Denver Bikeway Design Manual

Volume 2

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DENVER
THE MILE HIGH CITY

ACKNOWLEDGMENTS

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FIGURES

TABLES

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1. INTRODUCTION

The Denver Bikeway Design Manual (the Manual) provides bikeway facility designers with specific guidelines and standards to implement consistent and high-quality bikeways in Denver.

Volume 1 of the Manual provides the design principles and design user parameters to help designers make facility selection decisions. It also includes a chart to assist designers in selecting the right bicycle facility type based on a roadway's traffic volume and vehicle speeds; roadway characteristics to consider when identifying streets that are good candidates for a bicycle facility; information on the design process in general; and guidance for maintenance and operation of bikeways. In addition, Volume 1's appendices contain a Street Reconfiguration Decision-Making Flowchart and Bikeway Engineering Plan Submittal Checklist.

Volume 2 of the Manual provides design guidelines, design details, and associated treatments for the bicycle facilities. This Manual applies design principles to accommodate people bicycling as well as people using micromobility devices, such as scooters.

Designers should refer to the latest version of the Denver Department of Transportation and Infrastructure (DOTI) *Traffic Signal, Sign and Pavement Marking Standards* (TSSMS) and the *Transportation Standard Drawings for the Engineering Division* (TSD) for design details related to pavement design, curbs and gutters, ADA-compliant curb ramps, sidewalks, planting strips and amenity zones, traffic and pedestrian signals, and other roadway elements. The *Complete Streets Design Guidelines* and *Complete Streets Design Standards* should be consulted for information about overall street configuration and design parameters. The *Ultra-Urban Green Infrastructure Guidelines* should be consulted for information on including green infrastructure along bikeways.

On a street that is designated for a bicycle facility, if there is a discrepancy between TSSMS and TSD standards and the Manual standard drawings, designers should alert the DOTI project manager of any such discrepancy. The DOTI project manager will coordinate an internal citywide review to resolve the discrepancies among the affected agencies and/or divisions within DOTI. In addition, the difference should be reported to DOTI's Transportation and Mobility Engineering Division. Designers may be required to follow Capital Project Technical Variance processes in cases where the DOTI project manager considers the discrepancy from the Manual, TSSMS, and TSD to be significant.

The standard drawings presented in this Manual are focused on providing design guidance for typical conditions that designers face when designing bikeways. Where existing conditions are not explicitly addressed by the Manual, designers should use engineering judgment and identify treatments that comply with the design principles presented in Volume 1 of this Manual.

This Volume provides detailed design guidance, standard drawings, and considerations for three major types of linear bikeways: conventional and buffered bike lanes, protected bike lanes, and neighborhood bikeways. It provides standards to address multimodal connections, including bus and bicycle interactions and trail connections, and design tools such as bicycle signals and detection.

Designers should strive to apply the preferred dimensions presented in the Manual. **If designers recommend dimensions identified for constrained conditions for more than 150 feet, or when the minimum bikeway facility dimensions are not met (for any distance), they shall follow the bikeway design variance process outlined in Volume 1 of this Manual.**

2. CONVENTIONAL & BUFFERED BIKE LANES

Conventional and buffered bike lanes are defined as facilities within the street where space is designated exclusively for bicycle and micromobility users using only painted lines to separate these users from motor vehicle traffic. They are located adjacent to, and typically match the direction of, motor vehicle travel lanes. They are typically on the right side of the street and between the adjacent travel lane and the curb, shoulder, edge of pavement, or parking lane.

Figure 2-1: Gutter Extended Full Width of Bike Lane in Golden, CO

Zones and Design Elements

Conventional and buffered bike lanes can be broken into two distinct zones: the bike lane zone and the buffer zone. The buffer zone only applies to buffered bike lanes.

Bike Lane Zone

The bike lane zone is the designated operating space for bicyclists in the roadway. It may also be used by micromobility users within operating guidelines stipulated by DOTI. The width of the conventional and buffered bike lanes should follow the values in Table 2-1. The preferred width ranges account for the necessary horizontal offset from objects (e.g., parked cars, signs, etc.) to reduce the chance of pedal and handle bar strikes. The lower preferred widths (5 feet) only account for physical and minimum operating widths. Higher widths provide a higher level of comfort for people bicycling. The widths in these tables should be measured from the center of the bike lane striping to the edge of the gutter pan when the bike lane is adjacent to the curb.

Designers should provide the highest quality bike facility possible to increase safety and allow bicycle riders to safely pass one another. Wider riding space should be preferred to wide buffers where applicable (e.g., with only 9 feet to the curb including 2-foot gutter, use a 2-foot buffer and 5-foot bike lane instead of 4-foot lane with 3-foot buffer), except at intersections, where a wider buffer is preferred to increase offset from turning vehicles. Where bike lanes are located adjacent to back-in angled parking, the design of the parking spaces should be such that parked vehicles do not encroach into the bike lane. Bike lanes adjacent to head-in parking should be avoided.

Bike Lane Description	Preferred Width (ft)
Adjacent to curb* or edge of pavement	5 – 6.5**
Between travel lanes or buffers	5 – 6.5**
Adjacent to parking/loading	6 – 6.5**

*Excluding the gutter unless the gutter is widened to match the full width of the bike lane. When widening the gutter, construction joints should be sawcut rather than tooled to ensure a smoother surface. 4-foot minimum width is allowed next to 2-foot gutter pans in constrained conditions.

**If available width for the bike lane is greater than 6.5 feet, including gutter where applicable, a buffer should be included. See Table 2-3.

Table 2-1: Bike Lane Zone Widths

Figure 2-2: Bike Lane Shifting at an Intersection

Figure 2-3: Bicycle-Friendly Inlet Grates

In constrained conditions, the minimum bike lane width between bike lane striping and vertical elements may be reduced to 4 feet wide for lengths up to 150 feet to ensure connectivity of the bike lane. If the reduced clear width exceeds 150 feet in length, approval from DOTI is required as outlined in Volume 1 of this Manual. In locations where bicyclists are expected to pass one another frequently, the preferred width is 8 feet. Designers should be aware that narrow bike lanes may not be comfortable for people of all ages and abilities and therefore every effort should be made to use the higher widths outlined in Table 2-1.

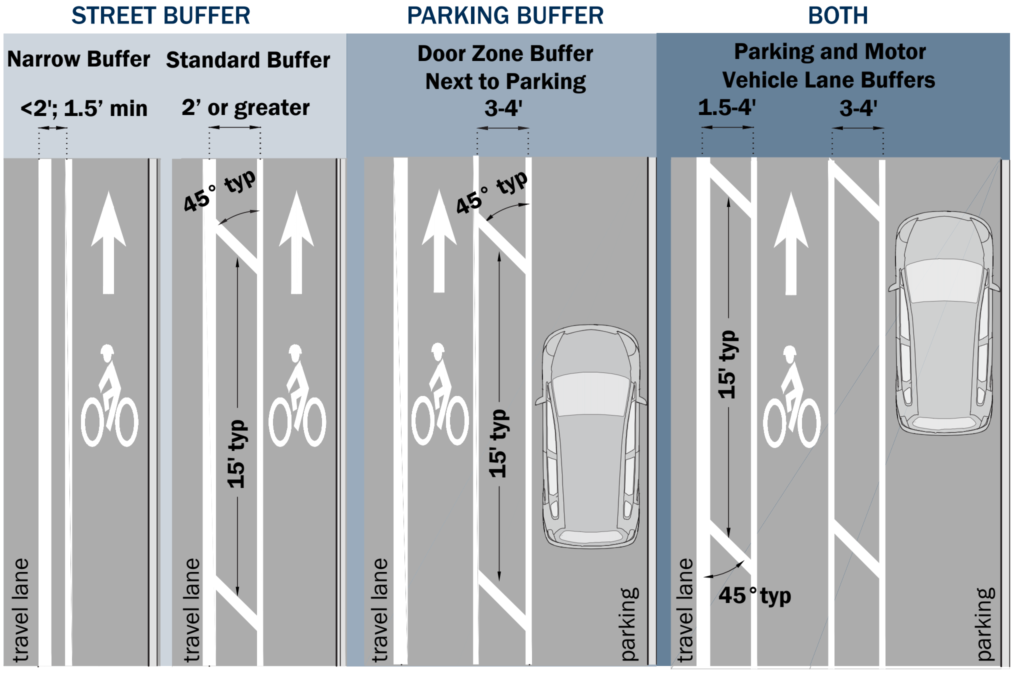
Within the bike lane zone, the horizontal and vertical alignment of the bike lane should be smooth. Horizontal tapers for bike lanes may differ from vehicular lane tapers, and should follow Table 2-2. The use of bicycle ramps should follow guidance in Chapter 5 of this Manual. The target bicyclist or e-scooter operating speed should be 8 mph at intersections and 10 mph along corridors, unless topography and engineering judgment suggests that most bicyclists may be moving much faster or slower. For more guidance on design speed, refer to Volume 1's Bicycle Operating Speed section.

Shifting Taper	
Preferred	**7:1**
Minimum*	**3:1**
Where operating speeds >20mph, use $L = WS^2/60$*, where*	
L = longitudinal lane shift (ft), minimum 20ft	
W = lateral width of offset (ft)	
S = target bicyclist operating speed (mph)	

* Acceptable in constrained conditions where anticipated operating speed is $\leq$ 13 mph

Table 2-2: Shifting Taper

Designers should provide a smooth riding surface for bicyclists to ensure their safety. Where drainage inlet grates are present in the gutter, designers shall install bicycle-friendly inlets per CCD STD DWG S-716.



See Standard Drawing BDS 2-2 for details

Figure 2-4: Typical Buffer Options

Buffer Zone

The buffer zone only applies to buffered bike lanes. It provides separation either between the adjacent travel lane and bike lane (street-buffered bike lane), or between the adjacent parking lane and bike lane (parking-buffered bike lane), or both. Figure 2-3 shows typical buffer options. Generally, a street-buffered bike lane is preferred, unless there is a parking lane with high turnover. When there is a parking lane with high turnover, a parking buffer may be recommended to ensure that bicyclists ride outside of the door zone of parked vehicles. Standard Drawing BDS 2-2 shows buffered bike lane marking details. Buffer widths are outlined in Table 2-3. At driveways and intersections, a minimum 8-foot street buffer where possible is recommended to improve visibility between bicyclists and turning vehicles.

Buffer Description	Preferred Width (ft)	Minimum Width (ft)
Street buffer*	3 – 6	1.5
Parking/loading buffer	4	3

*At driveways and intersections, a minimum 8-foot street buffer is preferred

Table 2-3: Buffer Zone Widths

Zone Selection

Buffered bike lanes provide greater comfort to bicyclists by providing horizontal separation from the adjacent travel lane, the adjacent parking lane, or both. When the space available for a bike lane is greater than 6.5 feet, a buffer should be used as it will reduce confusion by motorists who might otherwise mistake a wide bike lane as a parking or travel lane. A street-buffered bike lane is preferred; however, additional considerations include:

- A street buffer on uphill bike lanes and contraflow bike lanes is recommended to increase separation where vehicle and bicyclist speed differential is greater.
- The use of a parking buffer is desirable when parking turnover is frequent (e.g., short-term parking and commercial/downtown areas), or when larger vehicles typically use the parking lane. Where there is less than 3 feet of space for a parking buffer, include a narrower street buffer to maximize parking buffer space.
- When space allows, both a street buffer and a parking buffer are preferred.

Signs and Markings

Bike Symbol Placement

Bike symbol marking detail and placement should follow Standard Drawing BDS 2-1. For design consistency, bike symbols shall be placed in the following locations:

- On the far side of all intersections, 50 feet from the flare of the ADA ramp or tangent of the corner curb radius, whichever is farther from the intersection.
- On the near side of all signalized intersections and all intersections with an arterial street, 20 feet from the flare of the ADA ramp or tangent of the corner curb radius, whichever is farther from the intersection.
- Mid-block if the block is more than 500 feet.
- Mid-block if the horizontal or vertical curve of the street obstructs the view of a downstream intersection.
- Approximately 10 feet downstream of all loading zones. Additional bike symbols may be installed upstream of loading zones.
- Additional bike symbols may be installed with DOTI project manager approval, at locations where additional clarity of the bike lane is deemed necessary to help improve bicyclist safety (e.g., major driveways with high volumes of traffic).
- Approximately 10 feet downstream of high volume (>500 vehicles/day) driveways. Additional bike symbols may be installed upstream of high volume driveways.
- Bike symbols should include an arrow when the bike lane is installed on a one-way street, when the bike lane is contraflow, on protected bike lanes, and when the bike lane is located on an intersection approach between general purpose lanes.

Bike symbols should not be placed next to drainage inlets or at low points of the street where street debris are likely to collect on a regular basis. See Chapter 4 for shared lane marking symbol placement.

Centerline Markings

The type of centerline markings on a street with a bikeway facility depends on the average daily traffic (ADT) of the roadway. The following guidance should be used when installing centerline markings:

- On streets with < 3000 ADT, install yellow skip centerlines (unless the street is designated as a neighborhood bikeway, in which case a centerline is not recommended). Double yellow lines may be required in conditions with sight distance limitations.
- On streets with between 3000 and 5000 ADT, install yellow skip or solid double yellow centerlines, dependent on land use context, sight lines, and access needs.
- On streets with > 5000 ADT, install double yellow centerlines.

Bike Lane Sign Placement

At the beginning and end of a bike lane, the "BIKE LANE" sign (R3-17) and accompanying plaque ("BEGINS" (R3-17-BG-P) or "ENDS" (R3-17-BP)) shall be provided. 100 feet in advance of the bike lane terminus, include a supplemental "100 FT" (R3-17-5) plaque with "BIKE LANE + ENDS" signage, giving users sufficient opportunity to transition to a different corridor if desired. Where possible, designers should consider providing wayfinding signage to direct bicyclists to another bikeway in addition to the "BIKE LANE +ENDS" sign.

When used, bike lane signs should be placed adjacent to the bike symbol pavement marking. When a project removes parking to install a bike lane, the "NO PARKING TOW AWAY ZONE" (12R7-10A) should be used at the beginning and end of the block face or every 200 feet.

Driveways and Intersections

Driveway Treatment

The design of conventional or buffered bike lanes should follow the bikeway design principles outlined in Volume 1: speed minimization, visibility of all users, and separation of vulnerable roadway users. When striping a bike lane across a driveway, designers should consider the adjacent land uses. Standard Drawing BDS 2-2 shows buffered bike lane details across driveways that provide access to various types of land uses. The driveway pavement marking design is differentiated between low-volume driveways (providing access to single family and small multi-family homes) and high-volume driveways (providing access to large multi-family homes and commercial properties).

Loading Zone Treatment

When a bikeway traverses a loading zone, designers should do their best to reduce the potential for conflict between bicyclists, vehicles, and pedestrians. The preferred design requires loading activity to occur away from the curb (see Standard Drawing BDS 2-2). Where ADA accessible loading or parking is provided, designers should identify an accessible pedestrian route from the parking or loading zone to the curb. This can be done by adding a new ADA-compliant curb ramp or identifying a safe and accessible route to the nearest existing ADA-compliant curb ramp.

At locations where the loading zone cannot be located away from the curb, designers may allow loading activity to occur at the curb if adequate safety treatments can be implemented along the loading zone. At a minimum, adequate sight distance must be provided so that loading vehicles can clearly see bicyclists (see Buffered Bike Lane at Loading Zone Without Protection in Standard Drawing BDS 2-2).

Sometimes, consolidating multiple loading zones on a block or relocating loading zones can help increase bicyclist and pedestrian comfort. Work with DOTI's Curbside and Parking staff to determine the best option for doing so.

