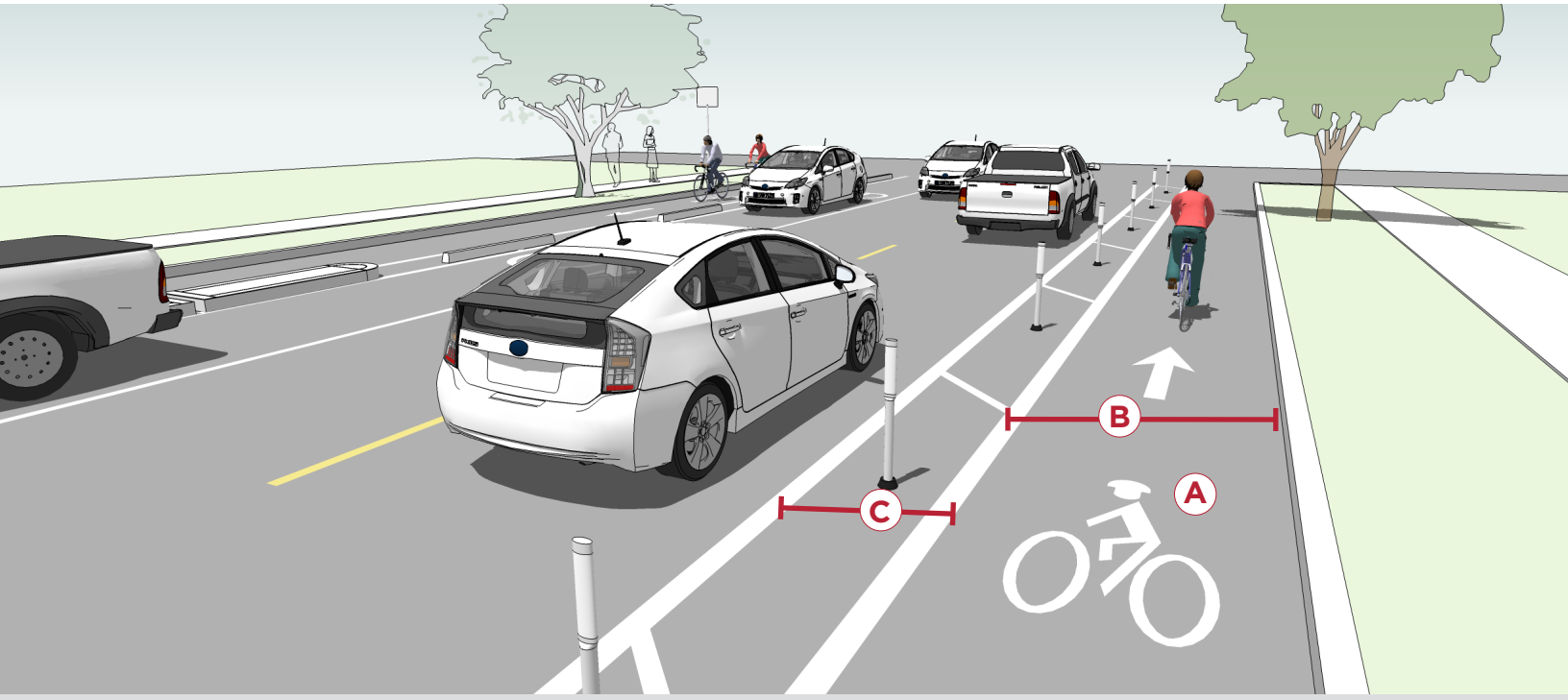
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

SEPARATED BIKE LANES

ONE WAY CYCLE TRACK

A one way cycle track provides protection to cyclists through physical barriers that can include bollards, parking, a planter strip, an extruded curb or on-street parking. Cycle tracks may be at street level or raised to the level of the adjacent sidewalk.



TYPICAL APPLICATION

- Streets with high motor vehicle volumes and/or speeds and high bicycle volumes.
- Streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- Appropriate for most riders on most streets, although intersections and other conflict areas may be challenging.

DESIGN FEATURES

A Pavement markings, symbols and/or arrow markings must be placed at the beginning of the separated bike lane and at intervals along the facility.

B 7 foot width preferred (5 foot minimum).

C 3 foot minimum buffer width adjacent to parking. 18 inch minimum adjacent to travel lanes **(NACTO, 2012).** Channelizing devices should be placed in the buffer area.

- If buffer area is 4 feet or wider, white chevron or diagonal markings should be used

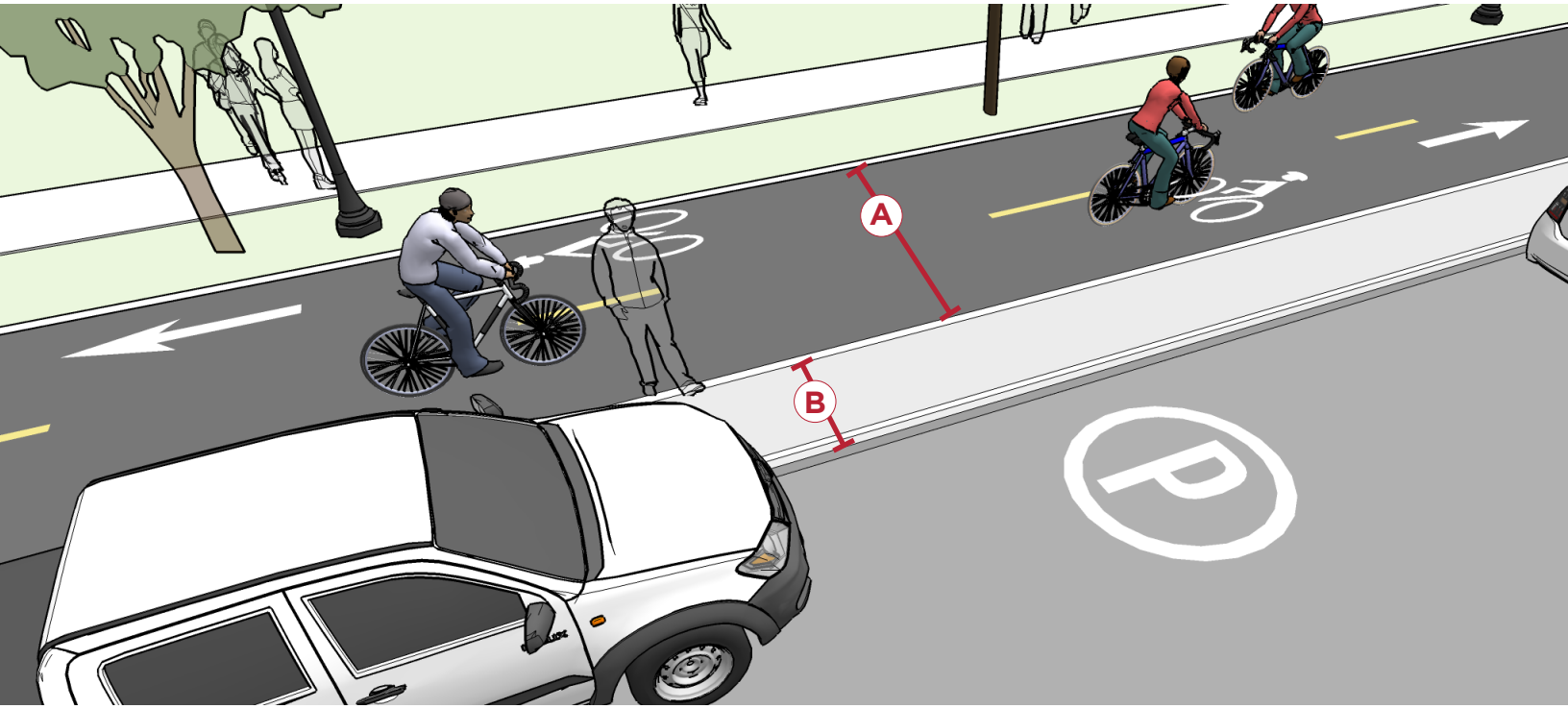
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

SEPARATED BIKE LANES

TWO-WAY CYCLE TRACK

Two-way cycle tracks are bicycle facilities 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.



TYPICAL APPLICATION

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

DESIGN FEATURES

A 12 foot operating preferred (10 ft minimum) width for two-way facility.

- In a constrained location, an 8 foot minimum operating width may be considered.

B Adjacent to on-street parking a 3 foot minimum width channelized buffer or island shall be provided to accommodate opening doors **(NACTO, 2012)**.

- Separation may be narrower than 5 foot if physical barrier separation is present **(AASHTO, 2013).**
- Additional signalization and signs may be necessary to manage conflicts at intersections.

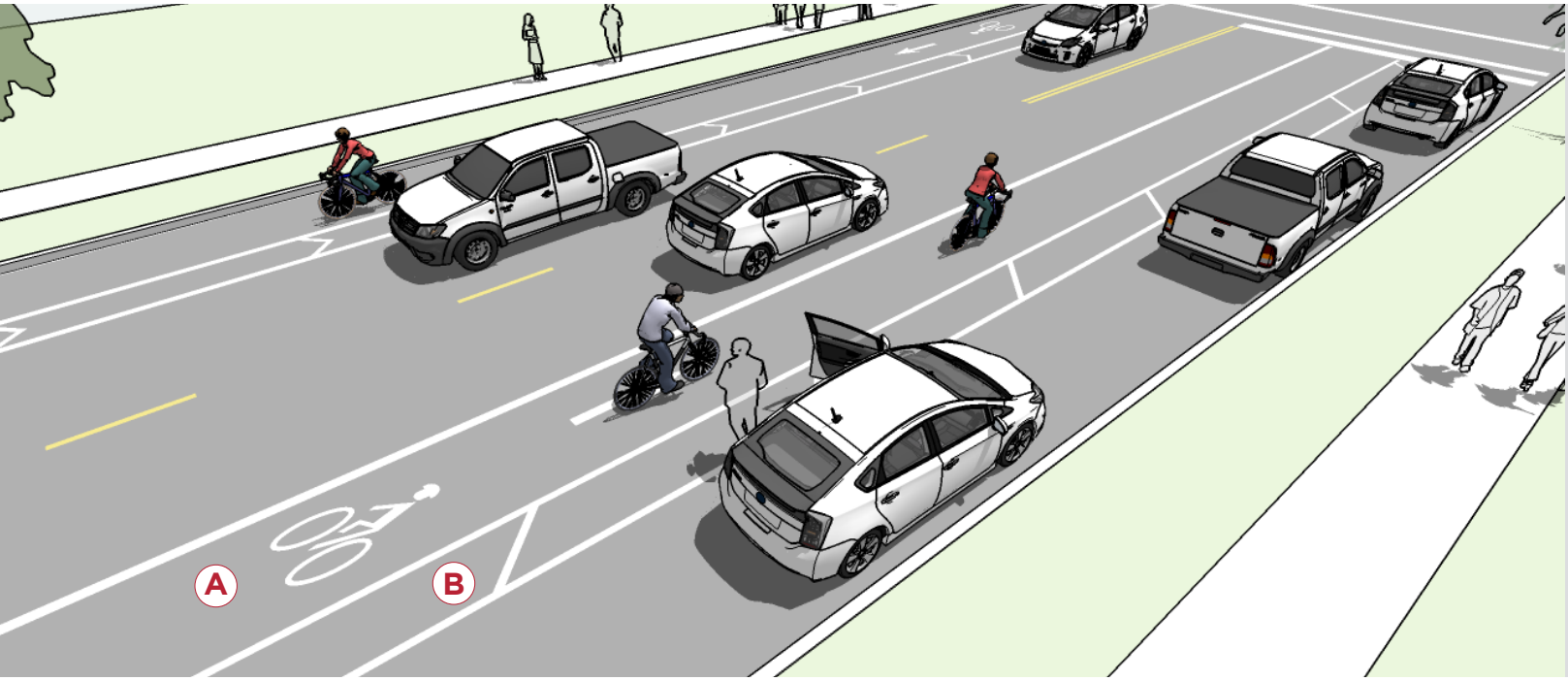
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

SEPARATED BIKE LANES/ON-STREET BIKE LANES

BUFFERED BICYCLE LANES

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



TYPICAL APPLICATION

- Anywhere a conventional bike lane is being considered.
- On streets with high speeds and high volumes or high truck volumes.
- On streets with extra lanes or lane width.

DESIGN FEATURES

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

B Buffers should be at least 2 feet wide. If buffer area is 4 feet or wider, white chevron or diagonal markings may be used.

- For clarity in potential conflict zones, such as driveways or minor street crossings, consider using a dotted line.
- There is no standard for whether the buffer is configured on the parking side, the travel side, or a combination of both.

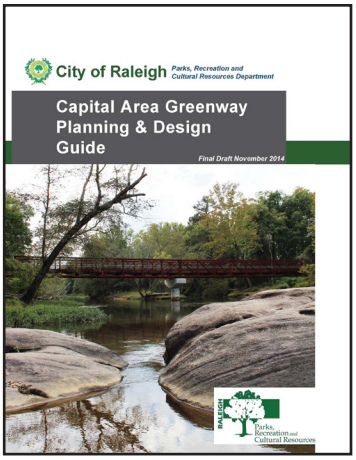
SHARED USE PATHS

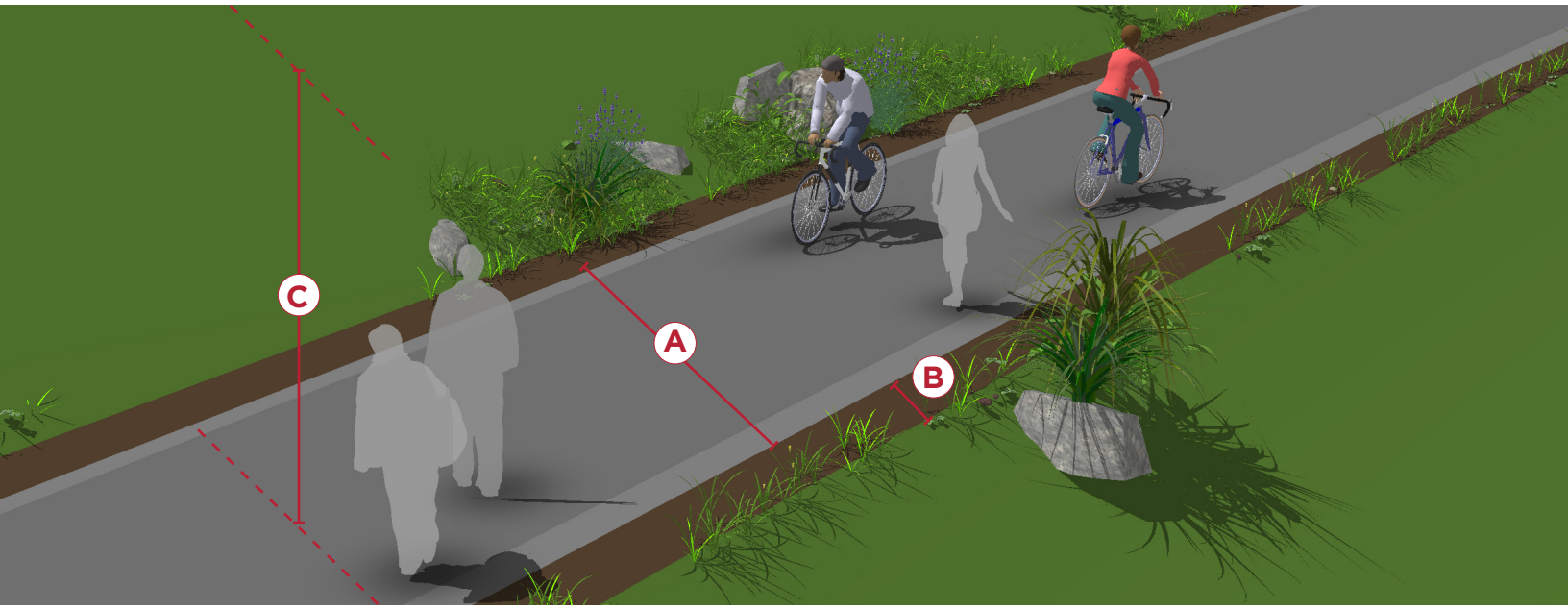
OVERVIEW

SHARED USE PATHS

A shared use path allows for two-way, off-street bicycle use and also may be used by multiple other users. non-motorized users. Shared use paths can provide a desirable facility, particularly for recreation, and users of all skill levels preferring separation from traffic.

Refer to the City of Raleigh Greenway Design Guidelines for more information on greenway trail development.





DESIGN FEATURES

Width

A 10 feet is recommended in most situations and will be adequate for low to moderate use. (8 ft constrained minimum)

- 12 feet is recommended for heavy use situations with high concentrations of multiple users. If additional width is available a separate track (5' minimum) can be provided for pedestrian use.

Lateral Clearance

B A 2 foot or greater shoulder on both sides of the path should be provided. An additional foot of lateral clearance (total of 3') is required by the MUTCD for the installation of signage or other furnishings.

- If bollards are used at intersections and access points, they should be colored brightly and/or supplemented with reflective materials to be visible at night.

Overhead Clearance

C Clearance to overhead obstructions should be 10 feet (8 feet minimum).

