

# DENVER BIKEWAY DESIGN GUIDELINES

## CONTENTS:

- Standards Based Design
- Design Needs of Bicyclists
- Facility Selection
- Bikeway Types
- Intersection Treatments

These design guidelines guide the development of bikeways in the City and County of Denver.

Robust **DESIGN GUIDELINES** provide the key dimensional characteristics of bikeway facility design and also provide contextual guidance for facility selection. The end result is the high-quality implementation of bikeways that, while allowing for design flexibility, also result in consistent details across projects city-wide.

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## STANDARDS BASED DESIGNS



The Denver Bikeway Design Guidelines were created based on national standards and guidelines and are tailored to meet the unique context of Denver. The sections that follow serve as an inventory of bicycle design treatments and provide guidelines for their development. These design guidelines are important because they represent tools for creating a bicycle-friendly, safe, accessible community. The following national standards are used by Denver as the basis of their design standards.

- The Federal Highway Administration’s (FHWA) **Manual on Uniform Traffic Control Devices** (MUTCD 2009) is the primary foundation on lane striping requirements, signal warrants, and recommended signage and pavement markings.
- FHWA has also published in 2015 **Separated Bike Lane and Planning Design Guide**, which outlines planning considerations for protected bicycle facilities, presents a suite of design recommendations based on corridor context, and highlights notable case studies from across the US.
- American Association of State Highway and Transportation Officials (AASHTO) **Guide for the Development of Bicycle Facilities**, updated in June 2012 provides guidance on dimensions, use, and layout of specific bicycle facilities.
- The National Association of City Transportation Officials’ (NACTO) 2012 **Urban Bikeway Design Guide** presents nationally recognized bikeway design treatments, and offers additional guidance on the bikeway types presented here.

Should these national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions. The guidelines are not a substitute for a thorough evaluation by a professional planner or engineer upon implementation of facility improvements.

## DESIGN NEEDS OF BICYCLISTS

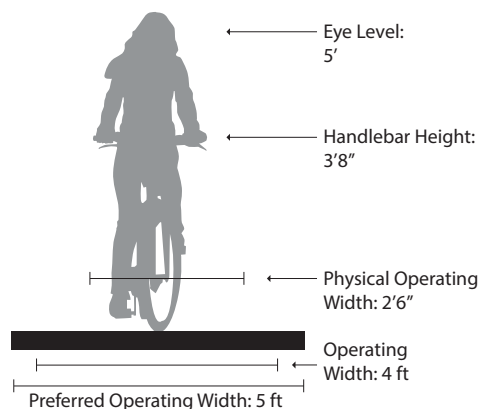
The purpose of this section is to provide the facility designer with an understanding of how typical bicyclists operate and how their bicycle influences that operation. By understanding the unique characteristics and needs of all bicyclists, adults, children and aging population, a facility designer can provide quality facilities and minimize user risk.

### Bicycle as a Design Vehicle

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 ease of getting on and off a bicycle). 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 of operating width, although four feet may be minimally acceptable.

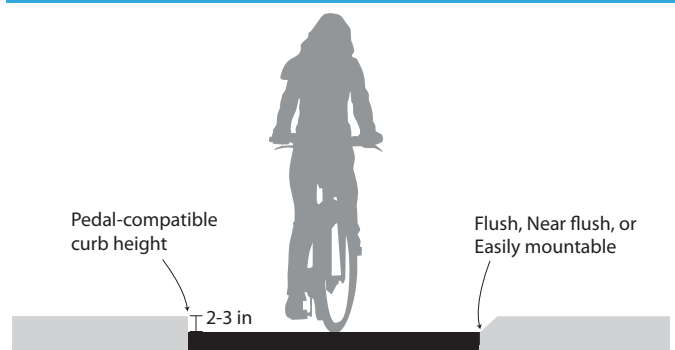
### TYPICAL ADULT BICYCLIST DIMENSIONS



### SHY DISTANCE FROM COMMON EDGE TYPES



### PREFERRED EDGE TYPES



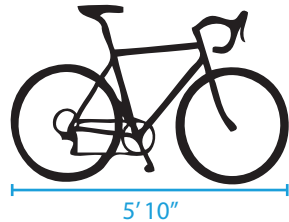
Source: AASHTO. *Guide for the Development of Bicycle Facilities*, 4th Edition. 2012.

Sustrans. *Handbook for Cycle-Friendly Design*. 2014

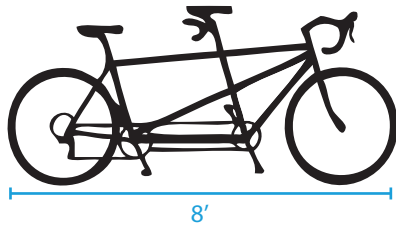


TYPICAL BICYCLE DIMENSIONS

**A**  
TYPICAL  
COMMUTE  
BICYCLE



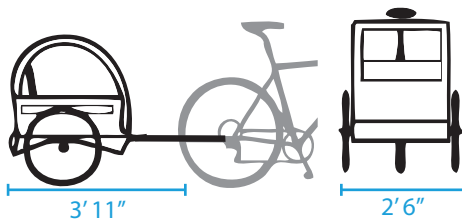
**B**  
TANDEM  
BICYCLE



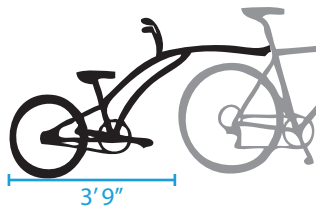
**C**  
SINGLE  
RECUMBENT  
BICYCLE



**D**  
CHILD  
TRAILER



**E**  
TRAILER  
BICYCLE



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

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 dimensions for bicycle types.

The City of Denver uses a commuter bicycle (Figure A) as a typical design vehicle when planning and engineering bicycle facilities. Where conditions allow, other bicycle types will be accommodated using best design practices.

**Design Speed Expectations**

The expectation that different types of bicyclists can maintain under various conditions also influences the design of facilities such as the width of shared use paths or the duration of bicycle signal phases at traffic signals. The table below provides typical bicyclist speeds for a variety of conditions.

**Bicycle Design Speed Expectations**

Bicycle Type	Feature	Typical Free Flow 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

Note: Tandem bicycles and bicyclists with trailers have typical free flow speeds equal to or less than upright adult bicyclists.

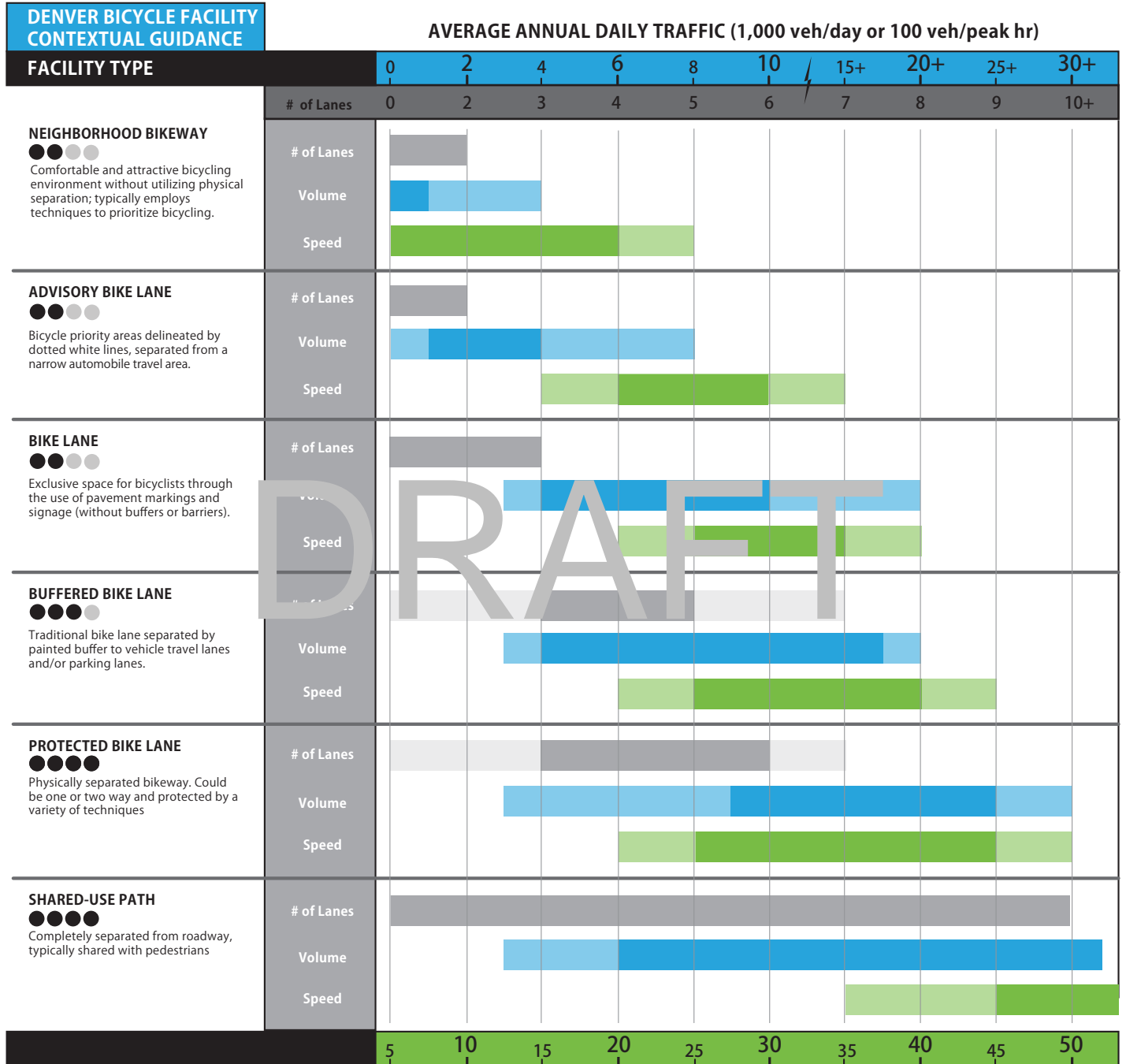


## BICYCLE FACILITY SELECTION

Selecting the best bikeway facility type for a given roadway can be challenging, due to the range of factors that influence bicycle users' comfort and safety. There is a significant impact on cycling comfort when the speed differential between bicyclists and motor vehicle traffic is high and motor vehicle traffic volumes are high. As a starting point to identify a preferred facility, the chart on the following page can be used to determine the recommended type of bikeway to be provided based on its vehicular configuration, speed and average annual daily traffic volume. To use this chart, identify the appropriate number of lanes, daily traffic volume and travel speed of the existing or proposed roadway, and locate the facility types created 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.

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**LEGEND**

SEPARATION	
●●●○	Minimal Separation
●●●○	Moderate Separation
●●●○	Good Separation
●●●●	High Separation

min	LANES	max
min	VOLUME	max
min	SPEED	max

Acceptable    Desired    Acceptable

POSTED TRAVEL SPEED (mph)





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Neighborhood bikeway in Portland, OR.



## NEIGHBORHOOD BIKEWAYS

### WHAT ARE THEY?

Neighborhood bikeways (also called “bicycle boulevards”) are low-volume, low-speed streets modified to enhance bicycle safety and comfort by using design treatments such as signage, pavement markings, speed and/or volume reduction features, and crossing improvements. These treatments generally encourage through movements of bicyclists while discouraging similar through-trips by non-local motorized traffic. Separated or protected bikeways are not generally necessary along neighborhood bikeways because street design itself creates a calm traffic environment where people biking and people driving can comfortably share the street.

# DRAFT

Denver Public Works’ non-motorized plan, Denver Moves Bicycle (2015) includes 97 miles of proposed neighborhood bikeways<sup>1</sup>. This accounts for nearly a quarter of the proposed bicycle network miles recommended for implementation. The neighborhood bikeways recommended in Denver Moves follow these design guidance principles.

### BENEFITS

These facilities offer a comfortable shared street environment on routes that are easy to find and follow using signs and pavement markings. Bikeways provide a range of benefits, including proximity to destinations, slow motor vehicle speeds, low or reduced motor vehicle volumes, minimal bicycle delay, safe and convenient crossings at major streets, clear and safe navigation at offstreet crossings, enhanced streetscapes and stormwater management opportunities. Many of the treatments presented in this section not only benefit people on bicycles, but they also help create calm neighborhood streets that benefit residents and improve safety for all street users.

<sup>1</sup> Denver Moves referred to neighborhood bikeways as “bike boulevards.”



## NEIGHBORHOOD BIKEWAYS

## ROUTE PLANNING

Neighborhood bikeways are established on streets that improve connectivity to key destinations and provide a direct, low-stress route for bicyclists. These are facilities with low motorized traffic volumes and speeds, designated and designed to give bicycle travel priority over other modes. Streets along classified neighborhood bikeways may require additional traffic calming measures to discourage through trips by motor vehicles and may need enhancement at intersections to create safe, convenient bicycle crossings at busy arterial streets.

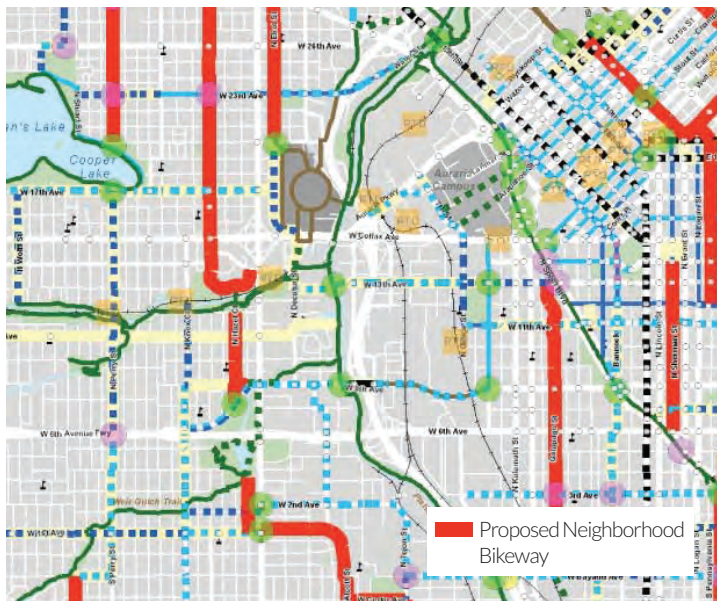
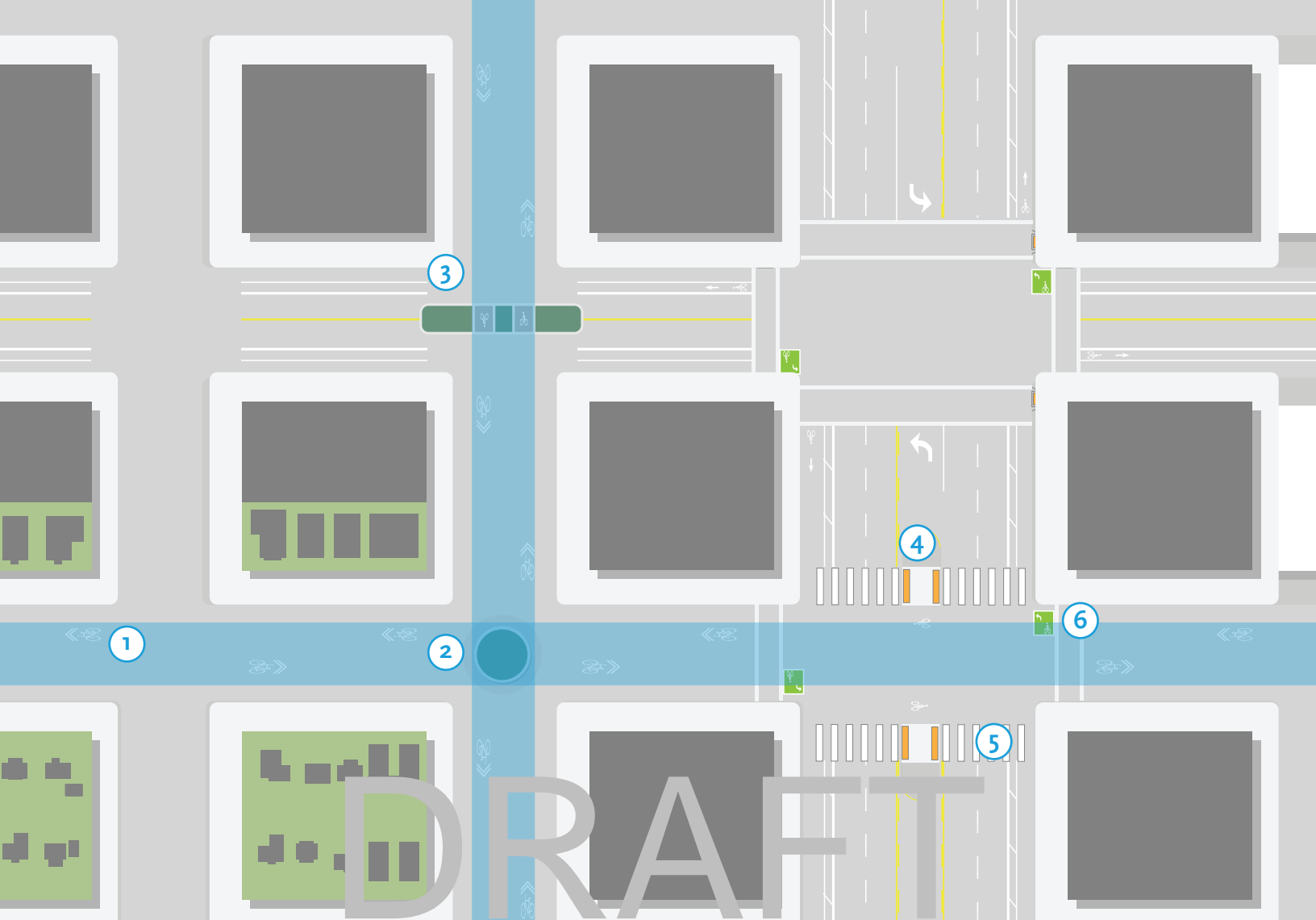
## BENEFITS

- Provides comfortable and attractive places to bicycle, attracting people of all ages and abilities.
- Signage and pavement markings serve as wayfinding for bicycle riders and also bring awareness to the street's status as a bikeway.
- Can benefit pedestrians, residents and other users through crossing improvements, traffic calming, landscaping, and reduced automobile volumes.
- Parking removal is less than other facilities with intersection treatments.

## TYPICAL APPLICATION

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





**NEIGHBORHOOD BIKEWAY NETWORK**  
City and County of Denver. *Denver Moves*, 2011.

## TREATMENT OPTIONS

- 1 SHARED LANE MARKINGS OR “SHARROWS”**  
Indicate a shared environment for all users, and also provides positioning guidance for bicyclists.
- 2 NEIGHBORHOOD TRAFFIC CIRCLE**  
Minor street crossing treatments that also provide traffic calming.
- 3 MEDIAN TRAFFIC DIVERTER WITH REFUGE ISLAND**  
Restrict through vehicle movements while providing refuge for bicyclists across one direction of traffic at a time at major street crossings.
- 4 MEDIAN REFUGE ISLAND**  
Placed at major street crossings to allow pedestrians and bicyclists to cross one direction of traffic at a time when gaps in traffic allow. Islands placed in the middle of the intersection also narrow the cross street, which may reduce speeds.
- 5 INTERSECTION CROSSING TREATMENTS**  
Pavement markings can be used to highlight to cross traffic that bicyclists and pedestrians are crossing the roadway at that location.
- 6 TWO-STAGE TURN QUEUE BOX**  
Can be used to provide a safe refuge for bicyclists on major streets that are turning left onto a neighborhood bikeway and waiting for a crossing opportunity.



## NEIGHBORHOOD BIKEWAYS

## SIGNS &amp; 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 for both bicyclists and motorists. Signs, and in some cases pavement markings, provide wayfinding to help bicyclists remain on the designated route.

## BENEFITS

- Signs and pavement markings differentiate neighborhood bikeways from other local streets, reminding people driving to watch for bicyclists.
- Decision signs marking the junction of two or more bikeways inform bicyclists of the designated bike route to access key destinations, including direction and distance.
- Pavement markings identify the route and can guide users through jogs in the route and navigating around intersections.