At locations where the loading zone is actively managed by an attendant (e.g., when valet operations are present in a loading zone) or where adequate space is available between the travel lane and a stopped vehicle in the loading zone for another vehicle to drive around, designers may consider providing access to the loading zone through an entry and an exit space in the street buffer zone. In this design option, the street buffer zone between the entry and exit access points should include a vertical element to reduce the length of the conflict area between bicyclists and vehicles.

Approach Treatment

Designers should consider three main factors when designing bikeways at intersections: intersection control, the presence of parking, and the need for a turn lane. Where right turn pockets are not required and conflicting peak hour turning volumes (left + right turns) exceed 150 vehicles, and where extra space is available (e.g., due to on-street parking restrictions at intersection approaches), a conventional or buffered bike lane can be transitioned to a protected bike lane to increase the comfort of the facility at the intersection (see Standard Drawing BDS 2-5). This treatment allows similar benefits as protected intersections to be applied to corridors with conventional and buffered bike lanes (see Chapter 3).

At intersection approaches with limited space where a right-turn lane is not required but there are relatively high right-turn volumes (more than 100 vehicles during the peak hour) or crash history, designers should consider adding a 2-foot minimum buffer with flex posts to provide added protection for bicyclists (see Standard Drawing BDS 2-6).

Turn Lane Treatment

The choice to add a turn lane pocket at an intersection is usually based on overall operation of the intersection and includes consideration of vehicle queuing and delay. When considering adding or maintaining a turn lane along a corridor that has a bike lane, the designer should refer to the following scenarios to determine which type of intersection design is preferred and whether the turn lane is necessary.

The decision to provide vehicular turn lanes and the type of bicycle accommodation should be based on available width and the ability to provide the safest bicycle facility design given the turning vehicle volumes. Careful consideration should be made on streets where buses and large freight vehicles frequently use turn lanes. Refer to the *Complete Streets Design Standards* to determine if an alternate design vehicle should be used, which can affect required lane widths.

The guidance outlined on the following pages is applicable to two-way and one-way streets with right-turn lanes and where left-side bikeways interact with dedicated left-turn lanes. The City Traffic Engineer must approve all lane removals.

As intersections are the locations where most conflicts occur, where additional space can be made available within the scope of the project (e.g., acquisition of right-of-way), intersection treatments should be designed with the highest degree of protection for people bicycling, as outlined in the following pages and in Chapter 3.

Scenario A: Available Width is <14 Feet

If the combined available width for a turn lane and a bike lane is less than 14 feet (after widths of all other travel and parking lanes have been reduced to the minimum allowed for the street type as identified in the *Complete Streets Design Standards*, and travel and parking lane removals has been considered), then designers must discuss the priorities for the intersection. The decision-making steps in this scenario are:

STEP 1: IS THE TURN LANE REQUIRED?

Designers should collect weekday AM and PM peak hour turning movement counts at the intersection and conduct operational analyses to confirm the need for the turn lane. On a two-way street, if there are more than 150 right-turning vehicles turning per hour, or 100 left-turning vehicles per hour, the turn lane is likely required. When designing for a high-comfort bikeway, the operational thresholds for the intersection should be increased using the following traffic capacity analysis parameters:

- Conduct analysis with a peak hour factor of 1.0.
- Modify other signal timing parameters as necessary to evaluate alternatives to providing the turn lane (cycle lengths, split-phasing options, force-offs, vehicle extensions, timing optimization etc.).
- Outside of downtown, accept level of service E for the lane group that includes the turning movement without the turn lane. In downtown, accept level of service F for the lane group that includes the turning movement without the turn lane.

If the turn lane is still required, go to Step 2. If not, design the approach as a protected intersection approach by removing the turn lane (see Standard Drawings BDS 2-5 and 3-6).

STEP 2: CAN AN ADJACENT TRAVEL LANE BE CONVERTED TO A TURN LANE?

If the traffic analysis shows that the turn lane is needed, evaluate whether an adjacent travel lane can be converted into a turn lane. If the analysis supports this lane reassignment, continue the bike lane up to the intersection and design the approach as a protected intersection approach with a bicycle signal (see Standard Drawing BDS 3-6).

Otherwise, go to Step 3.

STEP 3: CAN THE BIKE LANE TRANSITION TO BE AT SIDEWALK LEVEL OR INTERMEDIATE LEVEL?

If the roadway can be widened by narrowing the amenity zone or the sidewalk, the conventional bike lane can transition to a sidewalk-level or intermediate-level bikeway prior to the turn lane at the intersection. This is preferable to terminating the bike lane at the turn lane. Install a bicycle signal or a "BIKES USE PED SIGNAL" (R9-5) may be used unless the intersection includes an all-pedestrian phase (see Standard Drawing BDS 3-6).

Otherwise, go to Step 4.

STEP 4: DESIGN A MIXING ZONE.

When the aforementioned options are not feasible, a mixing zone should be designed to clarify the merge area between the bike lane and the turn lane. Where space allows, a buffered bike lane mixing zone with yield markings on entry for vehicles and shared lane markings within the turn lane should be provided (see Standard Drawing BDS 2-3).

Scenario B: Available Width is 14-17 Feet

If the combined available width for a turn lane and a bike lane is between 14 and 17 feet (after widths of all other travel and parking lanes have been reduced to the minimum allowed for the street type identified in the *Complete Streets Design Standards*, and travel and parking lane removals has been considered), then designers must discuss the priorities for the intersection. Designers should determine whether the turn lane is required based on the guidelines presented under Scenario A, Step 1. If the turn lane is required, consider the decision-making steps in this scenario:

STEP 1: CAN THE BIKE LANE TRANSITION TO BE AT SIDEWALK LEVEL OR INTERMEDIATE LEVEL?

If the bike lane elevation can transition at the intersection, design a sidewalk or intermediate-level bikeway with recommended street and sidewalk buffer from the intersection to the beginning of the turn lane transition. This may require reducing existing sidewalk or landscape space to minimum widths allowed in the *Complete Streets Design Standards* to accommodate the bike lane. Install a bicycle signal or a "BIKES USE PED SIGNAL" (R9-5) sign may be used unless the intersection includes an all-pedestrian phase (see Standard Drawing BDS 3-6).

Otherwise, go to Step 2.

STEP 2: CAN THE BIKE LANE TRANSITION TO THE LEFT OF THE RIGHT TURN LANE OR THE RIGHT OF THE LEFT TURN LANE?

Where turning vehicle volumes are less than 150 motor vehicles in the peak hour, the bike lane should transition to the left of the right-turn lane, or to the right of the left-turn lane (see Standard Drawing BDS 2-4). The conflict area should be marked with conflict zone markings and the bike lane and buffer should maintain the maximum width available given right-of-way availability. Flexible posts may be added to restrict motorist merging movements to the conflict zone. Designers must consider the maintenance impacts, especially during winter, that accompany any vertical element.

Otherwise, go to step 3.

STEP 3: PROVIDE A PROTECTED BIKE LANE TO THE RIGHT SIDE OF THE RIGHT-TURN LANE, OR LEFT SIDE OF THE LEFT-TURN LANE.

At locations where the turning vehicle volumes are equal to or greater than 150 motor vehicles in the peak hour, the bike lane should remain at the curb and a bicycle signal should be installed. If the transition to sidewalk or intermediate-level is not feasible, provide, at a minimum, a 10-foot right-turn lane and a 4-foot bike lane. Where additional space is available, add a buffer to provide separation between bicyclists and the turning vehicles (see Standard Drawing BDS 2-4).

Phase separation of the motor vehicle turn movement and the bicycle through movement is required when a bike lane is placed to the outside of a dedicated turn lane (see Standard Drawing BDS 2-4). Chapter 6 includes details for installation and signal phasing for bicycle signals.

Scenario C: Available width >17 feet

Where conventional bike lanes approach the intersection with available width greater than 17 feet, the bike lane may transition into a buffered bike lane and a turn lane or to a protected intersection. Designers should determine whether the turn lane is required based on the guidelines presented under Scenario A, Step 1. If the turn lane is required, consider the decision-making steps in this scenario as:

STEP 1: CAN A PROTECTED INTERSECTION BE INSTALLED?

If there is sufficient space to install a protected intersection or transition the bike lane to sidewalk-level with the required turn lane, follow guidance in Standard Drawing BDS 2-5 to design a protected intersection and install a bicycle signal phase that is separated from the conflicting turning movements. If the protected intersection is at sidewalk level, the "BIKES USE PED SIGNAL" (R9-5) sign may be installed in lieu of a bicycle signal unless the intersection includes an all pedestrian phase (see Standard Drawing BDS 3-6).

If there is not sufficient space for a protected intersection, go to Step 2.

STEP 2: DESIGN BUFFERED BIKE LANE WITH TURN LANE.

Where turning vehicle volumes are less than 150 motor vehicles in the peak hour, the bike lane should transition to the left of the right-turn lane, or to the right of the left-turn lane (see Standard Drawing BDS 2-4). The conflict area should be marked with green crossing markings and the bike lane and buffer should maintain the maximum width available given right-of-way availability. Flexible posts may be added to restrict motorist merging movements to the conflict zone.

At locations where the turning vehicle volumes are equal to or greater than 150 motor vehicles in the peak hour, the bike lane should remain at the curb and a bicycle signal should be installed. Where additional space is available, add a buffer and consider using vertical elements to provide separation between bicyclists and turning vehicles.

Intersection Treatment

When a conventional or buffered bike lane crosses a signalized intersection, green crossing markings should be installed (see Standard Drawing BDS 6-2).

When a conventional or buffered bike lane crosses an unsignalized intersection, if the conflicting turning volume is more than 100 vehicles in the peak hour or the intersection is a high crash location, green bikeway crossing markings should be installed. No bikeway crossing markings are required at any other unsignalized intersections along a conventional or buffered bike lane corridor.

Conventional & Buffered Bike Lane Standard Drawings

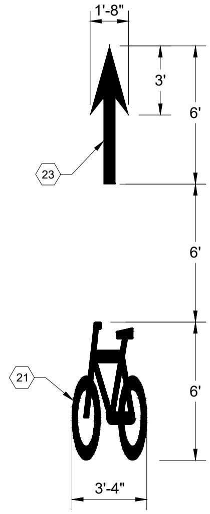
LEGEND:

1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
2 4" SKIP YELLOW CENTERLINE, 10' LINE, 30' GAP
3 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
4 4" SOLID YELLOW WITH 4" SKIP YELLOW, 10' LINE, 30' GAP, AND 4" SEPARATION
5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
7 4" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
9 8" DASHED WHITE LINE, 3' DASH, 9' GAP
10 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
11 WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
12 4" DASHED WHITE LINE, 3' DASH, 9' GAP
13 4" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
14 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
15 18" WHITE ADVANCED STOP BAR
16 WHITE YIELD LINE 24"X36" WITH 3" TO 12" SEPARATION
17 18"X10' WHITE CROSSWALK BAR
18 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
19 WHITE TURN ARROW MARKING
20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
21 WHITE BIKE SYMBOL MARKING
22 WHITE SHARED LANE MARKING SYMBOL
23 WHITE STRAIGHT BIKE ARROW MARKING
24 WHITE TURN BIKE ARROW MARKING
25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
26 WHITE SHARED LANE MARKING SYMBOL WITH DIRECTIONAL INDICATION
27 WHITE BI-DIRECTIONAL SHARED LANE MARKING SYMBOL
28 WHITE BICYCLE DETECTION PAVEMENT MARKING
29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN
30 36" YELLOW FLEXIBLE DELINEATOR POST
31 36" WHITE FLEXIBLE DELINEATOR POST
32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES
33 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH YELLOW STRIPES
34 10' LONG, 4" TO 6" HIGH PRECAST CONCRETE CURB
35 3' LONG, 5" HIGH MOUNTABLE RUBBER CURB WITH YELLOW STRIPES
36 2" TO 3" MAX HIGH RUBBER SPEED BUMP, BLACK AND WHITE
37 8" SOLID YELLOW LINE
38 18" SOLID YELLOW LINE
39 6' PEDESTAL POLE WITH BICYCLIST PUSH BUTTON
40 6' PEDESTAL POLE WITH PEDESTRIAN PUSH BUTTON
41 15' PEDESTAL POLE WITH BICYCLE SIGNAL HEAD
42 15' PEDESTAL POLE WITH PEDESTRIAN SIGNAL HEAD AND PEDESTRIAN PUSH BUTTON
43 2.54' LONG, 3.55" HIGH RECYCLED PLASTIC CURB WITH WHITE STRIPES
44 2.54' LONG, 3.55" HIGH RECYCLED PLASTIC CURB WITH YELLOW STRIPES
45 2.69' LONG, 5.12" HIGH RECYCLED PLASTIC CURB WITH WHITE STRIPES
46 2.69' LONG, 5.12" HIGH RECYCLED PLASTIC CURB WITH YELLOW STRIPES
47 4" DASHED DOUBLE YELLOW LINE, 2' DASH, 6' GAP, CENTERED WITH 4" SEPARATION
48 8" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
49 8" SOLID YELLOW 45° DIAGONAL CROSSHATCH AT 15' SPACING

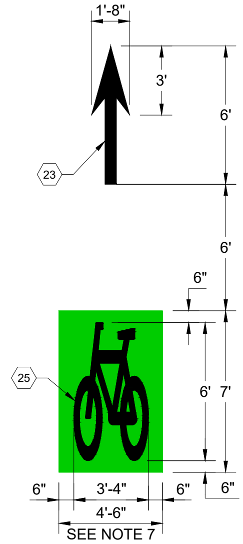
NOTES:

1. EPOXY PAVEMENT MARKING MATERIAL SHALL BE USED ON ASPHALT SURFACES UNLESS OTHERWISE APPROVED BY DOTI TRANSPORTATION OPERATIONS. FOR CONCRETE ROADWAY SURFACE, INLAID THERMOPLASTIC OR CONTRAST TAPE PAVEMENT MARKING MATERIAL SHALL BE USED FOR 5 9 20 UNLESS OTHERWISE APPROVED BY DOTI TRANSPORTATION OPERATIONS.
2. SPECIALTY MARKINGS 15 17 18 19 MATERIAL SHALL BE REFLECTORIZED PREFORMED THERMOPLASTIC (MIN. 90 MIL THICKNESS) FULL WIDTH WITHOUT SEAMS UNLESS OTHERWISE SPECIFIED.
3. ANY FINAL PAVEMENT MARKING QUANTITIES SHALL INCLUDE REMOVAL OF ANY CONFLICTING, PREVIOUS, OR DETOUR MARKINGS AS NECESSARY.
4. ALL OTHER PROVISIONS OF "CITY AND COUNTY OF DENVER STANDARDS AND SPECIFICATIONS" AND "STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION", STATE DEPARTMENT OF HIGHWAYS, STATE OF COLORADO, CURRENT EDITION SHALL APPLY.
5. ALL REMOVALS SHALL BE BY GRINDING, SANDBLASTING, OR WATER BLASTING METHODS PROVIDED THAT THE PAVEMENT SURFACE SHALL NOT BE MATERIALLY DAMAGED. THE PAVEMENT MARKINGS SHALL BE REMOVED TO THE EXTENT THAT THEY SHALL NOT BE VISIBLE UNDER DAY OR NIGHT CONDITIONS.