Striping

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

Appropriate Street Design Manual Street type

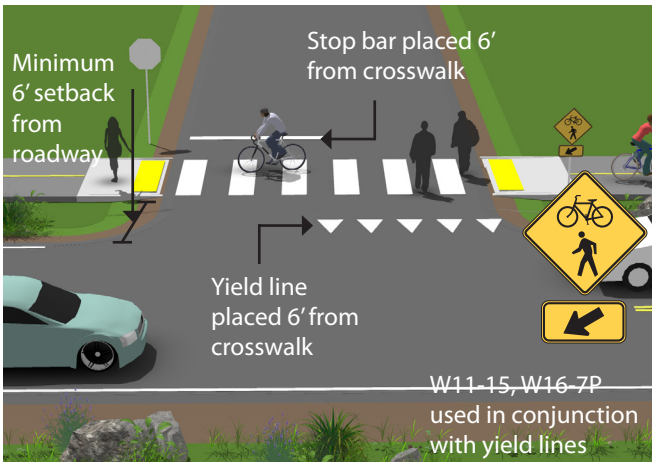
- **Major Streets**
- **Mixed-use Streets**

SHARED USE PATHS

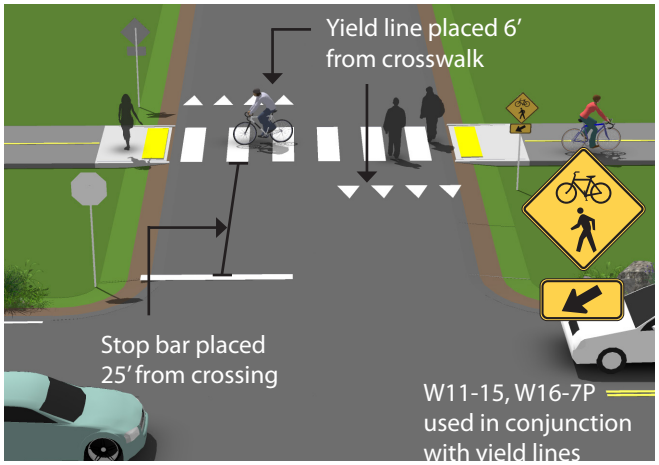
SHARED USE PATH ALONG ROADWAYS

Shared use paths along roadways, also called sidepaths, are a type of path that run adjacent to a street.

A ***Adjacent Path Crossing***



B ***Setback Path Crossing***



TYPICAL APPLICATION

- Where off-street bicycle and pedestrian facilities are desired.
- 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

DESIGN FEATURES

In general, there are two approaches to crossings:

A ADJACENT PATH CROSSING

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

B SETBACK PATH CROSSING

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

NEIGHBORHOOD BIKEWAYS

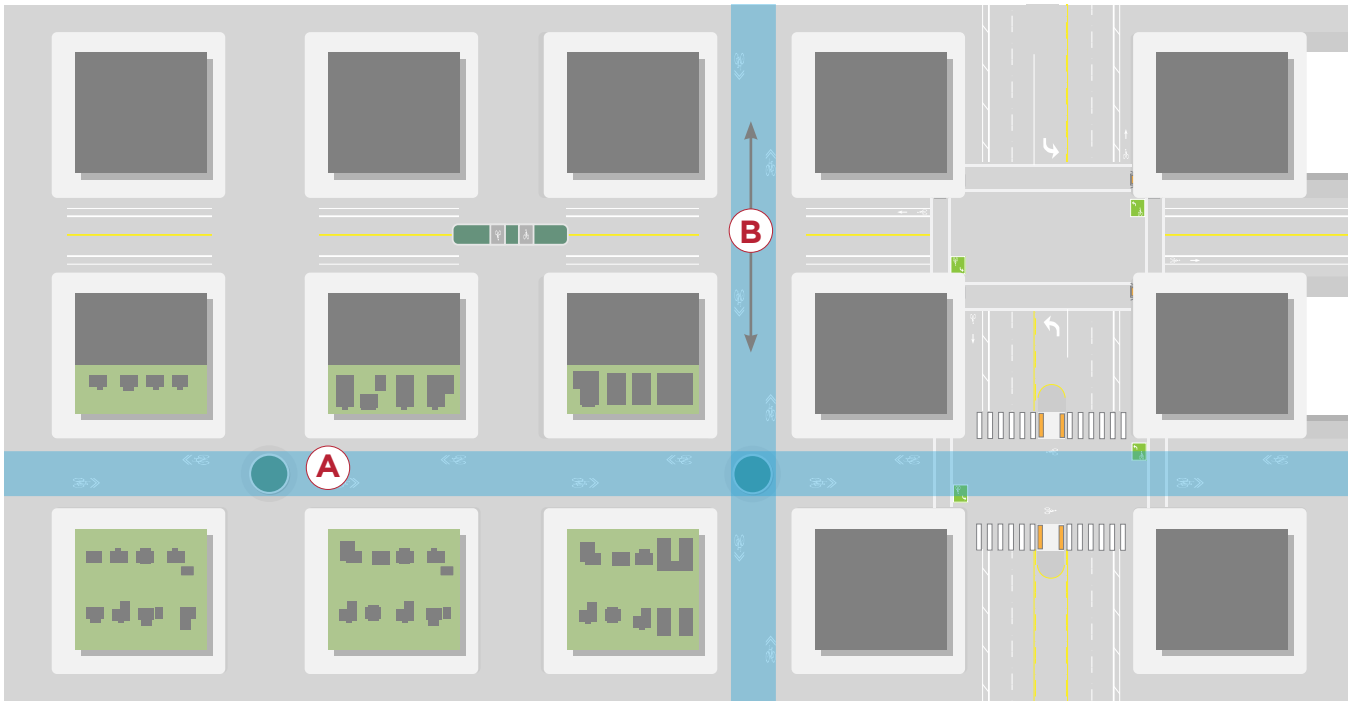
Appropriate Street Design Manual Street type

- **Local Streets**

NEIGHBORHOOD BIKEWAYS

ROUTE SELECTION

Neighborhood bikeways should be developed on streets that improve connectivity to key destinations and provide a direct route for bicyclists. Local streets with existing traffic calming, traffic diversions, or signalized crossings of major streets are good candidates, as they tend to have low motor vehicle speeds and volumes.



TYPICAL APPLICATION

- Routes should be parallel with and in close proximity to major thoroughfares.
- Routes should closely follow a desire line for bicycle travel that is ideally long and relatively continuous (2-5 miles).
- Streets with travel speeds at 25 mph or less and with traffic volumes of fewer than 3,000 vehicles per day. These conditions should either exist or be established with speed and volume management techniques.

DESIGN FEATURES

A Speed and volume management should be used to create appropriate conditions on routes that do not meet design thresholds.

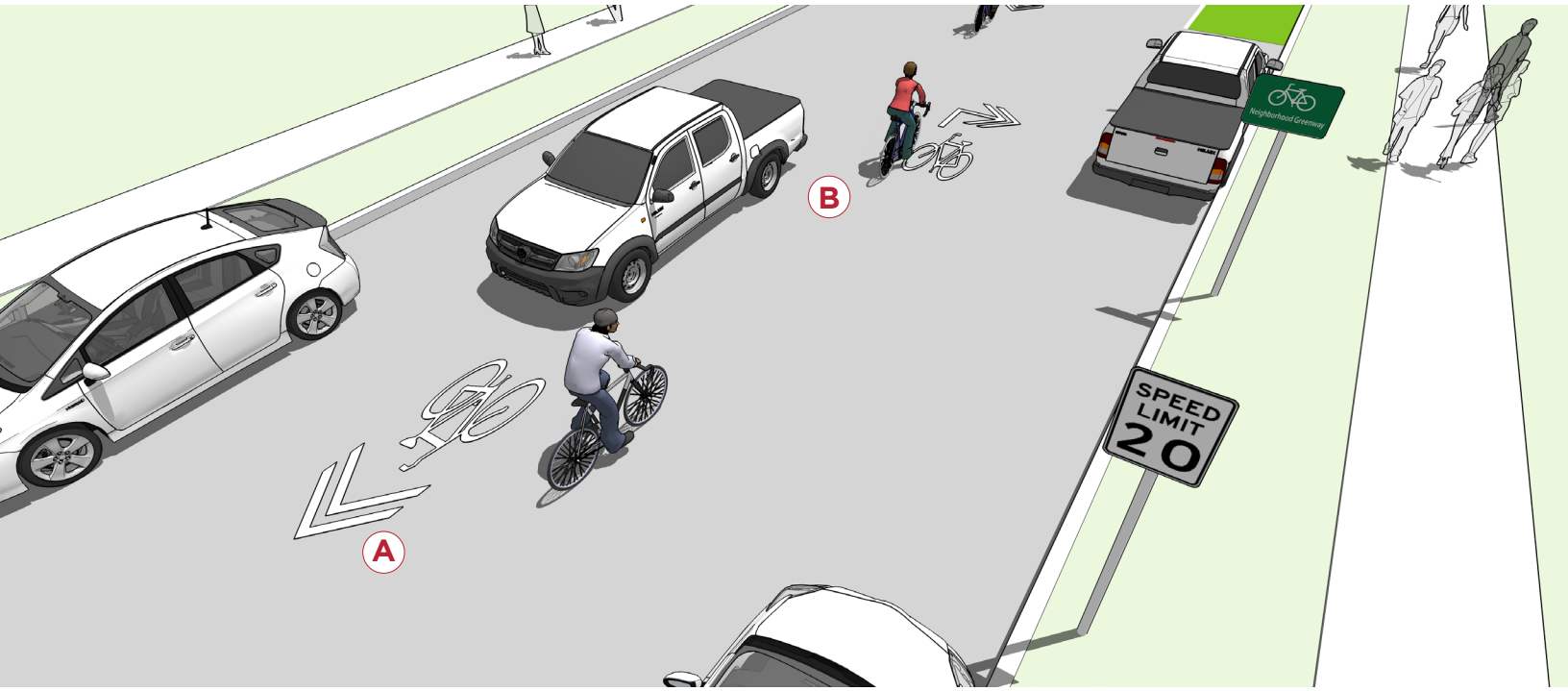
B Use of streets that parallel major streets can discourage non-local motor vehicle traffic without significantly impacting motorists.

- Can benefit pedestrians and other users through crossing improvements, wayfinding, landscaping, and reduced motor vehicle speeds and volumes.

NEIGHBORHOOD BIKEWAYS

SIGNS & PAVEMENT MARKINGS

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



TYPICAL APPLICATION

- Pavement markings identify the route and can guide users through jogs in the route.
- Signs and markings differentiate neighborhood bikeways from other local streets, reminding people driving to watch for bicyclists.
- Wayfinding signs displaying destinations, distances, and "riding time" can dispel common misperceptions about time and distance.

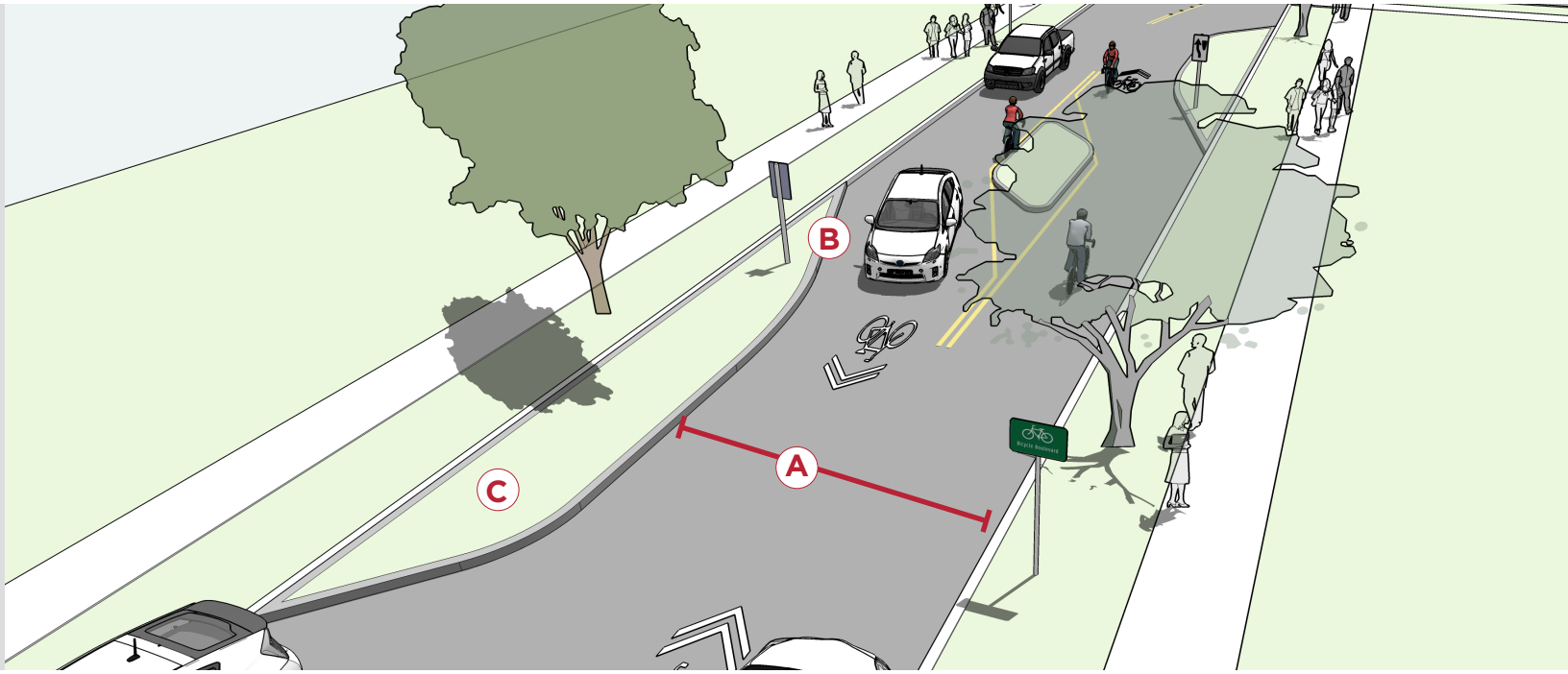
DESIGN FEATURES

- **A** Place symbols every 150-300 feet along a neighborhood bikeway, as well as after every intersection.
- **B** On narrow streets where a motor vehicle cannot pass a bicyclist within one lane of traffic, place markings in the center of the travel lane.
- Modified street signs identify and brand the route without introducing a new sign.
- Shared lane markings are a standard marking for shared lane conditions. Some cities use custom markings to identify their neighborhood bikeway network.

NEIGHBORHOOD BIKEWAYS

SPEED MANAGEMENT

Traffic calming devices cause drivers to slow down by constricting the roadway space or by requiring careful maneuvering. Such measures may reduce the design speed of a street, and can be used in conjunction with reduced speed limits to reinforce the expectation of lowered speeds. Refer to the *US Traffic Calming Manual* by Reid Ewing and Steven Brown for more details and techniques for traffic calming.



TYPICAL APPLICATION

- On neighborhood bikeways, where a reduction of vehicle speeds is desired, and where improved conditions for bicyclists, pedestrians and residents along the route is desired.
- Neighborhood bikeways should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.
- The design features explained in the image above is just one example of a traffic calming treatment. A context sensitive approach is needed to determine the preferred treatment.

DESIGN FEATURES

A Maintain a minimum clear width of 14 feet with a constricted length of at least 20 feet in the direction of travel.

B Traffic calming should be designed to minimize impacts to street cleaning equipment.

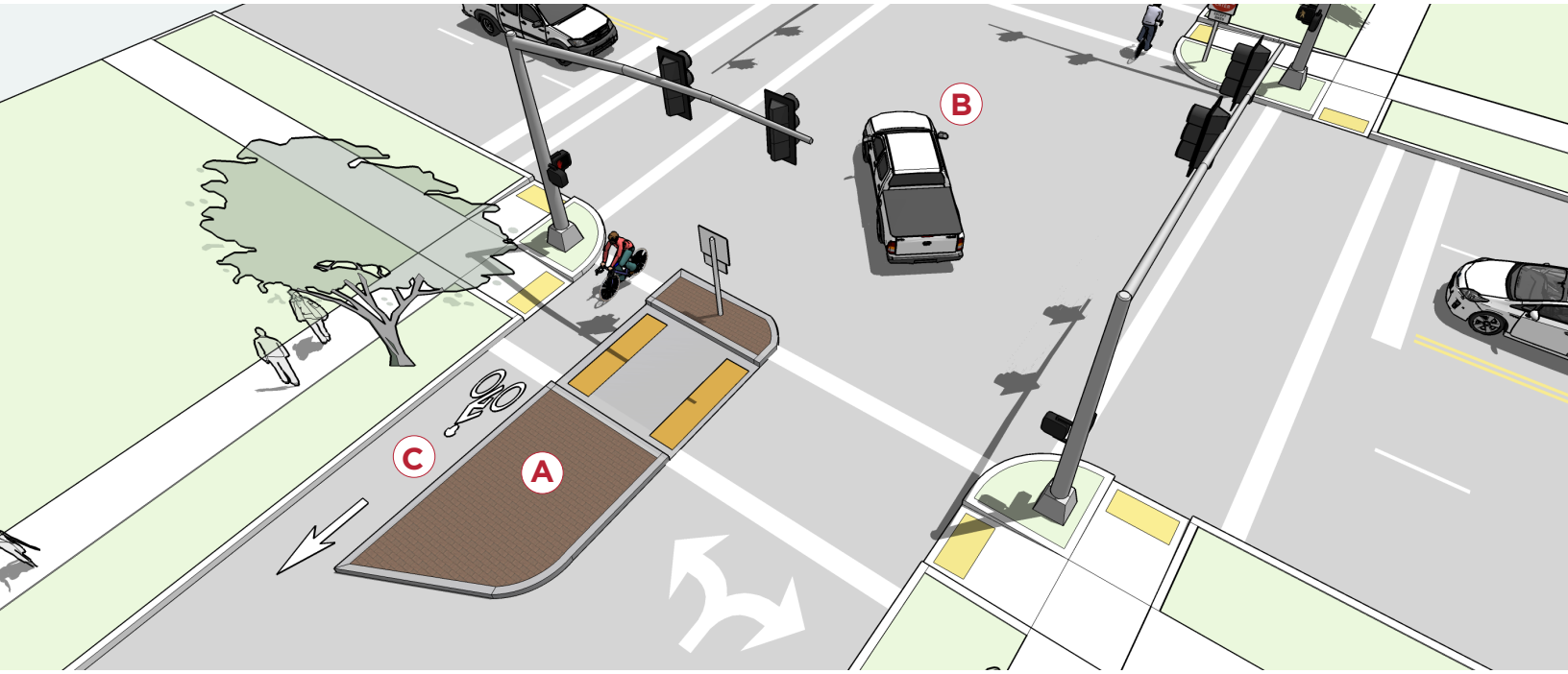
C Vegetation along the route should be regularly trimmed to maintain visibility and attractiveness.