## TYPICAL APPLICATION

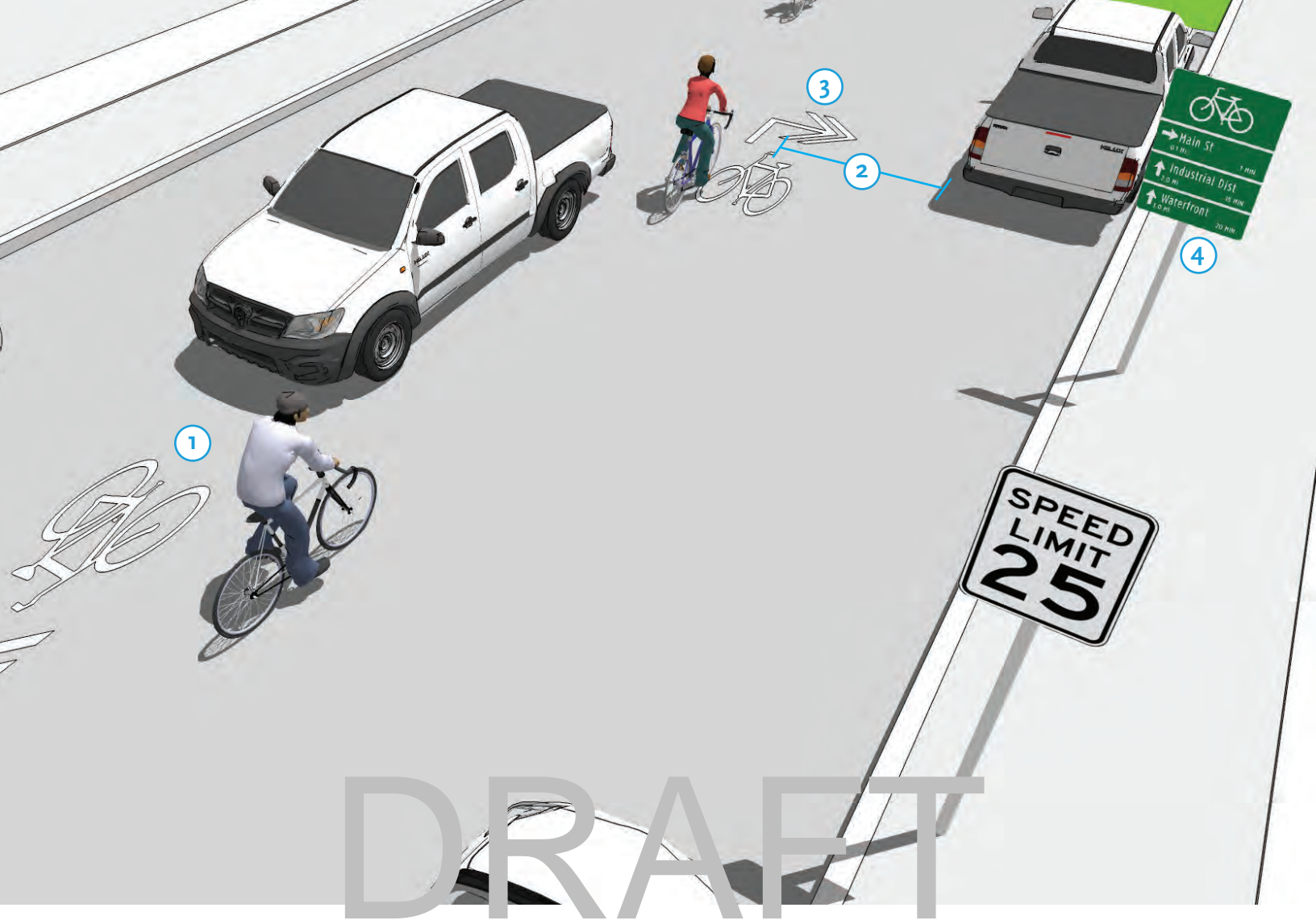
- Place pavement marking symbols every 150-300 feet along a neighborhood bikeway, as well as after every intersection.
- Supplemental street name signs may identify and brand the route without introducing a new sign. See example below.
- In narrow streets where a motor vehicle cannot pass a bicyclist within one lane of traffic, place pavement marking symbols in the center of the travel lane. Where on-street parking exists, the markings should be at least 4' from edge of the parking lane.
- Place wayfinding signage where two bikeways cross or when the bikeway route jogs.



## REFERENCES

NACTO. *Urban Street Design Guide*. 2013.





## TREATMENT OPTIONS

- 1 SHARED LANE MARKINGS OR "SHARROWS"**  
 Indicate a shared environment and sometimes direction and alerts motor vehicle drivers to the potential presence of bicyclists.
- 2 SUGGESTED BICYCLE AREA**  
 Provides positioning guidance for bicyclists outside of the door zone
- 3 PROVIDES A WAYFINDING ELEMENT ALONG BIKE ROUTES**  
 Neighborhood bikeway routes are sometimes circuitous, and clear route directions are important to provide.
- 4 SIGNAGE INDICATES TO BICYCLISTS THAT THEY ARE ON A DESIGNATED BIKEWAY**  
 Makes motorists aware of the bicycle route.



## NEIGHBORHOOD BIKEWAYS

## TRAFFIC CALMING

## TREATMENTS TO REDUCE SPEEDS

Traffic calming may include elements intended to reduce the speeds of motor vehicle traffic to be closer to bicyclist travel speeds. Although traffic calming is not used everywhere in Denver, application on neighborhood bikeways is possible.

Traffic calming treatments can cause drivers to slow down by constricting the roadway space or by requiring careful maneuvering. Such measures may reduce the design speed of a street, and can be used in conjunction with reduced speed limits to reinforce the expectation of lowered speeds.

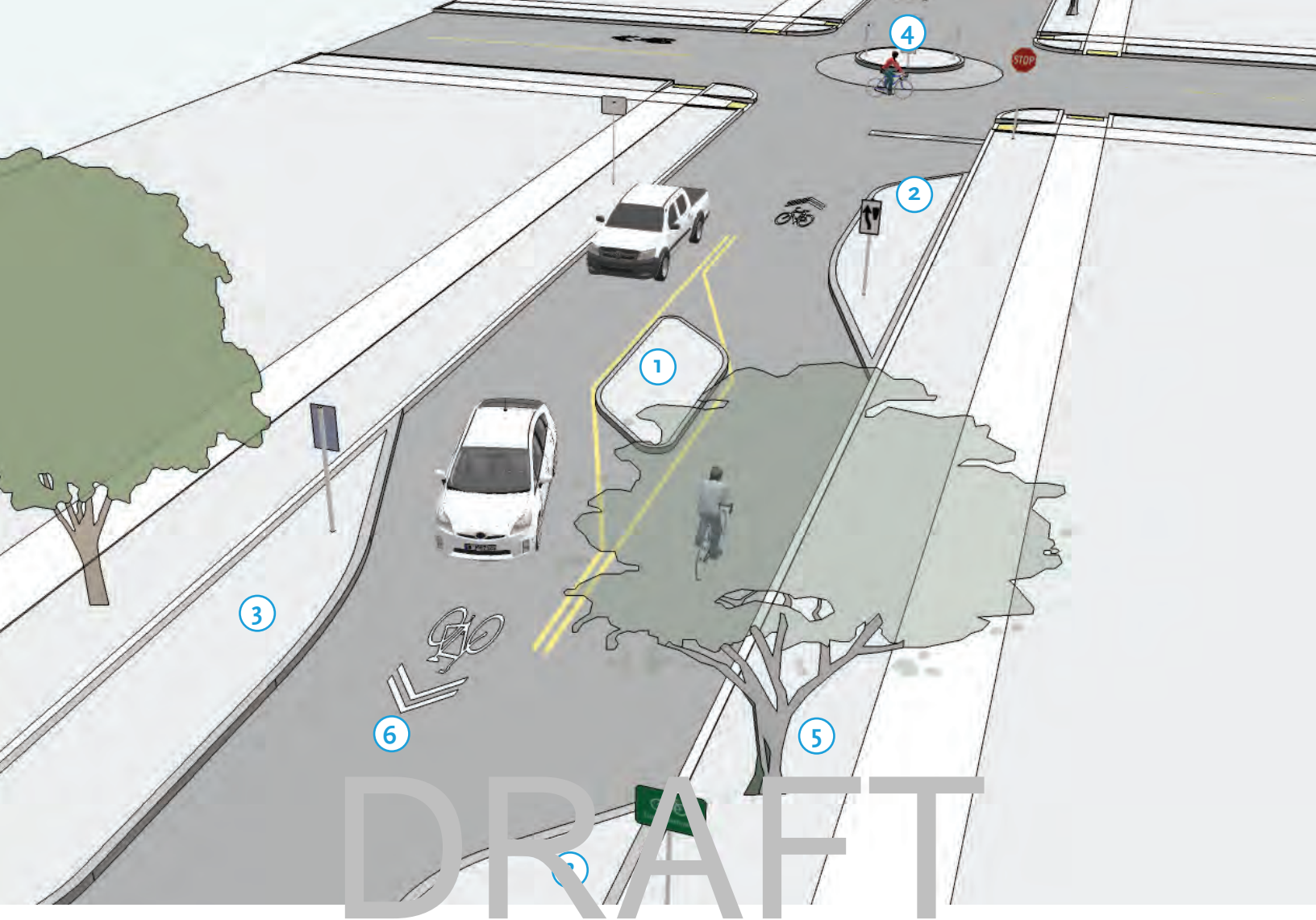
## BENEFITS

- Improves conditions for bicyclists, pedestrians, and residents along the neighborhood bikeway.
- Reduced travel speeds decrease the number of passing events between bicyclists and motor vehicles, reducing exposure to risks.
- Reduced travel speeds result in reduced injury severity in the event of a collision.

## TYPICAL APPLICATION

- Neighborhood bikeways should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 20 mph (25 mph maximum). Bikeways with average speeds above this limit should be considered for traffic calming measures.
- Maintain a minimum clear lane width of 18 feet with a constricted length of at least 20 feet in the direction of travel.
- 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 TRAFFIC CIRCLE**

Madison, Wisconsin

## TREATMENT OPTIONS

- 1 MEDIAN ISLAND**  
Creates pinchpoint for traffic in the center of the roadway and offers shorter crossing distances for pedestrians when used in tandem with a marked crossing.
- 2 CHICANE**  
Slows drivers by requiring vehicles to shift laterally through narrowed lanes and which avoids uninterrupted sightlines.
- 3 PINCHPOINT/CHOKER/CURB EXTENSION**  
Restrict motorists from operating at high speeds on local streets by visually narrowing the roadway.
- 4 NEIGHBORHOOD TRAFFIC CIRCLE**  
Reduces speed of traffic at intersections by requiring motorists to move cautiously through conflict points.
- 5 STREET TREES**  
Narrow a driver's visual field and creates a consistent rhythm and canopy along the street, which provides a unified character and facilitates place recognition.
- 6 SHARROW SYMBOL**  
Shared lane markings identify the route as a neighborhood bikeway, can guide users through jogs, and provide lane position guidance for bicyclists.



## NEIGHBORHOOD BIKEWAYS

## TRAFFIC CALMING

## TREATMENTS TO REDUCE VOLUMES

Traffic calming may include design elements that restrict certain movements for motorized travel to discourage the use of neighborhood bikeway corridors for through travel by automobiles by physically or operationally reconfiguring corridors and intersections along the route. Lower vehicle volumes increase bicyclists' comfort and reduce the number of potential conflicts.

Volume control treatments may be implemented based on the context of the neighborhood bikeway.

## BENEFITS

- Establishes and reinforces bicycle priority by restricting vehicle through movements.
- Improves bicyclist comfort and benefits pedestrians and residents by reducing traffic volumes along the bikeway.

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## TYPICAL APPLICATION

- Ideally 1,500 cars per day (3,000 cars per day maximum). Bikeways with daily volumes above this limit should be considered for traffic calming measures.
- Where traffic calming or diversion cannot reduce volumes below this maximum threshold, another bike facility type should be considered.
- While traffic calming methods are designed to restrict motor vehicle access, bicyclist passage should always be allowed.
- May be combined with recommended treatments at major street crossings.

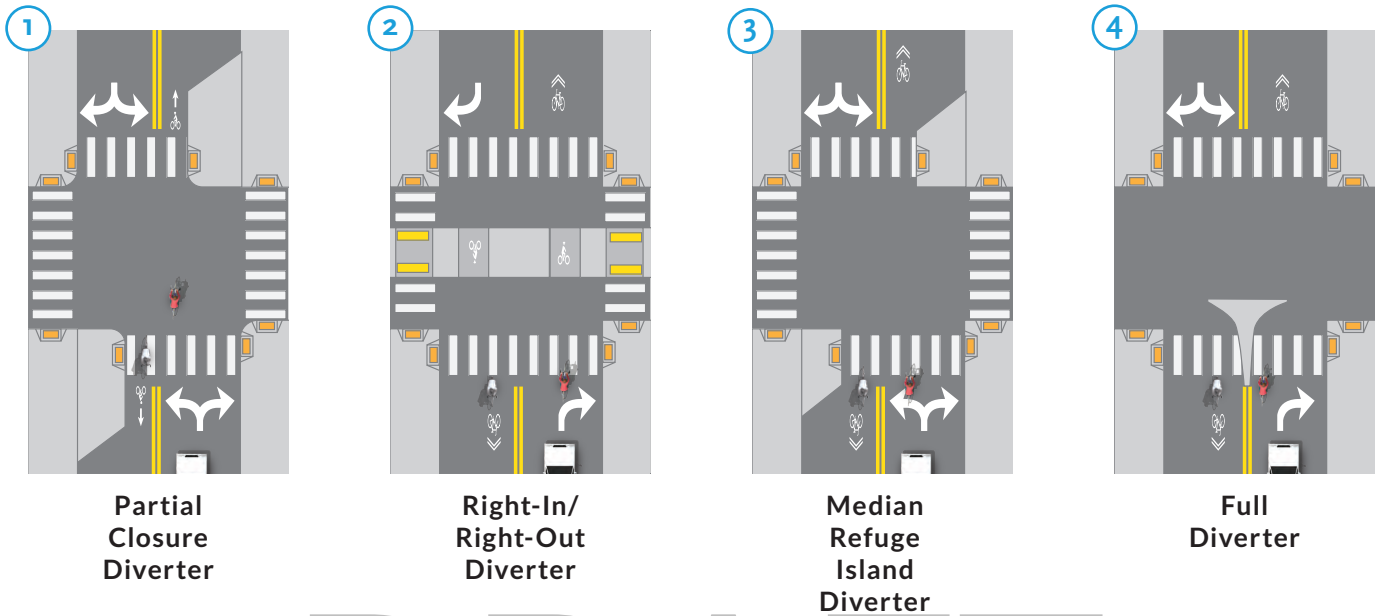
## REFERENCES

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- NACTO. *Urban Bikeway Design Guide*. 2012.
- Ewing et al. *U.S. Traffic Calming Manual*. 2009.
- Ewing, Reid. *Traffic Calming: State of the Practice*. 1999.





## TRAFFIC CALMING TREATMENTS TO REDUCE VOLUMES



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**FORCED RIGHT TURN**

Palo Alto, CA

### TREATMENT OPTIONS

- 1 PARTIAL CLOSURE DIVERTER**  
Allows bicyclists to proceed straight across the intersection but forces motorists to turn left or right. All turns from the major street onto the bikeway are prohibited. Can incorporate curb extensions with stormwater management features and/or a mountable island.
- 2 RIGHT-IN/RIGHT-OUT DIVERTER**  
Forces motorists to turn right while bicyclists can continue straight through the intersection. The island can provide a through bike lane or bicycle access to reduce conflicts with right-turning vehicles. Left turns from the major street onto the bikeway are prohibited, while right turns are still allowed.
- 3 MEDIAN REFUGE ISLAND DIVERTER**  
Restrict through and left-turn vehicle movements along the bikeway while providing refuge for bicyclists to cross one direction of traffic at a time. This treatment prohibits left turns from the major street, while right turns are still allowed.
- 4 FULL DIVERTER (OR CUL-DE-SAC)**  
Blocks all motor vehicles from continuing on a neighborhood bikeway, while bicyclists can continue unrestricted. Full closures can be constructed to be permeable to emergency vehicles.



## NEIGHBORHOOD BIKEWAYS

## MINOR STREET CROSSINGS

Minor Street Crossings are where neighborhood bikeways cross another local or residential collector street at unsignalized intersections and motor vehicle volumes and speeds are low. 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 street users.

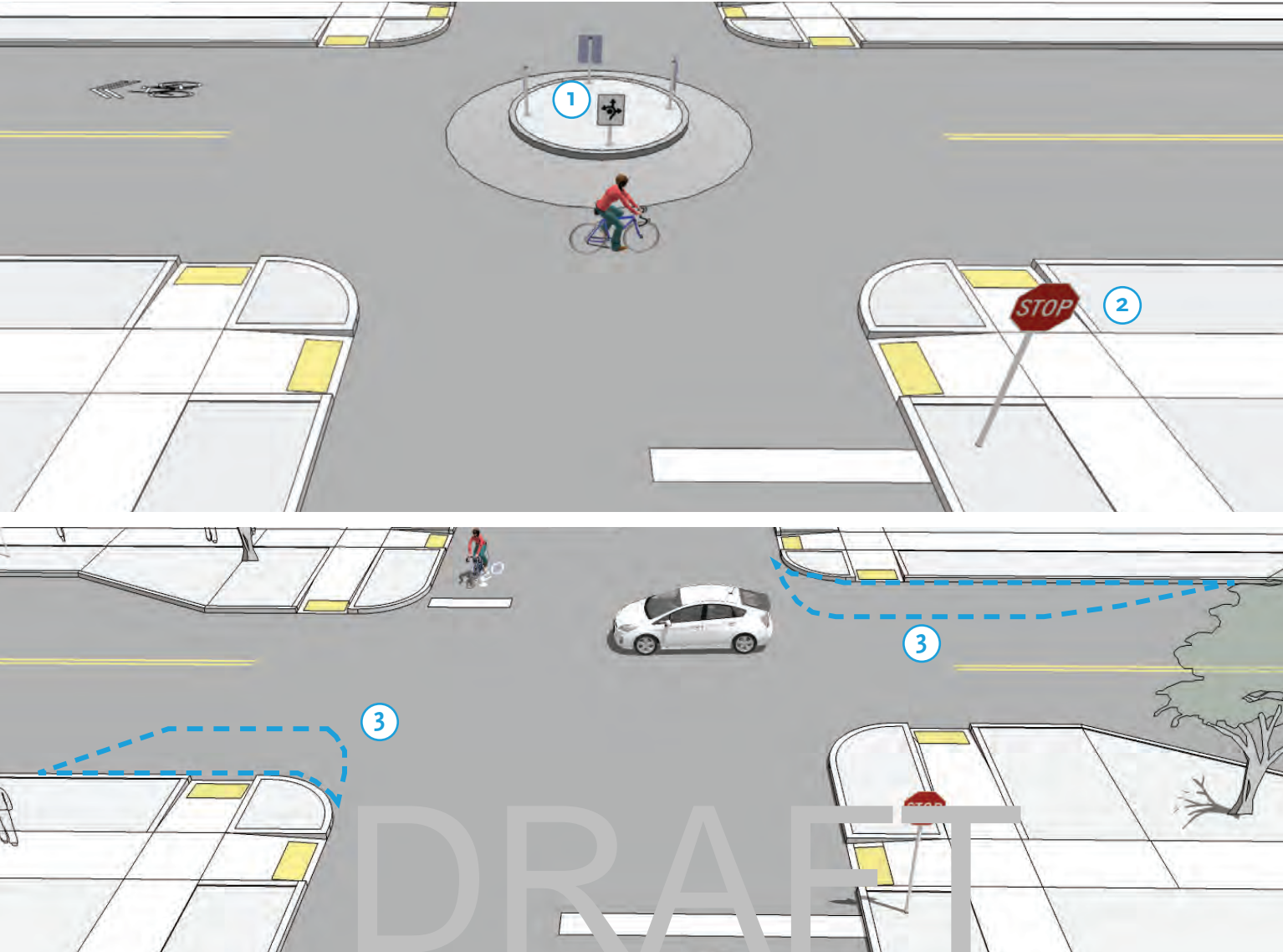
At these intersections, bikeways should have right-of-way priority to limit the number of stop signs and reduce bicycle delay along the route. Speed and volume control measures should be used in coordination with these treatments to prevent motorists from using the facility as a shortcut.

## BENEFITS

- Enable bicyclists to ride along the corridor with few stops which significantly reduce travel time, minimizes rider effort, and can improve stop compliance.
- Increases safety at intersections for all modes by improving visibility, maintaining appropriate speeds and reducing conflict potential and severity.

## TYPICAL APPLICATION

- At uncontrolled intersections of minor streets, neighborhood traffic circles may be used to reduce conflicts and maintain appropriate speeds.
- May be combined with recommended treatments at major street crossings.
- Along the neighborhood bikeway, the majority of stop signs should be turned towards cross traffic to maximize through bicycle connectivity and preserve momentum, if possible. Maximum frequency should be 1/4 mile.



**NEIGHBORHOOD TRAFFIC CIRCLE**

Bmore Bikes. Baltimore Bike Community, 2013.

## TREATMENT OPTIONS

- 1 NEIGHBORHOOD TRAFFIC CIRCLE**  
 Raised or delineated islands placed at minor street intersections that may be used to control intersection priority and slow motor vehicles.
- 2 STOP SIGN ON CROSS STREET**  
 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 every block is stop-controlled.
- 3 CURB EXTENSION**  
 Extending the curb at intersections can shorten crossing distance, creating conditions for bicyclists to more easily cross local and collector streets. Optional curb extensions have a dashed outline above.

Treatments presented on page 17 provides further guidance for minor street crossing treatments that calm traffic and reduce volumes.



## NEIGHBORHOOD BIKEWAYS

## MAJOR STREET CROSSINGS

Major Street Crossings are where neighborhood bikeways cross arterials and major collectors with right-of-way priority, either at signalized or unsignalized intersections. Motor vehicle speeds and volumes on these cross streets are generally moderate to high. These crossings pose a significant access and connectivity barrier and compromise safety for bicyclists and pedestrians.

Neighborhood bikeway retrofits are typically located on local streets without existing signalized accommodation at collector and arterial roadway crossings. Selection of crossing treatments depend on a variety of factors, including roadway width, speed, visibility, and the number and regularity of crossing gaps. The quality of treatments at major street crossings can significantly affect a bicyclist's choice to use a neighborhood bikeway, as opposed to another street that provides a crossing treatment.