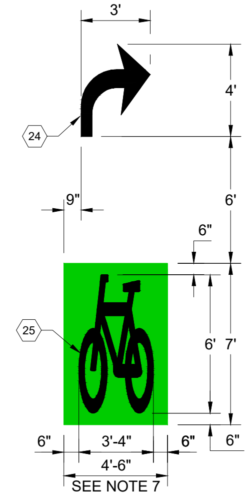
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKEWAY PAVEMENT MARKING KEYNOTE LEGEND AND GENERAL NOTES	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-0



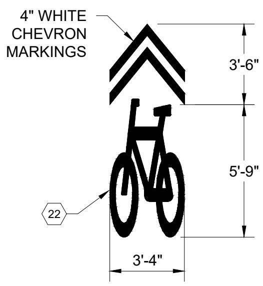
WHITE BIKE SYMBOL MARKING WITH WHITE STRAIGHT BIKE ARROW MARKING



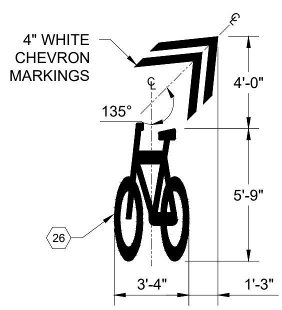
GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL WITH WHITE STRAIGHT BIKE ARROW MARKING



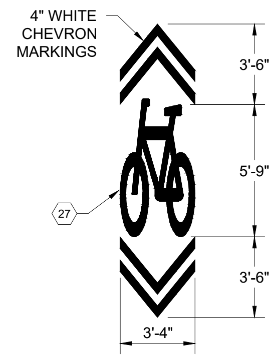
GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL WITH WHITE TURN BIKE ARROW MARKING



WHITE SHARED LANE MARKING SYMBOL



WHITE SHARED LANE MARKING SYMBOL WITH DIRECTIONAL INDICATION



WHITE BI-DIRECTIONAL SHARED LANE MARKING SYMBOL

LEGEND:

- (21) WHITE BIKE SYMBOL MARKING
- (22) WHITE SHARED LANE MARKING SYMBOL
- (23) WHITE STRAIGHT BIKE ARROW MARKING
- (24) WHITE TURN BIKE ARROW MARKING
- (25) GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- (26) WHITE SHARED LANE MARKING SYMBOL WITH DIRECTIONAL INDICATION
- (27) WHITE BI-DIRECTIONAL SHARED LANE MARKING SYMBOL

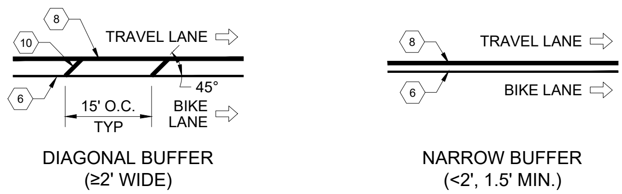
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. BIKE SYMBOL MARKINGS SHALL BE INSTALLED FAR-SIDE OF ALL INTERSECTIONS, AND NEAR-SIDE AND FAR-SIDE OF SIGNALIZED INTERSECTIONS AND ARTERIAL CROSSINGS. FAR-SIDE AND NEAR-SIDE BIKE SYMBOL MARKINGS TO BE INSTALLED 50' AND 20', RESPECTIVELY, FROM THE FLARE OF THE ADA RAMP OR TANGENT OF THE CORNER CURB RADIUS, WHICHEVER IS FARTHER FROM THE INTERSECTION.
4. BIKE SYMBOL MARKINGS SHALL BE LOCATED MID-BLOCK ON BLOCKS LONGER THAN 500' AND/OR BEFORE THE BEGINNING OF VERTICAL OR HORIZONTAL CURVE OF THE STREET WHERE THE CURVATURE OBSTRUCTS THE VIEW OF THE DOWNSTREAM BIKE SYMBOL.

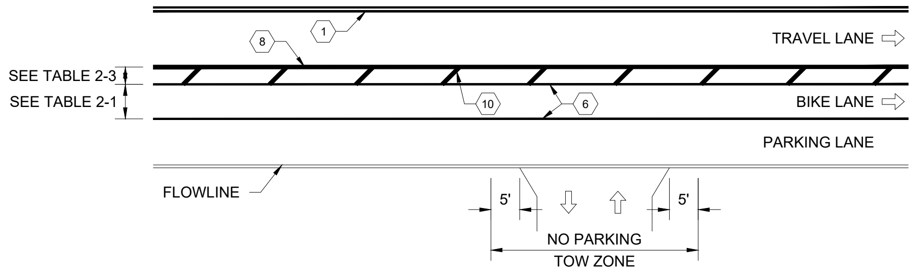
NOTES, CONTINUED:

5. BIKE SYMBOL MARKINGS SHALL BE PLACED TO AVOID THE WHEEL PATH OF MOTOR VEHICLES, DRAINAGE INLETS, AND LOW POINTS THAT REGULARLY COLLECT DEBRIS OR ARE INUNDATED.
6. GREEN BACKED BIKE MARKINGS SHALL BE USED IN PROTECTED BIKE LANES. GREEN BACKED BIKE MARKINGS ARE OPTIONAL UPSTREAM OF GREEN CROSSING MARKINGS AND MIXING ZONES.
7. BIKE MARKINGS SHALL BE INSTALLED OUTSIDE OF THE GUTTER PAN. IF THE BIKE LANE IS LESS THAN 4'-6" WIDE, EXCLUDING THE GUTTER PAN, THE GREEN BACKED BIKE SYMBOL SHALL BE TRIMMED EQUALLY ON EACH SIDE TO FIT WITHIN THE BIKE LANE AND OUTSIDE OF THE GUTTER.
8. STRAIGHT BIKE ARROWS SHALL BE INCLUDED ON DESIGN PLANS FOR CONTRAFLOW BIKE LANES, PROTECTED BIKE LANES, WHEN THE BIKE LANE IS INSTALLED ON A ONE-WAY STREET, AND WHEN A BIKE LANE IS LOCATED ON AN INTERSECTION APPROACH BETWEEN VEHICULAR TRAVEL LANES.
9. TURN BIKE ARROWS SHALL BE INCLUDED ON DESIGN PLANS FOR EXCLUSIVE BIKE TURN LANES AND ARE OPTIONAL WHEN A BIKE LANE TURNS FROM ONE ROADWAY ONTO ANOTHER ROADWAY.
10. SHARED LANE MARKINGS WITH DIRECTIONAL INDICATION REQUIRE FHWA REQUEST TO EXPERIMENT APPROVAL. SHARED LANE MARKINGS WITH DIRECTIONAL INDICATION MAY BE USED WHEN A NEIGHBORHOOD BIKEWAY TURNS FROM ONE ROADWAY ONTO ANOTHER ROADWAY.
11. BI-DIRECTIONAL SHARED LANE MARKINGS SHALL BE USED FOR ROADWAY WIDTHS LESS THAN 32', IF PARKING IS PERMITTED ON BOTH SIDES. SEE TABLE 4-3 FOR SHARED LANE MARKING PLACEMENT GUIDANCE.

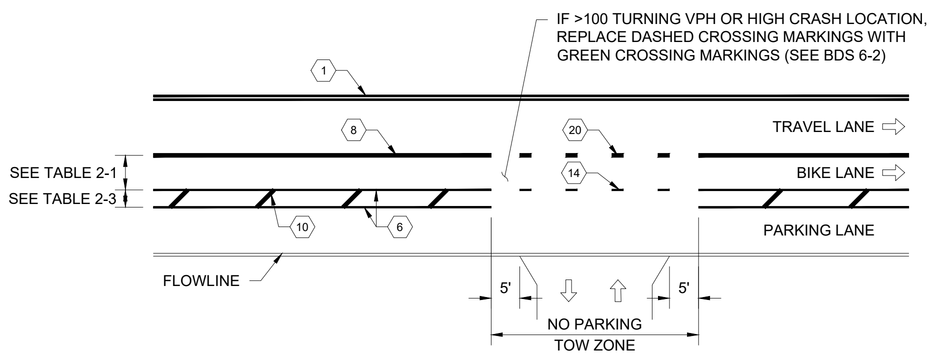
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE SYMBOL DETAILS	STD DWG NO. BDS 2-1



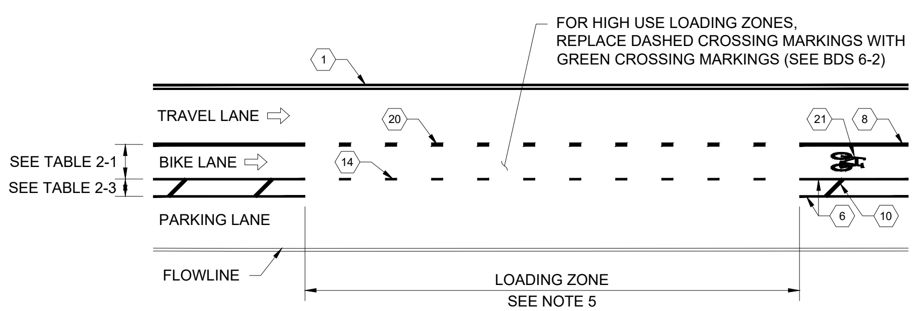
BUFFER ZONE TYPES
(SEE NOTE 4)



BUFFERED BIKE LANE
AT LOW VOLUME DRIVEWAY
(SINGLE FAMILY HOMES AND
SMALL MULTI-FAMILY)



BUFFERED BIKE LANE
AT HIGH VOLUME DRIVEWAY
(LARGE MULTI-FAMILY, ALLEYS,
AND COMMERCIAL)



BUFFERED BIKE LANE
AT LOADING ZONE

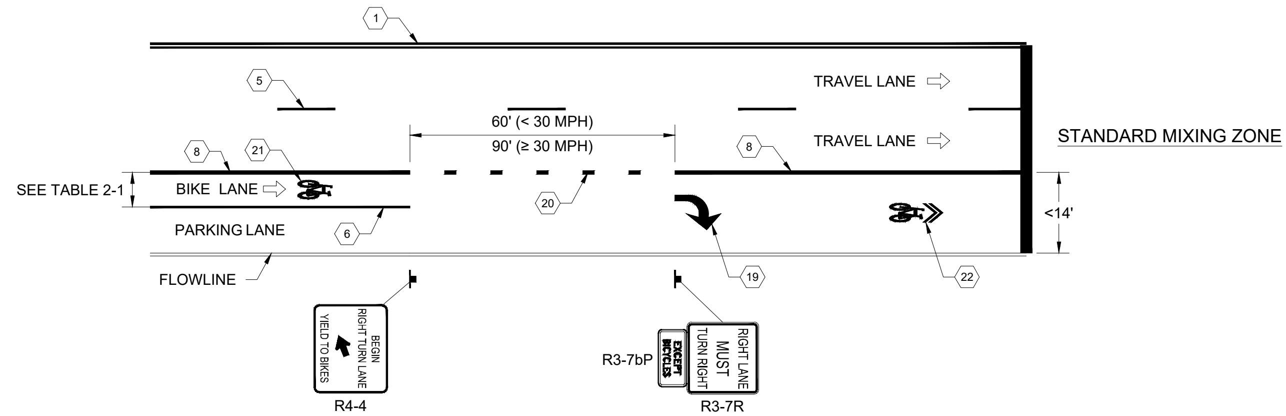
LEGEND:

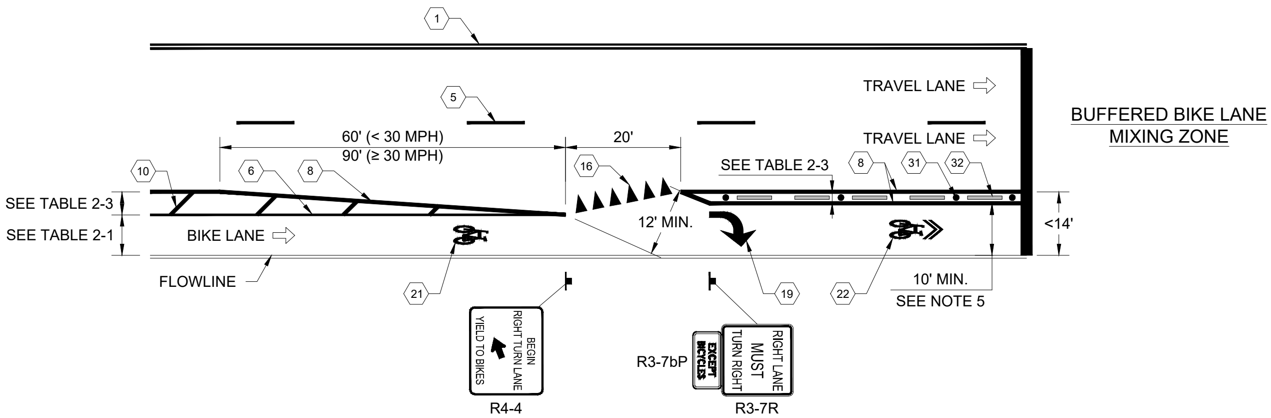
- 1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 14 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 21 WHITE BIKE SYMBOL MARKING

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. ALL TREATMENTS SHOWN ALSO APPLY TO CONVENTIONAL BIKE LANES.
3. BICYCLE LANES AS NARROW AS 4' IN WIDTH (EXCLUDING GUTTER PAN) ARE ALLOWABLE IN CONSTRAINED ENVIRONMENTS FOR 150' WITHOUT DESIGN VARIANCE APPROVAL.
4. SEE PAGE 13 FOR GUIDANCE ON DESIGNING A STREET BUFFER VERSUS A PARKING BUFFER.
5. IT IS PREFERRED TO RELOCATE EXISTING MID-BLOCK LOADING ZONES TO THE END OF THE BLOCK TO CONNECT WITH EXISTING ADA RAMPS. IF RELOCATION IS NOT POSSIBLE, LOADING ZONES MAY REQUIRE ADA COMPLIANT IMPROVEMENTS AT THE EXISTING CURB.
6. SEE PAGE 13 FOR GUIDANCE ON WHEN TO USE A STREET BUFFER VERSUS A PARKING BUFFER.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BUFFERED BIKE LANE MARKING DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-2





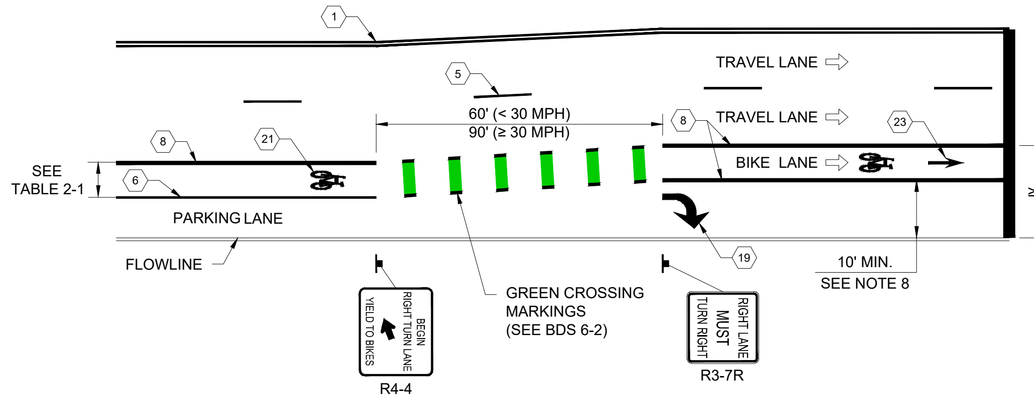
LEGEND:

- 1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 16 WHITE YIELD LINE 24"X36" WITH 4" TO 12" SEPARATION
- 19 WHITE TURN ARROW MARKING
- 20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 21 WHITE BIKE SYMBOL MARKING
- 22 WHITE SHARED LANE MARKING SYMBOL
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