- Horizontal speed control measures should not infringe on bicycle space. Where possible, provide a bicycle route outside of the element so bicyclists can avoid having to merge into traffic at a narrow pinch point.

NEIGHBORHOOD BIKEWAYS

VOLUME MANAGEMENT

Volume management measures reduce or discourage thru traffic on neighborhood bikeways by physically or operationally reconfiguring corridors and intersections along the route. Lower vehicle volumes increase bicyclists' comfort and reduce the number of potential conflicts. Implement volume control treatments based on the context of the neighborhood bikeway.



TYPICAL APPLICATION

- Volume management techniques establish and reinforce bicycle priority by restricting vehicle through movements.
- On neighborhood bikeways where a reduction of vehicle volumes down to 1,500 – 3,000 cars per day is desired.
- Where design treatments cannot reduce volumes below 3,000 cars per day, provide an on-street or physically separated bike lane.
- The design details described above is only one example of volume management and a context sensitive approach should be used to determine the most appropriate treatment.

DESIGN FEATURES

A While volume management methods are designed to restrict motor vehicle access, bicyclist passage should always be allowed.

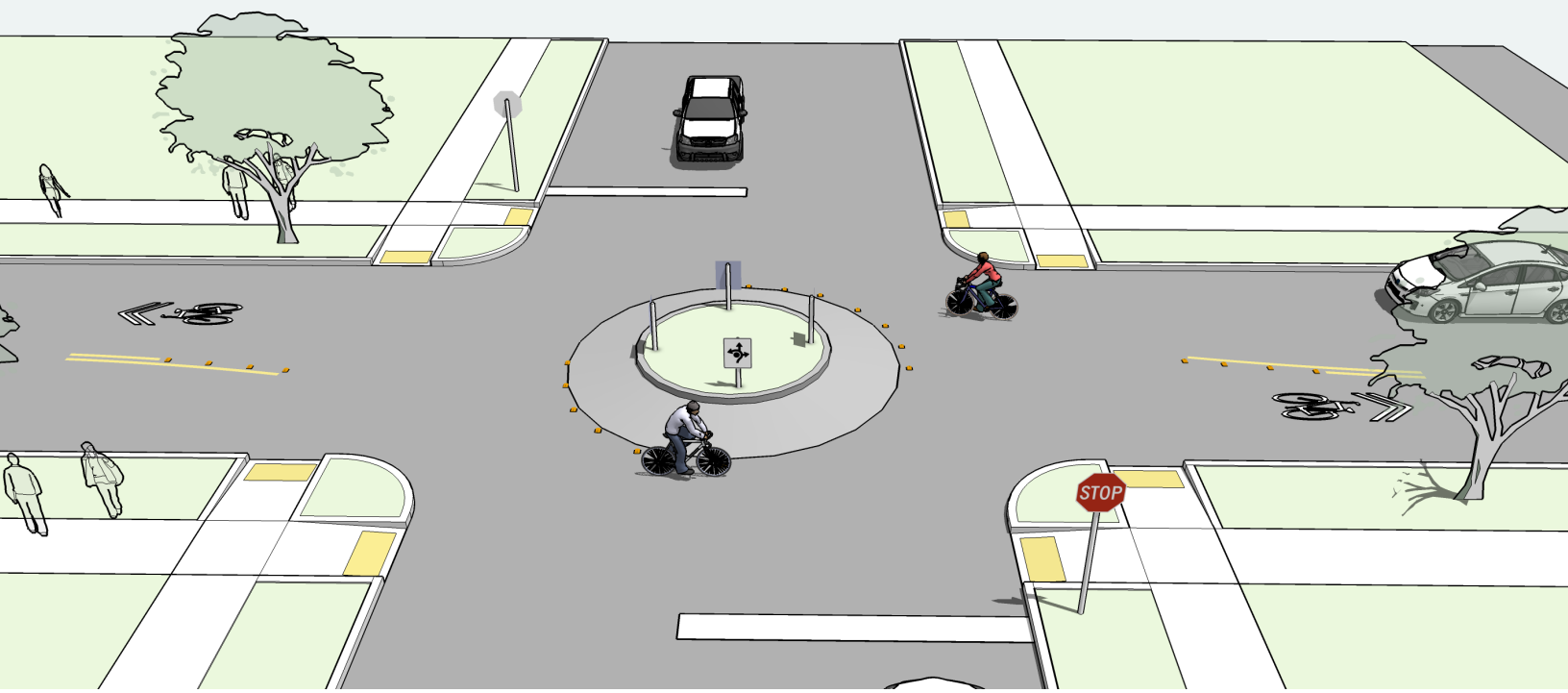
B May be combined with **Major Intersection Treatments**.

C Volume control measures should not prevent or slow down through bicycle travel. Markings should identify bicycle pass-through areas while restricting motor vehicle access.

NEIGHBORHOOD BIKEWAYS

MINOR INTERSECTION CROSSINGS

Treatments at minor roadway intersections are designed to improve the visibility of a neighborhood bikeway, raise awareness of motorists on the cross-street that they are likely to encounter bicyclists, and enhance safety for all road users. Physical volume and speed management techniques can prevent the neighborhood bikeway from encouraging high speed.



TYPICAL APPLICATION

- Where neighborhood bikeways must cross minor streets.
- On the neighborhood bikeway, the majority of intersections with minor roadways should stop-control cross traffic to minimize bicyclist delay. This will maximize bicycling efficiency.
- Neighborhood bikeways should have fewer stops or delays than other local streets. A typical bicycle trip of 30 minutes can increase to 40 minutes if there is a STOP sign at every block. Mini traffic circles may be used to control intersection priority and slow motor vehicles.

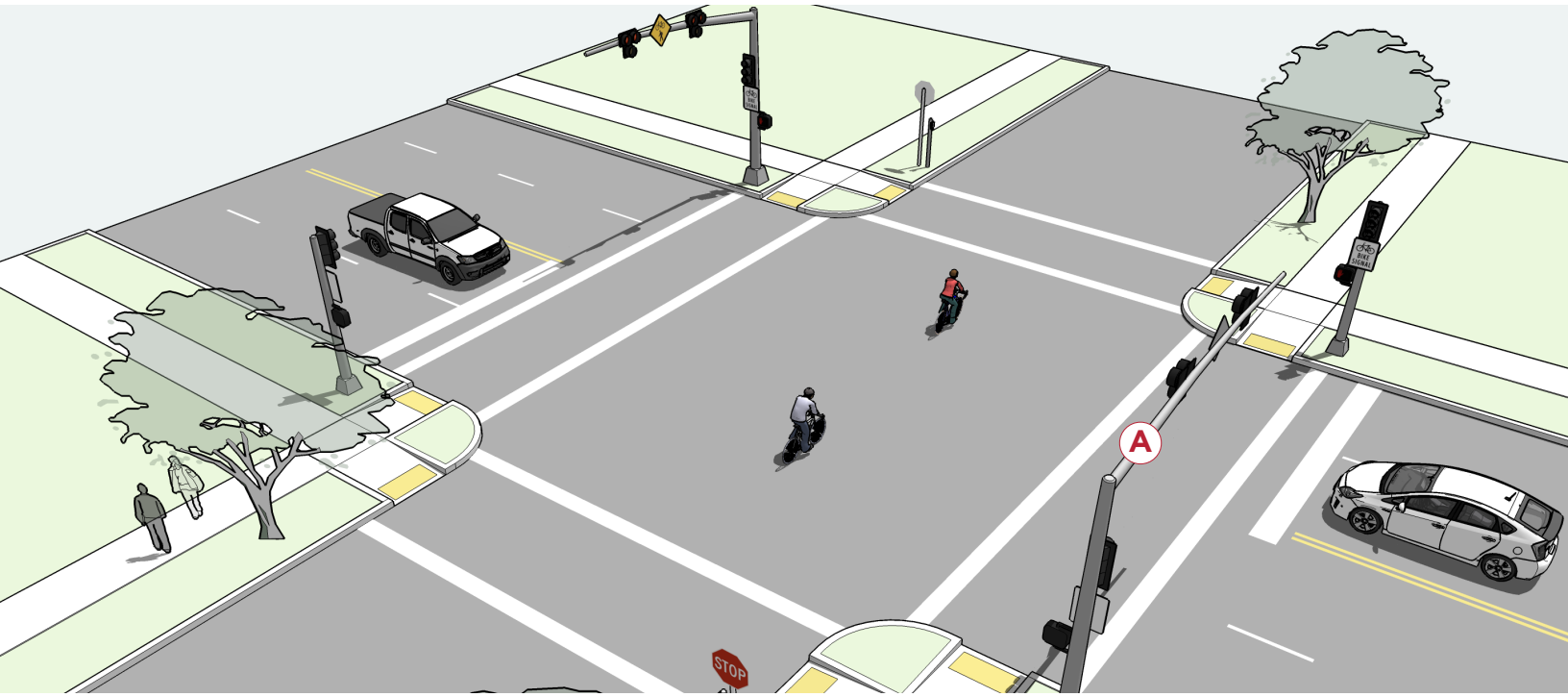
DESIGN FEATURES

- Traffic circles are a type of horizontal traffic calming that can be used at minor street intersections. Traffic circles reduce conflict potential and severity while providing traffic calming to the corridor.
- Curb extensions can be used to move bicyclists closer to the centerline to improve visibility and encourage motorists to let them cross.
- If a stop sign is present on the neighborhood bikeway, a second stop bar for bicyclists can be placed closer to the centerline of the cross street than the motorists' stop bar to increase the visibility of bicyclists waiting to cross the street.

NEIGHBORHOOD BIKEWAYS

MAJOR INTERSECTION CROSSINGS

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



TYPICAL APPLICATION

- Where neighborhood bikeways must cross major streets. The quality of neighborhood bikeways are often compromised by the comfort of these crossings.
- Without treatments for bicyclists, these intersections can become major barriers along the neighborhood bikeway and negatively impact safety.

DESIGN FEATURES

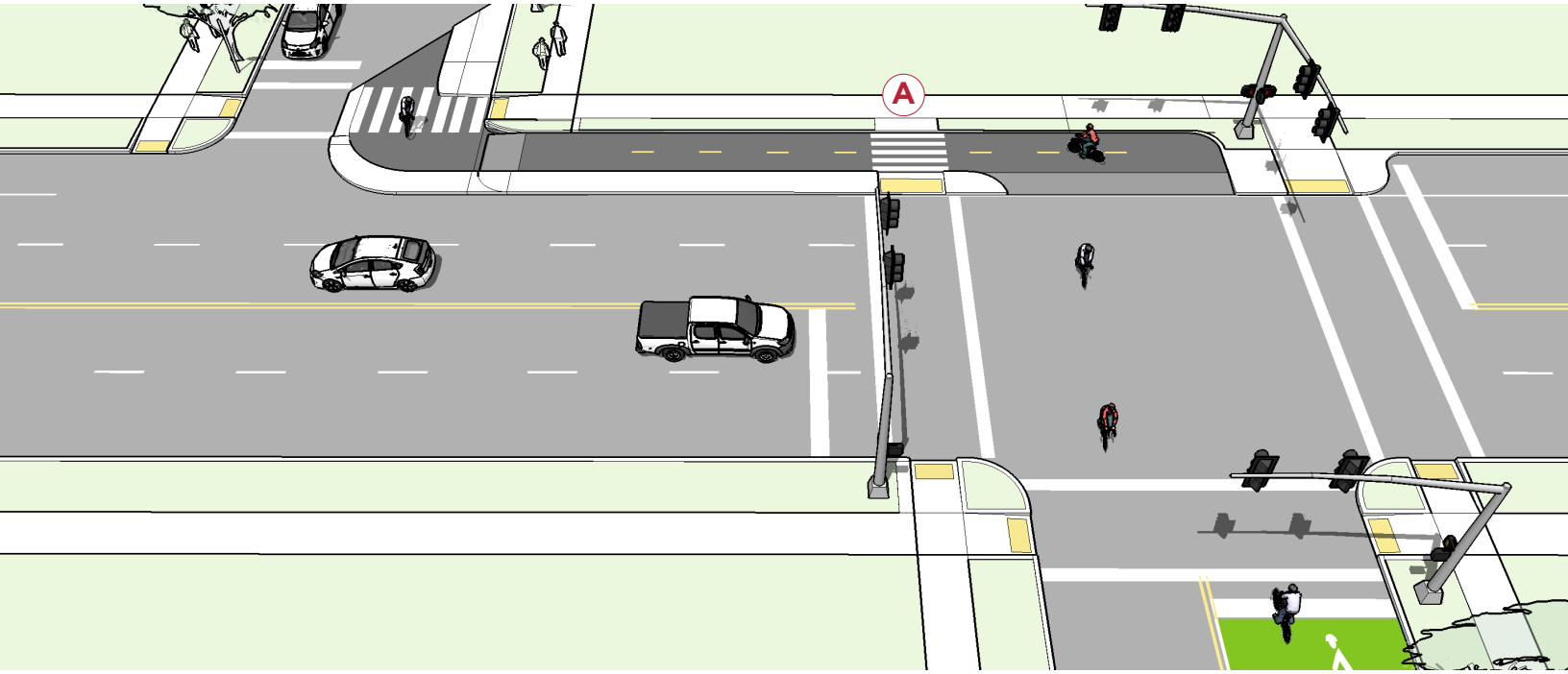
A **Hybrid beacons**, **active warning beacons** and **bicycle signals** can facilitate bicyclists crossing a busy street on which cross-traffic does not stop.

- **Bike boxes** increase bicyclist visibility to motorists and reduce the danger of right "hooks" by providing a space for bicyclists to wait at signalized intersections.
- **Median islands** provided at uncontrolled intersections of neighborhood bikeways and major streets allow bicyclists to cross one direction of traffic at a time as gaps in traffic occur.

NEIGHBORHOOD BIKEWAYS

OFF-SET INTERSECTION CROSSINGS

Off-set intersections can be challenging for bicyclists who are required to briefly travel along the busier cross street in order to continue along the neighborhood bikeway. Because neighborhood bikeways are located on local streets, the route is often discontinuous. Wayfinding and pavement markings assist bicyclists with remaining on the route.



TYPICAL APPLICATION

- Where neighborhood bikeways must be routed through off-set or skewed intersections.
- Where a cyclist must travel on a busier street than the neighborhood bikeway, in order to continue riding on the route.
- Appropriate treatments depend on volume of traffic including turning volumes, traffic speeds and the type of bicyclist using the crossing.

DESIGN FEATURES

A A **two-way separated bike lane** can be provided on one side of a busy street to connect neighborhood bikeway segments. This maneuver may be signalized on one side.

- **Bicycle left-turn lanes** can be painted where a neighborhood bikeway is offset to the right on a street that has sufficient traffic gaps. Bicyclists cross one direction of traffic and wait in a protected space for a gap in the other direction. The bike turn pockets should be at least 4 feet wide, with a total of 11 feet for both turn pockets and center striping.

ON-STREET BIKE LANES

Designated exclusively for bicycle travel, on-street bike lanes are distinguished from vehicle travel lanes by striping, and can include pavement stencils and other treatments. Bike lanes are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation. The Raleigh Street Design Guide provides guidance for bike lanes; this section of design guidelines matches those standards.

Bike lanes can increase safety and promote proper riding by:

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

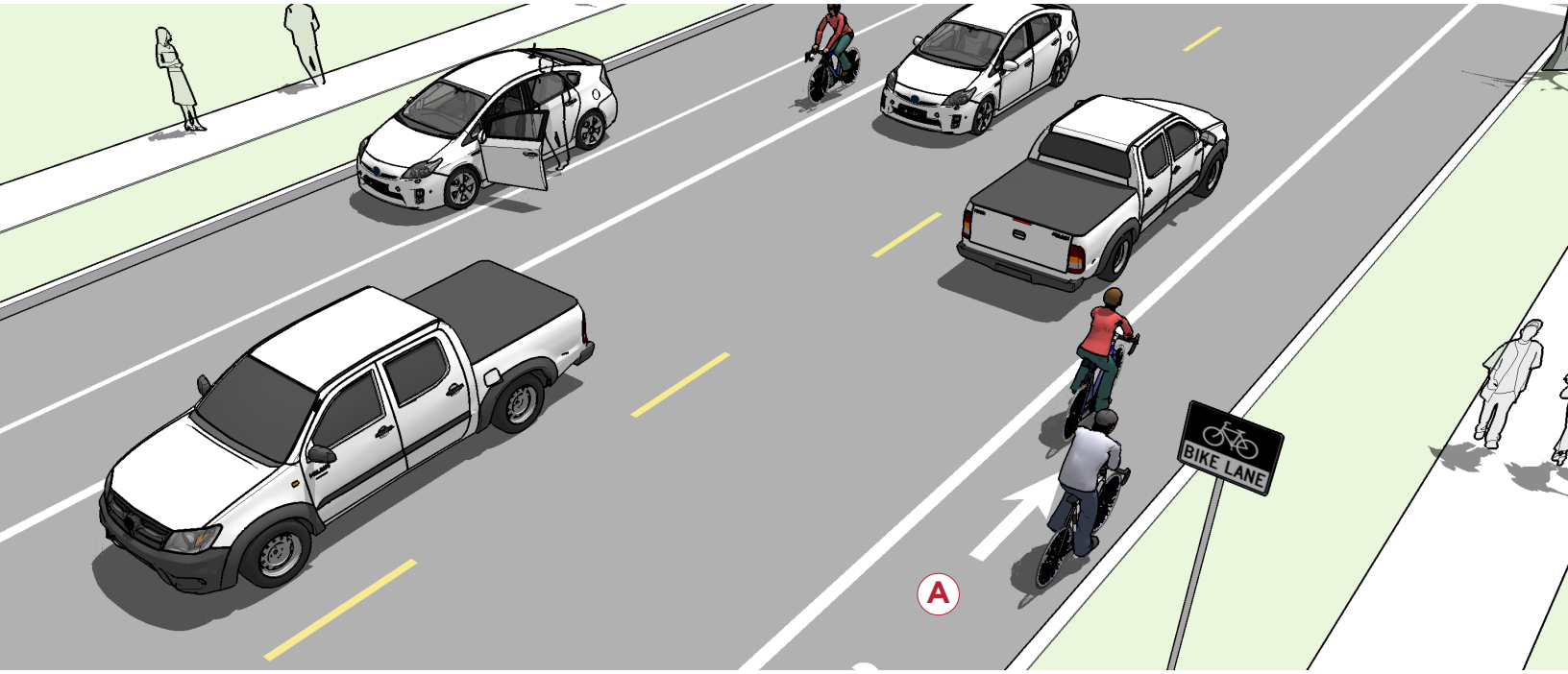
Appropriate Street Design Manual Street type

- Major Streets
- Mixed-use Streets

ON-STREET BIKE LANES

BICYCLE LANES

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



TYPICAL APPLICATION

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

DESIGN FEATURES

- (A) 6 foot width preferred, particularly adjacent to on-street parking. 4 foot width allowed in constrained right-of-way.
- The two foot gutter pan width shall not be included in the total bicycle lane width.
- Bicycle lane widths greater than 7 ft are discouraged as they may encourage motor vehicle use of bike lanes.