## BENEFITS

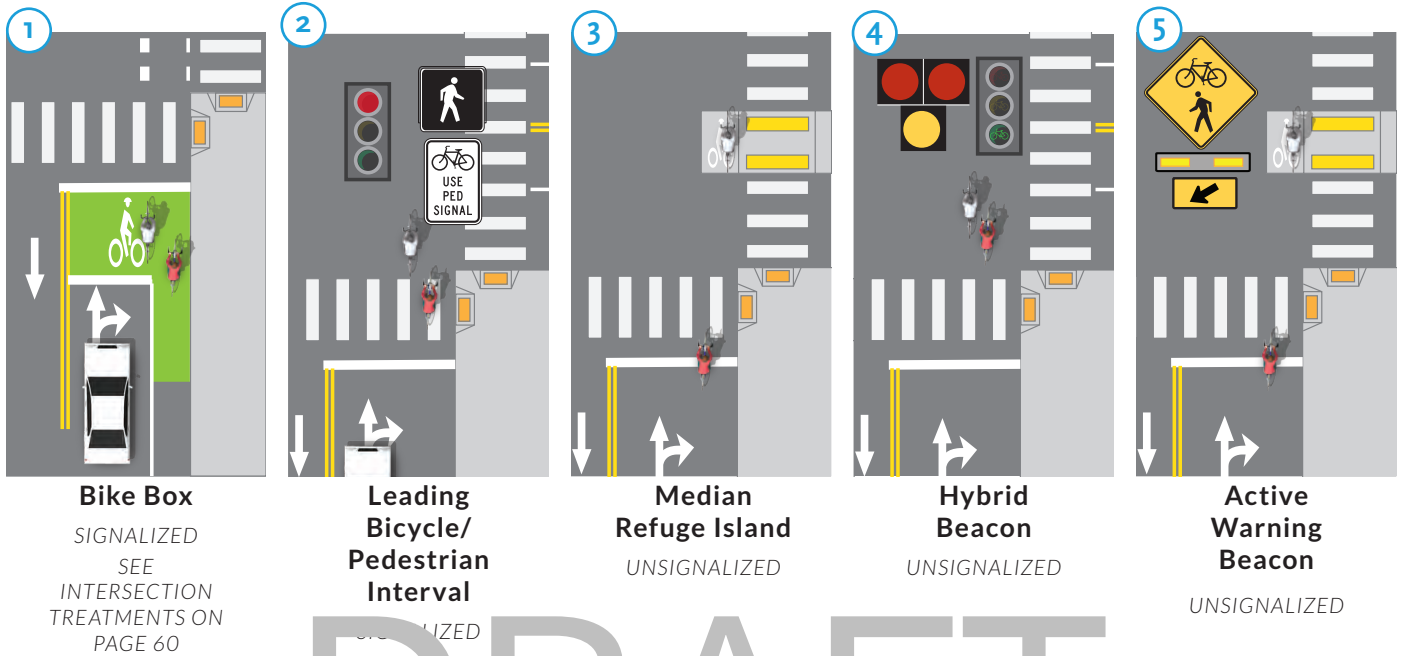
- Fills gaps in the active transportation network by improving access and connectivity, especially where there is no existing signal at major crossings.
- Improves safety conditions for bicycles and pedestrians by reducing crossing distance, improving visibility, encouraging or requiring driver yielding behavior, and raising awareness for all modes of potential conflict areas.

## TYPICAL APPLICATION

- Anywhere neighborhood bikeways intersect streets that are not stop controlled from the major approach (generally higher order streets such as major collectors and arterials).
- Major street crossing treatments should be selected based on traffic volumes, lane configurations, presence of medians and traffic control devices.



## MAJOR STREET CROSSING TREATMENTS



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BIKE SIGNAL

Portland, OR

### TREATMENT OPTIONS

- 1 BIKE BOX**  
Paired with traffic signals to allow bicyclists to position themselves ahead of automobiles waiting at the intersection and allow many bicyclists to move quickly through short duration green signals (see page 60 for further guidance).
- 2 LEADING INTERVAL OR PROTECTED BICYCLE SIGNAL PHASING**  
To enhance safety and visibility and reinforce right-of-way over turning vehicles, leading pedestrian walk signals provide pedestrians and bicyclists a 3-7 second head start ahead of traffic, when paired with MUTCD R9-6 signage and optional bike box. In high-conflict areas, protected bicycle signal phasing completely separates bicycle movements from all other traffic conflicts.
- 3 MEDIAN REFUGE ISLAND**  
Provides bicyclists and pedestrians refuge to cross one direction of traffic at a time at major crossings. Can also incorporate diversion to prohibit left turns by motor vehicles on the cross street and through or left turn movements on the bikeway.
- 4 HYBRID BEACON (OR HAWK)**  
Used to facilitate safe bicycle and pedestrian crossing where a bikeway intersects with major streets, in conjunction with advance warning signage and crosswalk markings. Provides positive stop control for areas that lack requisite side street volumes to warrant a full signal, or where full signal installation is not warranted. See MUTCD for guidance on applicable locations.
- 5 ACTIVE WARNING BEACON (OR RAPID FLASH BEACON)**  
Can be placed across a neighborhood bikeway crossing of a major street, in conjunction with a median island, advance warning signage and crosswalk markings to alert drivers to crossing bicyclists and pedestrians and to increase yield behavior.



NEIGHBORHOOD BIKEWAYS

# OFFSET INTERSECTIONS

Offset intersections are junctions at which two streets in a designated neighborhood bikeway corridor align asymmetrically with an intersecting roadway. Discontinuities in the street grid can periodically require riders using bikeways to turn briefly onto another street before resuming in the original direction. These intersections can be challenging for bicyclists who are required to briefly travel along the busier cross street in order to continue along a neighborhood bikeway.

Selection of the appropriate treatment depends on the width and traffic characteristics of the intersecting roadway and on whether the bikeway jogs to the right or to the left. Wayfinding and pavement markings assist bicyclists with remaining on the route.

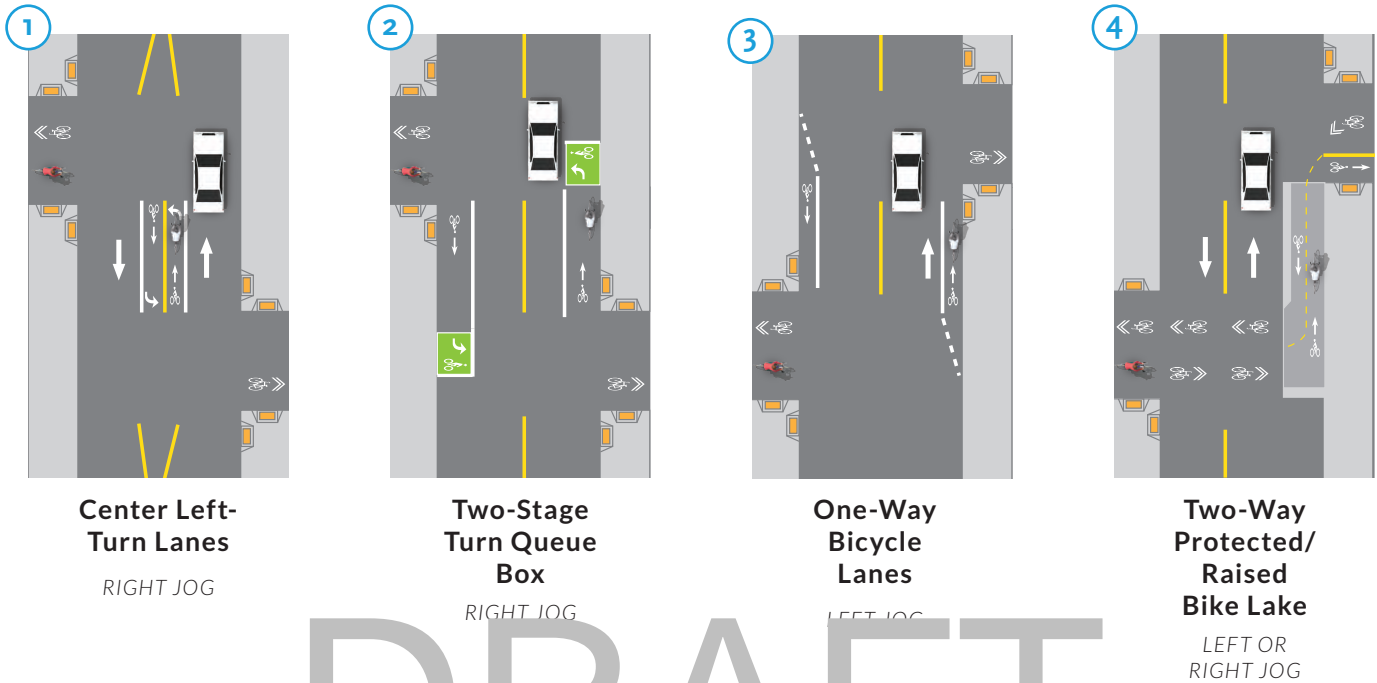
**BENEFITS**

- Creates a higher-quality overall bikeway network by providing safer conditions for crossing and turning or when using the short connecting street section.
- Provides continuity to neighborhood bikeway routes over a discontinuous street network.
- Establishes a low-stress connection with wayfinding elements for neighborhood bikeways that jog at one or multiple intersections, especially along busier cross streets.

**TYPICAL APPLICATION**

- Where a neighborhood bikeway has to turn or travels for a brief distance on another street.
- Select offset intersection treatments based on cross street volumes, lane configurations, direction of offset, presence of medians, and traffic control devices.

## OFFSET INTERSECTION TREATMENTS



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CENTER LEFT-TURN LANES

Portland, OR

### TREATMENT OPTIONS

- 1 CENTER 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.
- 2 TWO-STAGE TURN QUEUE BOX**  
At intersections with busier streets that may or may not include bicycle lanes, a two-stage turn queue box placed in the on-street parking lane can be used to provide a safe refuge for bicyclists that are waiting to turn left to continue on the neighborhood bikeway.
- 3 ONE-WAY BICYCLE LANES**  
Short bike lanes on the cross street assist with accessing a neighborhood bikeway that jogs, typically to the left. Crossing treatments should be provided on both sides to minimize wrong-way riding. Protected or raised bicycle lanes can be used to increase comfort at greater cost.
- 4 TWO-WAY PROTECTED/RAISED BICYCLE LANE**  
Can be provided on one side of a busy street to connect neighborhood bikeway segments. This maneuver may be signalized on one side and is typically protected using a physical barrier or raised above street level.  
  
Additional offset intersection treatments include bike boxes and bicycle signals (identified in other sections).



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Conventional bike lane along W 22<sup>nd</sup> Avenue in Denver.



## SEPARATED BIKEWAYS

### WHAT ARE THEY?

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

### TYPES OF FACILITIES

Separated bikeways come in a variety of forms:

#### CONVENTIONAL BIKE LANE

Designated for the exclusive use of bicycle riders using pavement markings and signage, generally between 5-7 feet wide and delineated with paint.

#### OFFERED BIKE LANE

Conventional lanes paired with a painted 2-3 foot buffer for increased separation between the bicycle lane and adjacent general travel and/or parking lanes.

#### ADVISORY BIKE LANE

Used on narrow, low-volume streets to provide a designated space for bicycle riders but also available to motorists if needed to pass oncoming traffic.

#### SHARED BIKE AND PARKING LANES

In areas which have limited, but intense on-street parking needs, lanes operate as de-facto bicycle lanes during periods of low parking.

### BENEFITS

Separated bikeways can increase safety and promote proper riding by:

- Defining street space for bicyclists and motorists.
- Discouraging bicyclists from riding on the sidewalk.
- Reducing the incidence of wrong way riding.
- Reminding motorists that bicyclists have a right to the street.

# DRAFT



## SEPARATED BIKEWAYS

## ADVISORY BIKE LANES

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

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

## BENEFITS

- Creates priority for bicyclists in what would otherwise be a shared-roadway condition.
- Increases predictability of bicyclist and motorist positioning and interaction.

## TYPICAL APPLICATION

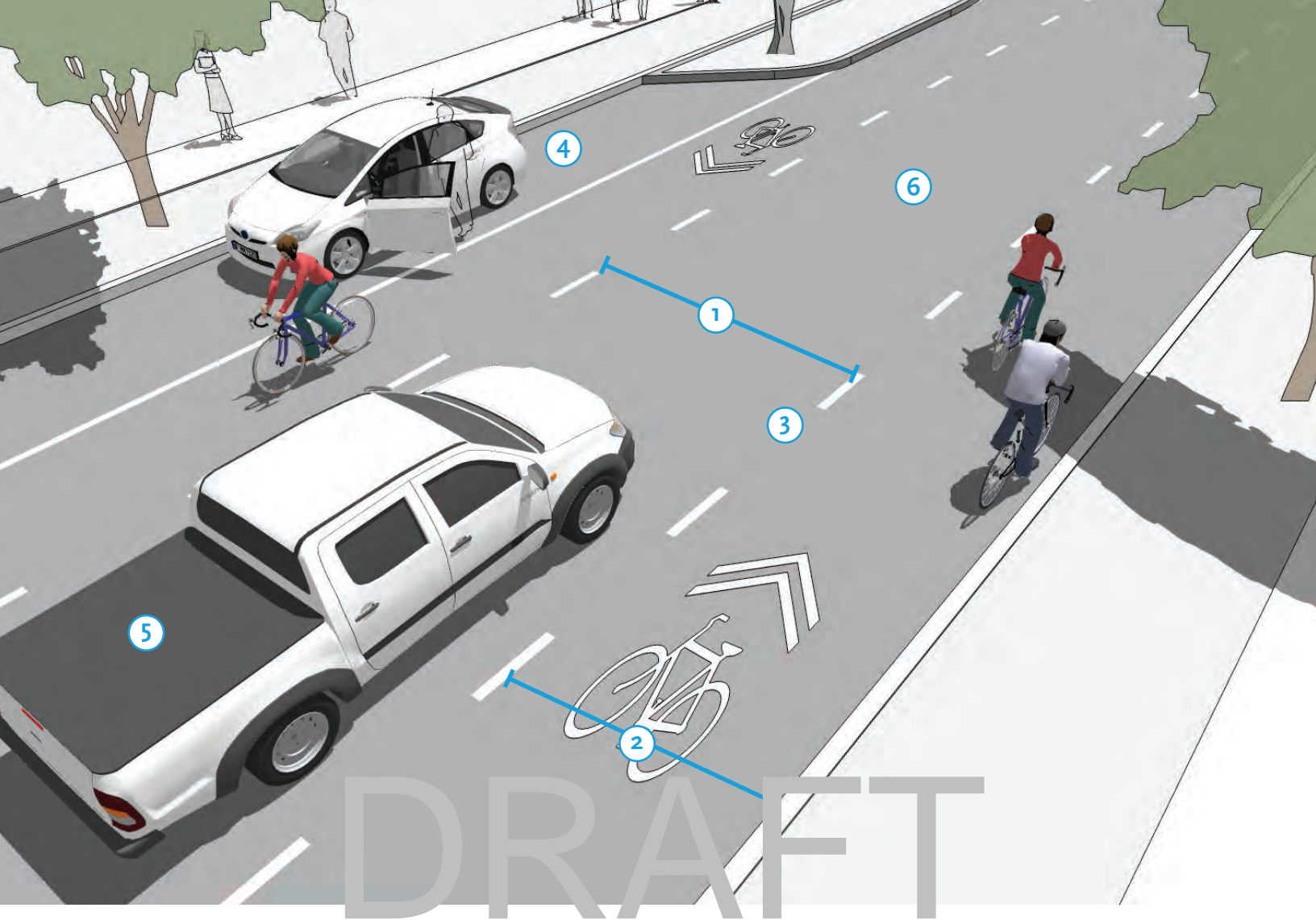
- Suitable for two-way streets where the speed/volume characteristics do not support shared operation between motorists and bicyclists and there is insufficient right-of-way for conventional bicycle lanes without challenging trade-offs.
- On-street parking may be included if there is the expectation of high utilization.
- No curbside center line installed on the existing roadway. Straight roadway segments with low bends, incline or sightline obstructions are preferred.
- Can be used on roadways with motor vehicle volumes between 1,500-4,000 ADT (<3000 ADT is preferred).



## REFERENCES

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





## DESIGN CRITERIA

- 1 **CENTER TWO-WAY TRAVEL LANE: 14-16' RECOMMENDED WIDTH**  
Opposing vehicles to negotiate space.
- 2 **ADVISORY BIKE LANE: 5-7' RECOMMENDED WIDTH**  
Provide positioning guidance for bicyclists
- 3 **DASHED LANE LINES**  
Permits encroachment as needed.
- 4 **HIGH UTILIZATION PARKING OR FREQUENT CURB EXTENSIONS**  
Defines the edge of the travelway.
- 5 **PEOPLE DRIVING YIELD TO BICYCLISTS**  
Drivers must pass with care.
- 6 **NO CONTINUOUS CENTERLINE**  
Promotes safer vehicle passing maneuvers by giving bicyclists more clearance.



ADVISORY BIKE LANES

Hanover, NH



## SEPARATED BIKEWAYS

## CONVENTIONAL BIKE LANES

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, street edge or parking lane.

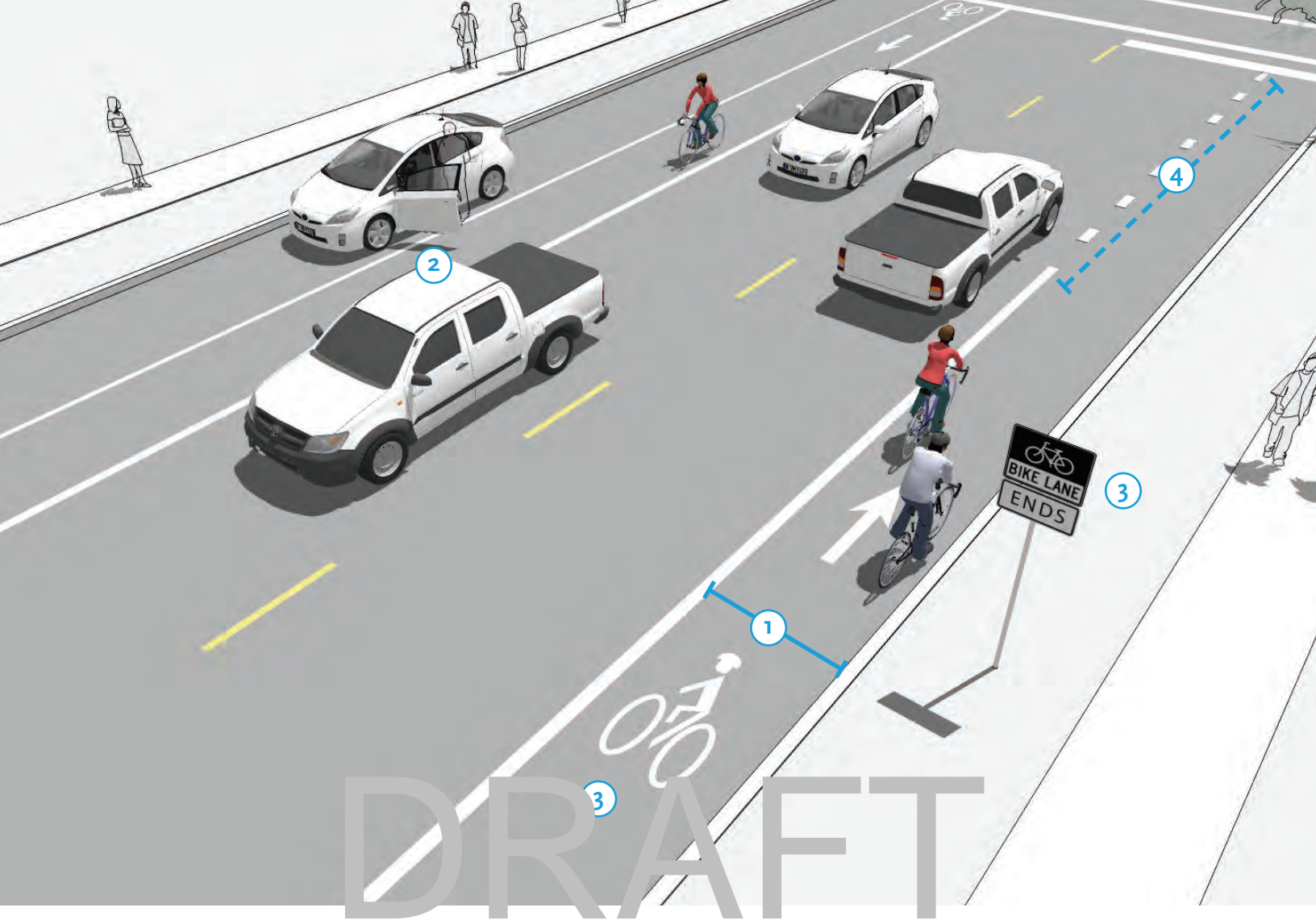
## BENEFITS

- Creates separation between bicyclists and automobiles.
- Increases predictability of bicyclist and motorist positioning and interaction.
- Increases total capacities of streets carrying mixed bicycle and motor vehicle traffic.
- Visually reminds motorists of bicyclists' right to the street.

## TYPICAL APPLICATION

- Suitable for collectors and arterials when ADT is 3,000 at minimum with the ideal range between 4,000-10,000 ADT
- Motor vehicle speeds should be at least 25 mph or greater.
- Typically located on the right side of roadway either adjacent to the curb or a curbside parking lane (if available). Where parking experiences higher turnover, there is preference for additional bikeway width.
- Truck traffic should consist of 2 percent or fewer of overall ADT.
- Left side bicycle lanes may be preferred on one-way streets or two-way median divided streets where there heavy right-turning traffic onto streets or driveways, or if there is a desire to reduce conflicts between buses and bicycle riders on streets with high transit activity.
- Contraflow bicycle lanes are designed to allow bicyclists to ride in the opposite direction of motor vehicle traffic, converting a one-way traffic street into a two-way street for bicycles. These lanes are separated with double yellow centerline striping.