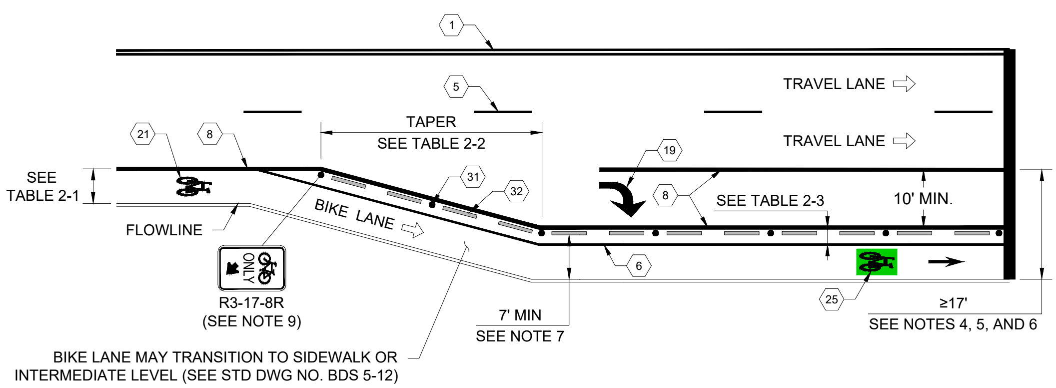
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. MIXING ZONE TREATMENT NOT APPLICABLE FOR RIGHT TURNING TRANSIT VEHICLES.
5. 10' MINIMUM, EXCLUSIVE OF GUTTER PAN.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE LANE AND RIGHT-TURN LAYOUT (<14 FEET)	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-3



BIKE LANE AND LOW VOLUME RIGHT TURN LANE LAYOUT (TURNING VOLUME ≤ 150 VPH)



BIKE LANE AND HIGH VOLUME RIGHT TURN LANE LAYOUT (TURNING VOLUME >150 VPH)

LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 19 — WHITE TURN ARROW MARKING
- 21 — WHITE BIKE SYMBOL MARKING
- 23 — STRAIGHT BIKE ARROW MARKING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

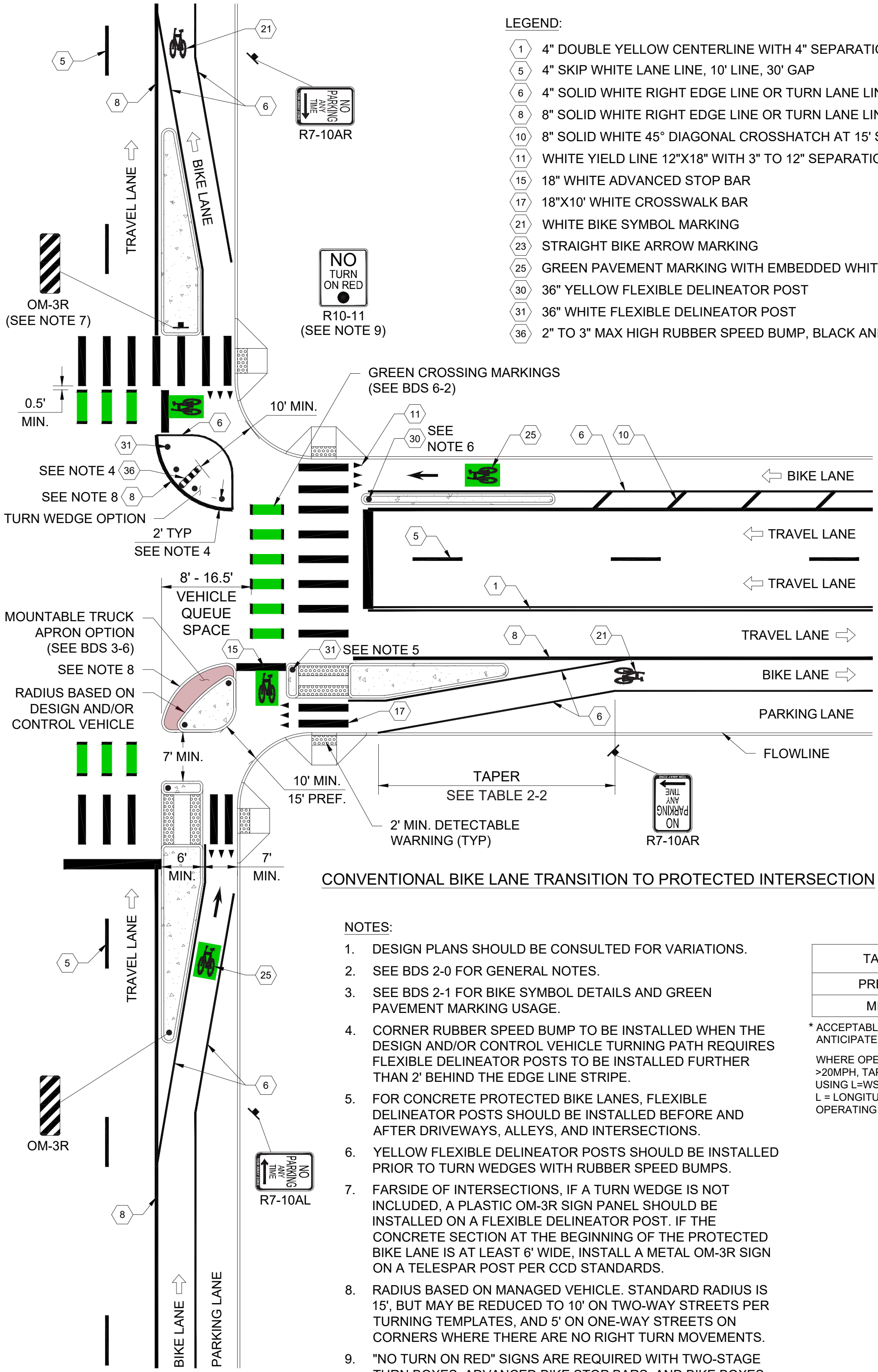
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. IF WIDTH IS <15.5', A SIDEWALK-LEVEL OR INTERMEDIATE-LEVEL BIKE LANE SHOULD BE PROVIDED ADJACENT TO A 10' RIGHT-TURN ONLY LANE, OR THE LATERAL SHIFT TREATMENT DETAIL ON BDS 3-5 MAY BE USED WITH DOTI APPROVAL.
5. BIKE SIGNAL REQUIRED IF BIKE LANE REMAINS AT STREET LEVEL.
6. IF BIKE LANE IS TRANSITIONED TO SIDEWALK OR INTERMEDIATE LEVEL, A "BIKES USE PED SIGNAL" R9-5 SIGN MAY BE INSTALLED UNLESS THE INTERSECTION INCLUDES AN ALL PEDESTRIAN PHASE.
7. 7' MINIMUM CLEAR SPACE IS REQUIRED BETWEEN VERTICAL PROTECTION ELEMENTS AND FACE OF CURB FOR SNOW MAINTENANCE.
8. 10' MINIMUM, EXCLUSIVE OF GUTTER PAN.
9. R3-17-8R SIGN TO BE PLASTIC AND INSTALLED ON FLEXIBLE DELINEATOR POST.
10. STRAIGHT BIKE ARROWS SHALL BE INCLUDED ON DESIGN PLANS FOR CONTRAFLOW BIKE LANES, PROTECTED BIKE LANES, WHEN THE BIKE LANE IS INSTALLED ON A ONE-WAY STREET, AND WHEN A BIKE LANE IS LOCATED ON AN INTERSECTION APPROACH BETWEEN VEHICULAR TRAVEL LANES.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE LANE AND RIGHT-TURN LAYOUT (≥14 FEET)	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-4



LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 — 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 11 — WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- 15 — 18" WHITE ADVANCED STOP BAR
- 17 — 18"X10' WHITE CROSSWALK BAR
- 21 — WHITE BIKE SYMBOL MARKING
- 23 — STRAIGHT BIKE ARROW MARKING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 30 — 36" YELLOW FLEXIBLE DELINEATOR POST
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 36 — 2" TO 3" MAX HIGH RUBBER SPEED BUMP, BLACK AND WHITE

CONVENTIONAL BIKE LANE TRANSITION TO PROTECTED INTERSECTION

NOTES:

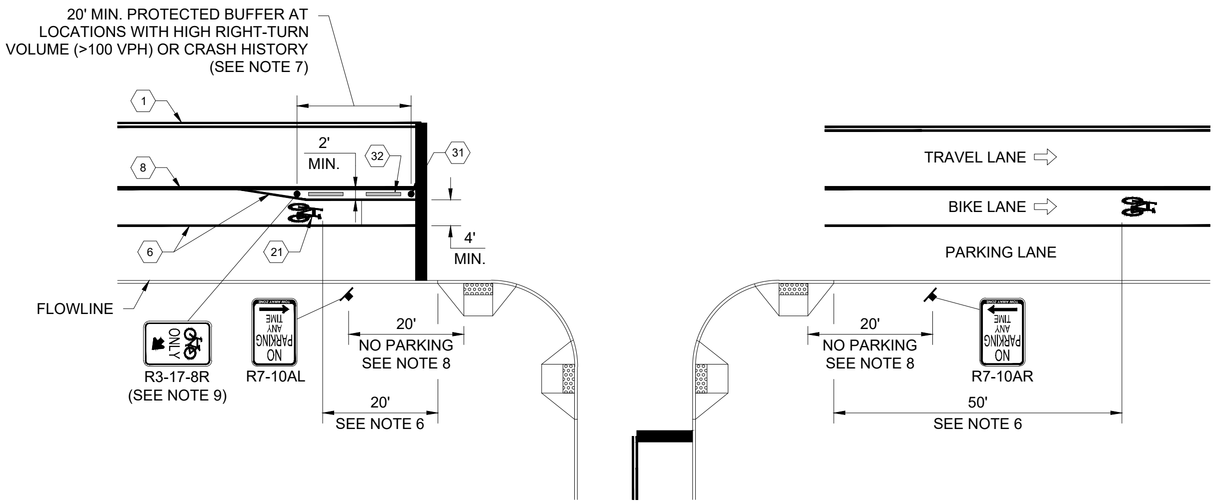
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. CORNER RUBBER SPEED BUMP TO BE INSTALLED WHEN THE DESIGN AND/OR CONTROL VEHICLE TURNING PATH REQUIRES FLEXIBLE DELINEATOR POSTS TO BE INSTALLED FURTHER THAN 2' BEHIND THE EDGE LINE STRIPE.
5. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
6. YELLOW FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED PRIOR TO TURN WEDGES WITH RUBBER SPEED BUMPS.
7. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.
8. RADIUS BASED ON MANAGED VEHICLE. STANDARD RADIUS IS 15', BUT MAY BE REDUCED TO 10' ON TWO-WAY STREETS PER TURNING TEMPLATES, AND 5' ON ONE-WAY STREETS ON CORNERS WHERE THERE ARE NO RIGHT TURN MOVEMENTS.
9. "NO TURN ON RED" SIGNS ARE REQUIRED WITH TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE LANE TRANSITION TO PROTECTED INTERSECTION	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-5



LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 21 — WHITE BIKE SYMBOL MARKING
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. ADVANCED BICYCLE STOP BARS MAY BE INCLUDED AT SIGNALIZED APPROACHES PER BDS 6-1.
5. BIKEWAY CROSSING MARKINGS SHALL BE PLACED PER BDS 6-2.
6. BIKE SYMBOL MARKINGS SHALL BE INSTALLED FAR-SIDE OF ALL INTERSECTIONS, AND NEAR-SIDE AND FAR-SIDE OF SIGNALIZED INTERSECTIONS AND ARTERIAL CROSSINGS. FAR-SIDE AND NEAR-SIDE BIKE SYMBOL MARKINGS TO BE INSTALLED 50' AND 20', RESPECTIVELY, FROM THE FLARE OF THE ADA RAMP OR TANGENT OF THE CORNER CURB RADIUS, WHICHEVER IS FARTHER FROM THE INTERSECTION.
7. DESIGN SHOWN SHOULD ONLY BE USED WHEN SPACE IS LIMITED, SEE BDS 2-5 FOR PREFERRED DESIGN. WHERE SPACE IS AVAILABLE, A TURN WEDGE SHOULD ALSO BE INCLUDED.
8. A LARGER DIMENSION MAY BE USED BASED ON ENGINEERING JUDGEMENT.
9. R3-17-8R SIGN TO BE PLASTIC AND INSTALLED ON FLEXIBLE DELINEATOR POST.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE LANE MARKINGS AT INTERSECTIONS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 2-6

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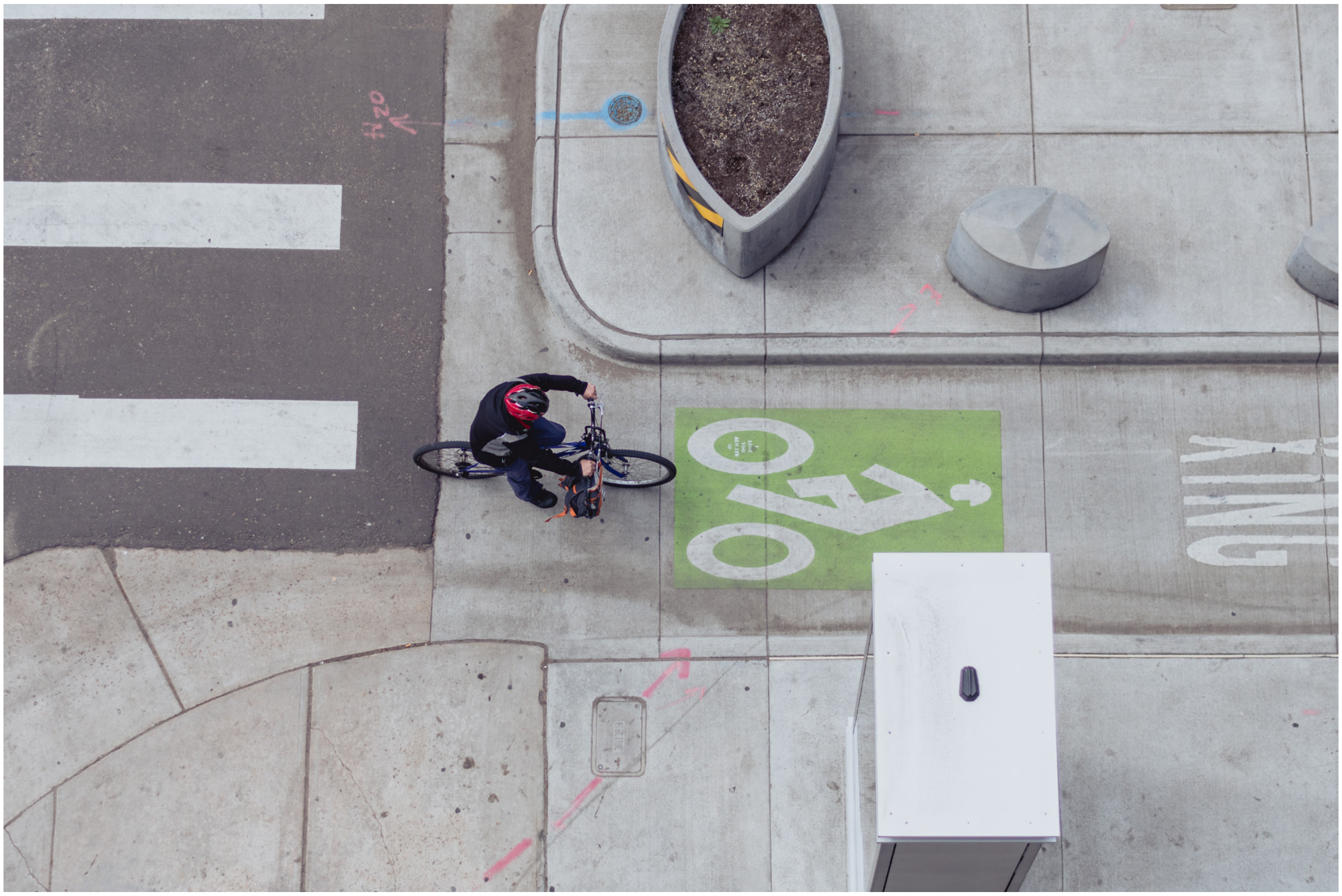


3. PROTECTED BIKE LANES

A protected bike lane is an exclusive bicycle facility that is physically separated from motor vehicle lanes through the use of a vertical element or combination of vertical elements such as cast-in-place or precast curbs, flexible delineator posts, and engineered rubber curbs. These facilities, along with neighborhood bikeways and trails, make up the backbone of Denver's high-comfort network, where *Interested but Concerned* riders typically feel most comfortable riding.