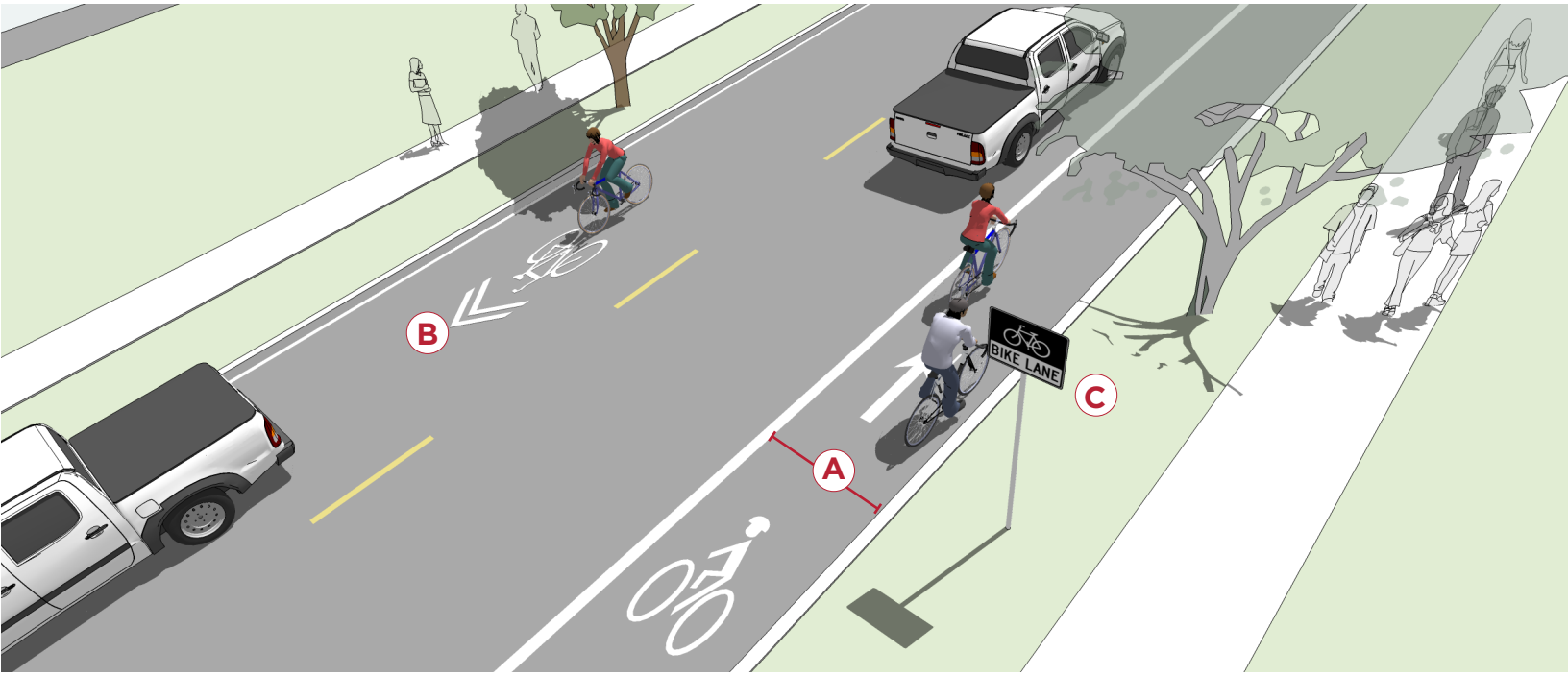
Appropriate Street Design Manual Street type

- **Mixed-use Streets**
- **Local Streets**

ON-STREET BIKE LANES

UPHILL BIKE CLIMBING LANE

Uphill bike lanes (also known as "climbing lanes") enable motorists to safely pass slower-speed bicyclists, thereby improving conditions for both travel modes. This combination is a good solution in constrained rights-of-way where there is not enough pavement width to add bicycle lanes on both sides of the roadway.



TYPICAL APPLICATION

- On streets with shared road bicycle facilities but no bike lanes, where a bicycle must travel uphill
- Where greater distance between motor vehicles and adjacent bicyclists is desired.

DESIGN FEATURES

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

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

C May also include a Bike Lane sign (MUTCD R3-17).

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SHARED ROADWAYS

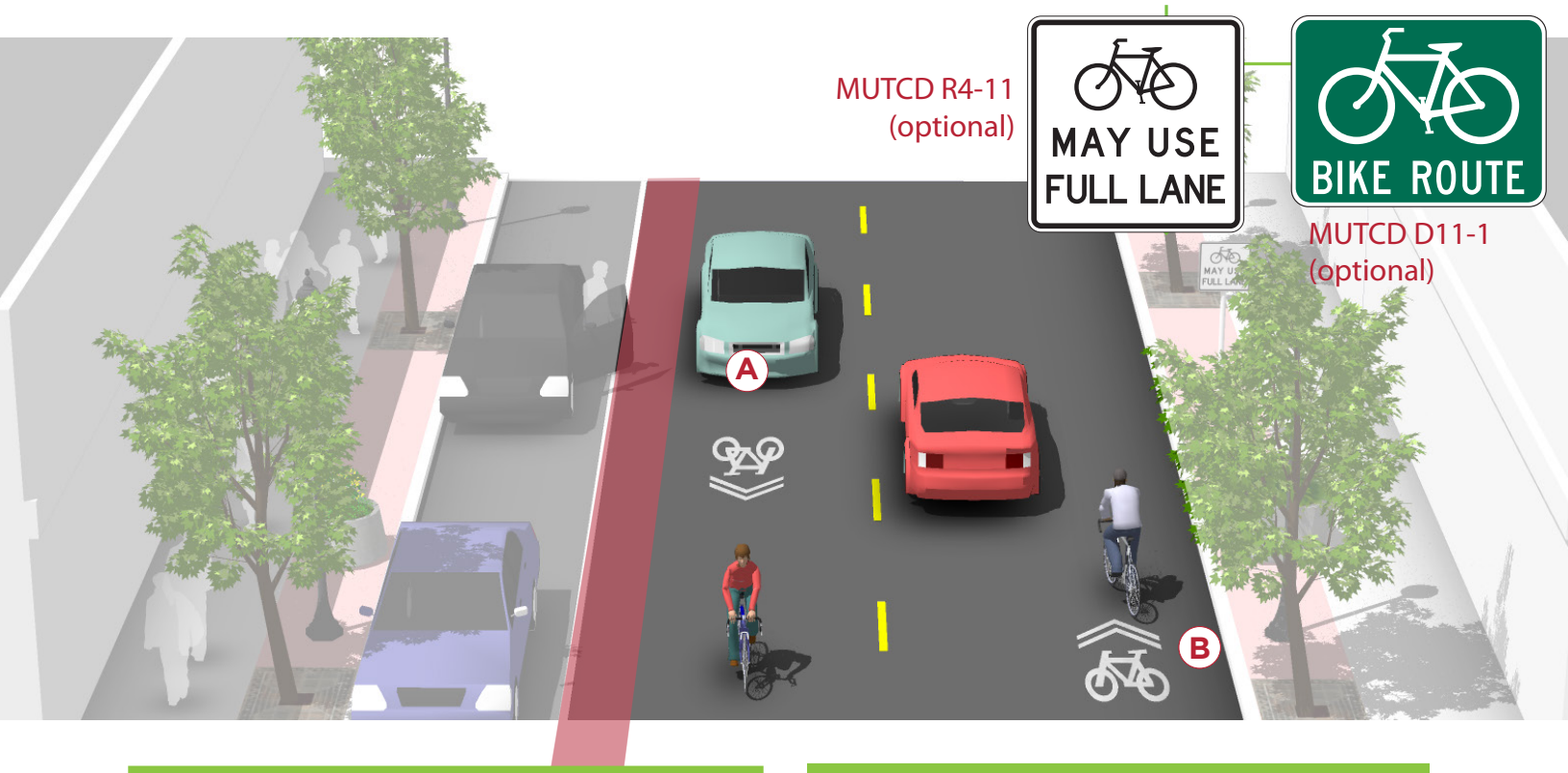
SHARED ROADWAYS

Appropriate Street Design Manual Street type

- **Local Streets**
- **Mixed-use Streets**

MARKED SHARED ROADWAY

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.



TYPICAL APPLICATION

- May be used on streets with a posted speed limit of 35 mph or under, although vehicle speeds less than 30 mph is preferred.
- Used to provide continuity with other bicycle facilities (usually bike lanes).
- May be used on higher volume roads with wide outside lanes or shoulders. On these streets, signed shared roadways are not suitable for children or casual, less experienced bicyclists.

DESIGN FEATURES

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

B On wide outside lanes with no parking (≥ 14 ft), place the marking 4 feet from edge of curb to promote bicycle travel to the right of motor vehicles.

- Minimum placement of SLM marking centerline is 11 feet from edge of curb where on-street parking is present. If parking lane is wider than 7.5 feet, the SLM should be moved further out accordingly.

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INTERSECTION TREATMENTS

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

Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

PROTECTED INTERSECTION

A protected intersection uses a collection of intersection design elements designed to maximize user comfort within the intersection and promote a high rate of yielding to people bicycling. The design is based on a setback bikeway crossing using physical separation within the intersection to define the turning paths of motor vehicles, slow motor vehicle turning speed, and offer a comfortable refuge for people bicycling while waiting at a red signal.

Davis, CA - The protected intersection connects buffered bicycle lanes and conventional bicycle lanes.

BENEFITS

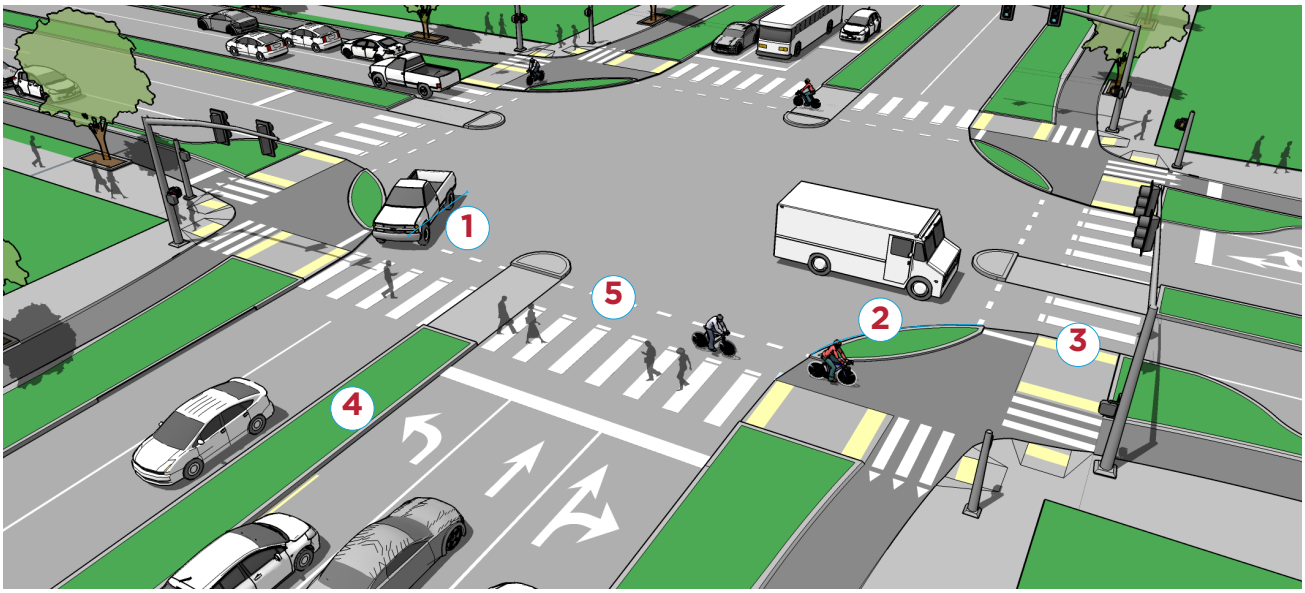
- Slows driver turning speed.
- Improves driver sightlines of people biking.
- Provides deceleration zone for yielding drivers.
- Provides a physically protected space for people waiting at an intersection on a red signal.
- Shortens crossing distances for people walking and riding a bicycle.

For more information see "Lessons Learned: Evolution of the Protected Intersection" (2015) by Alta Planning and Design: http://altaplanning.com/wp-content/uploads/Evolution-of-the-Protected-Intersection_ALTA-2015.pdf

TYPICAL APPLICATION

- At signalized intersections along streets with separated bicycle lanes.
- Connecting two or more Regional Active Transportation Network facilities.
- Along crossings of major or minor streets to slow vehicles and increase yieldings.
- At corner locations where pedestrian curb extensions are desired.
- Are often compatible with conventional bicycle lanes or neighborhood bikeway facilities by transitioning the bikeway into separated bicycle lanes just upstream of the intersection.

PROTECTED INTERSECTION



DESIGN GUIDANCE

1. Setback bicycle crossing of 20ft allows for one passenger car to queue while yielding. A larger setback is desired in high speed areas (>35 mph). Small setback distance is possible in slow-speed, space constrained conditions.
2. Corner safety island with a 15-20ft corner radius slows motor vehicle speeds. Larger radius designs may be possible when paired with a deeper setback or a protected signal phase.
3. A forward stop bar should indicate the area for people bicycling to wait at a red signal.
5. If a permissive left turn is allowed, a median island extending into the intersection should be used to channelize and direct left turning motor vehicles.
4. Intersection crossing markings should be used to identify the bicycle crossing. Consider green pavement to highlight the crossing area.

Salt Lake City, UT - The protected intersection is used to improve safety and circulation at an intersection where two separated bicycle lanes cross.

FURTHER CONSIDERATIONS

Colored pavement may be used within the corner refuge area to clarify use by people bicycling and discourage use by people walking or driving.

Intersection approaches with high volumes of right turning vehicles should provide a dedicated right turn only lane paired with a protected signal phase to separate the right turn movements from through bicycle movements (Stanek, 2015).

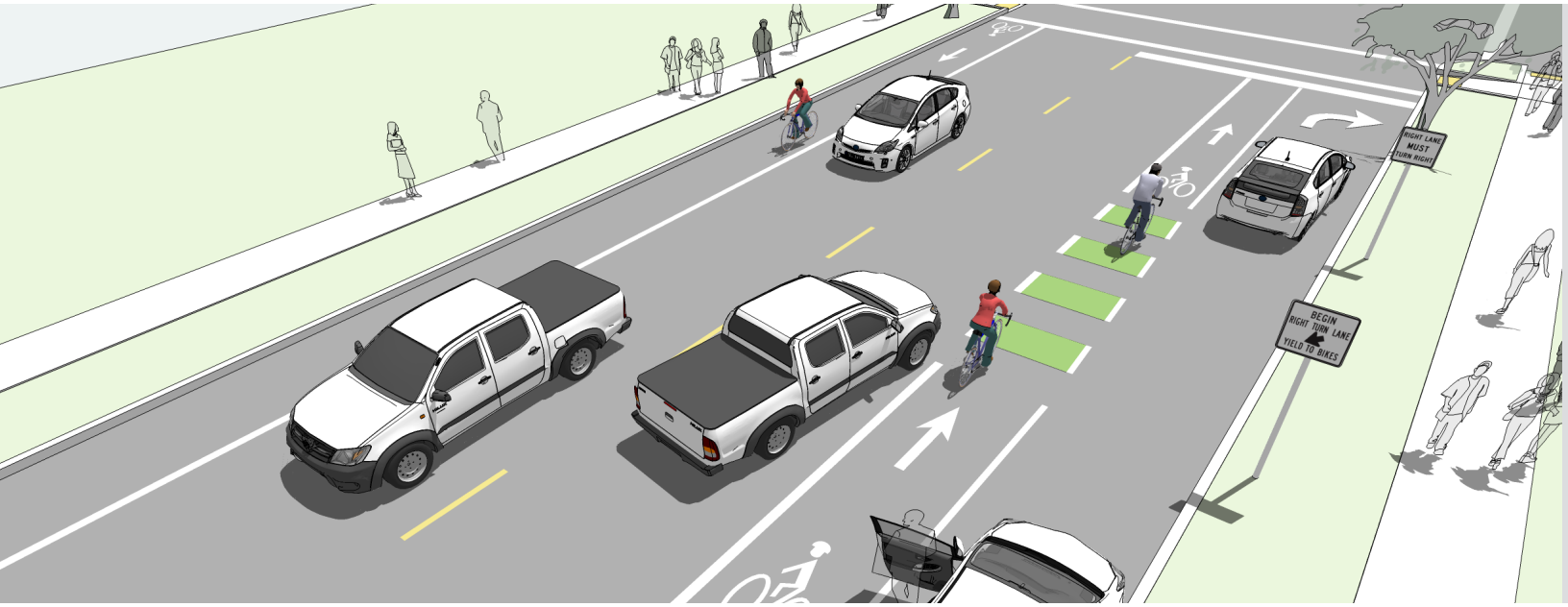
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

BIKE LANES AT ADDED RIGHT TURN LANES

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



TYPICAL APPLICATION

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

DESIGN FEATURES

- Mark inside line with 6” stripe.
- Continue existing bike lane width; standard width of 5 to 6 feet (4 feet in constrained locations.)
- Use R4-4 BEGIN RIGHT TURN LANE YIELD TO BIKES signage to indicate that motorists should yield to bicyclists through the conflict area.
- Maintaining a straight bicycle path reinforces the priority of bicyclists over turning cars. Drivers must yield to bicyclists before crossing the bike lane to enter the turn only lane.