14<sup>TH</sup> STREET CONVENTIONAL BIKE LANE

Denver, CO

## DESIGN CRITERIA

- 1 DESIRED BIKE LANE DIMENSIONS: 6 FEET WIDTH**

Minimum dimensions vary with curbface conditions:

  - 4 foot minimum width when no curb and gutter is present.
  - 6 foot minimum width when adjacent to curb and gutter, or 3 feet more than the gutter pan width if the gutter pan is wider than 2 feet.
  - 5 foot minimum when adjacent to on-street parking, with consideration of a 2-3 foot parking-side buffer.
- 2 REDUCE CAR DOOR CONFLICTS**

Separation between bike lane striping and parking boundary reduces risks.
- 3 "BIKE LANE" SIGNAGE AND MARKINGS**

Bike lane signage may be located at the beginning and end of a bike lane. Symbol markings are used to define the bike lane and designate that portion of the street for preferential use by bicyclists, and shall be placed outside of the motor vehicle tread path at the far side beyond intersections, driveways, and merging areas in order to minimize wear.
- 4 DASHED LINES AT BUS STOPS AND SIGNALIZED INTERSECTIONS**

Alert cyclists to potential conflicts with transit and turning vehicles at designated stops and intersections.



## SEPARATED BIKEWAYS

## BUFFERED BIKE LANES

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

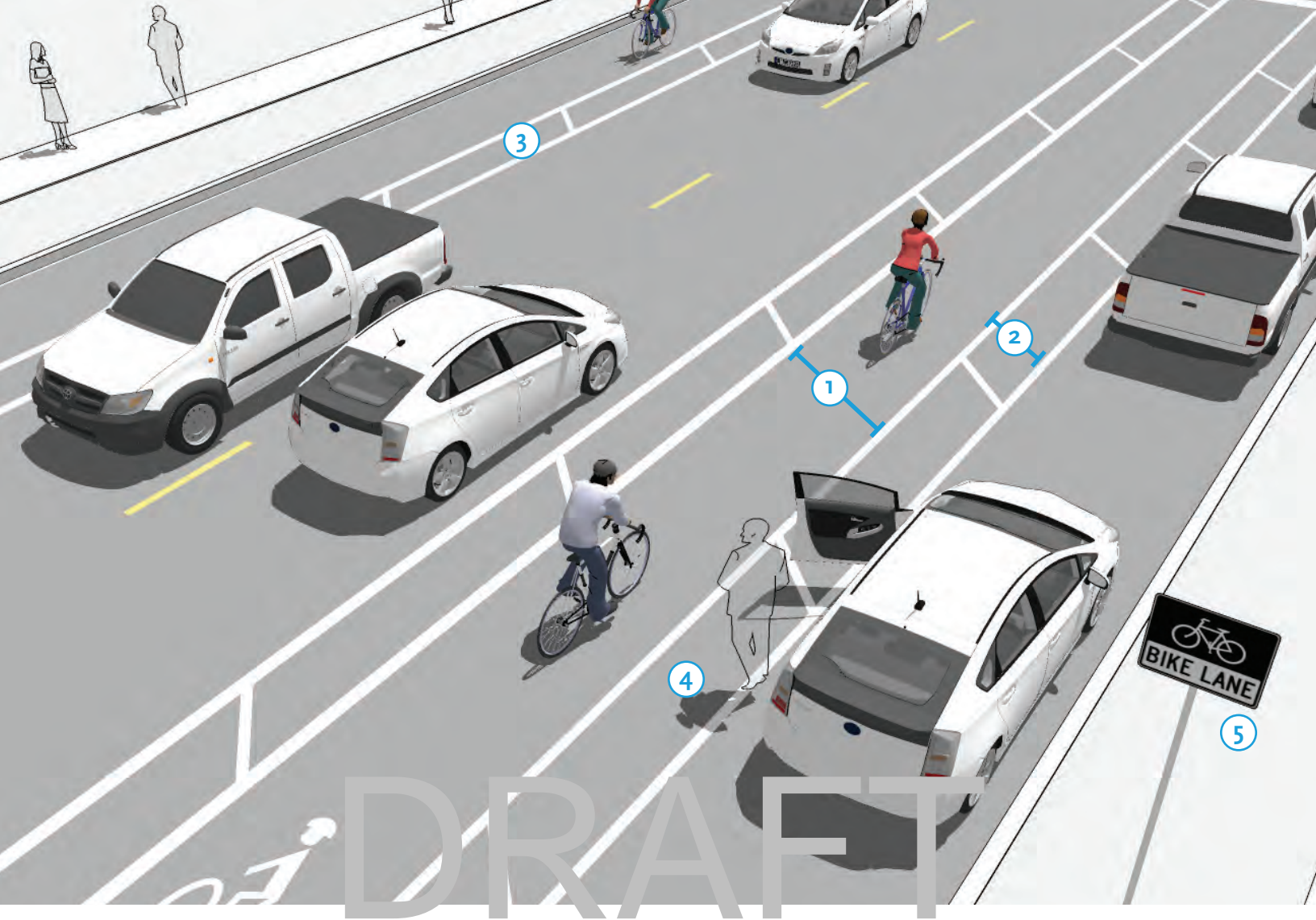
## BENEFITS

- Provides greater distance between motor vehicles and adjacent bicyclists.
- Provides space for bicyclists to pass another bicyclist without encroaching into the adjacent motor vehicle travel lane.
- Encourages bicyclists to ride outside of the door zone when buffer is between parked cars and bike lane.
- Provides a greater space for bicycling without making the bike lane appear so wide that it might be mistaken for a travel lane or a parking lane.

## TYPICAL APPLICATION

- Suitable for collectors and arterials when ADT is 3,000 at minimum with the ideal range between 4,000-17,000 ADT
- Motor vehicle speeds should be at least 20 mph or greater.
- Typically located on the right side of roadway either adjacent to the curb or a curbside parking lane (if available).
- Truck traffic should consist of 2-10 percent of overall ADT.
- Left side bicycle lanes may be preferred on one-way streets or two-way median divided streets where there heavy right-turning traffic onto streets or driveways, or if there is a desire to reduce conflicts between buses and bicycle riders on streets with high transit activity.
- There is no standard for whether the buffer is configured on the parking side, the travel side, or a combination of both. The exact configuration should be based on available road width and the objectives of the design.
- A travel side buffer is ideal to improve bicyclist comfort when automobile and truck volumes and speeds are relatively high. A parking side buffer is preferred in areas of high parking turnover and improve safety by reducing conflicts with opening car doors. Along corridors with relatively high bicycle and automobile travel volumes and parking activity, a buffer is preferred on both sides of the bicycle lane.





**CHAMPA STREET BUFFERED BIKE LANE**

Denver, CO

## DESIGN CRITERIA

- 1 BIKE TRAVEL AREA DIMENSIONS: 5 FEET MINIMUM WIDTH**  
 Where bicyclist volumes are high, bicycle speed differentials are significant, or where side-by-side riding is desired. Preferred bicycle travel area dimensions is 7 feet wide.
- 2 BUFFER DIMENSIONS: 3 FEET WIDTH PREFERRED**  
 Buffer should be marked with 2 solid white lines with interior diagonal cross hatching. For clarity at driveways or minor street crossings, consider a dotted line for the buffer boundary where cars are expected to cross. In constrained conditions, the minimum width for a buffer is 1 foot 8 inches.
- 3 TRAVEL LANE BUFFER**  
 Creates a lower-stress facility for bicycle riders on busier streets.
- 4 PARKING SIDE BUFFER**  
 Separation between bike lane striping and parking to reduce risks of car door conflicts.
- 5 "BIKE LANE" SIGNS**  
 Optional features such as signage may be located at the beginning and end of a marked bike lane.

Travel lane buffer (3) and parking side buffer (4) can be combined.



## SEPARATED BIKEWAYS

## SHARED BIKE AND PARKING LANES

Shared bike and parking lanes are marked parking lanes which have a very low weekday utilization rate and/or few street facing residences. The parking lanes provide overflow parking for adjacent perpendicular residential streets or adjacent land uses such as churches, schools, or recreation facilities which have limited, but intense on-street parking needs. During periods of low parking use or restricted parking use the parking lane can operate as a de-facto bicycle lane or shoulder for bicycle use.

### BENEFITS

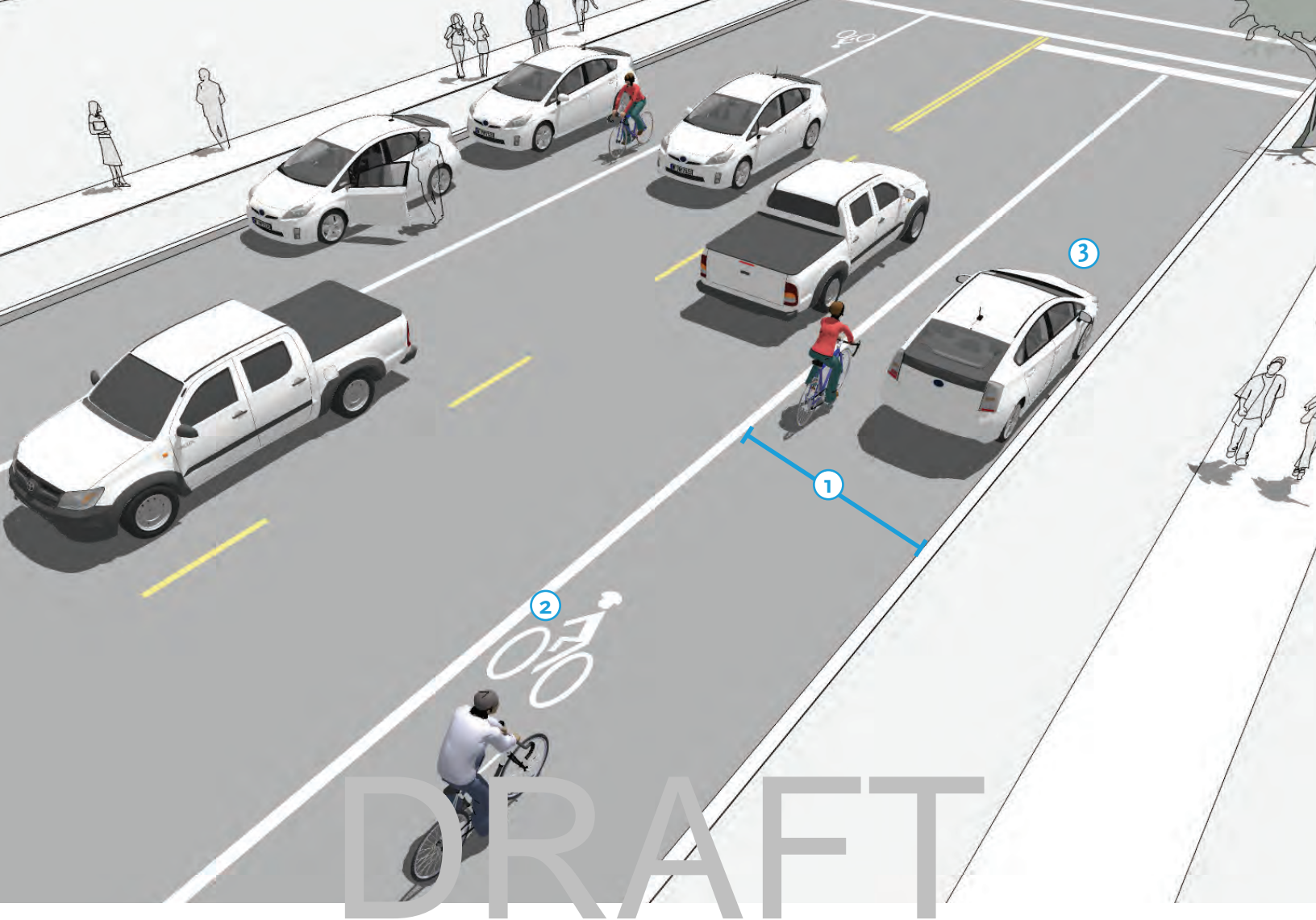
- Increases separation from vehicular traffic and reduces stress caused by acceleration and operating speed differentials between bicyclists and motorists.
- Allows for bicycle facilities on streets with on-street parking that are not otherwise wide enough to provide full-width bicycle lanes.

### TYPICAL APPLICATION

- Consider where the removal of parking is not feasible due to high parking demands from adjacent land uses during specific times.
- Located on streets in residential neighborhoods with limited commercial activity.
- Use streets with generally 5-10% parking occupancy along each block during off peak times. Blocks with higher occupancy will result in undesirable conditions where cyclists will be required to weave in and out of traffic or stop for gaps in traffic to pass parked vehicles, compromising rider comfort and safety.

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SHARED BIKE AND PARKING LANE ALONG FRANKLIN STREET

Denver, CO

## DESIGN CRITERIA

- 1 SHARED BIKE LANE/PARKING LANE**  
 9-10 feet from curb to edge line. Lines should be continuous through driveways.
- 2 BIKE LANE SYMBOL**  
 Indicates bicycle use of lane.
- 3 LOW PARKING UTILIZATION**  
 5- 10% utilization in off peak times. Consider restricting parking during times of low parking utilization to avoid door zone conflicts.



One-way protected bike lane along Bannock Street in Denver.

## PROTECTED BIKEWAYS

### WHAT ARE THEY?

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

### TYPES OF FACILITIES

# DRAFT

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

#### ONE-WAY PROTECTED BIKE LANE

An exclusive one-way bicycle facility adjacent to, but separated from vehicular traffic by a physical barrier and combines the user experience of a separated path with the on-street infrastructure of a bike lane.

#### TWO-WAY PROTECTED BIKE LANE

Similar to a one-way system, but instead are physically separated bicycle lanes that allow bicycle movement in both directions on one side of the street.

### BENEFITS

By separating bicyclists from motor traffic, protected bike lanes can offer a higher level of comfort than bike lanes and are attractive to a wider spectrum of the public. Intersections and approaches must be carefully designed to promote safety and facilitate left-turns for bicyclists from the primary corridor to cross street.



## PROTECTED BIKEWAYS

## ONE-WAY PROTECTED BIKE LANES

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

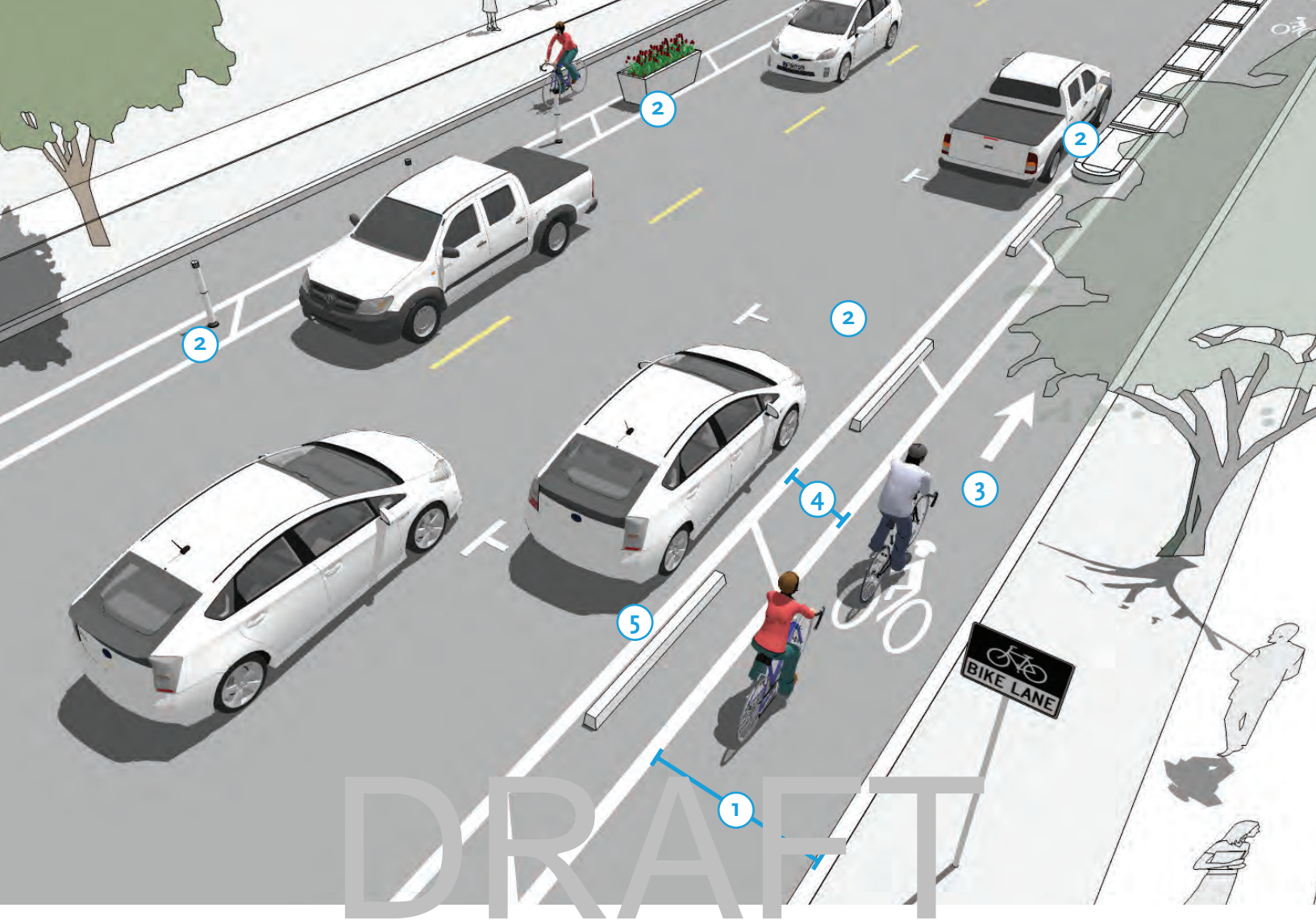
## BENEFITS

- Dedicated and protected space for bicyclists makes it an attractive facility for riders of all levels and ages.
- Lower implementation cost compared to street reconstruction by making use of existing pavement and drainage and by considering using a parking lane as a barrier.
- Reduces or eliminates risk and fear of collisions with opening parked car doors and overtaking vehicles.
- Discourages double parking in the bike lane.
- Improves perceived safety for bicycle riders.

## TYPICAL APPLICATION

- Along streets on which conventional bicycle lanes would cause many bicyclists to feel stress because of factors such as multiple lanes, high traffic volumes, high speed traffic, high incidence of double parking, and high parking turnover.
- Along streets with high bicycle volumes.
- Along streets with high motor vehicle volumes (9,000-25,000 ADT desired) and relatively high speeds (25+ mph).
- Along streets with high truck traffic (10% of total ADT).
- Suitable in areas of high parking turnover.
- Along streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and/or signalized intersection treatments.
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.





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15<sup>TH</sup> STREET ONE-WAY PROTECTED BIKE LANE

Denver, CO

## DESIGN CRITERIA

- 1 1-WAY PROTECTED LANE DIMENSIONS: 5 FEET MINIMUM WIDTH**

In areas with high bicycle volumes or uphill sections to facilitate safe passing behavior, the minimum desired width is 7 feet.
- 2 PHYSICAL SEPARATION**

Vertical separation treatments such as parking lanes, bollards, movable planters or raised curbs may be utilized.
- 3 BICYCLE LANE SYMBOL MARKINGS**

Should be placed at the beginning and end of a protected bicycle lane and at periodic intervals along the facility based on engineering judgment to define the bike direction.
- 4 BUFFER DIMENSIONS: 1.5 FEET MINIMUM WIDTH**

The desired minimum width is 3 feet and should be marked with 2 solid white lines with interior diagonal cross hatching. For clarity at driveways or loading zones, consider a dotted line for the buffer boundary where cars are expected to cross.
- 5 BARRIER PLACEMENT**

Where possible, physical barriers such as bollards or removable curbs should be oriented towards the inside edge of the buffer to provide as much extra width as possible for bicycle use.



## PROTECTED BIKEWAYS

## TWO-WAY PROTECTED BIKE LANES

Two-way protected bike lanes are physically separated bike lanes that allow bicycle movement in both directions on one side of the street. Two-way protected bike lanes share some of the same design characteristics as one-way protected bike lanes, but may require additional considerations at driveway and intersection crossings. A two-way protected bike lane may be configured at street level or as a raised protected bike lane with vertical separation from the adjacent travel lane.