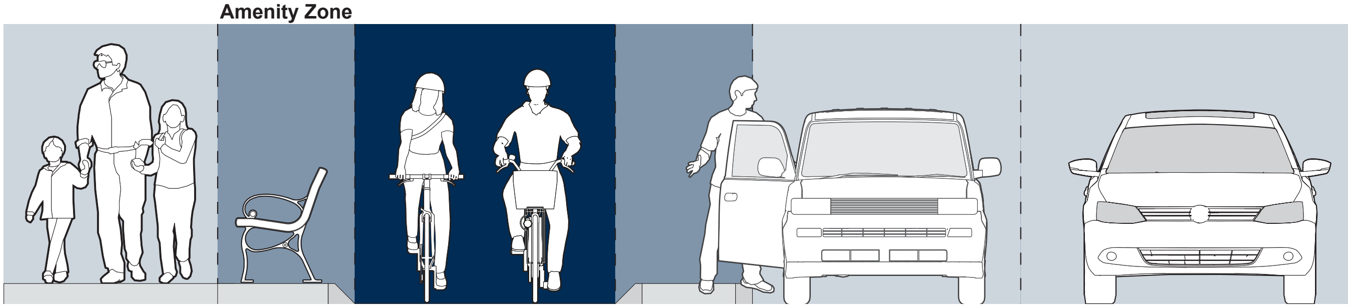


Figure 3-1: Protected Bike Lane Zones

Zones

Protected bike lanes have three zones: the bike lane, the street buffer, and the sidewalk buffer or amenity zone (Figure 3-1).

Bike Lane Zone

The preferred width ranges of a protected bike lane are provided in Table 3-1 and Table 3-2. The width ranges represent the physical or operating space of bicyclists, not accounting for gutter or shy space when adjacent to a vertical curb or other vertical objects in the sidewalk buffer, as shown in Figure 3-2. The widths in these tables should be measured from the center of the bike lane striping to the edge of the gutter pan.

Within the bike lane zone, the horizontal and vertical alignment of the bike lane should be smooth. Bicyclists should not need to climb sudden steep inclines, nor should they be forced to veer sharply from side to side to stay in the bike lane. Horizontal tapers should follow the equation in Table 2-2.

Typically, the most comfortable and predictable design is to provide a one-way protected bikeway in the same direction as adjacent vehicle travel lanes. This is particularly important where there are frequent driveways, turn conflicts, or insufficient project budget to install bicycle signal phases. Two-way protected bike lanes can be considered on one-way streets where it is critical to provide contraflow bicyclist connections, where driveways are extremely infrequent, for short connections where streets jog, and where project budget allows for the necessary signal infrastructure to be installed.

5-Year Anticipated Peak Hour Directional Bicyclist Volume	Preferred One-Way Bike Lane Width		
	Between 2 Vertical Elements or Curbs	Adjacent to One Vertical Element/ Curb	Sidewalk-Level
<150	5’ – 8.5’	6’ – 8’	5’ – 7.5’
150–500**	8.5’ – 10’	8’ – 9.5’	7.5’ – 9’
>500**	≥10’	≥9.5’	≥9’

Note: Widths do not include gutter or shy distance from vertical elements. Between two vertical elements or curbs, a minimum width of 7 feet of clear space is required for maintenance.

**It is assumed that streets on Denver’s Core Network described in Volume 1 fall within these anticipated bicyclist volume ranges.

Table 3-1: One-Way Bike Lane Zone Widths

5-Year Anticipated Peak Hour Directional Bicyclist Volume	Preferred Two-Way Bike Lane Width		
	Between 2 Vertical Elements or Curbs*	Adjacent to One Vertical Element/ Curb*	Sidewalk-Level*
<150	10’ – 12’	9.5’ – 11.5’	9’ – 11’
150–500**	12’ – 16’	11.5’ – 15.5’	11’ – 15’
>500**	>16’	>15.5’	>15’

Note: Widths do not include gutter or shy distance from vertical elements.

*For shared-use paths, a minimum of 5-foot width should be added to these dimensions to accommodate pedestrians, except when the peak hour bicycle volume forecast is less than 150. Street buffer and/or amenity zone widths shall be added to bike lane and shared-use path widths.

**It is assumed that streets on Denver’s Core Network described in Volume 1 fall within these anticipated bicyclist volume ranges.

Table 3-2: Two-Way Bike Lane Zone Widths

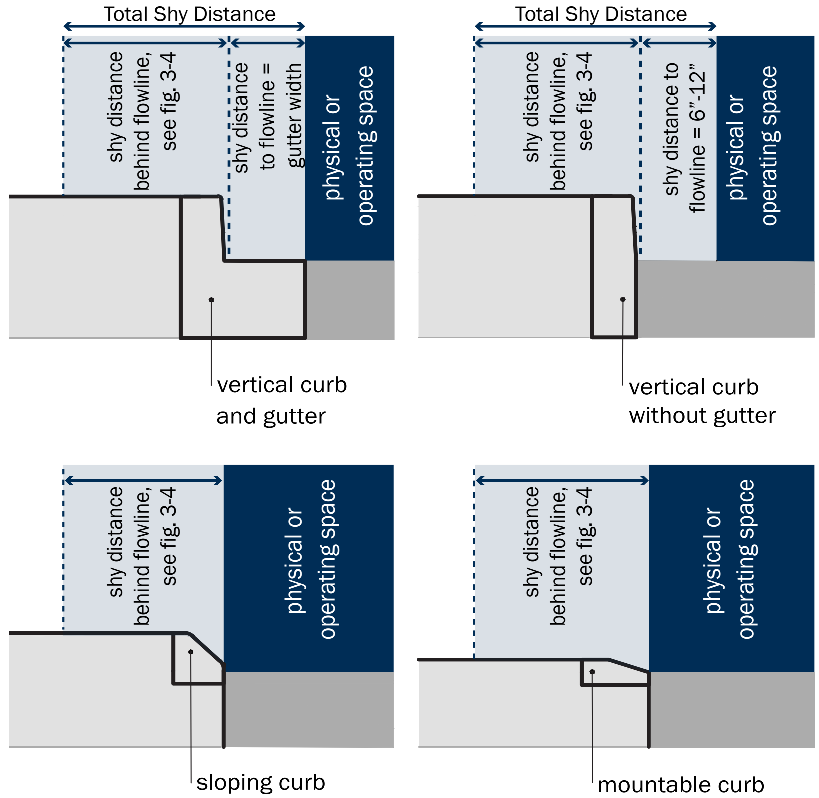


Figure 3-2: Shy Distance Adjacent to Typical Curbs

SHARED USE PATHS

Shared-use paths, sometimes called shared-use sidewalks, are facilities meant for pedestrians and bicyclists to share space and are typically appropriate in suburban contexts where pedestrian and bicyclist volumes are very low. A supplemental “USE SIDEWALK” sign (8”x24”) that matches the color of the bicycle wayfinding sign should be included at the beginning and end of the facility and where shared use paths intersect other bikeways. Centerline striping and directional arrows are not required on these facilities, but should be installed when the peak hour bicyclist volume is >150.

CONSTRAINED CONDITIONS

In constrained conditions, such as behind accessible parking or at floating bus stops, bike lane widths may be reduced to maintain network connectivity. However, minimizing the bike lane width for longer than 150 feet may impact the bicyclists’ comfort, safety, and ability to pass one another within the bike lane. These factors should be evaluated when determining whether to implement constrained widths for extended lengths. In constrained conditions, bike lanes may be reduced to the following widths for lengths up to 150 feet to ensure connectivity of the bike lane. For reduced bike lanes that extend longer than 150 feet, an approval from DOTI is required as outlined in Volume 1 of this Manual.

In constrained conditions for one-way bike lanes, the minimum width can be reduced to 4 feet if at sidewalk level, 4 feet if adjacent to one curb, and 7 feet if between two curbs, including gutter pan widths.

For two-way bike lanes, the minimum width can be reduced to 7.5 feet if at sidewalk level, 8 feet if adjacent to one curb, and 8.5 feet if between two curbs, including gutter pan widths.

Designers should ensure that any reduced widths can accommodate a bike with trailer as the design vehicle. If a bikeway is in between two vertical curbs, designers should ensure that at least 7 feet of clearance is provided between the vertical curbs to allow for maintenance of the facility.

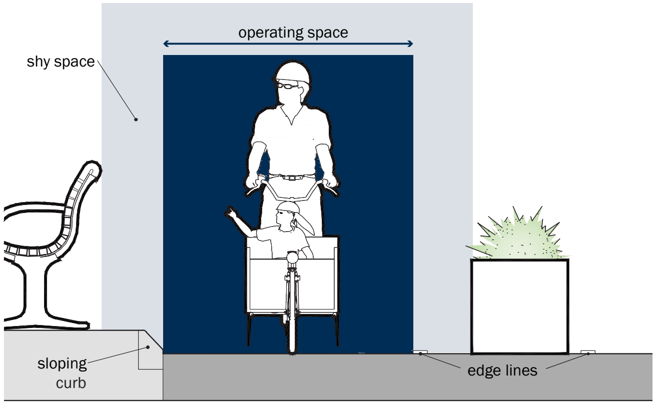


Figure 3-3: Typical Protected Bike Lane Cross-Section

Street Buffer Zone

The street buffer zone provides horizontal separation between the adjacent travel lane and bicyclists, and contains vertical elements, which provide some level of protection for bicyclists and a visual cue to motorists. Widths should follow the values in Table 3-3 and shy distances between rideable space and intermittent and continuous vertical elements should follow Figure 3-4.

The design of the street buffer and the selection of vertical objects to place within the zone are a function of the bike lane elevation and the available width for the street buffer zone. Table 3-4 identifies commonly used vertical objects and considerations. For contraflow bike lanes, a minimum 3' street buffer should be used to increase separation between bicyclists and vehicles traveling in the opposite direction.

Designers may also install bike parking corrals in street buffers with adequate offsets from travel and bike lanes. See Chapter 6 for more detail on bike parking placement.

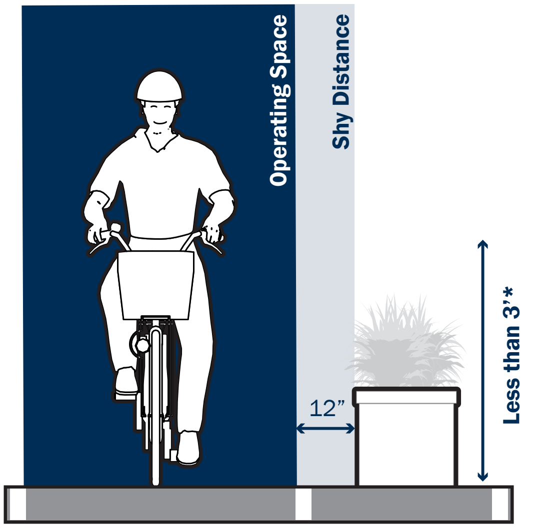
Street Buffer Zone Use*	Preferable Width (ft)	Minimum Width (ft)
No adjacent curb use	≥3	1.5**
Adjacent parking or shared mobility	≥4	3
Adjacent valet or loading zone	≥5	5

*Refer to Intersection Treatments for widths at intersections.

**Increase to 3 feet for intermediate and sidewalk-level protected bike lanes if gutter is not present along curb or if contraflow. 1.5-foot dimension is allowed for street-level protected bike lanes in constrained conditions only.

Table 3-3: Street Buffer Zone Widths

Intermittent Elements



*Where intermittent objects are more than 3 feet tall, 18 inches of shy distance is required

Continuous Elements

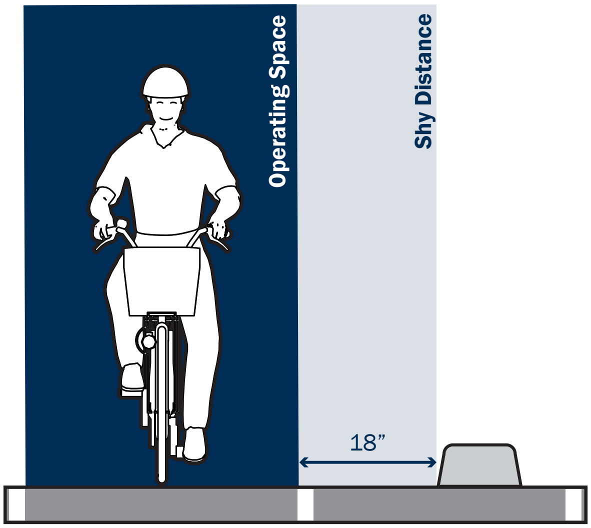


Figure 3-4: Shy Distance from Continuous and Intermittent Vertical Elements

Vertical Object	Pros	Cons
Low-Cost Treatments (Traffic Cones, Flexible Delineator Posts, Engineered Rubber Curb, etc.)	• Strong visual barrier within the street buffer zone • Can be installed quickly and easily modified • Can be installed at a low cost	• Can allow encroachment by motor vehicles • Requires regular maintenance • Flexible intermittent devices may not attract all *Interested but Concerned* bicyclists
Green Infrastructure, Vegetation, Planters (when approved by DOTI)	• Positive impact on streetscape and aesthetics • Strong visual vertical element • May offer continuous protection depending on the placement, size, and weight of planters • Improves air quality and cools streets, while mitigating drainage issues	• Regular trimming required to ensure vegetation does not block sight lines • Require continuous maintenance/watering, typically from an outside maintenance entity • Can be expensive to maintain
Precast or Cast-in-Place Curb	• Strong, continuous visual barrier within the street buffer zone • Low maintenance required	• More expensive • More permanent and costly to remove • Some flex posts are still needed for maintaining visibility in winter months • Requires street sweeper/snow plow that fits between curb and edge of roadway
Elevated Bikeway with Vertical Curb	• Attracts highest proportion of *Interested but Concerned* population • Minimizes space needed for buffer treatments • Provides easy access to adjacent land uses	• Most expensive • Stormwater management needs extra consideration • Requires a detectable edge between the sidewalk and bike lane • Special maintenance agreement must be established with appropriate entity

Table 3-4: Street Buffer Vertical Object Considerations

Sidewalk Buffer Zone

The sidewalk buffer provides separation between pedestrians and bicyclists. This zone should not reduce the required sidewalk width for the street type identified in the *Complete Streets Design Standards*. The buffer should discourage pedestrian encroachment into the bike lane and vice versa. The preferred width varies based on the elevation of the bike lane and the use of the sidewalk buffer (see Table 3-5). In some street cross-sections, the sidewalk buffer may act as the amenity zone along the sidewalk and may be furnished with street trees, benches, street lighting, trash receptacles, bike parking racks, or green infrastructure. When raised bike lanes are located at sidewalk-level with minimal sidewalk buffer, a directional indicator strip shall be installed adjacent to the buffer and is included as part of the sidewalk width. This aides pedestrians with no or low vision (see Chapter 6).

Bike Lane Type	Minimum Sidewalk Buffer Width (ft)
Street-level bike lane	0.5
Intermediate-level bike lane	0.5
Sidewalk-level bike lane	1
When the following are used in the sidewalk buffer, add the dimensions below to the minimum width above:	
Signs, Utility Poles, Signal Cabinets, Furniture	2
Green Infrastructure	3
Bike Parking	6*
Trees	7

*At locations where an adult bicycle with trailer is used as a design vehicle, increase the buffer to 10 feet.