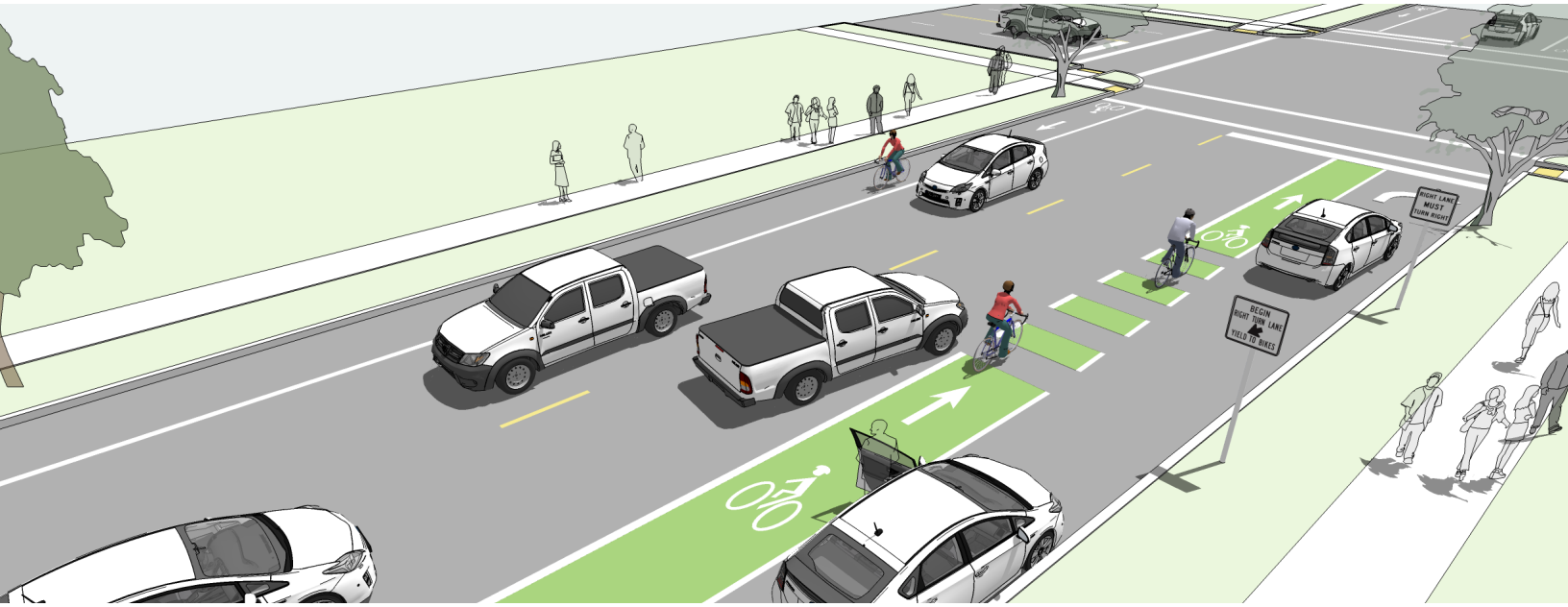
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

COLORED BICYCLE LANES

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



TYPICAL APPLICATION

- Within a weaving or conflict area to identify the potential for bicyclist and motorist interactions and assert bicyclist priority.
- Across intersections, driveways and Stop or Yield-controlled cross-streets.
- Green colored pavement shall be used in compliance with FHWA Interim Approval.

DESIGN FEATURES

- Typical white bike lanes (solid or dotted 6" stripe) are used to outline the green colored pavement.
- In exclusive use areas, color application should be solid green.
- In weaving or turning conflict areas, preferred striping is dashed, to match the bicycle lane line extensions.
- The colored surface should be skid resistant and retro-reflective.
- While other colors have been used (red, blue, yellow), green is the recommended color in the US.

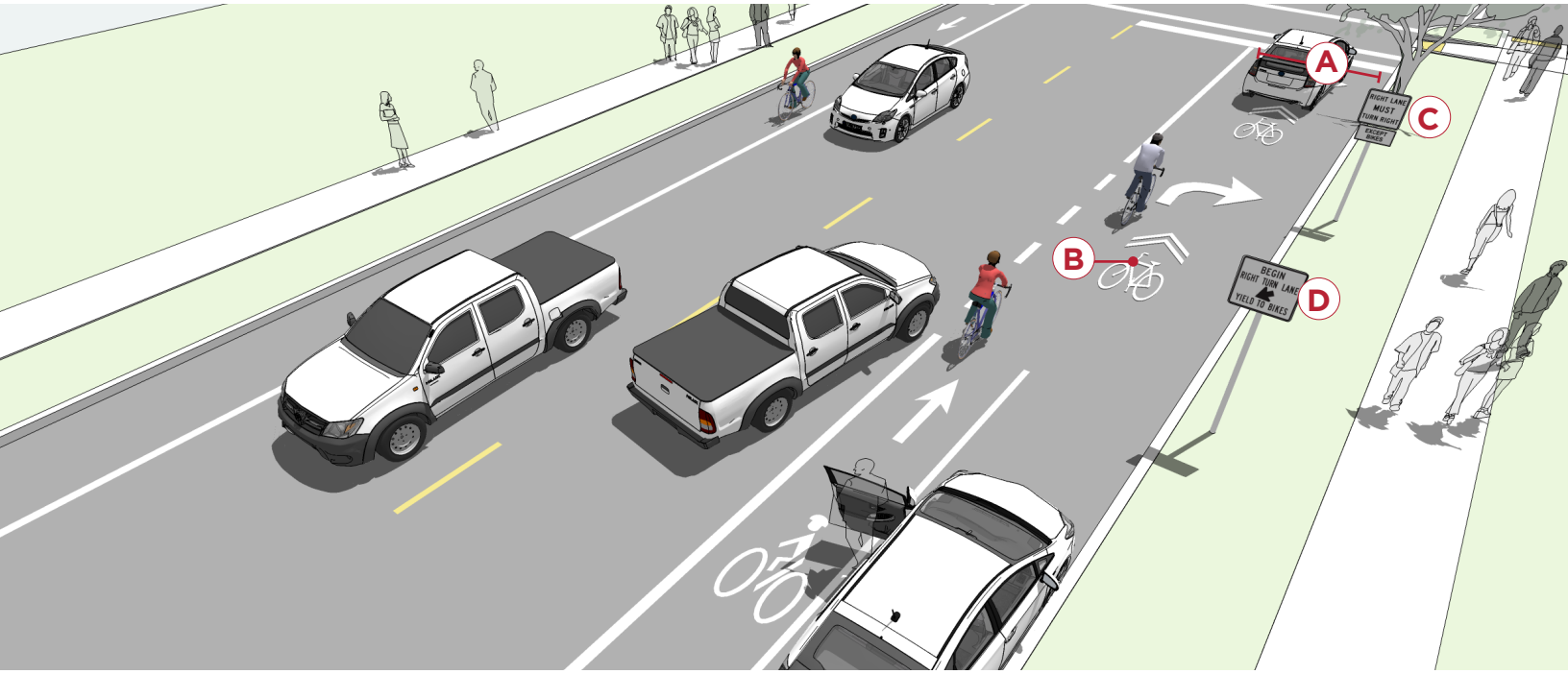
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

COMBINED BIKE LANE/TURN LANE

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



TYPICAL APPLICATION

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

DESIGN FEATURES

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

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

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

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

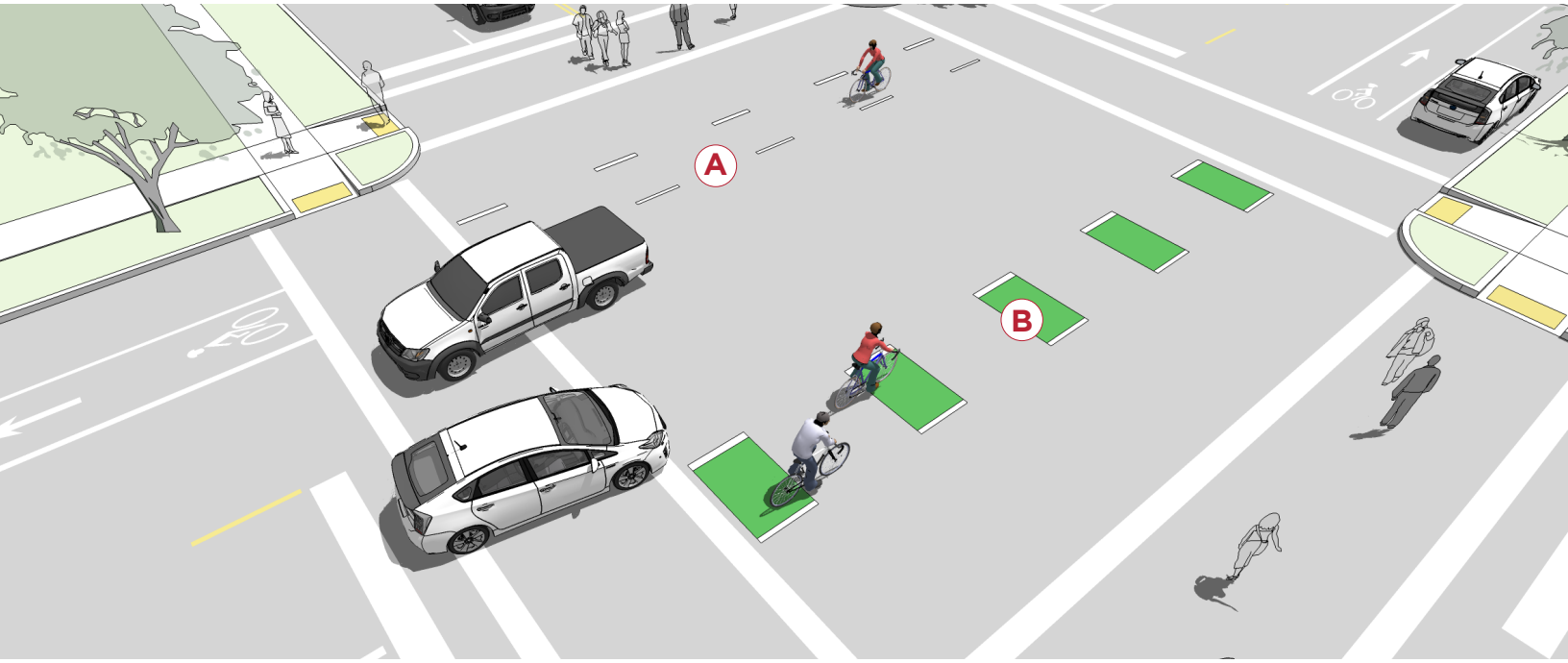
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

INTERSECTION CROSSING MARKINGS

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



TYPICAL APPLICATION

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

DESIGN FEATURES

- Intersection markings should be the same width and in line with leading bike lane.
- (A) Dotted lines should be a minimum of 6 inches wide and 4 feet long, spaced every 12 feet.
- All markings should be white, skid resistant and retro reflective.
- (B) Green pavement markings may also be used.

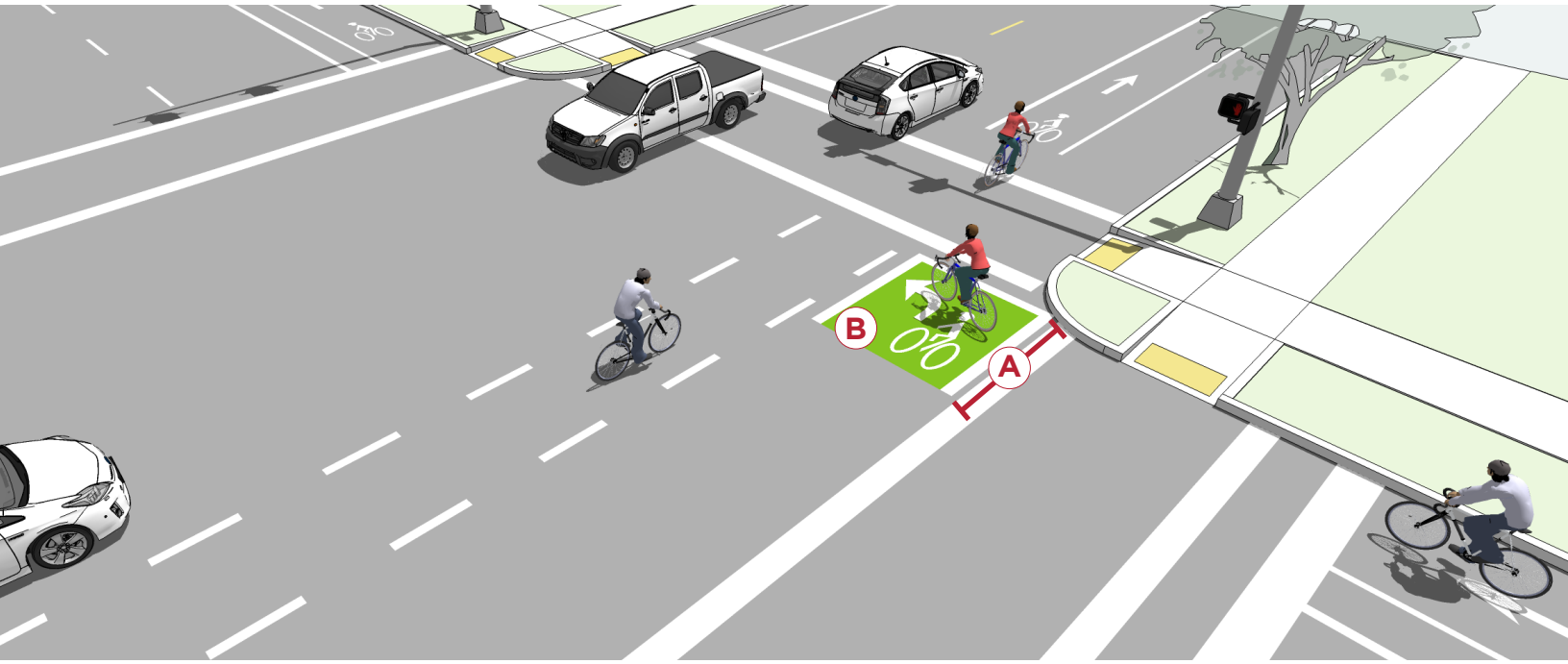
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

TWO-STAGE TURN BOXES

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



TYPICAL APPLICATION

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

DESIGN FEATURES

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

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

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

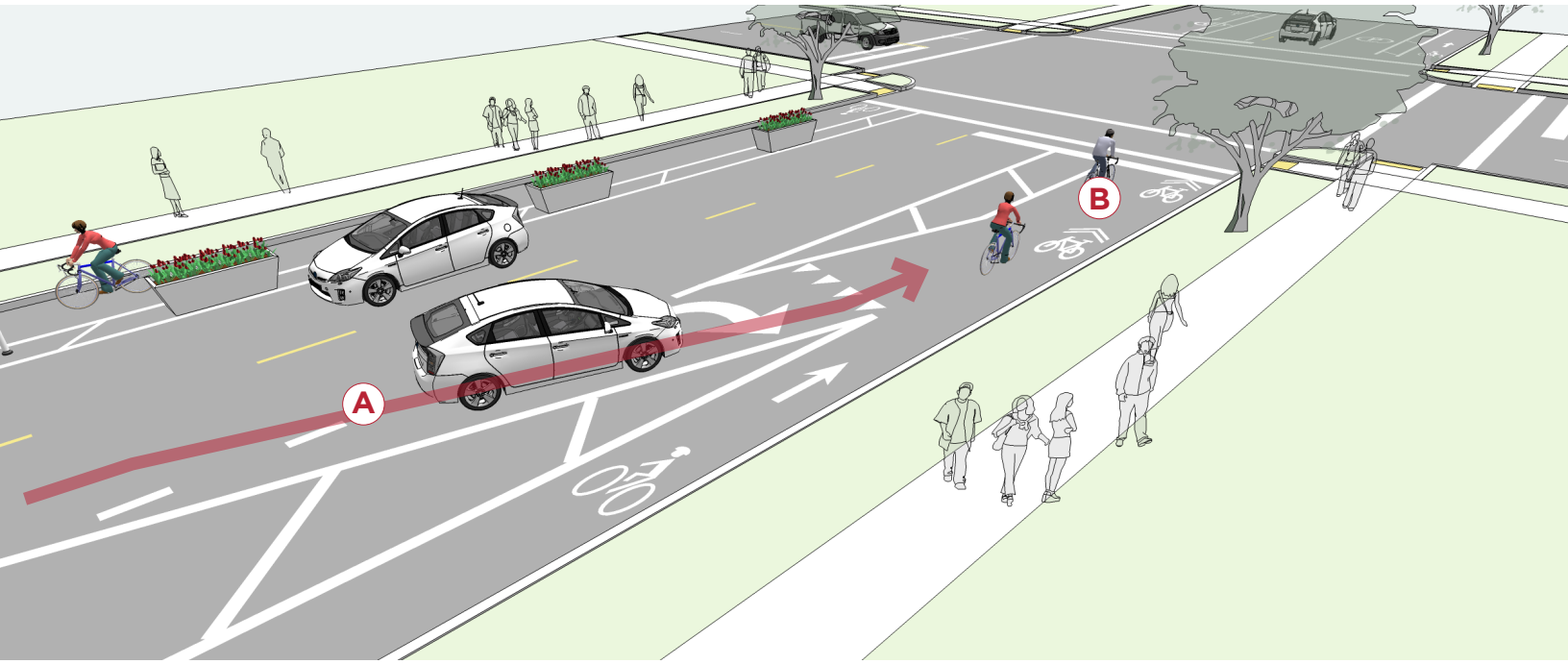
Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

INTERSECTION TREATMENTS

SEPARATED BIKE LANE MIXING ZONE

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



TYPICAL APPLICATION

- Where through bicyclists and right-turning automobile conflicts are common.
- Most appropriate in areas with low to moderate right-turn volumes.
- Streets with a right turn lane but not enough width to have a standard width bicycle lane at the intersection.