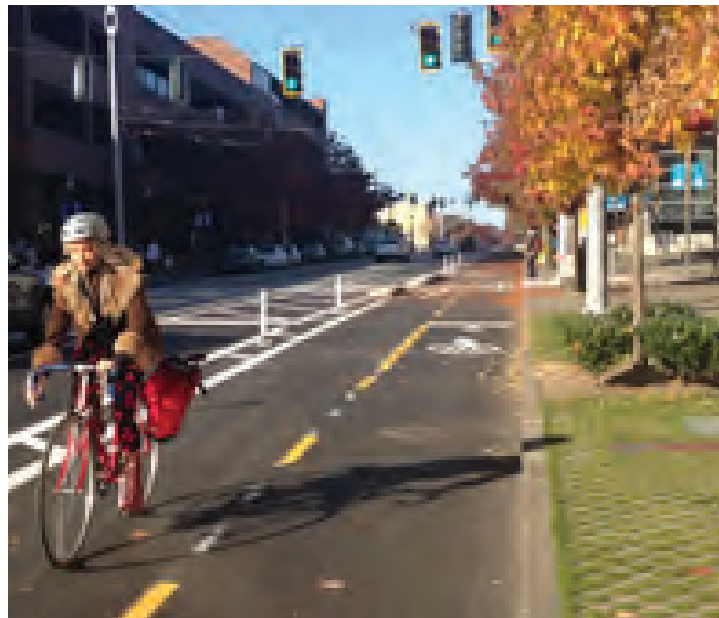
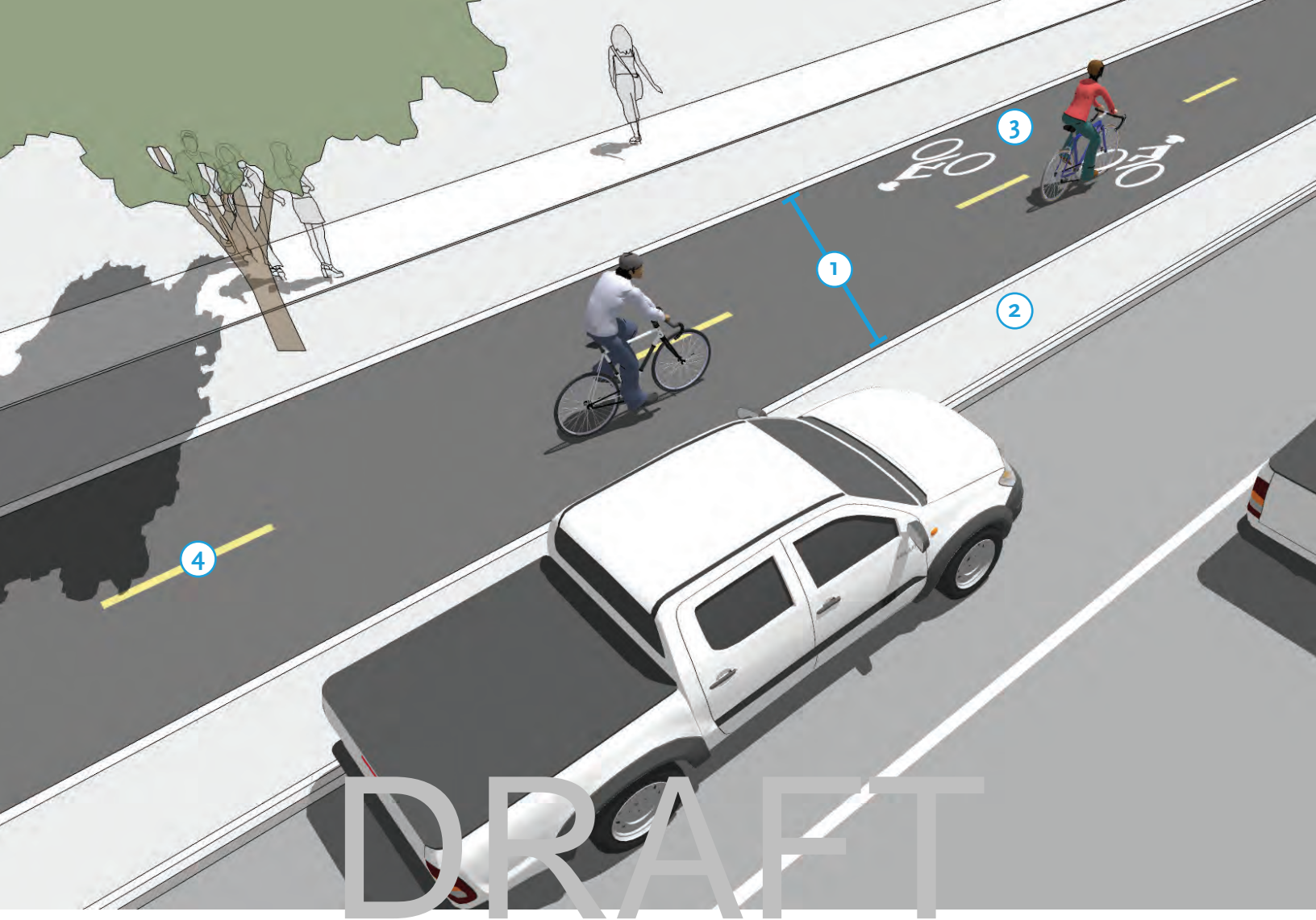
## BENEFITS

- On one-way streets, increases the density of the bicycle network, improving connectivity and directness of bicycle routes.
- Lower implementation cost compared to street reconstruction by making use of existing pavement and drainage.
- When connecting to shared use path facilities, provides an extended trail experience.
- Reduces or eliminates risk and fear of collisions with opening parked car doors and overtaking vehicles.
- Dedicated and protected space for bicycling makes it an attractive facility for riders of all levels and ages.
- Discourages double parking in the bike lane.
- Improves perceived safety for bicycle riders.

## TYPICAL APPLICATION

- Along streets with few conflicts such as driveways or cross-streets on one side of the street.
- Along streets where there is not enough room for a one-way protected lane on both sides of the street.
- Along one-way streets by incorporating a contraflow lane to create a two-way facility.
- Along streets with high bicycle volumes.
- Along streets where more destinations are on one side thereby reducing the need to cross the street.
- Along streets with high motor vehicle volumes (9,000-25,000 ADT desired), high truck volumes (10% of total ADT), and relatively high speeds (25+ mph).
- Additional signalization and signs are necessary to manage conflicts at driveways, intersections and contraflow movements on one-way streets.
- Suitable in areas of high parking turnover.
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.





**BROADWAY AVENUE TWO-WAY PROTECTED BIKE LANE**

Seattle, WA

## DESIGN CRITERIA

- 1 2-WAY PROTECTED LANE DIMENSIONS: 8 FEET MINIMUM WIDTH**  
 Desired width is 12 feet in areas with high bicycle volumes or uphill sections to facilitate safe passing behavior.
- 2 BUFFER DIMENSIONS: 3 FEET WIDTH PREFERRED**  
 Desired minimum width for a parking buffer is 3 feet to allow for passenger loading and to prevent door conflicts. Other vertical separation strategies are tubular markings, movable planters or raised curbs create designated and safe lanes for bicyclists. In constrained conditions or when not adjacent to a parking lane, the minimum width for a buffer is 1 foot 8 inches.
- 3 BICYCLE LANE PAVEMENT MARKINGS**  
 Should be placed at the beginning of a cycle track and at periodic intervals along the facility to define the bike direction.
- 4 FACILITY ORIENTATION**  
 Two-way protected bicycle lanes on two-way streets are not as desirable due to challenges for roadway user expectancy at intersections and driveways. While a two-way protected bicycle lane can be placed on the left or right side of a one-way street, the left side is preferred for the same reasons, with the contraflow lane located to the left of all other traffic lanes.



## PROTECTED BIKEWAYS

## BARRIER TYPES FOR PROTECTED BIKE LANES

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

## BENEFITS

- Vertical barriers provide comfort for users of all ages and abilities.
- Barriers can define the edge of adjacent parking lanes, minimizing encroachment into the bikeway.
- Barriers should accommodate snow removal and maintenance of the protected bikeway.

## TYPICAL APPLICATIONS

**Barrier types appropriate for retrofit projects:**

- Parked cars
- Flexible delineators or bollards
- Planters
- Parking stops
- Concrete barrier

**Barrier types appropriate for reconstruction projects:**

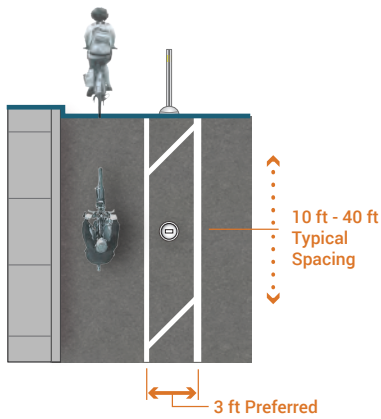
- Curb separation
- Landscaped Medians
- Raised protected bike lane with vertical or mountable curb
- Pedestrian safety islands

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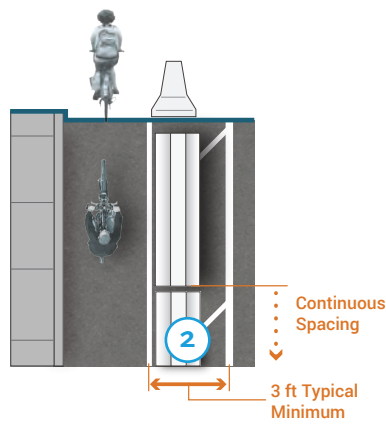




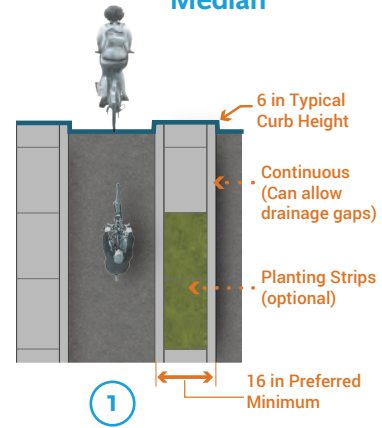
### Delineator Posts/Bollards



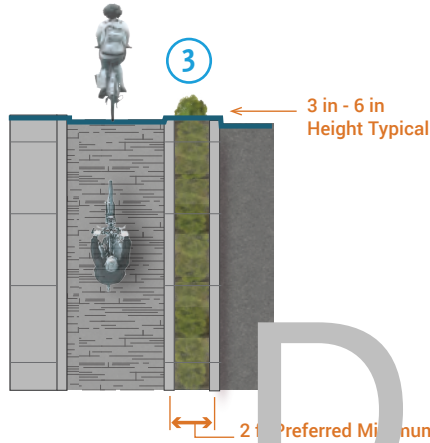
### Parking



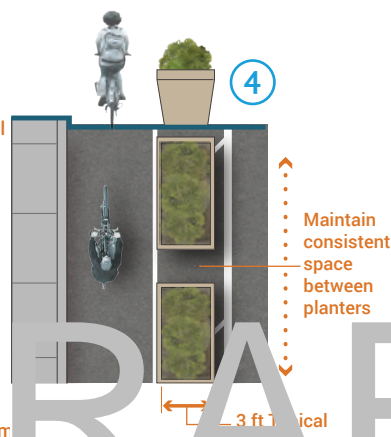
### Concrete Barrier or Raised Median



### Raised Lane



### Planters



Source: FHWA Separated Bike Lane Planning and Design Guide, 2015

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INDIANAPOLIS CULTURAL TRAIL PROTECTED BIKE LANE

Indianapolis, IN

## DESIGN CRITERIA

- 1 **MAXIMIZE EFFECTIVE OPERATING SPACE**  
Place curbs or delineator posts as far from the through bikeway space as practicable. Allow for adequate shy distance from vertical elements to maximize useful space.
- 2 **WHEN NEXT TO PARKING, ACCOMMODATE OPENING DOORS**  
Allow for 3 feet of space in the buffer space to allow for opening doors and passenger unloading.
- 3 **INTEGRATE LANDSCAPING AND STORMWATER MANAGEMENT**  
The presences of landscaping in medians, planters and safety islands increases comfort for users and enhances the streetscape environment.
- 4 **CONSIDER MAINTENANCE NEEDS**  
In constrained conditions, the barrier type may need to be removable to allow for regular maintenance. 7' minimum clear zone distance between curb and separation element to allow for maintenance.



PROTECTED BIKEWAYS

# DRIVEWAYS

The added separation provided by protected bike lanes creates additional considerations at intersections and driveways when compared to conventional bicycle lanes. Special design guidelines are necessary to preserve sightlines and denote potential conflict areas between modes, especially when motorists turning into or out of driveways may not be expecting bicycle travel opposite to the main flow of traffic.

At driveways and crossings of minor streets, bicyclists should not be expected to stop if the minor street traffic does not stop.

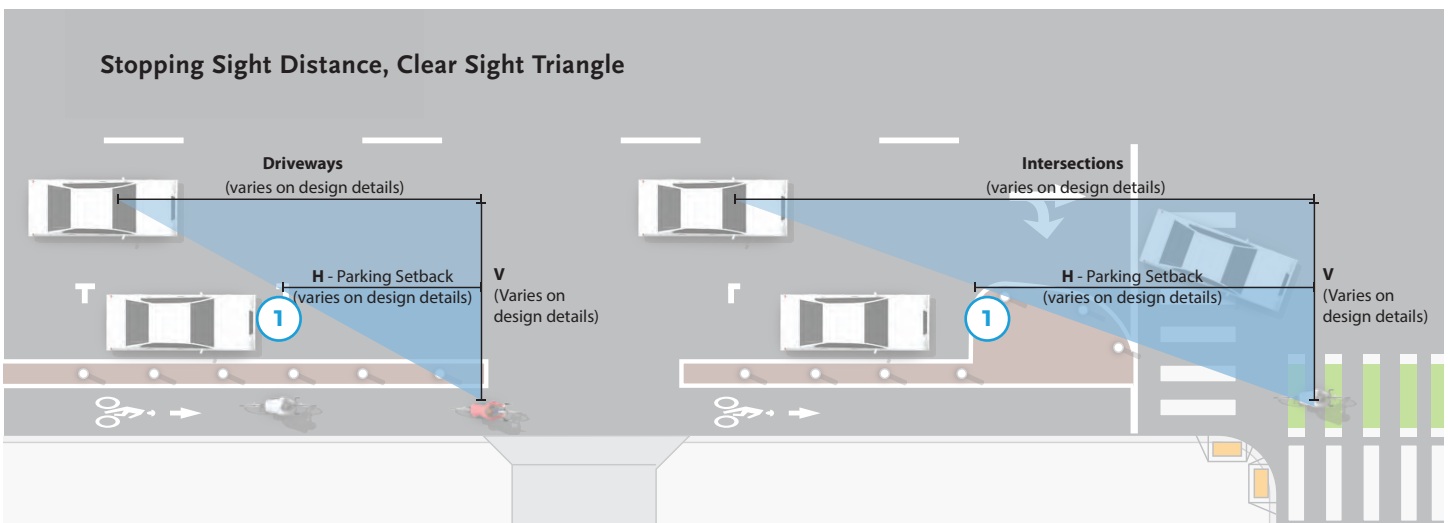
**BENEFITS**

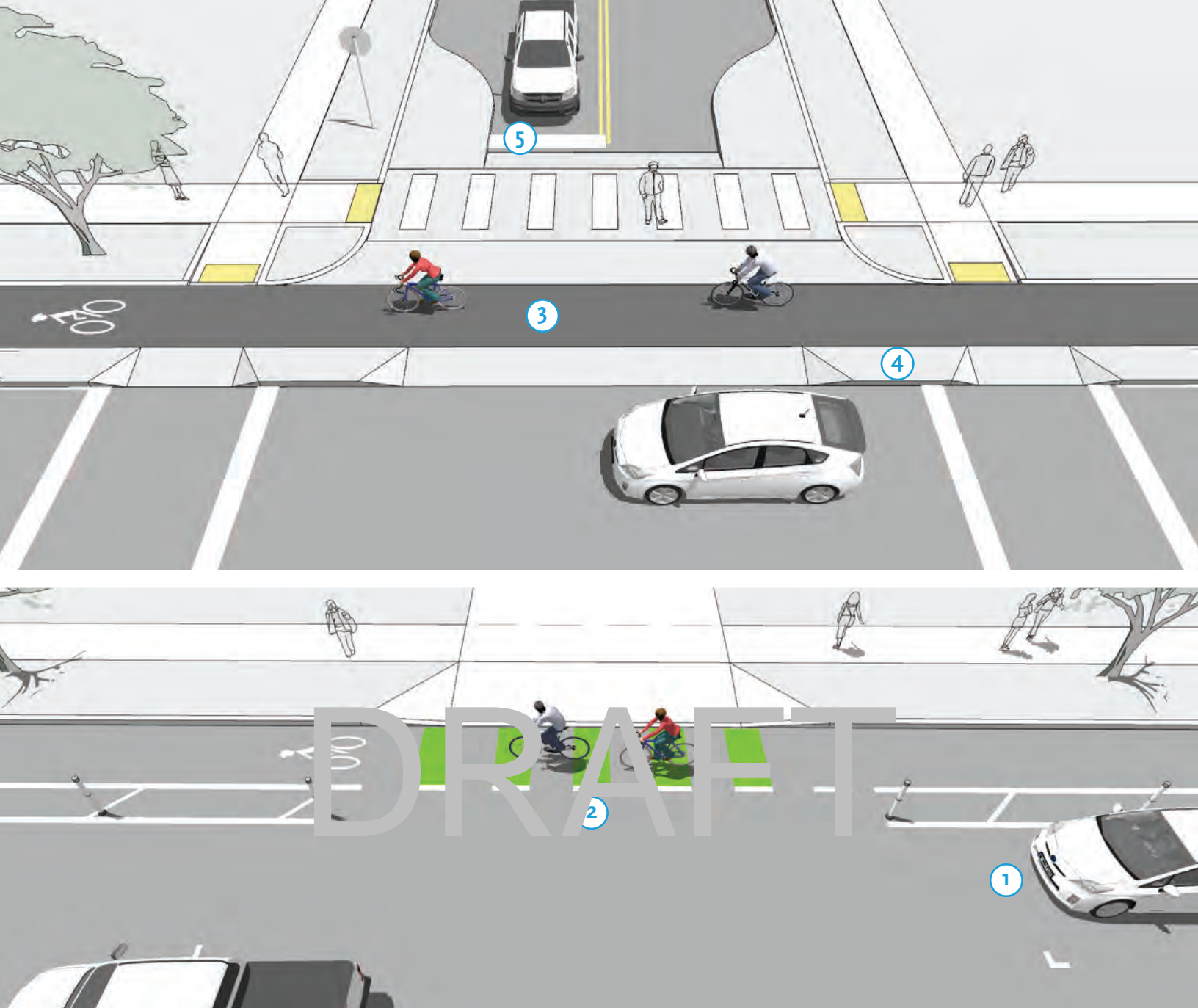
- Removing obstructions and providing clear sight distance at crossings increases visibility of bicyclists.
- Treatments designed to constrain and slow turning motor vehicle traffic will slow drivers to bicycle-compatible travel speeds prior to crossing the protected bike lane.

**TYPICAL APPLICATION**

- Along streets with protected bike lanes where there are intersections and driveways.
- Higher frequency driveways or crossings may require additional treatment such as conflict markings and signs.
- See AASHTO for guidance on intersection and driveway parking setbacks based on turning speeds.

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## DESIGN CRITERIA

- 1 PARKING SETBACK BEFORE INTERSECTION AND DRIVEWAY**  
Remove parking to allow for the appropriate clear sight distance before driveways or intersections to improve visibility. The desirable no-parking area varies with designated speed.
- 2 DENOTE CONFLICT AREAS**  
Use colored pavement markings and/or shared line markings through conflict areas at intersections.
- 3 RAISED BIKE LANE TREATMENT**  
If a raised bike lane is used, the height of the lane should be maintained through the crossing, requiring automobiles to cross over.
- 4 REDUCE VEHICLE TURNING SPEEDS**  
Motor vehicle traffic crossing the bike lane should be constrained or channelized to make turns at sharp angles to reduce travel speed prior to the crossing.
- 5 SETBACK STOP BAR**  
Motor vehicle stop bar on cross-streets and driveways is setback from the intersection to ensure that drivers slow down and scan for pedestrians and bicyclists before turning.



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Protected bike lane along 15<sup>th</sup> Street in Denver.

## INTERSECTION TREATMENTS

### WHAT ARE THEY?

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. The configuration of a safe intersection for bicyclists may include elements such as colored pavement markings, signage, medians, signal detection and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort.

### TYPES OF FACILITIES

The level of treatment required for bicyclists at an intersection will depend on the type of bicycle facility, whether bicycle facilities are intersecting, the vehicular operations of the intersection (including the volume of traffic and transit stop facilities), and the adjacent street function and land use.

# DRAFT

### EVENTS

The following intersection treatments may be used alone or in conjunction depending on the context of the intersection.

Well-designed intersections that integrate bicycle facilities reduce conflict between bicyclists (and other vulnerable street users) and vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes. Intersection treatments can improve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.



INTERSECTION TREATMENTS

# BIKE LANES WITH THROUGH/TURN LANES

In Denver, people driving are required to make turning movements “as closely as practicable to the curb or edge of the roadway.” When a bicycle lane approaches an intersection adjacent to a shared through/turn lane, the bicycle lane should be designed to permit turning vehicles to enter the bicycle lane prior to turning.