Table 3-5: Sidewalk Buffer Zone Widths

Figure 3-5: Protected Bike Lane with Standard Sign Placement

Typical Sign Placement

The placement of signs adjacent to a bike lane impacts the effective width of the bike lane zone. If a sign is placed too close to a bike lane, users will shy away from it, reducing the usable width of the bike lane. Signs should be located no closer than 1.5 feet from the edge of the bike lane. In constrained locations, the sign may be located closer, recognizing the impact this will have on the bike lane width. Designers should also consider the height of the bottom of the sign panel and its width to ensure that the sign panel does not encroach on the operating space of the design user.

If the sign is located in the street buffer or at intersection corners, the sight lines for motor vehicles should be considered when determining the mounting height. At locations where sight lines are not a concern, and the signs do not pose as a potential hazard to pedestrians, signs may be located a minimum of 1 foot from the turning envelope of intersections and driveways in the street or sidewalk buffer. At all other locations, sign installation should follow DOTI TSSMS Standard Drawings 16.2.5 and 16.2.6.

Where a street buffer includes concrete protection that is wider than 3 feet, supplemental parking or loading signs can be mounted in the street buffer for increased visibility. When a two-way protected bike lane is used, this is especially true, as the location of parking will be further from the curb. Supplemental signs may be mounted on plastic posts when a street-level bike lane is used to reduce maintenance.

Tradeoffs by Zone

Ideally, every protected bike lane would have a bike lane, street buffer, and sidewalk buffer zone that meet the preferred width values. In many cases, these widths will not be available. The following strategies should be implemented for choosing where to reduce widths. Designers should document this assessment and present it as part of bikeway design variance applications, where necessary.

1. **Narrow travel lanes**: Vehicle lanes along the corridor should be reduced to the minimum value allowed by DOTI (see the *Complete Streets Design Standards* and DOTI *Transportation Standard Drawings for the Engineering Division*).

2. **Eliminate travel or parking lane**: If the traffic volume or parking utilization of the study street or adjacent streets are relatively low, eliminating a travel or parking lane may be feasible. Designers should follow the Street Reconfiguration Decision-Making Flowchart in Appendix A of Volume 1 of this Manual to determine when this treatment is applicable. The City Traffic Engineer must approve all lane removals. Work with DOTI Curbside & Parking to determine if existing ADA parking spaces are still being used or needed.

3. **Narrow the sidewalk buffer**: For street-level and intermediate-level bike lanes, the sidewalk buffer is less important because there is a curb between the sidewalk and bike lane. If the sidewalk buffer on a sidewalk-level protected bike lane is reduced to the minimum value, a directional indicator strip shall be installed (see Chapter 6). In areas with high pedestrian activity (e.g., downtown, commercial areas), reduction of the sidewalk buffer on a sidewalk-level bikeway is not recommended. In such areas, if horizontal space is constrained, designers should consider converting the sidewalk-level bike lane to either an intermediate or street-level bike lane to reduce the necessary width of a sidewalk buffer.

4. **Narrow the bike lane to minimum widths:** The minimum bike lane width can be used for up to 150 feet to maintain the bikeway where all other zones have been narrowed, where the street buffer width is more critical (e.g., driveways and intersections), or where site constraints leave no other option. It is preferable to maintain a minimum width bike lane than to remove the bikeway or switch bikeway types. Designers should use the design variance process outlined in Volume 1 to obtain approval from DOTI to use minimum widths for distances greater than 150 feet.

5. **Narrow the street buffer**: The street buffer width is critical for safety at locations where motor vehicles cross the bike lane (e.g., intersections and driveways). At these locations, the street buffer should be the last zone to be narrowed and should only be done so in combination with additional measures, such as leading bike intervals, installation of vertical protection on the outer buffer stripe of pavement markings, green pavement markings, and regulatory signing. In constrained conditions where the street buffer needs to be narrowed to install a bikeway facility, designers should consider raising the bike lane to an intermediate or sidewalk-level facility. This allows for installation of vertical curb which provides an additional level of protection.

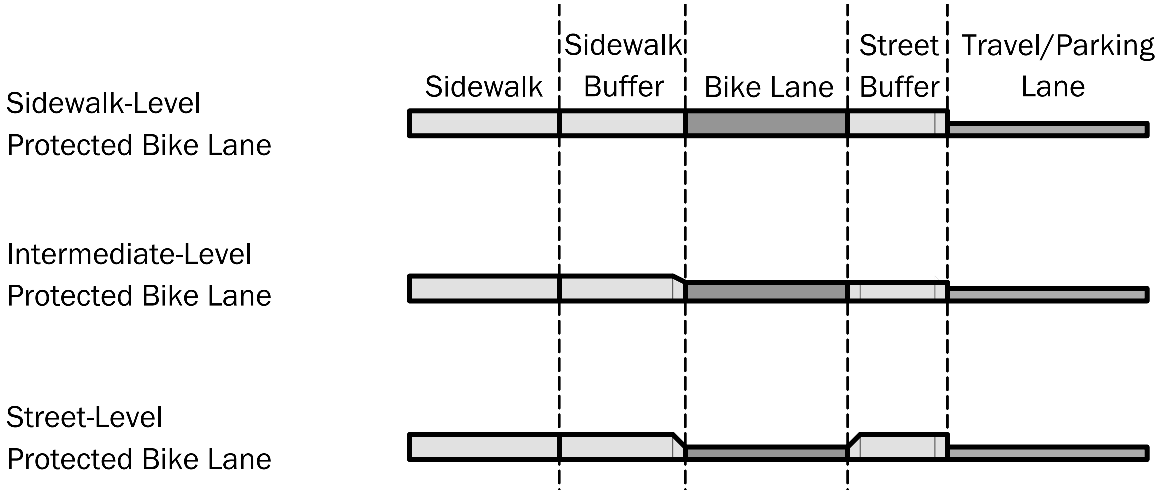


Figure 3-6: Protected Bike Lane Elevations

Elevation

Protected bike lanes may be located at various elevations: street-level, intermediate-level, and sidewalk-level. Figure 3-5 shows the distinctions between each. Each elevation has advantages and challenges.

Street-Level: A street-level bike lane is preferred in a retrofit situation, where relocating the existing curbs may not be possible or cost-effective. The impacts to existing utilities, especially drainage infrastructure, is usually minimal with a bike lane at this elevation.

This elevation minimizes the potential for pedestrian encroachment into the bicycle lane as there is a full height curb between the bike lane and the sidewalk. For this reason, a street-level bike lane reduces the necessity of a wide sidewalk buffer. Street-level bike lanes, however, require vertical elements in the street buffer zone to provide adequate protection for bicyclists from vehicles and to be designated as a protected bike lane.

On one-way street-level protected bike lanes, it is preferred to narrow the clear width of the bike lane on the far side of each intersection to 7 feet and then widen to the values listed in Table 3-1. This narrowing should deter vehicles from entering the bike lane while still maintaining adequate clear space for maintenance.

Standard Drawings BDS 3-1 and 3-2 show the details for street-level protected bike lanes.

Intermediate-Level: An intermediate-level bike lane may increase the comfort of bicyclists, improve visibility of bicyclists along the corridor, and slow turning motorists at driveways. This elevation minimizes the potential for pedestrian encroachment into the bicycle lane by maintaining some elevation difference between the bike lane and the sidewalk. For this reason, an intermediate-level bike lane reduces the necessity of a wide sidewalk buffer.

The elevation difference between the sidewalk and an intermediate-level bike lane is generally between 2 and 3 inches to reduce the risk of pedal strikes. Providing sloped curbs with an intermediate-level bike lane can reduce the shy distance required (see Figure 3-2).

Maintenance for intermediate-level bike lanes will occur per City and County of Denver maintenance policies. A special maintenance agreement may be required with the appropriate entity (e.g., business improvement district, general improvement district, local maintenance district, DOTI green infrastructure program, Denver Parks and Recreation, or master development agreement).

Figure 3-7: Sidewalk-Level Bike Lane

Standard Drawing BDS 3-3 shows the cross-section for intermediate-level bike lanes and driveway treatments. The drawing details both attached and detached bike lanes and sidewalks. The terms attached and detached refer to whether the facility is attached or detached from the face of curb. A detached facility includes a street buffer between the facility and face of curb, which is preferred because it increases the visibility of bicyclists from turning vehicles. However, availability of right-of-way and location of the existing sidewalk will determine whether a detached facility is feasible.

Sidewalk-Level: A sidewalk-level bike lane can be the most comfortable facility for *Interested but Concerned* bicycle riders due to increased separation from motor vehicles. Elevation of these facilities minimizes required shy distances from curb faces. Raised street and driveway crossings are easier to design with a sidewalk-level bike lane, since they do not require additional ramps or drainage infrastructure. Detached sidewalk-level bike lanes are preferred, as they allow for a wider street buffer, which increases the visibility of bicyclists. Attached sidewalk-level bike lanes can be less comfortable for *Interested but Concerned* riders and are not preferred.

The importance of a sidewalk buffer is higher with a sidewalk-level bike lane. A directional indicator strip shall be included when the minimum sidewalk buffer width is used (see Chapter 6). When a sidewalk buffer is not feasible, designers should consider an intermediate-level or street-level bike lane. If curbs, planters, or other vertical elements are included in the sidewalk buffer, shy distances need to be accounted for as outlined in Figure 3-4.

As with intermediate-level bike lanes, maintenance of sidewalk-level bike lanes shall occur per City and County of Denver maintenance policies and may require a maintenance agreement with the appropriate entity.

Standard Drawing BDS 3-4 shows the cross-section for sidewalk-level bike lanes and driveway treatments.

Intersection Treatments

Intersection Design Principles

As noted in Volume 1, bikeway design should follow three key principles: speed minimization, separation of vulnerable roadway users, and visibility of all users. These principles apply to the intersection design of protected bike lanes in the following ways.

SPEED MINIMIZATION

Intersections should be designed to slow the speed of turning motorists (10 mph or less), which can improve yielding, reduce stopping distances, and reduce the number of crashes and crash severity. The effective radius of the intersection corner plays a large role in determining the speed at which turning motorists may negotiate the corner. The effective radius should be reduced to a value which ensures slower speed turns for more common vehicles (managed vehicles, such as passenger vehicles). In order to accommodate larger vehicles (design/control vehicles, such as SU-30 trucks and fire trucks), truck aprons or corner wedges/speed bumps may be used at intersection corners (see BDS 3-6).

The speed of left-turning motorists crossing a protected bike lane should also be considered. Channelizing devices, such as hardened centerlines and medians, can be used to establish a sharper turn angle, which reduces the speed of motorists, can improve yielding, and can reduce the severity of crashes.

It may also be necessary to slow the speed of bicyclists approaching an intersection, especially where the grade of the roadway will frequently result in higher speed of travel. Bending the bike lane away from the adjacent motor vehicle lane is preferred, as this creates a larger offset at the intersection from turning vehicles, while also introducing horizontal deflection in the bike lane. The offset may also allow for a corner island to be used. Where horizontal deflection is not feasible due to geometric constraints, designers may consider vertical deflection for bicyclists with a raised facility at the intersection.

Any vertical deflection should be reviewed for drainage flow impact and may require additional design treatments to address stormwater flows. In addition, designers should consider interaction with pedestrians and ensure that adequate sidewalk buffer or directional indicators are present for the raised portion of the facility.

Where they are used, mixing zones should be designed to encourage slow speeds within the areas where bicyclists and motorists will mix. Minimizing the merge length, using advanced signage, and implementing traffic calming along the corridor will help improve yielding and encourage slower speeds.

SEPARATION OF MODES

Protected and buffered bike lanes minimize the interaction between motorists and bicyclists through the use of a street buffer. It is preferred that physical separation of a bike lane continues up to the intersection, limiting the exposure to crossing vehicles at the intersection. For this reason, mixing zones are generally not preferred treatments and should only be considered in limited circumstances.

When the volume of turning motorists during the peak hour is high, the right-turning and/or left-turning motorists should be separated from the through bicycle movement by different signal phases to eliminate the interaction between motorists and bicyclists (see Figure 3-7).

The designer should consider how bicyclists may transition to intersecting corridors. In many cases, a turn box can accommodate the left turn in two stages (see Chapter 6). This design eliminates the need to merge with adjacent motor vehicle traffic to access a left turn pocket, or to turn left from the adjacent lane.

VISIBILITY

Adequate sight lines are needed between all roadway users as they approach an intersection. When a parking lane is present, parking should be restricted at intersections and mixing zones to provide adequate sight distance between motorists and bicyclists. Designers should provide adequate approach clear space, as shown in Table 3-6 and illustrated in Figure 3-6, based on the effective vehicle turning radius and corresponding vehicular turning speed.

Where space allows, bicycle corrals, micromobility parking, motorcycle parking, and low-profile plants can be placed at the corner to activate the space while providing better visibility.

Where permissive turns are allowed across the bike lane, a horizontal offset from the travel lane provides space for motorists to yield to bicyclists and improves the motorists' field of vision at the point of crossing.

Where bicyclists must yield to pedestrians, signal infrastructure, street trees, and other vertical objects should not block sight lines between roadway users.

Effective Vehicle Turning Radius	Vehicular Turning Speed	Approach Clear Space
<18 ft**	<10 mph*	20 ft
18 ft **	10 mph	40 ft
25 ft	15 mph	50 ft
30 ft	20 mph	60 ft
>50 ft	25 mph	70 ft

*Stop controlled intersections and most low volume driveways and alleys

**Preferred turning radius

Table 3-6: Approach Clear Space

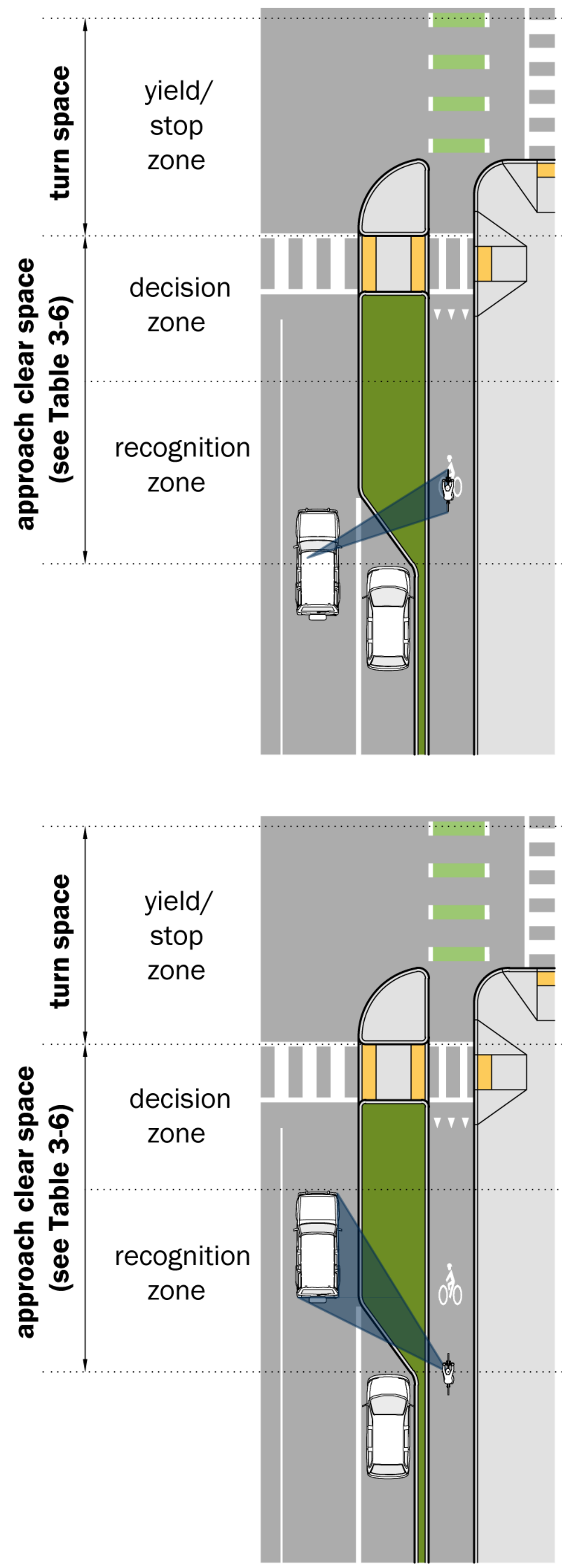


Figure 3-8: Intersection Sight Distance

Intersection Treatment Selection

Similar to conventional bike lanes, the choice of the intersection treatment for protected bike lanes is a function of the intersection control, the presence of parking, and the presence of dedicated turn lanes. In all cases, the preferred intersection treatment is to continue the protected bike lane up to the intersection, minimizing exposure. **Designers should follow the Turn Lane Treatment section in Chapter 2 to determine specific design treatments based on available widths.**

When continuing the bike lane up to the intersection, the designer should first consider the intersection control. When the intersection approach is uncontrolled, the bike lane should bend away from the adjacent travel lane, increasing the street buffer to at least 8 feet for a protected intersection for appropriate vehicle queuing space. Green bicycle crossing markings and regulatory signs should be added to clarify intended interactions between roadway users. The geometry of the intersection should ensure that turning motorists negotiate their turn at slow speeds. If turning volumes are high at multiple intersections along the corridor during the peak hour, it may not be appropriate to use a two-way protected bike lane on a two-way street.