DESIGN FEATURES

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

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

- The transition to the mixing zone should begin 70 feet in advance of the intersection.
- Shared lane markings should be used to illustrate the bicyclist's position within the lane.
- A yield line should be used in advance of the intersection.

INTERSECTION TREATMENTS

BICYCLE SIGNAL HEAD & PROTECTED SIGNAL PHASE

Appropriate Street Design Manual Street type

- **Major Streets**
- **Mixed-use Streets**

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

TYPICAL APPLICATION

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

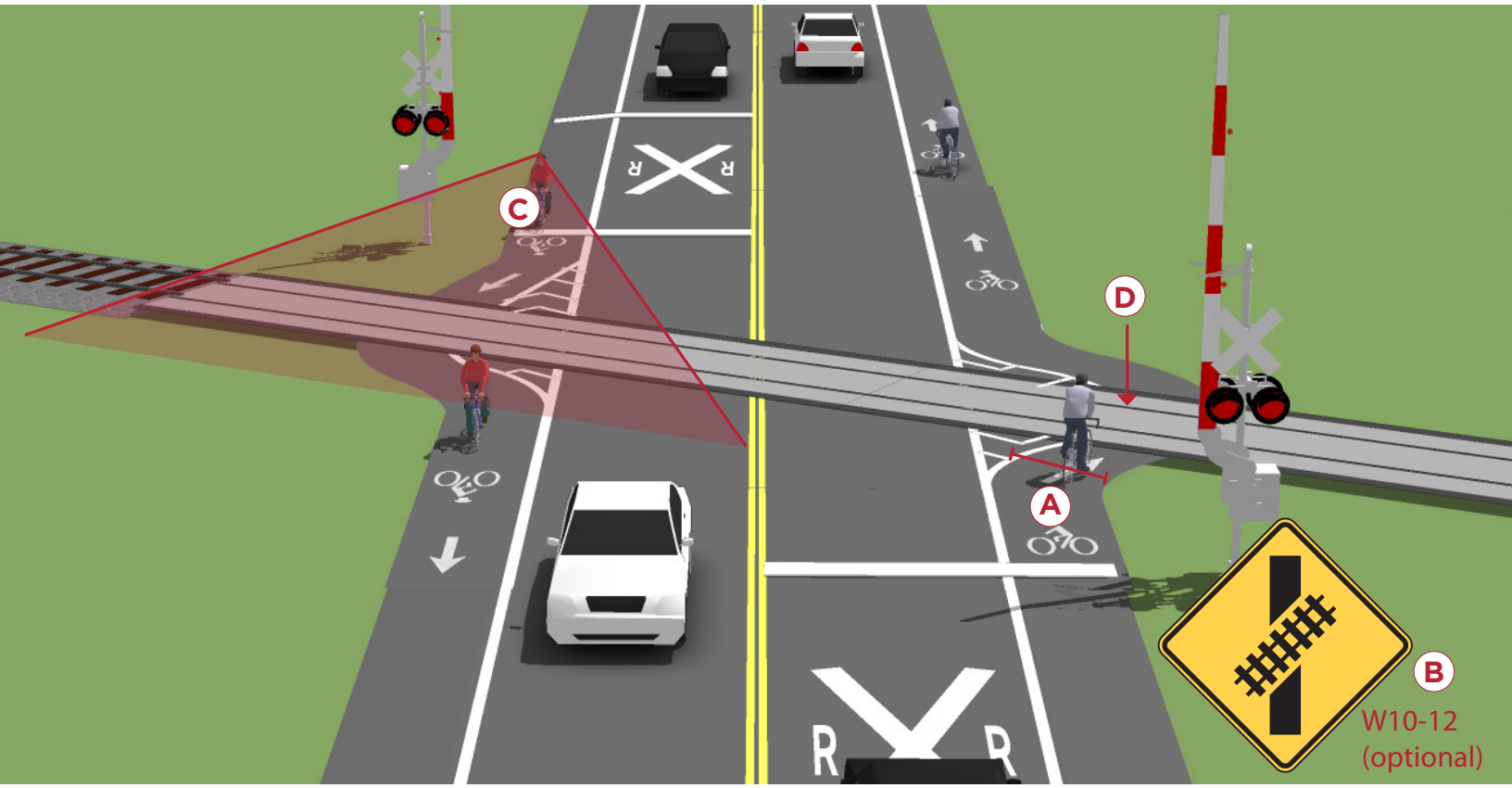
DESIGN FEATURES

- An additional "Bicycle Signal" sign should be installed below the bicycle signal head.
- Designs for bicycles at signalized crossings should allow bicyclists to trigger signals and safely maneuver the crossing.
- On bikeways, signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists.

INTERSECTION TREATMENTS

AT-GRADE RAILROAD CROSSING

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.



TYPICAL APPLICATION

- Where bike lanes, shoulders or physically separated bike lanes cross railroad tracks.
- Provide extra design attention to angled track crossings.
- 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.

DESIGN FEATURES

A 6 ft minimum shoulder/bike lane width.

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

C 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).

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

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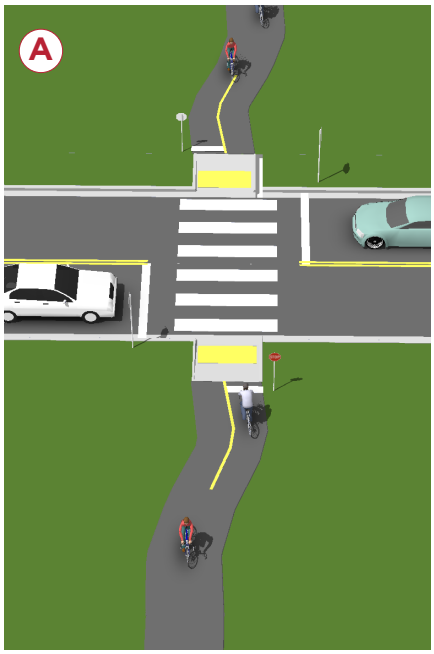
SHARED USE PATH CROSSINGS

SHARED USE PATH CROSSINGS

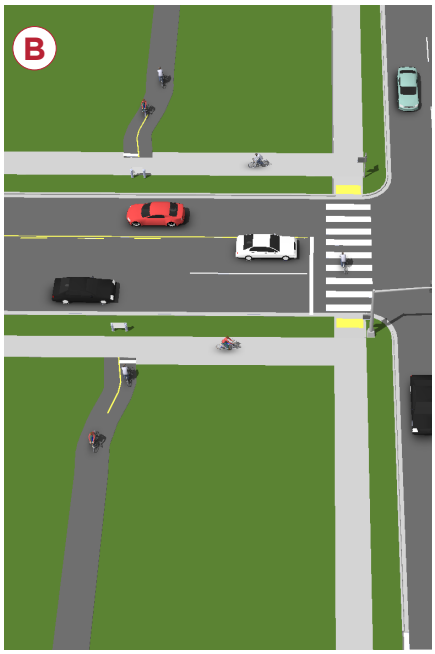
STREET CROSSINGS

The approach to designing path crossings of streets depends on an evaluation of vehicular traffic, line of sight, pathway traffic, use patterns, vehicle speed, road type, road width, and other safety issues such as proximity to major attractions.

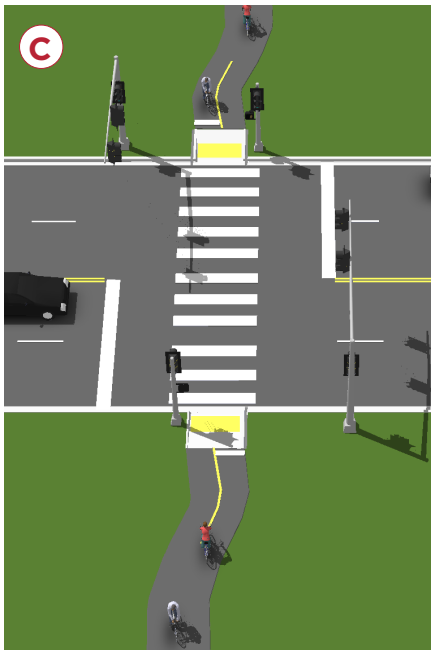
Marked Uncontrolled Crossing



Route Users to Signal



Signal Control



DESIGN FEATURES

A MARKED CROSSINGS

- Appropriate on a two lane road with ≤9,000-12,000 Average Daily Traffic (ADT) volume, and ≤ 35 mph speed.
- Crossings of streets with higher speeds, higher volumes, and additional lanes requires additional enhancements such as median islands or active warning beacons.

B ROUTE USERS TO SIGNAL

- Path crossings should not be provided within approximately 300 feet of an existing signalized intersection. If possible, route path directly to the signal.
- Barriers and signing may be needed to direct shared use path users to the signalized crossings

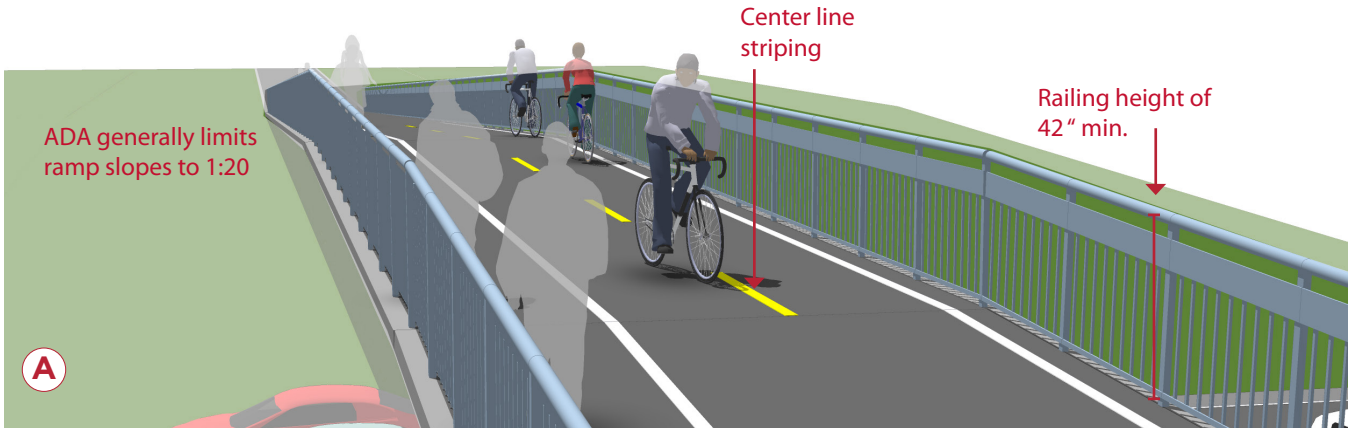
C SIGNAL CONTROLLED CROSSINGS

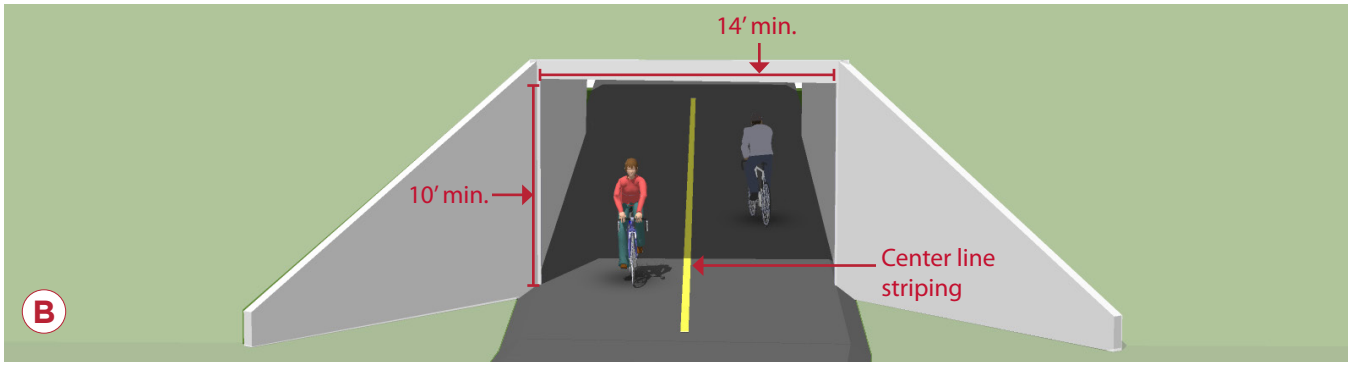
- Full traffic signal installations must meet MUTCD pedestrian, school or modified warrants.
- Located more than 300 feet from an existing signalized intersection.
- Push button actuation for shared use path users.
- The maximum delay for activation of the signal should be two minutes.

SHARED USE PATH CROSSINGS

GRADE SEPARATED CROSSINGS

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





TYPICAL APPLICATION

- 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.

DESIGN FEATURES

A OVERCROSSING:

- 14 feet width preferred, 8 foot minimum.
- If overcrossing has any scenic vistas, additional width should be provided to allow for stopping.

B UNDERCROSSING:

- 14 foot minimum width, greater widths preferred for lengths over 60 feet.
- 10 foot minimum height.
- Lighting should be considered during the design process for any undercrossing.