## BENEFITS

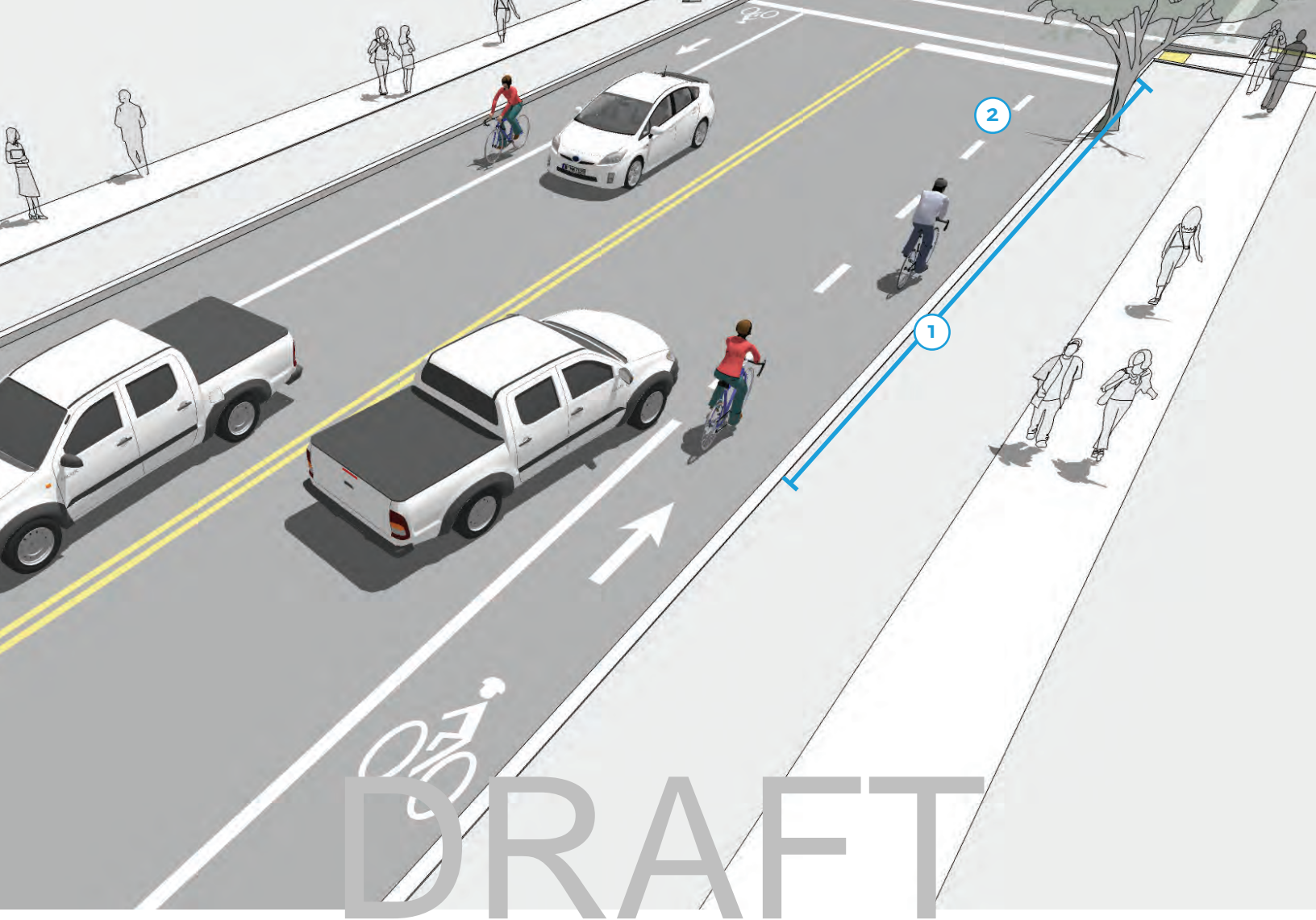
- Permits drivers to enter the bike lane in order to turn from the lane closest to the curb.
- Street users negotiate conflicts upstream from the intersection, reducing the potential for hooks within the intersection.

## TYPICAL APPLICATION

- Streets with curbside bicycle lanes approaching a signalized intersection where turns are permitted.
- Streets with curb extensions occupying the parking lane at intersections.
- A shared bike/turn lane should be considered in areas with on-street parking and high turn volumes, but not enough room for a bicycle lane and a turn only lane.

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**BANNOCK STREET BIKE LANE**

Denver, CO

**DESIGN CRITERIA**

- 1 DASHED LANE LINE**  
 Where motorist turns are permitted from the general purpose travel lane, the solid bike lane should be dashed 50 feet in advance of signalized intersections.
- 2 LANE STRIPING DETAILS AT APPROACH**  
 Dashed striping should be 8 inch lines in 2 foot segments with 4 foot gaps.

INTERSECTION TREATMENTS

# BIKE LANES AT ADDED TURN LANES

An appropriate treatment at turn-only lanes is to introduce an added turn lane to the outside of the bicycle lane. The area where people driving must cross the bicycle lane should be marked with dashed lines to identify the potential conflict area. Dashed green pavement markings may also be added at intersections with a high turn volume. Signage should indicate that motorists must yield to bicyclists through the conflict area.

**BENEFITS**

- Bicyclists and drivers negotiate the turn conflict upstream of the intersection.
- The bicycle lane maintains a straight path, and drivers must weave across, providing clear right-of-way priority to bicyclists.

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**TYPICAL APPLICATION**

- Streets with right-turn lanes and right side bike lanes.
- Streets with left-turn lanes and left side bike lanes.
- Green dashed markings are used when peak hour turn volume is above 150.

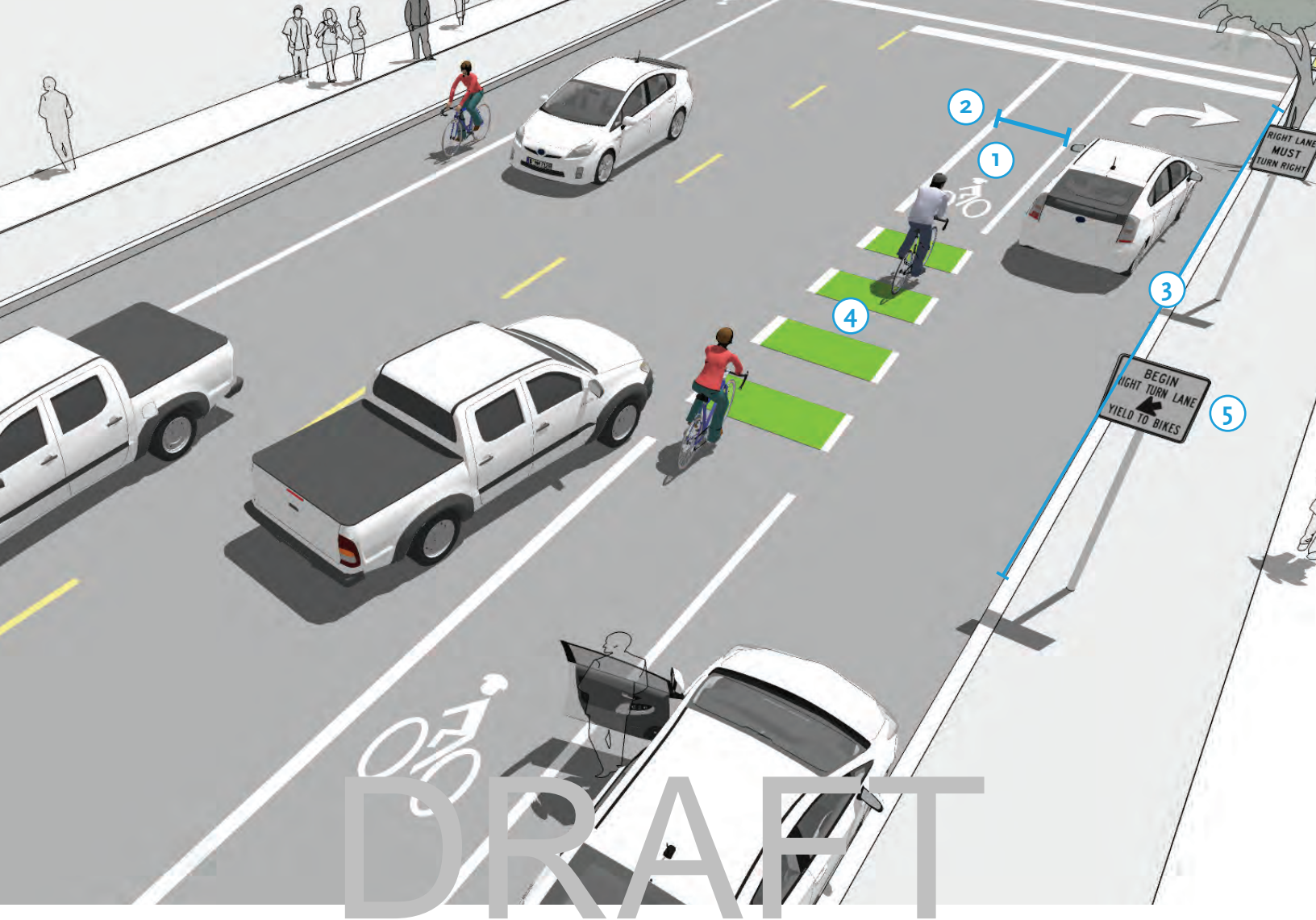


LAWRENCE STREET BIKE LANE AT ADDED TURN LANES

Denver, CO







18<sup>TH</sup> STREET BIKE LANE AT ADDED TURN LANES

Denver, CO

## DESIGN CRITERIA

- 1 BICYCLE MARKING**  
Used to clarify bicyclist positioning.
- 2 BIKE LANE DIMENSIONS AT STOP BAR: 5-6 FEET STANDARD WIDTH**  
Should match leading bike lane width when possible. Minimum width is 5 feet. If street width exists, add 8" stripe or buffer.
- 3 DASHED WHITE CONFLICT ZONE MARKINGS AT LOW TURN VOLUME INTERSECTIONS**  
Should begin a minimum of 50 feet in advance of the conflict zone location.
- 4 COLOR CONFLICT ZONE MARKINGS AT HIGH TURN VOLUME INTERSECTIONS**  
Alerts both motorists and bicyclists that they are in a conflict zone where both bicyclists and vehicles are crossing.
- 5 YIELD SIGNING**  
Use R4-4 BEGIN RIGHT TURN LANE YIELD TO BIKES signage to indicate that motorists should yield to bicyclists through the conflict area.

INTERSECTION TREATMENTS

# BIKE LANES AT THROUGH LANES TO TURN LANE TRANSITION (DROP LANES)

When a through lane transitions directly into a turn only lane, bicyclists traveling in a curbside bike lane must move laterally to the left or right of the turn lane. Pavement markings indicate to bicyclists to accept gaps in traffic and control the transition.

## BENEFITS

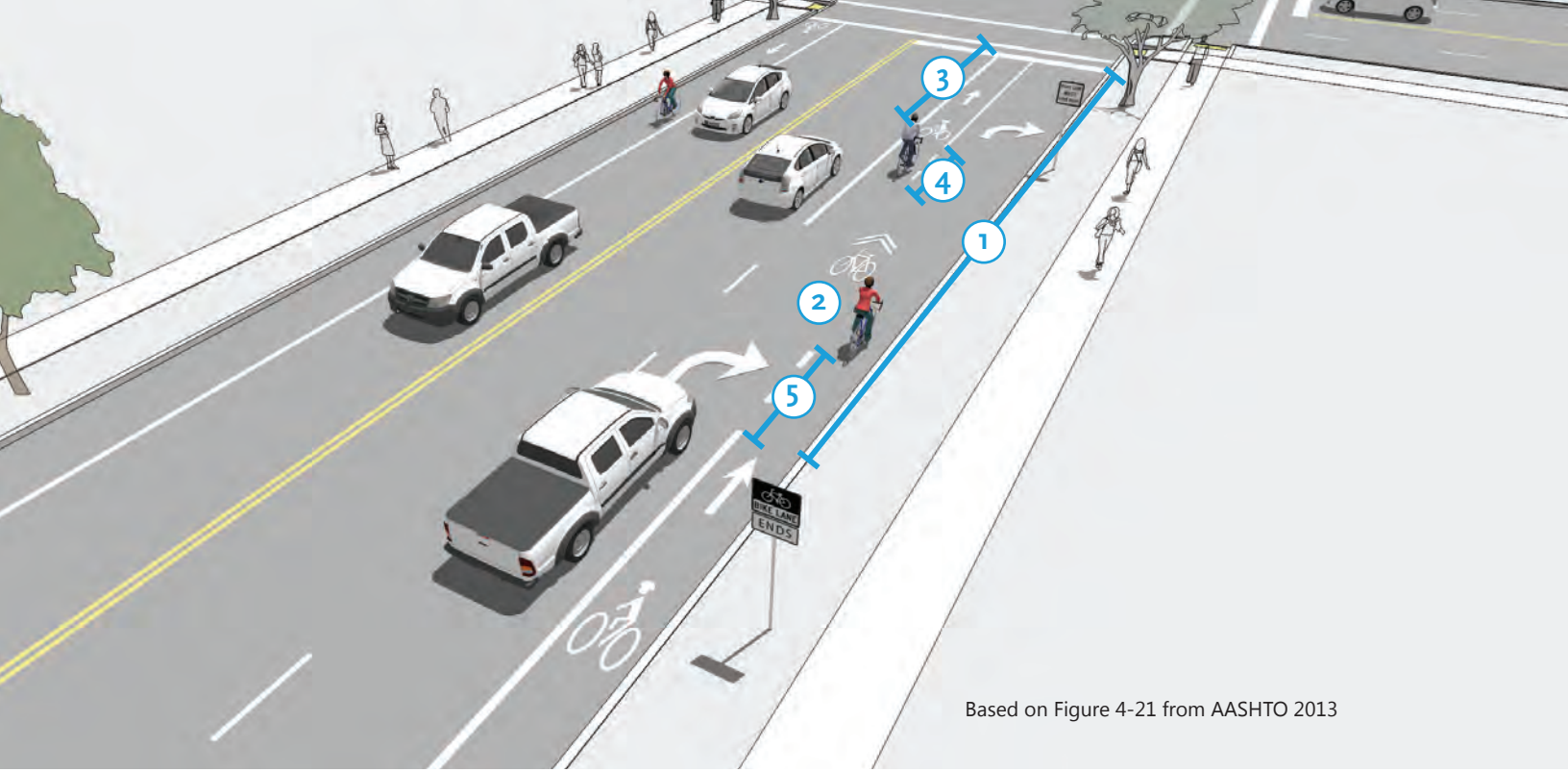
- Striping indicates to bicyclists that they must use caution and merge when safe gaps are present.
- This treatment functions for skilled riders, but is not appropriate for riders of all ages and abilities. If a low stress crossing is desired in these locations, consider a **Protected Bicycle Signal Phase**.

## TYPICAL APPLICATION

- Streets with curbside bike lanes where a through travel lane transitions into a turn only lane.
- Turn only drop lanes should be avoided where possible. Alternative design strategies include roadway reconfigurations to remove the dropped lane, or bicycle signals with a protected signal phase to eliminate turning conflicts.

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Based on Figure 4-21 from AASHTO 2013



BIKE LANE AT THROUGH LANE

Tucson, AZ

**DESIGN CRITERIA**

- 1 DROP BIKE LANE**  
End the on-road bike lane with dashed lines at least 125 feet in advance of the intersection to indicate to bicyclists to enter the general purpose travel lane.
- 2 ENCOURAGE SAFE MERGINS**  
Use Shared Lane markings in the general purpose to raise awareness to the presence of bicyclists in the travel lanes during the transition segment. The transition area should be a minimum of 100 feet long.
- 3 REESTABLISH THE BIKE LANE**  
Reestablish a standard or wide bicycle lane next to the turn only lane.

**DROP LANE TRANSITION DISTANCES** Overall Length **(1)**

	150'	100'	80'
Turn Bay Length <b>(3)</b>	50'	30'	20'
Number of Sharrows <b>(2)</b>	2	1	1
Dash Length <b>(4)</b>	25'	20'	20'
Dash Length <b>(5)</b>	25'	20'	20'



INTERSECTION TREATMENTS

# SHARED BIKE/TURN LANE

Where there is not room for a conventional bicycle lane and turn lane, a shared bike/turn lane creates a shared lane where bicyclists can ride straight through an intersection and turning motor vehicles yield to through traveling bicyclists. The combined bicycle lane/ turn lane places shared lane markings within a turn only lane.

**BENEFITS**

- Maintains the integrity of the bikeway in situations where it would otherwise be dropped.
- Shared bike/turn lane creates safety and comfort benefits by negotiating conflicts upstream of the intersection area.

**TYPICAL APPLICATION**

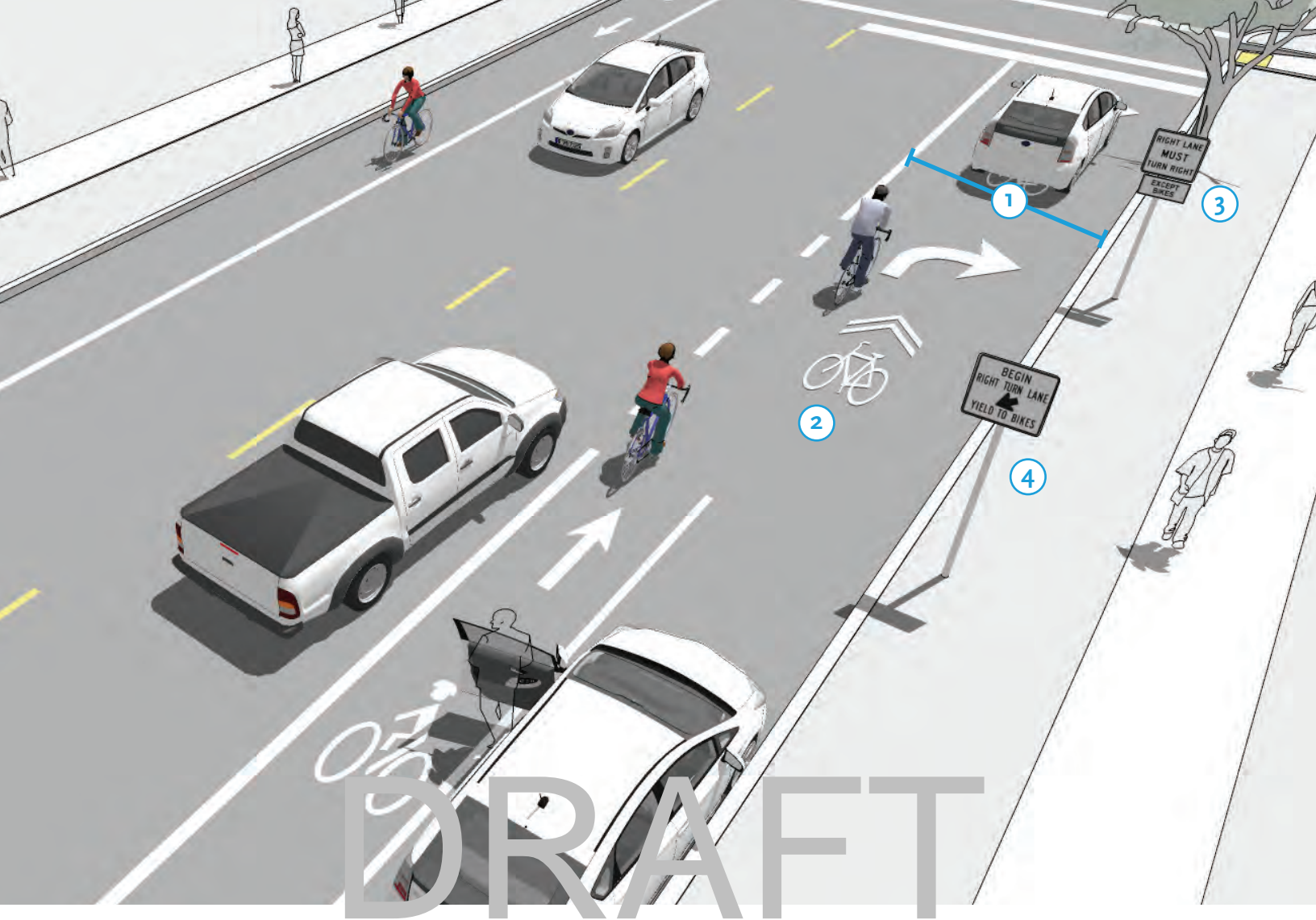
- Most appropriate in areas with low posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less) where there is a presence or need for a turn only lane.
- May not be appropriate for high speed arterials or intersections with long turn lanes.
- May not be appropriate for intersections with large percentages of right-turning heavy vehicles. Peak hour turn volume should be below 150 veh/hr, with below 100 veh/hr preferred.
- Used along narrow bikeways that do not have sufficient width for mixing zone configuration.
- May be used with protected bike lanes.



SHARED BIKE/TURN LANE

Billings, MT





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15<sup>TH</sup> STREET SHARED BIKE/TURN LANE

Denver, CO

## DESIGN CRITERIA

- 1 ENCOURAGE IN-LINE OR MERGING OPERATION**  
 Maximum shared turn lane width is 13 feet; narrower is preferable. (NACTO, 2012)
- 2 MARKINGS MAINTAIN BICYCLE PRIORITY**  
 Shared Lane Markings should indicate preferred positioning of bicyclists within the combine lane.
- 3 BICYCLE EXCEPTION IN TURN LANE**  
 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.
- 4 YIELD TO BIKES**  
 Use R4-4 BEGIN RIGHT TURN LANE YIELD TO BIKES signage to indicate that motorists should yield to bicyclists through the conflict area.



## INTERSECTION TREATMENTS

## MIXING ZONE

A mixing zone creates a shared space travel lane where turning motor vehicles yield to bicyclists. Geometric design of the mixing zone 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.