When a protected bike lane is continued up to a signalized intersection, the number of right and left-turning motorists (regardless of whether a turn pocket is available) during the peak hour must be considered. Figure 3-7 identifies the thresholds where signal phase separation between bicyclists and turning motorists shall be included. Below these thresholds, permissive turns across the bike lane are acceptable. Where an exclusive right turn lane is present to the left of a bike lane, or an exclusive left turn lane is present to the right of a bike lane, designers should install a bike signal in accordance with the MUTCD. See Chapter 6 for more information regarding the design of bicycle signals. **Designers should use engineering judgment and evaluate the impact of the bike signal on intersection operations, signal coordination, and project cost to determine whether to install a bike signal.**

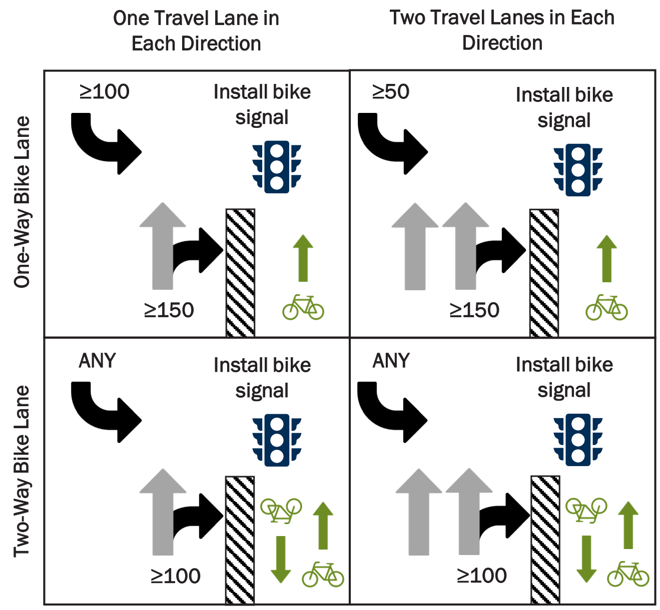


Figure 3-9: Signal Phase Separation of Turning Motorists

As with intersections where the approach is uncontrolled, green bicycle crossing markings and regulatory signs should be added to the crossing and a street buffer of at least 8 feet should be used for appropriate vehicle queuing space. Advanced bicycle stop bars (see Chapter 6) and leading bicycle intervals may also be considered.

An alternative to continuing the protected bike lane up to the intersection is a mixing zone. This design is not feasible for two-way protected bike lanes. Even for one-way protected bike lanes, a mixing zone is generally not preferred, as it increases exposure to motor vehicles. However, in extremely constrained conditions where other strategies to provide adequate width have failed and the turn lane is required, a mixing zone may be installed (see Chapter 2 for additional guidance). If additional space is available at the intersection, designers should allocate the space to increase the street buffer for added protection. Standard Drawing BDS 3-5 shows the turn lane treatment and mixing zone treatment design details.

At all way stop controlled intersections, adequate intersection sight distance and approach clear space should be provided. If the number of right-turning vehicles is high, designers should consider incorporating a protected corner treatment, where space is available.

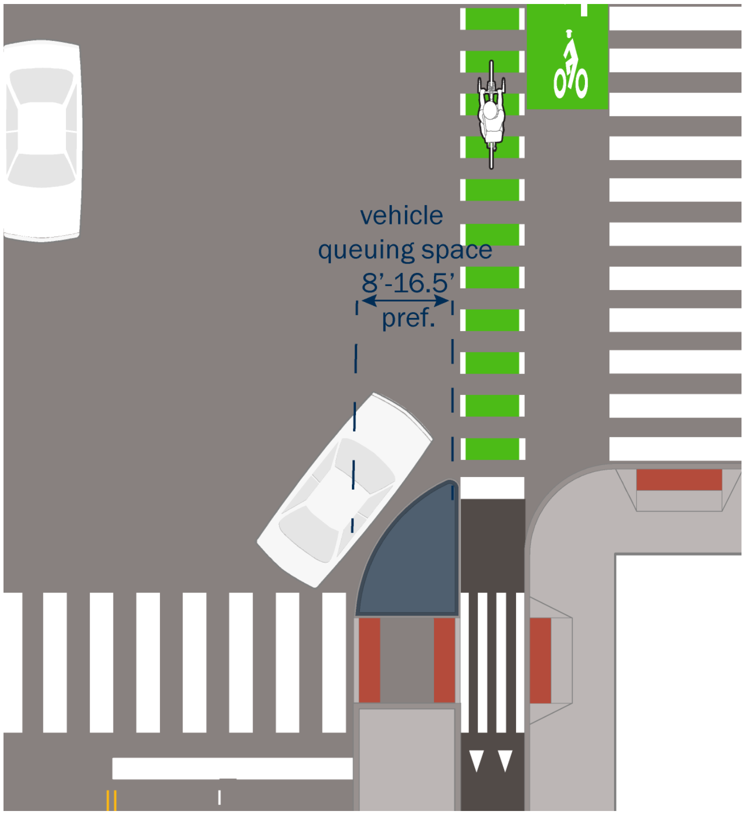


Figure 3-10: Protected Intersection Offset

Protected Intersections

At uncontrolled approaches of intersections and at signalized intersections where the turning vehicle volumes in the peak hour do not exceed the thresholds in Figure 3-7, it is still important to create an offset between the adjacent vehicle lane and the bike crossing. The street buffer width should be designed to result in a buffer zone between 8 and 16.5 feet from the adjacent motor vehicle lane. This treatment has been shown to significantly reduce crashes at uncontrolled and permissive conflict locations [1, 2]. Standard Drawing BDS 3-6 shows design details for protected corner treatments.

The recessed crossing usually allows a corner island or wedge to be constructed, which provides the following benefits:

- Helps establish the horizontal offset between the adjacent motor vehicle lane and the bike crossing, creating a motorist yield zone
- Helps tighten the intersection corner to slow turning vehicles
- Positions bicyclists waiting to cross ahead of the adjacent motor vehicle lane via an advanced bicycle stop bar, where they are more visible
- Creates queuing space for bicyclists making a two-stage turn, outside of the path of through bicyclists
- Allows for a pedestrian refuge island, shortening the crossing length and reducing exposure

1. Schepers, J.P., P. A. Kroeze, W. Sweers, and J.C. Wust. Road Factors and Bicycle-Motor Vehicle Crashes at Unsignalized Priority Intersections. Accident Analysis and Prevention, Vol. 43, 2011, pp. 853-861.
2. Madsen, T., and H. Lahrmann. Comparison of Five Bicycle Facility Designs in Signalized Intersections Using Traffic Conflict Studies. Transport Research Part F, Vol. 46, 2017, pp. 438-450.

Figure 3-11: Protected Intersection in Boulder, CO

When on-street parking is located along the corridor, normal parking restrictions at intersections will allow space for a larger street buffer width as the protected bike lane approaches the intersection.

When there is no parking along the corridor, an offset can be created by narrowing the sidewalk buffer and increasing the width of the street buffer as the protected bike lane approaches the intersection. When using the minimum width for a sidewalk buffer, directional indicators shall be installed to create a detectable edge. If the sidewalk buffer needs to be narrowed further, consider changing the bike lane elevation to create a detectable edge without directional indicators.

When the street buffer is at least 6 feet in width, it may be used as a pedestrian refuge island, allowing the crossing distance to be shortened. In this case, pedestrians would cross the protected bike lane at a yield-controlled crossing, then cross the motor vehicle lanes. When the crossing is located at a signalized intersection, the designer can consider reducing the signal timing for the pedestrian crossing to reflect the shorter crossing distance.

Yield markings (and associated R9-6 sign) and crosswalk markings should indicate the right-of-way between bicyclists and pedestrians at these locations. The pedestrian push button and associated signal head (when present) can be located within the pedestrian refuge island if adequate space is available to meet ADA requirements.

When the street buffer is less than 6 feet in width and there is not room for a refuge island, the crossing cannot be shortened, and the associated signal timing (if signalized) must be calculated for the entire street width.

At all intersections, the designer should consider using the R10-15B sign (post-mounted or mounted to the signal pole/mast arm) with bike and pedestrian symbols to communicate the right-of-way between motorists and bicyclists when signal phase separation is not used. At signalized intersections, using a flashing yellow arrow beneath a green ball may be considered to further clarify the interaction.

Figure 3-12: Truck Apron with Corner Island in San Francisco (left) and Turn Wedge in Denver (right)

Protected Corner Treatments

CORNER ISLANDS AND TURN WEDGES

A corner island is a raised area inside an intersection that decreases the corner radius and slows turning movements for motor vehicles. They are typically not mountable by motor vehicles and are constructed using concrete or curbing. For constructability and maintenance purposes, the entire protected corner should be concrete. Distinct color should be used on the corner island to ensure that it is distinct from the adjacent protected bike lane and vehicle travel lane.

Turn wedges, on the other hand, can be constructed with low-cost materials such as paint and flexible delineator posts or engineered rubber curbs and/or rubber speed bumps and are usually at street level. When using a rubber speed bump in the corner wedge, a yellow flex post shall be used in place of the last flex post before the turn wedge to indicate to snow plow drivers where speed bumps might be hidden under snow.

Oftentimes, turn wedges are constructed to be easily mountable by large trucks, which need larger turn radii than passenger vehicles. These designs are typically used in protected intersections to reduce crash risk and increase visibility of all roadway users. These treatments provide space for bicyclists waiting to turn or proceed through an intersection and allow space for a pedestrian refuge island. This shortens crossing distances and increases visibility of people crossing the street.

While interim materials do not provide the same level of crash protection as a vertical curb, they provide the horizontal offset and visual narrowing needed to maintain the design principles of a protected intersection.

Standard Drawing BDS 3-6 shows details for corner islands and turn wedges in a protected intersection.

TRUCK APRONS

A truck apron is a design strategy used to accommodate the turning needs of large vehicles while slowing the turning speeds of smaller vehicles by reducing the actual radius. A truck apron is designed to be mountable by larger vehicles (the design or control vehicle) to accommodate their larger effective turning radius needs. The mountable surface encourages the managed vehicle, typically a passenger (P), to turn outside the apron at a slower speed by designing to accommodate their effective turning radius (Figure 3-9). The designer should reference the *Complete Streets Design Standards* to identify the design and control vehicle needs at a specific intersection.

Truck aprons can be installed with corner reconstruction or in a retrofit condition. They can be constructed with a gap between the mountable curb and the curb face to facilitate surface drainage, if necessary.

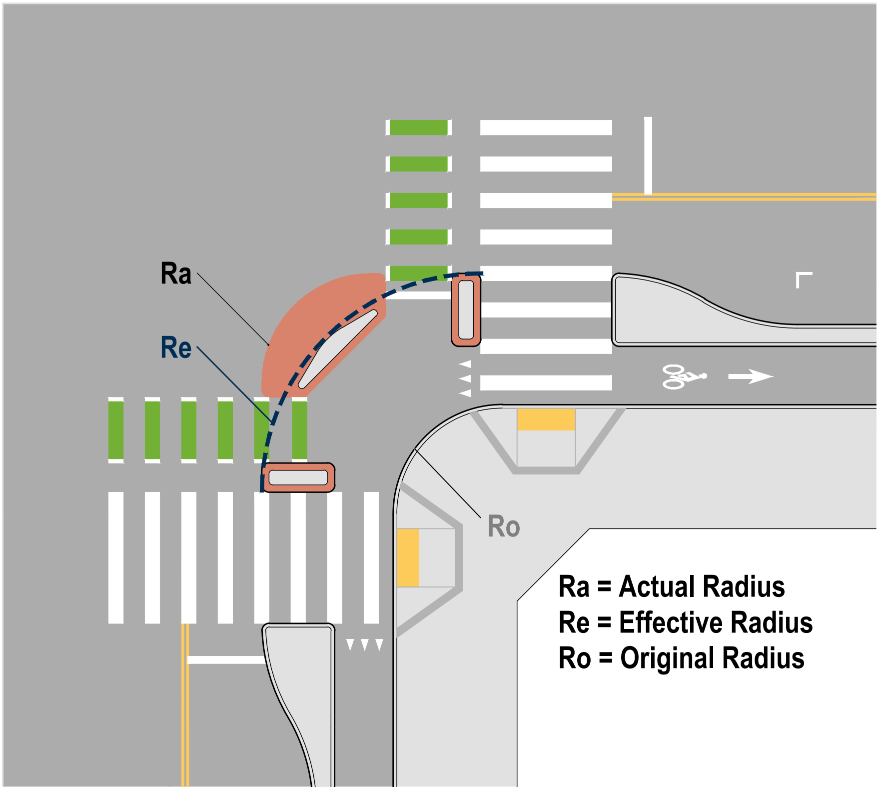


Figure 3-13: Actual vs Effective Radius

For constructability and visibility, truck aprons have a minimum size requirement to be effective. Where the distance between the effective radius and the actual radius is less than 5 feet, truck aprons are not feasible. A smaller distance will become difficult to visually differentiate from the surrounding surfaces and may be more difficult to construct.

The pavement color and texture within the truck apron should be distinct from the adjacent roadway and sidewalk. This helps motorists understand that this is not an area to drive over and helps pedestrians understand that this is not an area where it is safe to wait. Colored and/or textured concrete helps define the edge of the apron.