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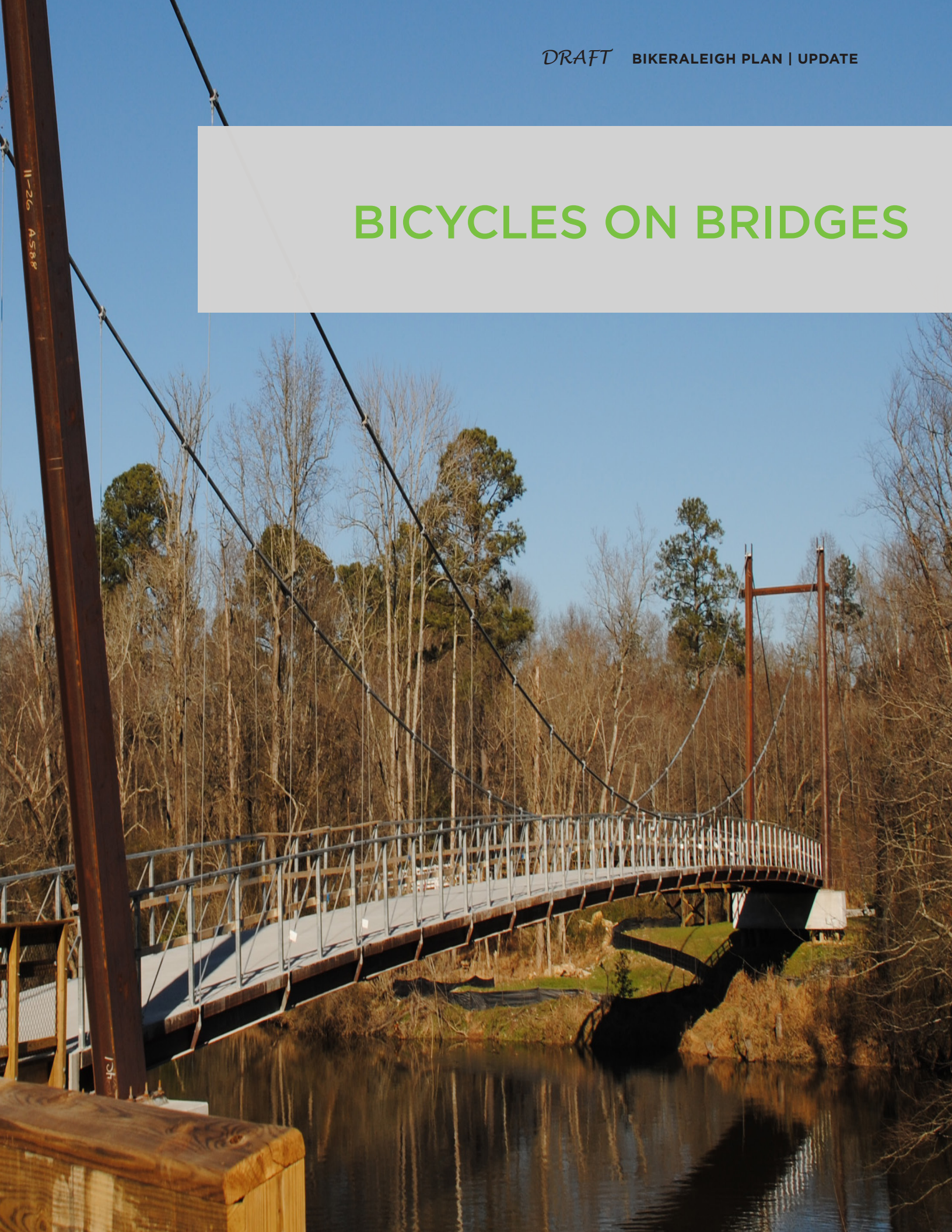
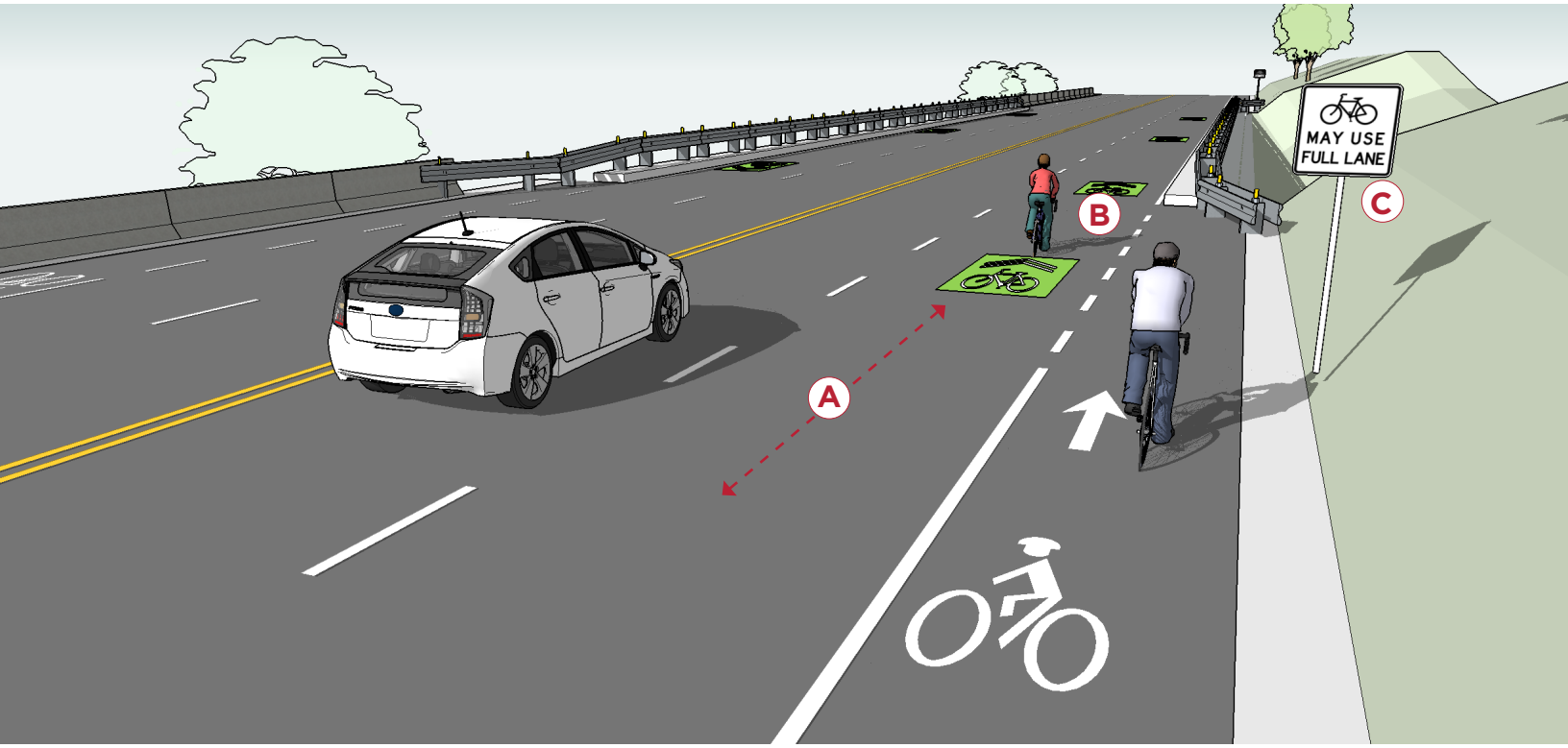
BICYCLES ON BRIDGES



BICYCLES ON BRIDGES

SHARED LANES ON BRIDGES

Constrained spaces such as bridges may require shared lane operation of bicyclists and cars for a short distance. Enhanced marking and signage can alert all road users to this changed condition.



TYPICAL APPLICATION

- On existing bridges lacking space for dedicated bicycle facilities.

DESIGN FEATURES

A Shared lane markings should be placed in the center of the travel lane. If the outside lane is 14 ft wide, the center of the shared lane marking may be placed 4 ft from the curb line.

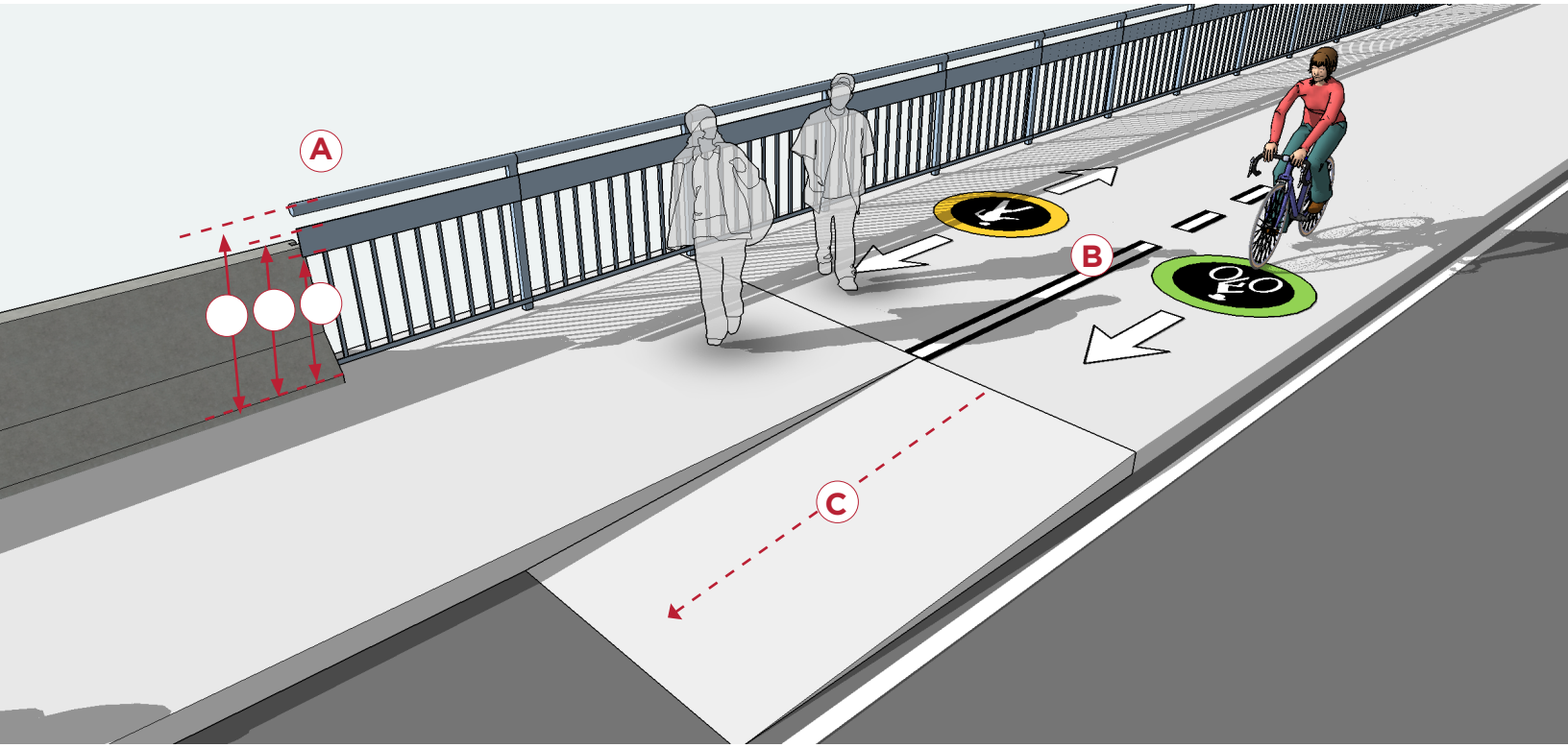
B Some jurisdictions are experimenting with green colored pavement to enhance the shared lane marking. (requires FHWA experimentation approval)

C Bikes May Use Full Lane sign (R4-11) should be used to remind users of the bicyclists right to occupy a travel lane.

BICYCLES ON BRIDGES

PATHS ON BRIDGES

Paths attached to bridges should provide adequate width for intended user type and travel direction and should use bicycle compatible railings.



TYPICAL APPLICATION

- Paths retrofit on the side of bridges
- Wide bridge sidewalks functioning as shared use paths

DESIGN FEATURES

A Bicycle compatible "Rub Rail" design should be used to prevent snags with bicycle handlebars.

B User stencils and striping may be used to clarify user mode and direction.

C Transition ramps off of the bridge path should be gradual.

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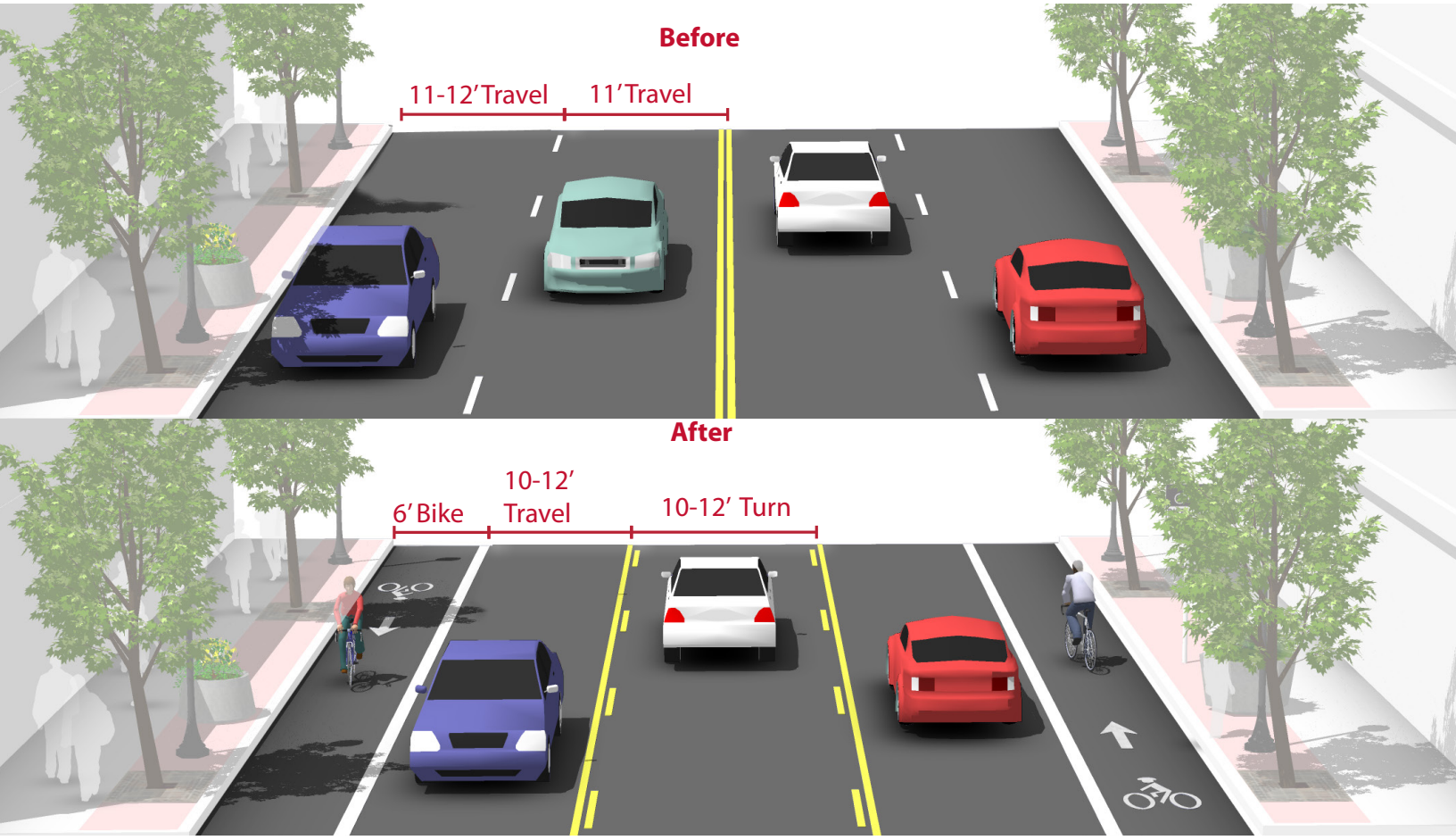
RETROFITTING STREETS

RETROFITTING STREETS

LANE RECONFIGURATION

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 bicycle lane retrofit projects.



TYPICAL APPLICATION

- On existing streets operating below current built capacity that lack bicycle infrastructure.
- One common conversion is from a four lane undivided streets to a three lane street including a center turn lane.

DESIGN FEATURES

Vehicle lane width:

- Width depends on project. Narrowing may not be needed if a travel lane is removed.

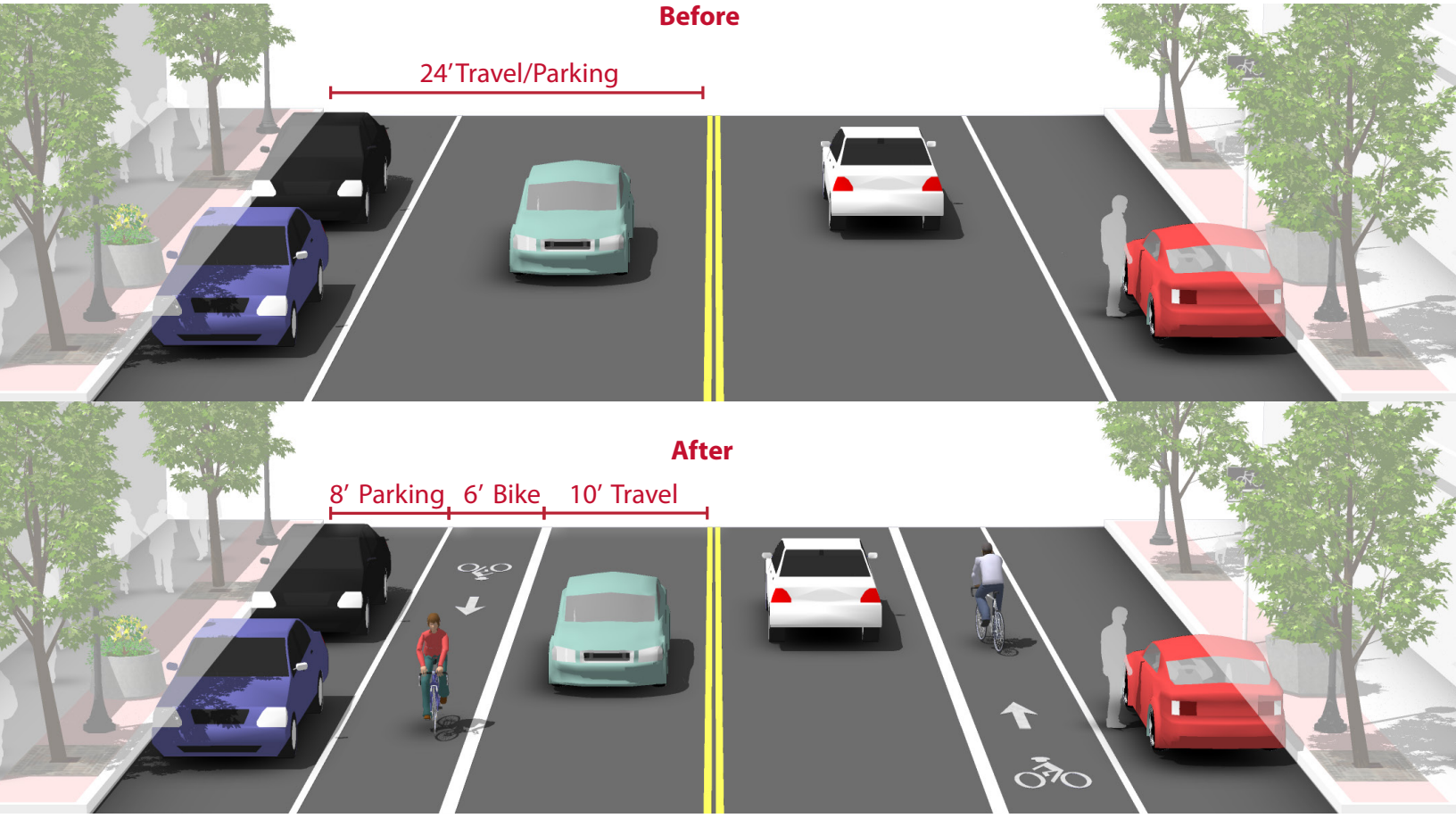
Bicycle lane width:

- Guidance on bicycle lanes applies to this treatment.

RETROFITTING STREETS

LANE NARROWING

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.



TYPICAL APPLICATION

- On existing streets with wide travel lanes (11-15 feet) that lack bicycle infrastructure.