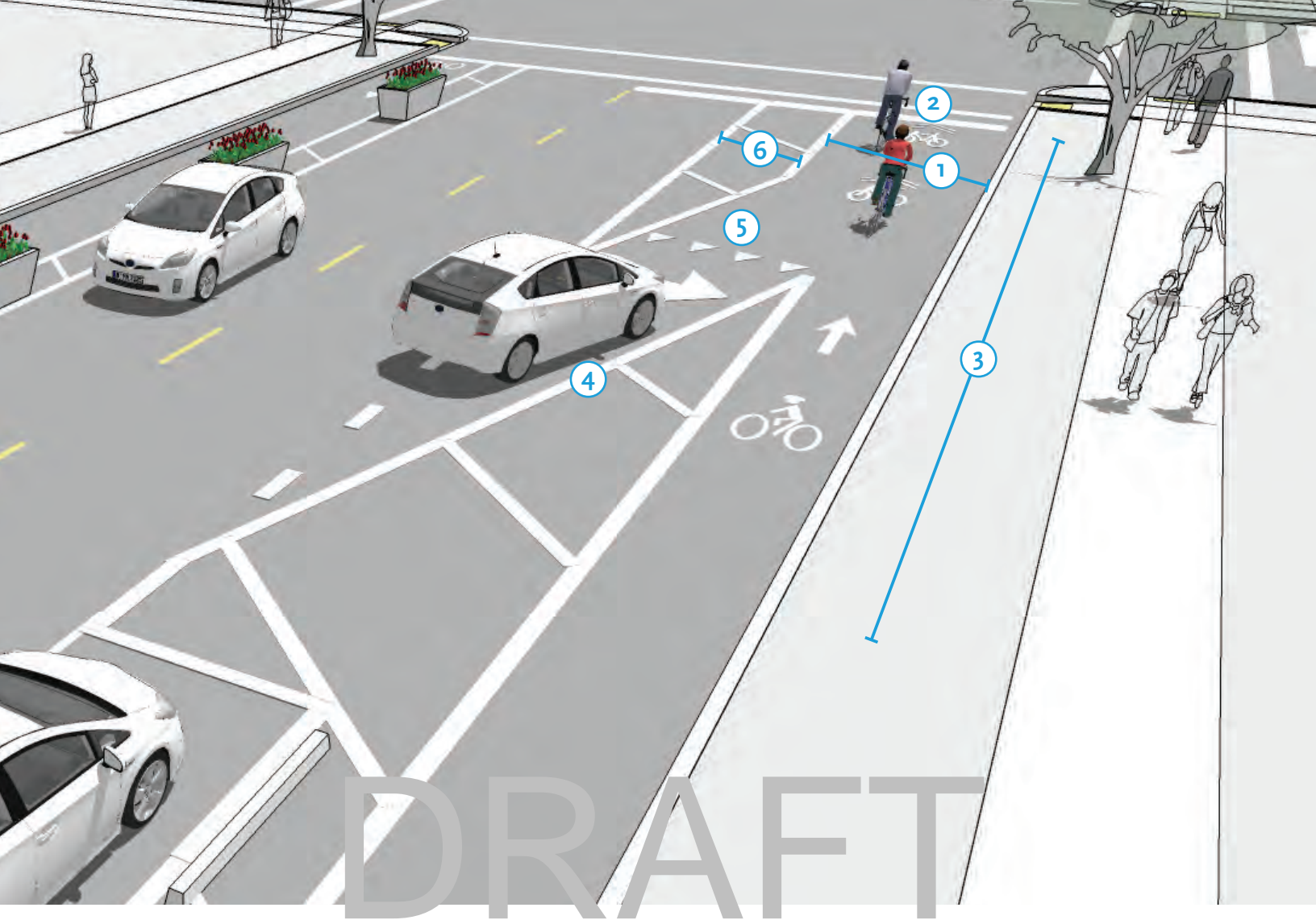
## BENEFITS

- Reduced right- or left-hook risks by negotiating conflicts upstream of the intersection.
- May provide an alternative to protected signal phasing, reducing delay to all users.

## TYPICAL APPLICATIONS

- Used with wide buffered or protected bikeways to provide enough room to establish a formal “yield” area for motor vehicles.
- Most appropriate in areas with low to moderate turn volumes (typically less than 150 per hour).
- Potential option when there is a presence or need for a turn only lane.
- Use aggressive transition taper dimensions and short storage length to promote slow motor vehicle travel speeds, make bicyclists more visible, and establish clear right-of-way priority.





ARAPAHOE STREET MIXING ZONE

Denver, CO

## DESIGN CRITERIA

- 1 **SHARED LANE DIMENSIONS: 13 FEET MAXIMUM WIDTH**  
Creates clear expectations of in-line operations.
- 2 **SHARED LANE BICYCLE MARKING**  
Used to clarify bicyclist positioning within the combined lane.
- 3 **MIXING ZONE LENGTH: 75 FEET PREFERRED**  
Should begin a minimum of 70 feet and a maximum of 100 feet in advance of the intersection. The objective is to not store all vehicles queued to turn.
- 4 **ENTRANCE TO MIXING ZONE: 7:1 RECOMMENDED TAPER RATE**  
Should be abrupt and accommodate a 20 mph entry speed for motor vehicles.
- 5 **YIELD LINE**  
Call attention to motorists approaching the to mixing zone.
- 6 **BUFFER AREA/PHYSICAL DELINEATORS**  
The mixing zone should be buffered 2-6 feet from the through travel lane. Flex posts may be installed to separate the mixing zone from the adjacent through lane. However, this may result in abrupt transitions and is most appropriate in slow-speed conditions ( $\leq 20$  mph).

INTERSECTION TREATMENTS

# BIKE LANES AT CHANNELIZED TURN LANES

Bicycle friendly channelized turn lanes can reduce the risk of potential conflicts between bicyclists and turning vehicles by improves sight lines of turning vehicles, slows turning vehicle speed, and reminding users of bicycle priority in weave areas.

## BENEFITS

- Improves yielding compliance and safety over conventional auto-priority channelized turn lanes.
- Provides priority for through traveling bicyclists over turning motor vehicles.

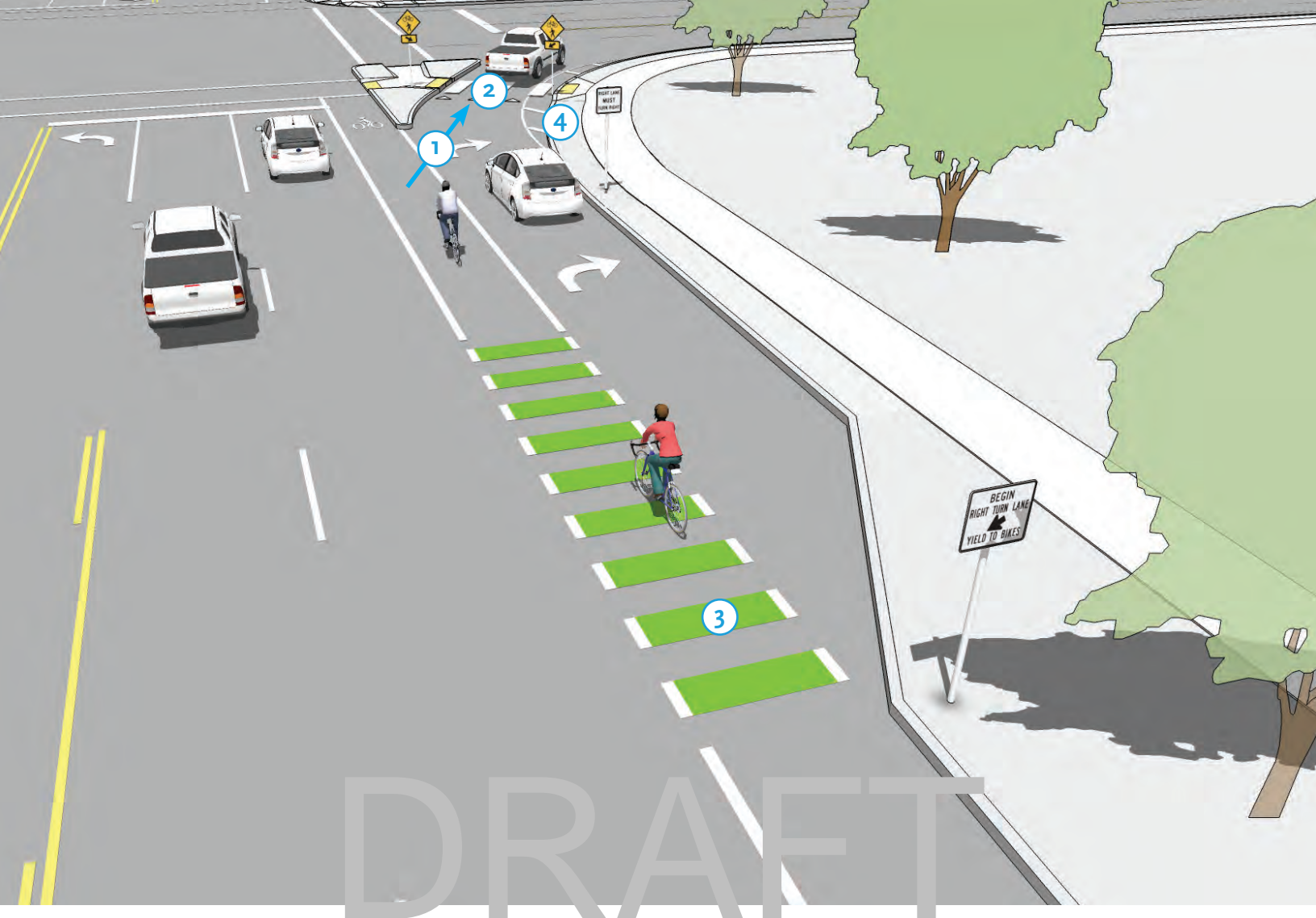
## TYPICAL APPLICATION

- At signalized intersections.
- Intersections with high right-turn traffic volumes, and very low levels of pedestrian activity.
- Wide streets with long crossing distances.
- Increase intersection efficiency and reduce unnecessary delay at areas with high right-turn traffic volumes.
- As an improvement to intersections with an existing traditional channelized right-turn lane.

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ARAPAHOE STREET CHANNELIZED TURN LANE

Denver, CO

## DESIGN CRITERIA

- 1 **APPROACH ANGLE**  
The preferred angle of approach is no more than 15-30 degrees<sup>1</sup>.
- 2 **SLOW SPEEDS**  
Design the right turn lane to encourage appropriate deceleration in preparation for yielding to crossing pedestrians. (<20 mph preferred).
- 3 **BICYCLE PRIORITY**  
Colored pavement should be used at high turn volume locations where motor vehicles are directed to weave across bicycle lanes. (NACTO, 2012)
- 4 **CORNER APRON**  
Painted or raised corner apron can control passenger car speeds while permitting access by large vehicles.

<sup>1</sup> FHWA. *Pedestrian Facilities User Guide*. 2002.



## INTERSECTION TREATMENTS

## BIKE LANES AT ENTRANCE RAMPS

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

## BENEFITS

- Design improves bicycle comfort and priority.
- Design permits safe crossings in unfavorable conditions.

## TYPICAL APPLICATION

- Streets with high speed freeway style merge lanes.
- Streets with multiple ramp lanes.
- Low ease of use facilities.
- Design strategies differ for low-speed and high-speed configurations.
- Even with signage and striping improvements, free-flow ramps present significant challenges for pedestrians and bicyclists; reconfiguring the intersection is the preferred treatment (Caltrans Complete Intersections, 2010).

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**WEST 23<sup>RD</sup> AVENUE BIKE LANE AT ENTRANCE RAMP**  
Denver, CO

## DESIGN CRITERIA

- 1
**DENOTE CONFLICT AREAS**  
 Bike lane should travel straight through the merge area. Use dashed lines, conflict pavement markings and signs to define bicyclist priority over merging traffic.

## INTERSECTION TREATMENTS

# BIKE LANES AT EXIT RAMPS

Arterials with freeway-style exit ramps can create difficulties for bicyclists. Exit lanes typically have intrinsic visibility problems because of low approach angles and feature high speed differentials between bicyclists and motor vehicles.

### BENEFITS

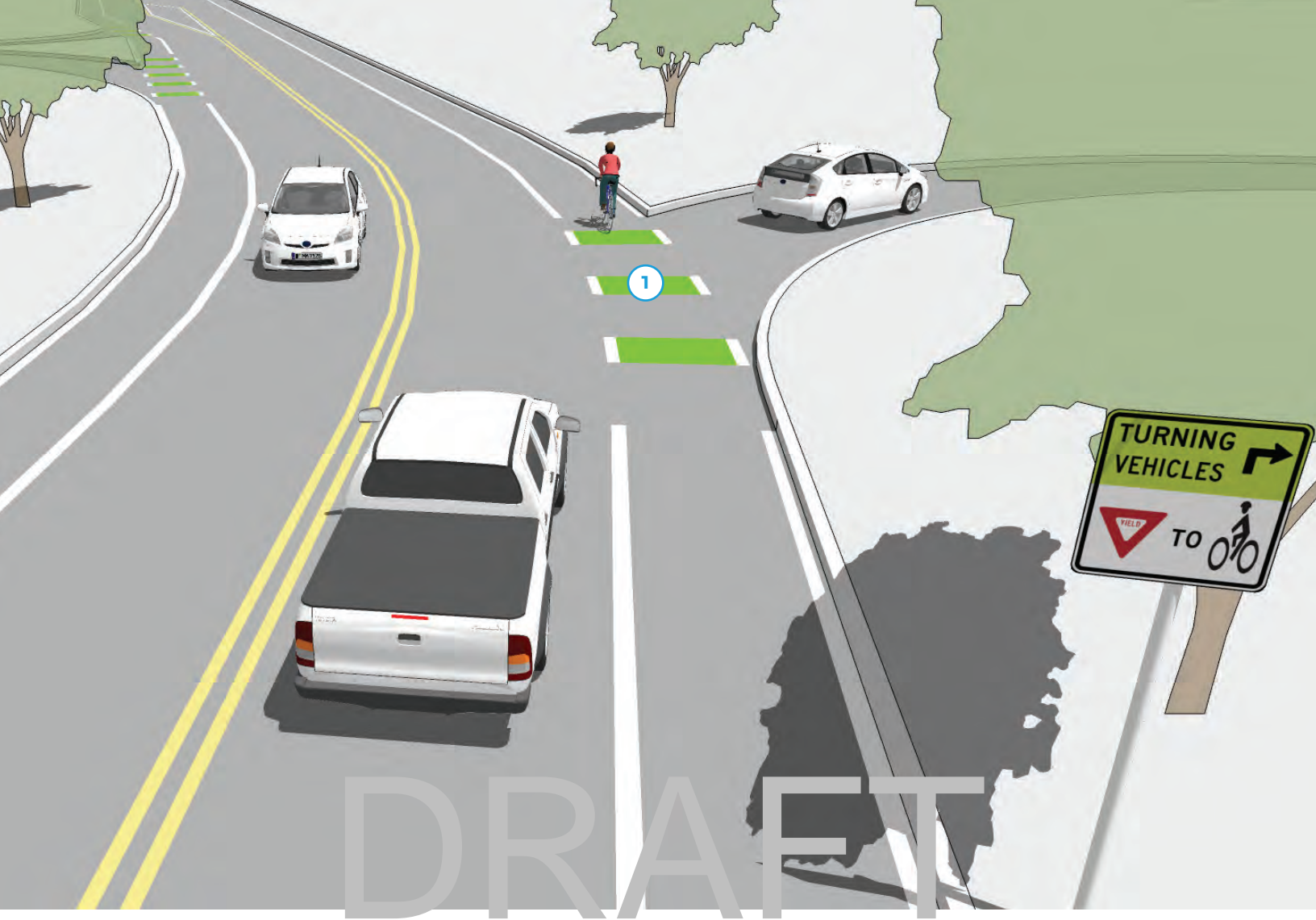
- Design improves bicycle comfort and priority.
- Design permits safe crossings in unfavorable conditions.

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### TYPICAL APPLICATION

- Conditions with double exit lanes.
- Streets with bicycle lanes
- Streets with freeway style exit ramps.
- Where the expected user is a skilled adult rider.
- Grade separation designs utilizing a bicycle path could be used if the approach ramp elevations are appropriate, and if bicycle volumes are fairly high and motor traffic volumes are high. Standard bicycle path geometric guidelines would be applied to the approaches to a grade separated crossing for a bikeway.





WEST 23<sup>RD</sup> AVENUE BIKE LANE AT ENTRANCE RAMP  
Denver, CO

## DESIGN CRITERIA

- 1
**DENOTE CONFLICT AREAS**  
 Bike lane should travel straight through the merge area. Use dashed lines, conflict pavement markings and signs to define bicyclist priority.

## INTERSECTION TREATMENTS

## BIKE BOX

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.

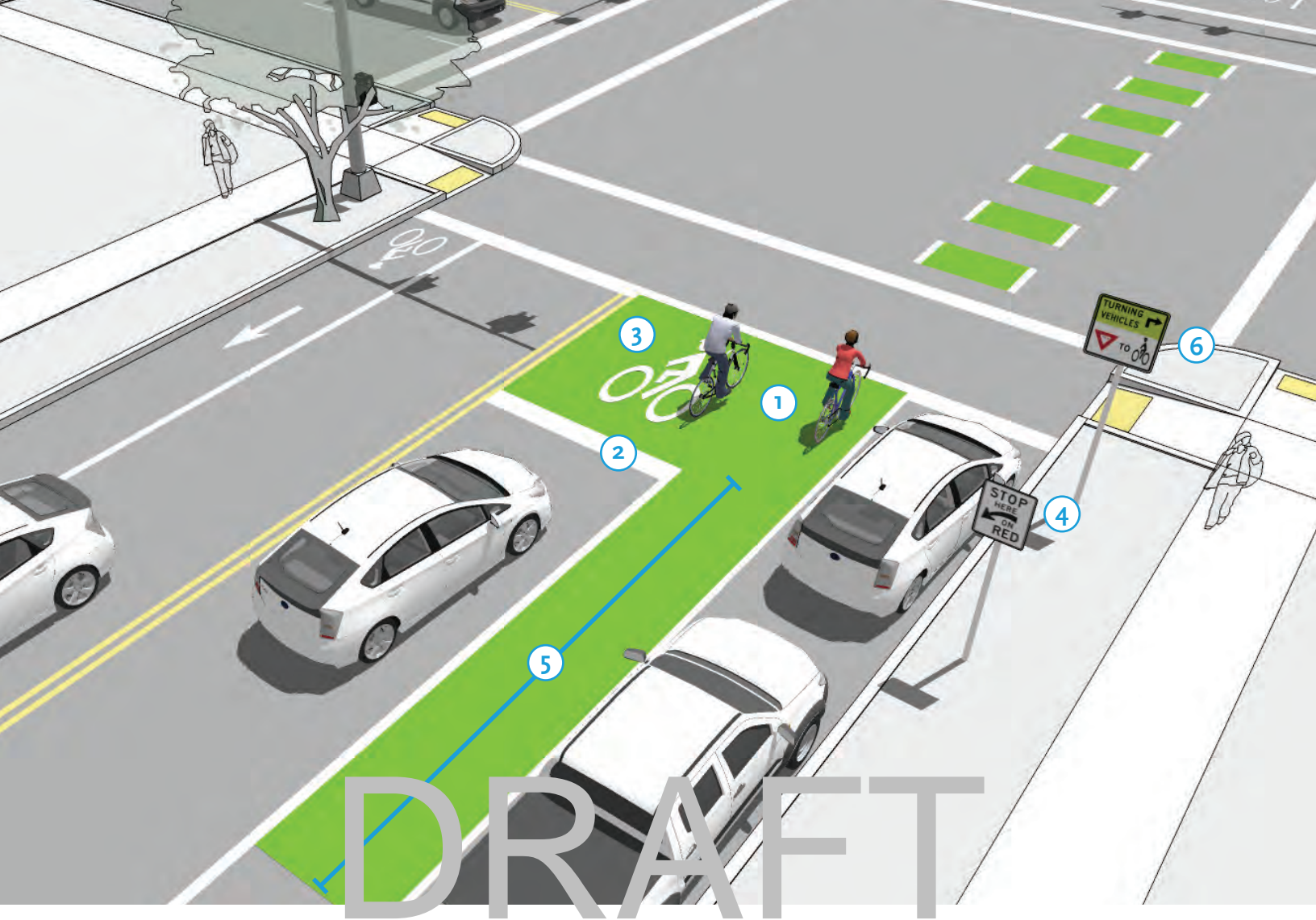
## BENEFITS

- Increases visibility of bicyclists.
- Groups bicyclists together to clear an intersection quickly, minimizing impediment to transit or other traffic.
- Helps prevent 'right-hook' conflicts with turning vehicles at the start of the green indication.
- Pedestrians benefit from reduced vehicle encroachment into the crosswalk.

## TYPICAL APPLICATION

- Used where there is a through/right option lane to mitigate the risk of right hook incidents or to queue large numbers of bicycles.
- They are particularly useful on local or minor collector streets that receive limited green time at signals, to allow all bicyclists to clear the intersection in one signal cycle.
- Cross product of peak hour bicycle volumes and peak hour automobile volumes should be greater than 5,000.
- Lower volume locations may be appropriate based on engineering study or safety risk.
- Right turns on red are strictly prohibited.
- May be used with bike lanes, protected bike lanes or neighborhood bikeways.





**BIKE BOX**  
Denver, CO

## DESIGN CRITERIA

- 1 BIKE BOX**  
A box formed by transverse lines to hold queuing bicyclists, typically 10-16 feet deep from the back of the crosswalk to the motor vehicle stop bar. Use of green colored pavement is optional for enhanced awareness.
- 2 STOP LINES**  
Used to indicate the point behind which motor vehicles are required to stop at traffic signals.
- 3 PAVEMENT MARKINGS**  
Centered in the bike box to designate the space for bikes only.
- 4 "STOP HERE ON RED" SIGN (MUTCD R10-6)**  
Used to reinforce observance of stop line for vehicles and should be post-mounted at the stop line to reinforce observance for motorists. In addition, a "No Turn on Red" (MUTCD R10-11) shall be installed overhead on a signal pole to prevent vehicles from entering the bike box.
- 5 INGRESS LANE (OPTIONAL)**  
Used to provide access to the box and define the bicycle space, 25-50 feet back of the stop bar.
- 6 OPTIONAL SIGN (MUTCD MODIFIED R10-15)**  
Used to remind right turning motorists to yield the right-of-way to pedestrians and bicyclists.



## 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.

In Denver, two strategies will be employed in high-conflict areas: Type 1, with white and green filled dashed lines and Type 2, with white dotted lines with chevron markings.

## BENEFITS

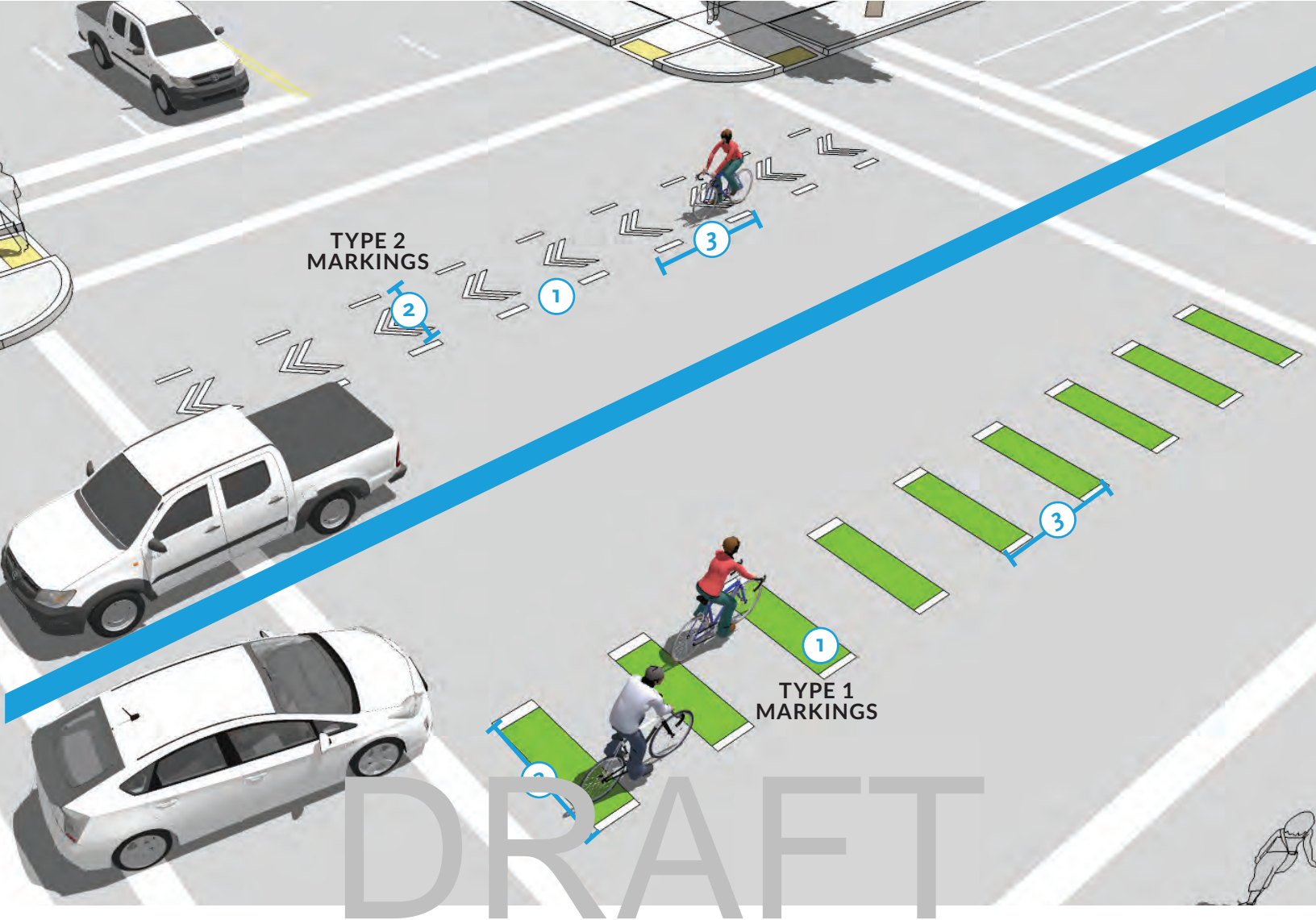
- Raises awareness for both bicyclists and motorists to potential conflict areas.
- Reinforces that through bicyclists have priority over turning vehicles or vehicles entering the roadway (from driveways or cross streets).
- Reduces bicyclist stress by delineating the bicycling zone.
- Reduces conflicts between bicyclists and turning motorists.

## TYPICAL APPLICATION

- Streets with protected bike lanes may be used at high volume intersections and special situations with buffered and conventional facilities.
- Where streets cross driveways.
- At indirect paths through intersections.
- High volumes of adjacent and/or crossing traffic.
- Where potential conflicts exist between through bicyclists and adjacent traffic.
- Type 1 markings are used in turn conflict situations.
- Type 2 markings are used where no turning conflict is present at intersection.







15<sup>TH</sup> STREET INTERSECTION MARKINGS

Denver, CO

### DESIGN CRITERIA

- 1 **CROSSING PAVEMENT MARKINGS**  
Used to designate bicycle crossing space at intersections.
- 2 **CROSSING LANE STRIPE DIMENSIONS: 6 FEET TYPICAL**  
Should match width and positioning of the leading bike lane.
- 3 **DASHED LINE SPACING**  
Consists of 6 inch, 2 foot long dashed white lines with 4-6 foot gaps from the center of the dashed line. Distributing markings across travel lanes to avoid vehicular tire paths will result in reduced wear and maintenance.

## INTERSECTION TREATMENTS

## PROTECTED SIGNAL PHASE

Bike 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.

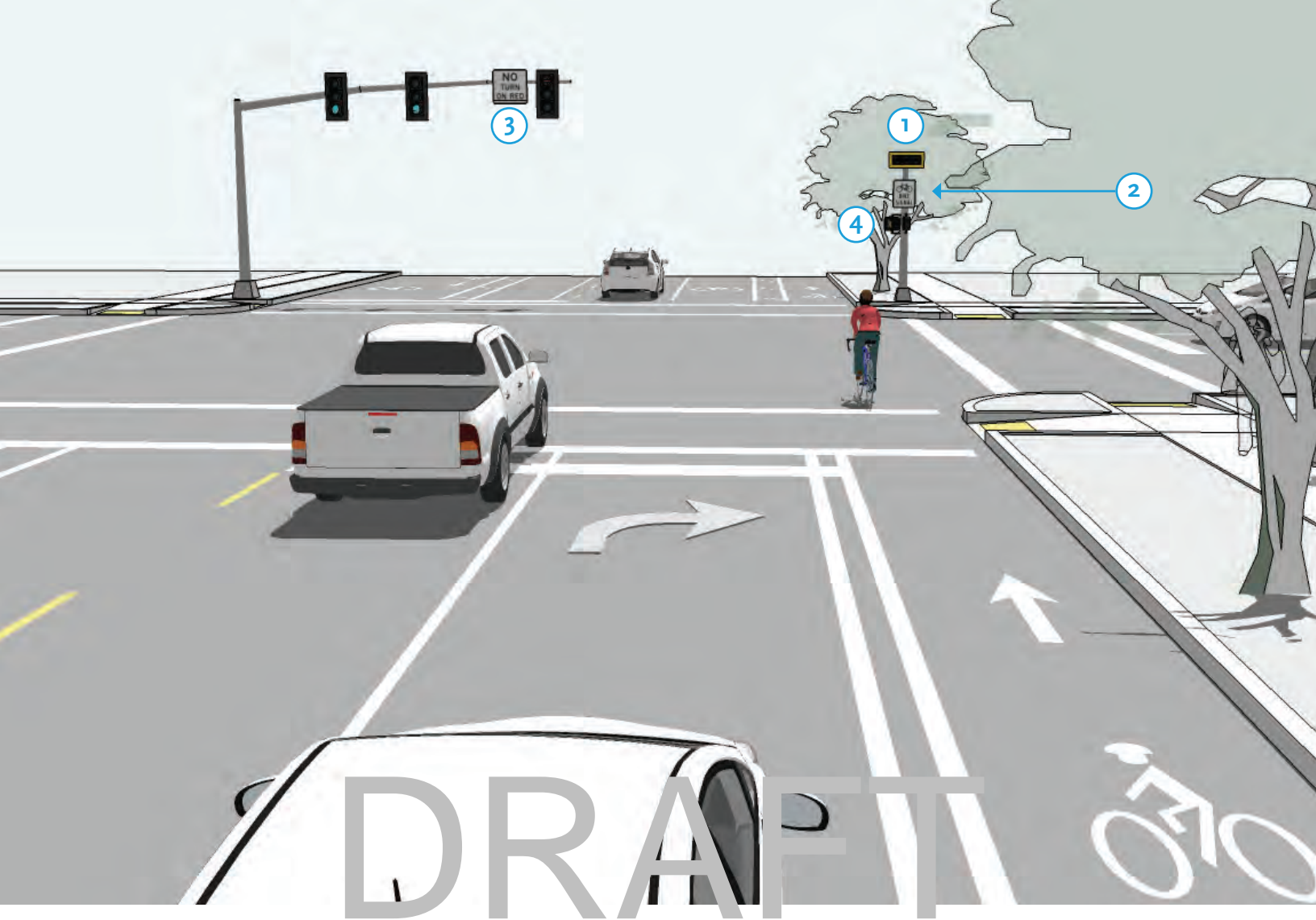
## BENEFITS

- At intersections with contra-flow (opposite direction) bicycle movements that otherwise would have no signal indication.
- Eliminates conflicting movements at signalized intersections.
- Simplifies bicycle movements through complex intersections.

## TYPICAL APPLICATION

- Two-way protected bike lanes where contra-flow bicycle movement or increased conflict points warrant protected operation.
- Used where right-turn volume is typically over 150 per hour or where full signal protection is desired along bikeway.
- 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.
- Used with neighborhood bikeways.





ARAPAHOE STREET BIKE SIGNAL

Denver, CO

## DESIGN CRITERIA

- 1 BICYCLE SIGNAL HEAD**  
 Shall be placed in a location clearly visible to oncoming bicyclists.
- 2 SUPPLEMENTAL "BICYCLE SIGNAL" SIGN (MUTCD R10-10B)**  
 Increases comprehension for all users.
- 3 RIGHT TURNS ON RED PROHIBITED**  
 Necessary when bicycle signal is green to prevent conflicts and to meet FHWA regulations. MUTCD R10-11a sign is depicted.
- 4 SIGNAL TIMING**  
 Bicycle signal phase timing is based on crossing distance. Longer yellow signal time is recommended for wider intersections so that crossing bicyclists are not as worried about being in conflict with cross-traffic. The clearance interval (defined as the combined duration of yellow + all red phase) should provide ample clearance time for bicyclists entering on a green signal indication.

## INTERSECTION TREATMENTS

## TWO-STAGE TURN BOX

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

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

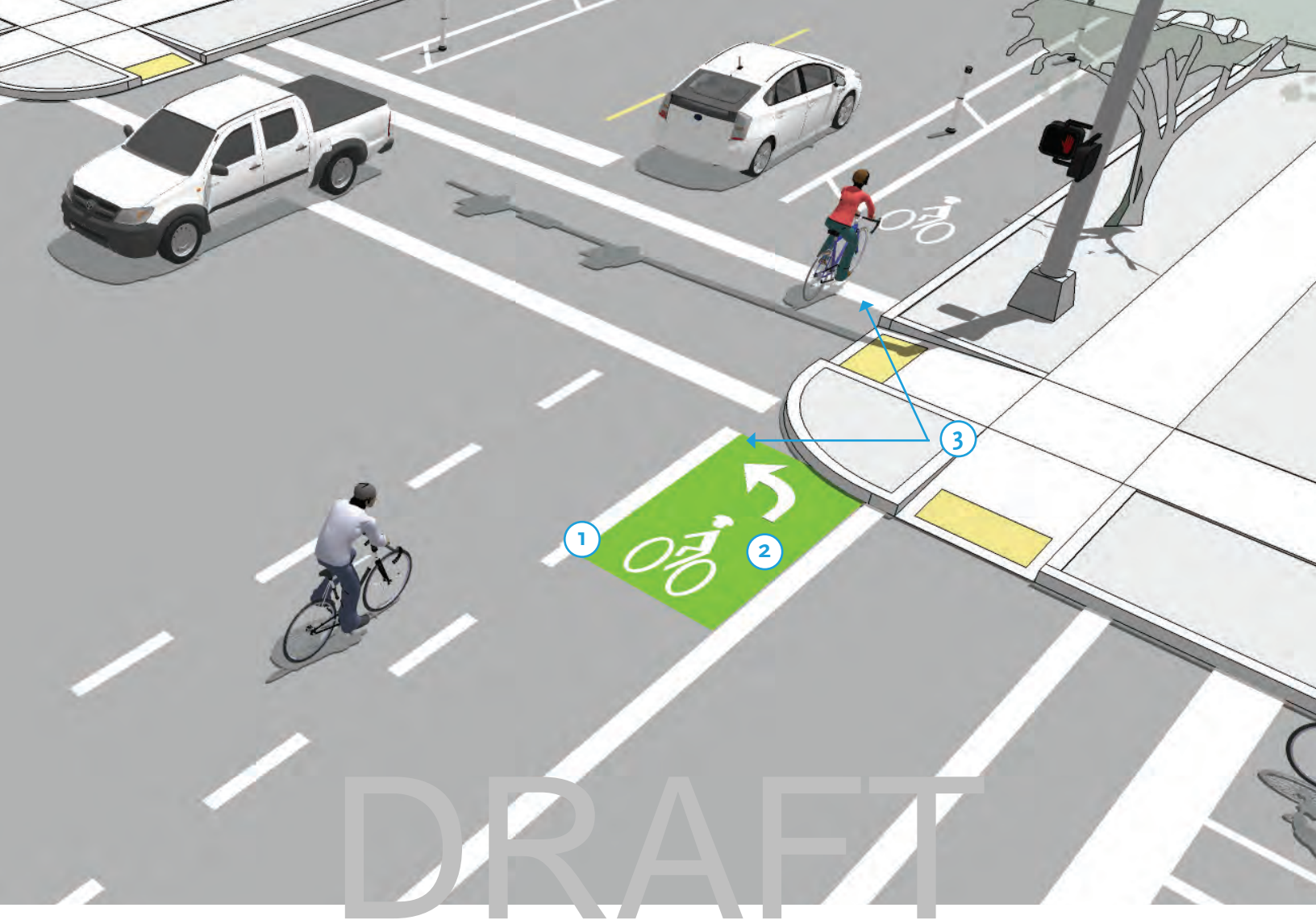
## BENEFITS

- Formalizes existing bicyclist behavior.
- Reduces turning conflicts between bicyclists and motor vehicles.
- Prevents conflicts arising from bicyclists queuing in a bike lane or crosswalk.
- Separates turning bicyclists from through bicyclists.

## TYPICAL APPLICATION

- Preferred treatment to assist turning maneuvers on protected bikeways, instead of requiring bicyclists to merge to make a vehicular left turn.
- Required for protected bikeways to assist left turns from a right side facility, or right turns from a left side facility.
- Strongly recommended on streets with 2+ lanes in each direction.
- Recommended to assist turning maneuvers where neighborhood bikeways intersects protected bike lanes.





15<sup>TH</sup> STREET TWO-STAGE TURN BOX

Denver, CO

## DESIGN CRITERIA

- 1 TWO-STAGE TURN BOX DIMENSIONS: 6' X 6' PREFERRED**

Designated space to hold multiple queuing bicyclists and formalize two-stage turn maneuvers. 3' x 6' minimum dimensions can provide adequate storage for a single bicyclist. The box can also be expanded across adjacent travel lanes to increase storage capacity.
- 2 TURN BOX MARKINGS**

The turn box should be outlined with 4 inch white stripes around three edges, leaving the entrance direction "open". Green color application may raise conspicuity of the turn box for all users. Bicycle stencil and turn arrow pavement markings shall be used to indicate proper bicycle direction and positioning.
- 3 PROTECTED AREA**

Within the shadow of an on-street parking lane, protected bike lane buffer area, or between the bicycle lane and the pedestrian crossing. Consider providing a "No Turn on Red" (MUTCD R10-11) on the cross street to prevent motor vehicles from entering the turn box.



INTERSECTION TREATMENTS

# BICYCLE TRANSIT BYPASS

A bicycle transit bypass is a channelized lane for bicyclists designed to provide a path for bicyclists to pass stopped transit vehicles, and clarify interactions between passengers and bicyclists.

This is particularly helpful on corridors with high volumes of transit vehicles and bicyclists, where “leapfrogging” may occur, and on protected bike lane corridors where maintaining physical separation is important to maintain user comfort.

**BENEFITS**

- Minimizes conflict between bicyclists and transit vehicles.
- Clarifies user expectations for bicyclist path and pedestrian crossing locations.
- Reduces delay for transit when transit vehicles stop in-lane.
- Prioritizes transit, bicyclists and pedestrians.

**TYPICAL APPLICATION**

- Routes where bike lanes or protected bike lanes and transit operations overlap.
- Transit island should be wide enough to accommodate mobility devices.
- Transit island stops to maximize usable space for transit riders, bicyclists and pedestrians.

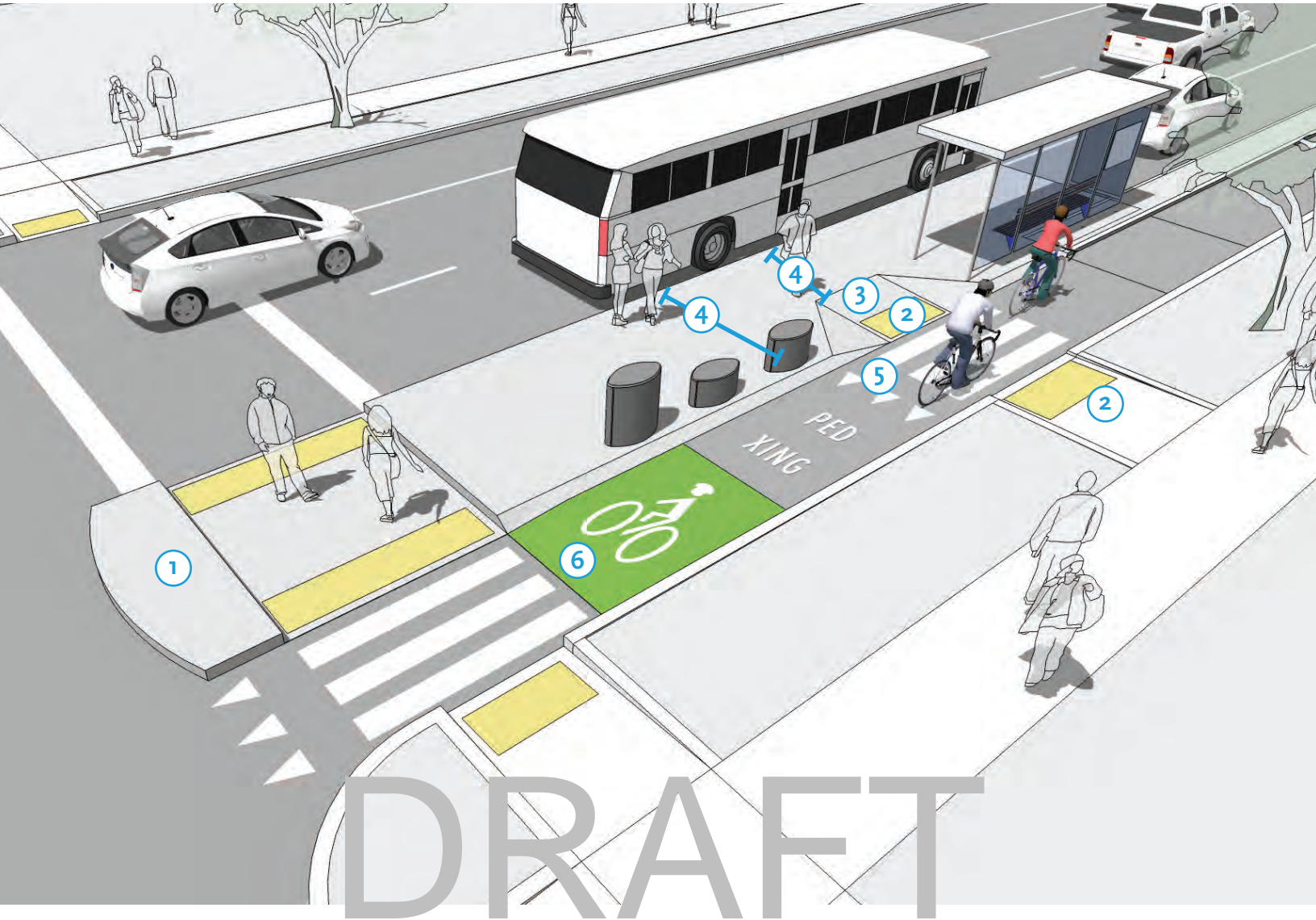
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**REFERENCES**

NACTO. *Urban Street Design Guide*. 2013.





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15<sup>TH</sup> STREET BICYCLE TRANSIT BYPASS

Denver, CO

## DESIGN CRITERIA

- 1 PEDESTRIAN REFUGE ISLAND (OPTIONAL)**  
Shortens crossing distance.
- 2 PEDESTRIAN RAMP INTO CROSSWALK**  
ADA compliant ramps.
- 3 DIRECT PEDESTRIANS TO CROSSING LOCATIONS**  
Consolidates conflicts.
- 4 ROOM FOR WAITING AND LOADING**  
High volume stops should have room for shelters and seating. The bus stop island should be a minimum of 6 feet, with 10 feet preferred at stops with higher transit activity. At least 5 feet clear width shall be provided between the streetside curb and the top of the ramp in the island.
- 5 BICYCLISTS YIELD TO PEDESTRIANS**  
Signs and pavement markings clarify expectations. The bike lane could also ramp up to sidewalk level at this crossing to reduce bicycle speeds and enhance ADA access to the stop.
- 6 BICYCLE LANE ENTRY PAVEMENT MARKINGS**  
Defines the bike lane at stops near intersections to minimize intrusion from pedestrians except at designated crossings.



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