DESIGN FEATURES

Vehicle lane width:

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

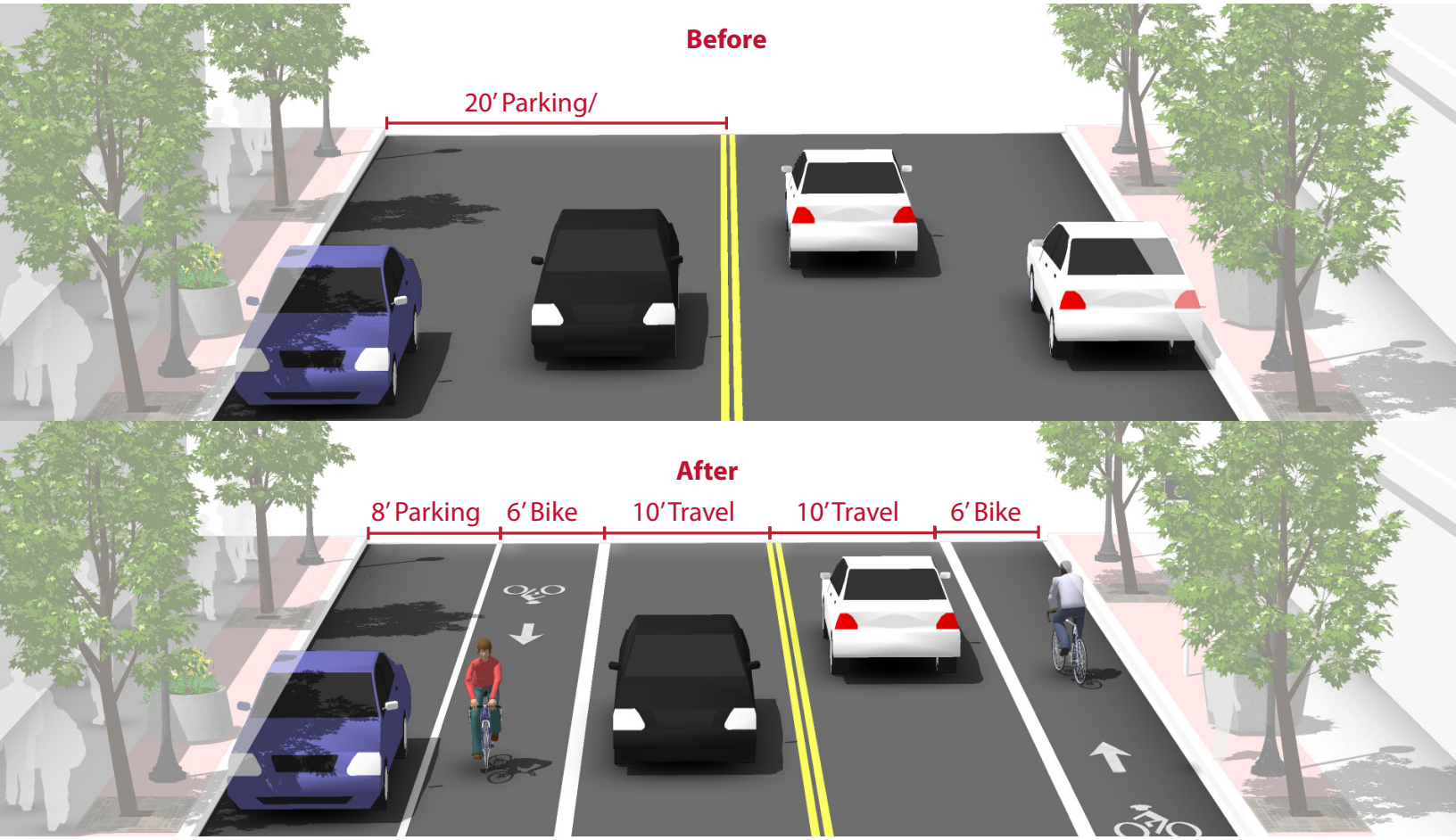
Bicycle lane width:

- 6 feet wide preferred (5 foot minimum)

RETROFITTING STREETS

PARKING REDUCTION

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.



TYPICAL APPLICATION

- On existing streets with underutilized parking (< 50% occupancy)

DESIGN FEATURES

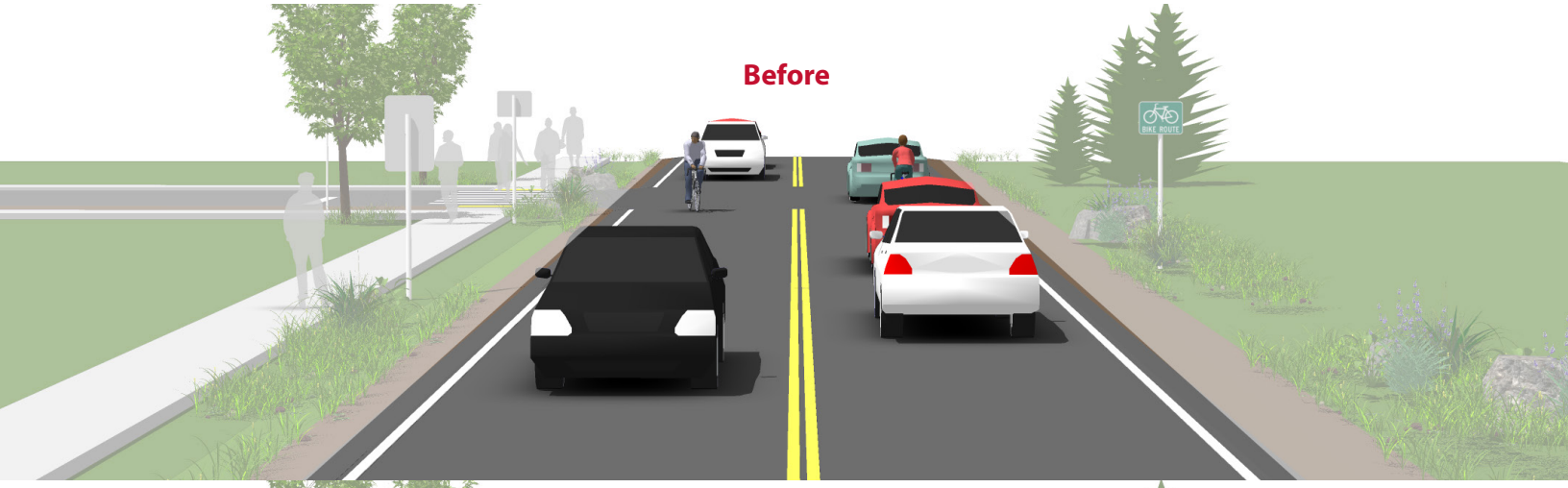
Vehicle lane width:

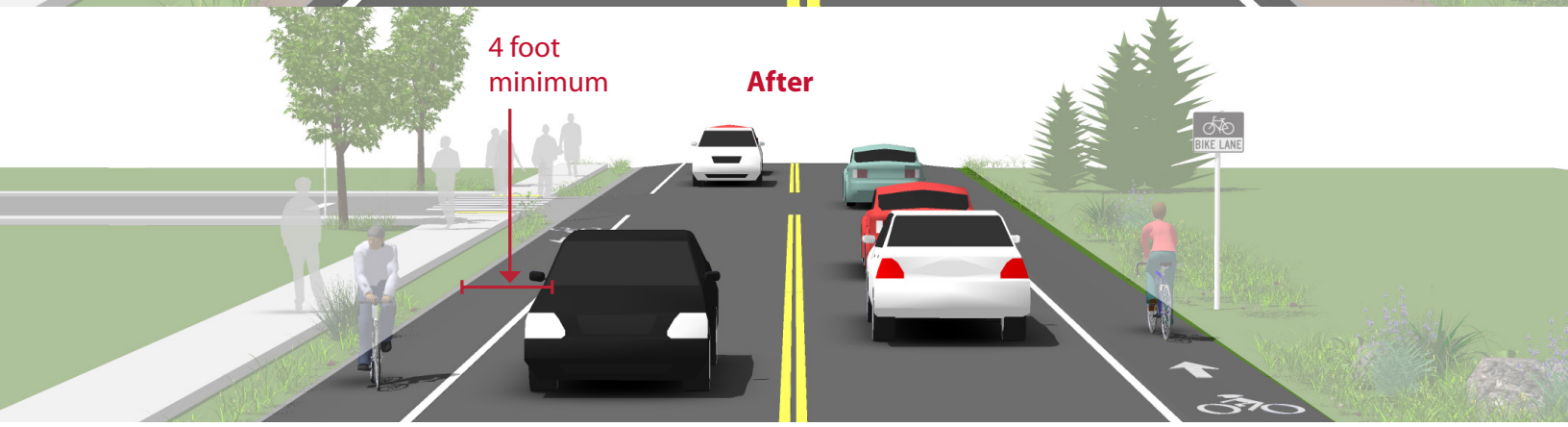
- Parking lane width depends on project. No travel lane narrowing may be required depending on the width of the parking lanes.

RETROFITTING STREETS

ROADWAY WIDENING

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.





TYPICAL APPLICATION

- On existing streets that lack bicycle infrastructure.
- Roadway widening is most appropriate on roads lacking curbs, gutters and sidewalks.

DESIGN FEATURES

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

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BICYCLE SIGNING & WAYFINDING

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

BICYCLE SIGNING & WAYFINDING

WAYFINDING SIGN TYPES

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

A

D11-1c

B

D1-1

C

D11-1/D1-3a

TYPICAL APPLICATION

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

DESIGN FEATURES

A Confirmation signs indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route. Can include destinations and distance/time but do not include arrows.

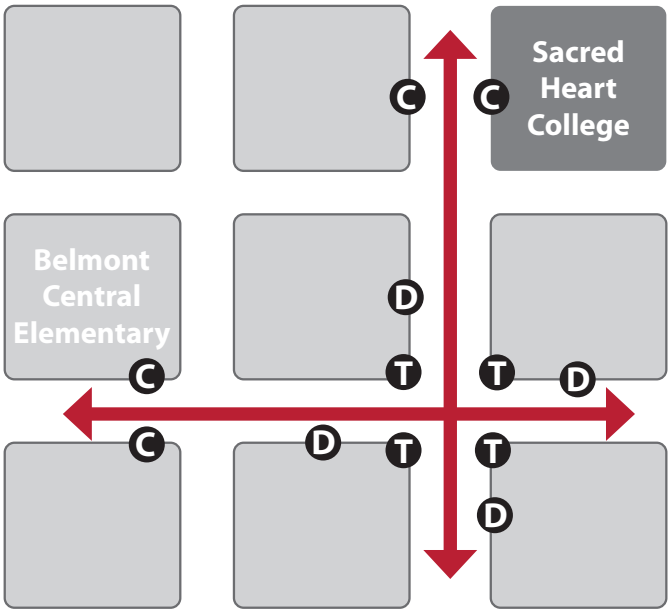
B Turn signs indicate where a bikeway turns from one street onto another street. These can be used with pavement markings and include destinations and arrows.

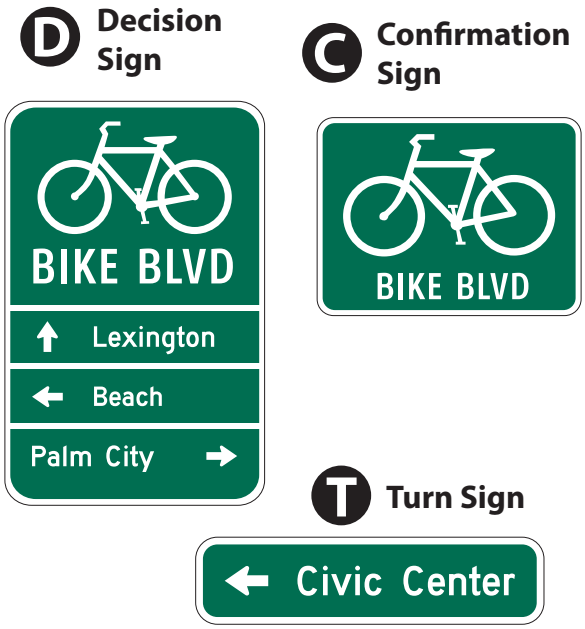
C Decisions signs indicate the junction of two or more bikeways and inform bicyclists of the designated bike route to access key destinations. These include destinations, arrows and distances. Travel times are optional but recommended.

BICYCLE SIGNING & WAYFINDING

WAYFINDING SIGN PLACEMENT

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





TYPICAL APPLICATION

Confirmation Signs

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

Turn Signs

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

Decision Signs

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

DESIGN FEATURES

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

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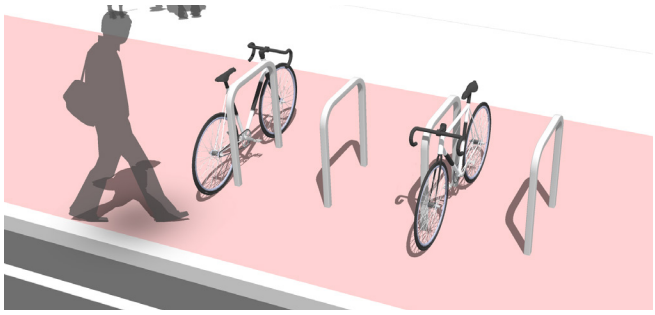
BICYCLE PARKING AND OPERATIONS

BICYCLE PARKING & OPERATIONS

BIKE PARKING

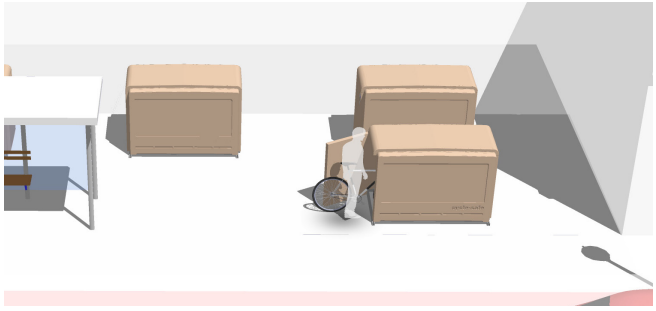
Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. This may be short-term parking of 2 hours or less, or long-term parking for employees, students, residents, and commuters.

Bike Racks



Bike Corral

Bike Locker



Secure Parking Area

DESIGN FEATURES

Bike Racks

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

Bike Corrals

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

Bike Lockers

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

Secure Parking Area

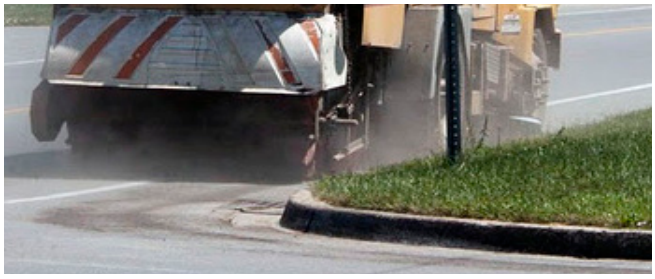
- Closed-circuit television monitoring with secure access for users.
- Double high racks & cargo bike spaces.
- Bike repair station with bench and maintenance item vending machine.
- Bike lock "hitching post" – allows people to leave bike locks.

BICYCLE PARKING AND OPERATIONS

SWEEPING

TYPICAL APPLICATION

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.



FURTHER CONSIDERATION

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

SIGNAGE

TYPICAL APPLICATION

Bike lanes, shared shoulders, neighborhood bikeways, 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.

FURTHER CONSIDERATION

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

BICYCLE PARKING & OPERATIONS

ROADWAY SURFACE

TYPICAL APPLICATION

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.

FURTHER CONSIDERATION

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

PAVEMENT OVERLAYS

TYPICAL APPLICATION

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.

FURTHER CONSIDERATION

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

BICYCLE PARKING AND OPERATIONS

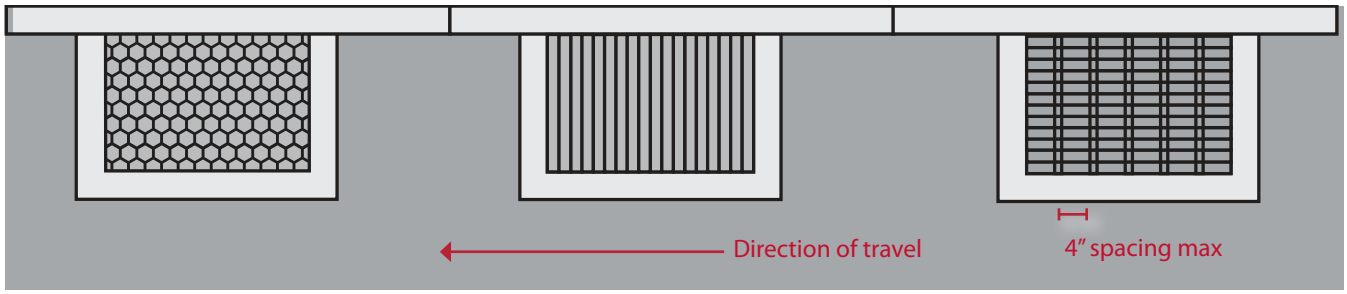
DRAINAGE GRATES

TYPICAL APPLICATION

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. While the City street standard doesn't include grates, NCDOT streets do.

FURTHER CONSIDERATION

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



GUTTER TO PAVEMENT TRANSITION

TYPICAL APPLICATION

Streets in Raleigh generally have 2 feet gutter pans, where water collects and drains into catch basins. Some streets are paved directly to the edge of curb while 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.

FURTHER CONSIDERATION

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

BICYCLE PARKING & OPERATIONS

LANDSCAPING

TYPICAL APPLICATION

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.

FURTHER CONSIDERATION

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

MAINTENANCE MANAGEMENT PLAN

TYPICAL APPLICATION

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.

FURTHER CONSIDERATION

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