See Standard Drawing BDS 3-6 for truck apron design. More information can be found in the *Complete Streets Design Standards.*

Driveway Volume	Markings (BDS 6-2)	Signs	Elevation Consideration	Geometry Considerations
Minimal (single-family residential) **<25 vehicles/day**	Dashed bicycle crossing markings **shall** be used. Bike lanes can be maintained through single-family driveways	The driveway does not require a STOP or YIELD sign	The bike lane *may* be located at any elevation	A typical driveway apron **should** be used
Low (small multi-family residential) **25 - 500 vehicles/day**	Green bicycle crossing markings **shall** be used to indicate that bicyclists have the right-of-way	STOP or YIELD signs *may* be appropriate	The bike lane *may* be located at any elevation	A typical driveway apron **should** be used
High (large multi-family residential, commercial, and lots with >100 parking spaces) **>500 vehicles/day**	Green bicycle crossing markings **shall** be used to indicate that bicyclists have the right-of-way	STOP or YIELD signs are recommended; the R10-15 sign **should** be considered	The designer **should** consider a sidewalk-level bike lane (or transitioning to sidewalk-level)	A street buffer that provides a motorist yield zone between 8 and 16.5 feet **should** be used

Table 3-7: Driveway Treatments

Driveways and Curb Cuts

Driveway volumes may be characterized as minimal (less than 25 vehicle crossings per day), low (between 25 and 500 vehicle crossings per day), and high (greater than 500 vehicle crossings per day). Minimal-volume driveways are typically single-family residential driveways, or other infrequently used access points. Low- and high-volume driveways should be designed with intersection design principles in mind. Consult Table 6-1 for information on when to use each bikeway crossing marking type at street intersections.

Table 3-7 identifies treatments that are appropriate for the different driveway types. Green and dashed bikeway crossing markings are found in Standard Drawing BDS 6-2. Directional indicators shall be used along sidewalk-level bike lanes and at driveways where intermediate-level bike lanes ramp up to sidewalk-level (Standard Drawing BDS 3-3). For two-way bikeways, green bikeway crossing markings should be used at all driveways and curb cuts, regardless of driveway volume.

Raised Crossings

Raised crossings (either at driveways or side streets) of the protected bike lane are an effective strategy for reducing crashes between motorists and bicyclists because they slow the turning speed of motor vehicles, increase visibility of bicyclists, and increase yielding behavior of motorists. They may be especially beneficial when a two-way protected bike lane is used. Raised crossings are more easily accommodated when the bike lane is at an intermediate or sidewalk-level elevation.

Raised crossings can be used at driveways, alleys, unsignalized street crossings, and channelized right turns. When designing raised crossings, ensure that they meet accessibility requirements, including desired slopes and provision of tactile warnings at major crossings, where appropriate. See the *Complete Streets Design Standards* for more information about raised pedestrian crossings.

Raised crossings at driveways should utilize DOTI TSD Standard Drawings 6.0 - 6.3 for Residential, Commercial, and Multi-Family Curb Cuts as a guide and accommodate the bike lane using design principles outlined in Volume 1, (minimizing speed, increasing visibility, and providing separation). When a street buffer is present, the design of the driveway should follow standards for a detached sidewalk. When a street buffer is not present, the designer should consider if the bike lane may bend out, away from the vehicle travel lane, creating space for a street buffer and allowing the driveway design to follow the standards for a detached sidewalk.

Similarly, raised crossings at alleys should utilize DOTI TSD Standard Drawing 10.1 - 10.3 for Alley Cuts as a guide and use the design principles outlined in Volume 1 to accommodate bike lanes. The design should follow the standards for a detached sidewalk.

At unsignalized street crossings and channelized right turns, the raised crossing should be designed to be between 3 inches and 6 inches higher than the existing pavement. The vehicular approach and departure ramps of the raised crossing should have a vehicular taper of 5% to 8%, resulting in a ramp length of 3 feet to 10 feet. At these locations, the raised crossing may be constructed out of either asphalt or concrete.

When a raised crossing is added to an existing location, the designer should consider the impacts on stormwater drainage, as the raised crossing is likely to divert existing stormwater flow and create a new low point. It is preferred that a new drainage inlet with a bicycle-friendly inlet grate (see CCD STD DWG S-716) is provided at the new low point if positive drainage is not achievable. Inlets must also be accessible by DOTI Wastewater Management Division maintenance vacuum and jet trucks.

Figure 3-14: Bikeway Crossing and Signage at Hotel Zone in Denver

Curb Space Management

Protected bike lanes typically occupy street space next to the curb, which results in repurposing existing curbside uses. As such, when installing a protected bike lane, evaluation of the curbside space needs is required. Main factors to consider include current signed uses and on-street demands for parking, loading, and accessibility.

Loading Zones

Designated loading zones may accommodate passenger loading (pick-up and drop-off at schools, hotels, hospitals, etc.), commercial loading (goods or parcel deliveries), or both. If a mid-block loading zone cannot be made accessible per ADA, the loading zone should be moved to the intersection to utilize existing curb ramps.

At loading zones, the street buffer width should follow the values in Table 3-3. Where valet parking services are permitted, the loading zone should be placed on the street side of the bike lane to reduce conflict between motor vehicles and bicyclists. At these locations or where shared mobility passenger loading is present, the following treatments should be considered within the street buffer and bike lane zones:

- Use a 5' street buffer, as indicated in Table 3-3 for loading zones.
- Utilize pavement markings and use signage to reflect the right-of-way between bicyclists and pedestrians.

Standard Drawing BDS 3-7 shows design guidance for a passenger loading zone adjacent to a bikeway facility.

Accessible Parking Spaces

Designers should consider the need for accessible parking and loading areas along protected bike lanes. For retrofit locations, designers should recognize that while existing corridors may not have dedicated accessible parking spaces, existing curbside parking is often at least partially accessible (e.g., accommodates passenger side door and lift access). Shifting parking away from the sidewalk can reduce the number of parking spaces that would be fully or partially accessible.

Proximity to key destinations or favorable roadway grades may require locating accessible parking on a block face with protected bike lanes. Accessible parking can be provided at intersections to allow intersection curb ramps to also serve as the accessible route for the parking space (see Standard Drawing BDS 3-8). In constrained locations where accessible parking is provided, the protected bike lane may be narrowed to the minimum constrained width adjacent to the parking.

MID-BLOCK ACCESSIBLE PARKING

Accessible parking may be located at a mid-block location (see Standard Drawing BDS 3-8) where intersection locations are infeasible or if proximity to a specific destination is advantageous. In constrained locations where accessible mid-block parking is provided, the protected bike lane may be narrowed to the minimum constrained width adjacent to the parking.

ACCESSIBLE PASSENGER LOADING ZONES

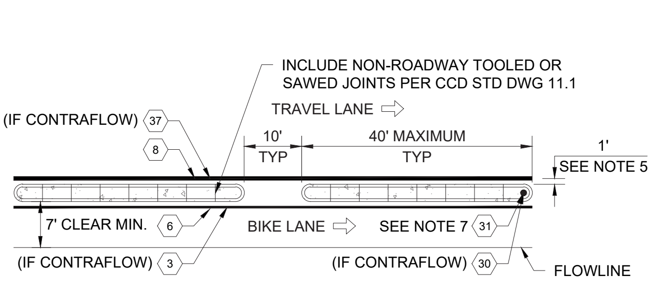
Passenger loading zones should be accessible to individuals with disabilities (see Standard Drawing BDS 3-7). Refer to current pedestrian accessibility guidelines for accessible passenger loading and surface guidance. If necessary, the bike lane may be narrowed to the minimum constrained width at accessible loading zones to accommodate the pedestrian access route.

Accessible loading zones at intersection locations should use the same design as accessible on-street parking spaces (Standard Drawing BDS 3-8).

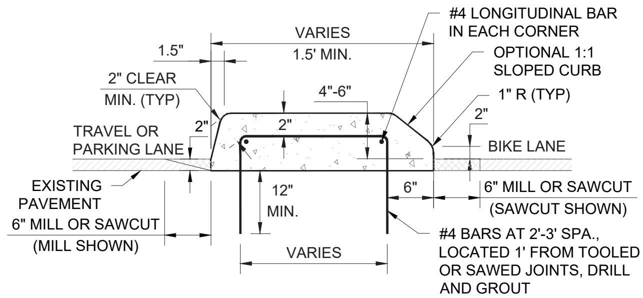
At locations without on-street parking, a lateral deflection (bend-out) of the protected bike lane may be required to accommodate an accessible loading zone. Bike lane deflection should occur gradually, but should not exceed the shifting taper guidelines in Table 2-2 to maintain bicyclist safety and comfort. An appropriate sidewalk width for the street type identified in the *Complete Streets Design Standards* must be maintained.

Protected Bike Lane Standard Drawings

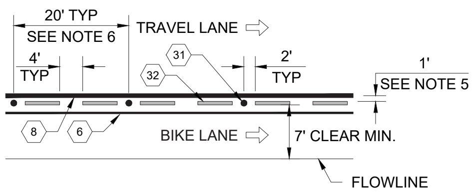
STANDARD DRAWING BDS 3-1	**Street-Level Protected Bike Lane Buffer Details**
STANDARD DRAWING BDS 3-2	**Street-Level Protected Bike Lane Marking Detail at Driveway / Curb Cut**
STANDARD DRAWING BDS 3-3	**Intermediate-Level Protected Bike Lane at Standard Residential Curb Cut**
STANDARD DRAWING BDS 3-4	**Sidewalk-Level Protected Bike Lane at Standard Residential Curb Cut**
STANDARD DRAWING BDS 3-5	**Turn Lane and Mixing Zone Treatment Details**
STANDARD DRAWING BDS 3-6	**Protected Corner Treatment Details**
STANDARD DRAWING BDS 3-7	**Loading Zone at Protected Bike Lane Details**
STANDARD DRAWING BDS 3-8	**Accessible Parking Space Details**



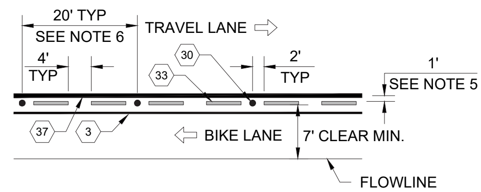
CAST-IN-PLACE CONCRETE CURB SEQENCE



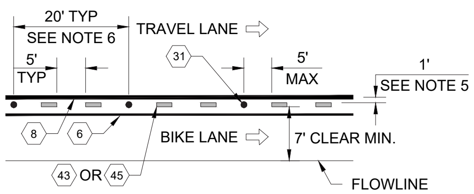
CAST-IN-PLACE CONCRETE - SECTION



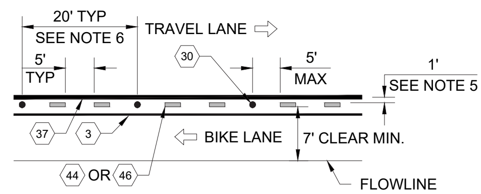
BUFFER WITH RUBBER CURBS AND FLEX POSTS



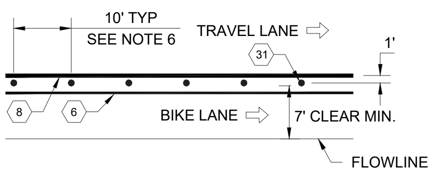
CONTRAFLOW BUFFER WITH RUBBER CURBS AND FLEX POSTS



BUFFER WITH RECYCLED PLASTIC CURBS AND FLEX POSTS

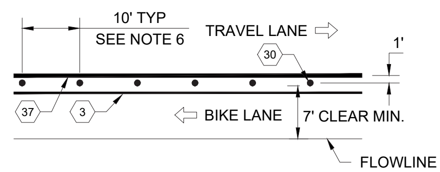


CONTRAFLOW BUFFER WITH RECYCLED PLASTIC CURBS AND FLEX POSTS



BUFFER WITH EMBEDDED ANCHOR CUP FLEX POSTS

(SEE NOTE 10)



CONTRAFLOW BUFFER WITH EMBEDDED ANCHOR CUP FLEX POSTS

(SEE NOTE 10)

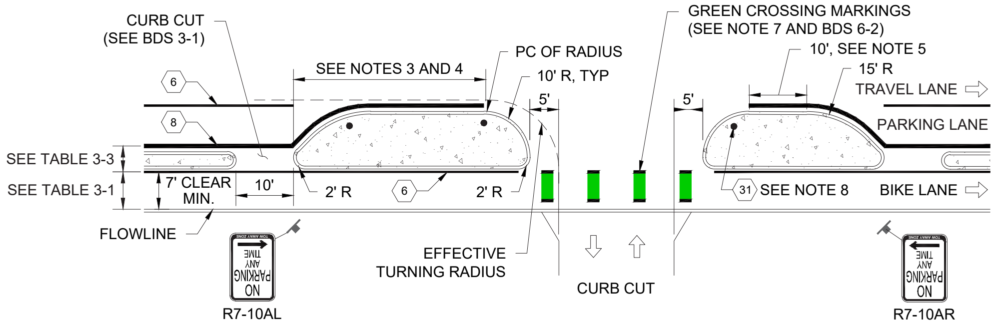
LEGEND:

- 3 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 30 36" YELLOW FLEXIBLE DELINEATOR POST
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES
- 33 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH YELLOW STRIPES
- 37 8" SOLID YELLOW LINE
- 43 2.54' LONG, 3.55" HIGH RECYCLED PLASTIC CURB WITH WHITE STRIPES
- 44 2.54' LONG, 3.55" HIGH RECYCLED PLASTIC CURB WITH YELLOW STRIPES
- 45 2.69' LONG, 5.12" HIGH RECYCLED PLASTIC CURB WITH WHITE STRIPES
- 46 2.69' LONG, 5.12" HIGH RECYCLED PLASTIC CURB WITH YELLOW STRIPES

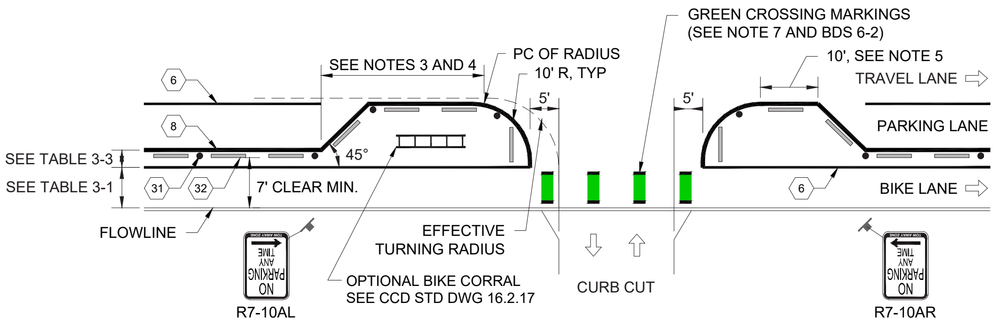
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE TABLE 3-1 FOR ONE-WAY BIKE LANE ZONE WIDTHS, TABLE 3-2 FOR TWO-WAY BIKE LANE ZONE WIDTHS, AND TABLE 3-3 FOR STREET BUFFER ZONE WIDTHS.
5. 1' FROM CENTERLINE OF STRIPE TO FACE OF CURB PROTECTION. MAY REDUCE TO 0.5' IN CONSTRAINED CONDITIONS, WITH DOTI APPROVAL.
6. WHEN BUFFER IS ADJACENT TO METERED PARKING, ALIGN FLEX POSTS WITH PARKING METERS. WHEN FIRE HYDRANTS ARE LOCATED ADJACENT TO BUFFER, REMOVE FLEX POSTS 10' ON EITHER SIDE OF THE HYDRANT.
7. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
8. BIKEWAY PROTECTION ELEMENTS SHALL BE MAXIMUM 4 INCHES IN HEIGHT IF WITHIN THE 20' UNOBSTRUCTED WIDTH PER DENVER BUILDING AND FIRE CODE SECTION 503.2.1. DFD MAY REQUIRE THIS MAXIMUM HEIGHT OUTSIDE OF UNOBSTRUCTED WIDTH DEPENDING ON LAND USE.
9. TYPE OF BIKEWAY PROTECTION ELEMENT TO USED IN DESIGN MUST BE CONFIRMED WITH DOTI PM AT CONCEPT LEVEL. OTHER FORMS OF PROTECTION MAY BE USED IF APPROVED BY DOTI.
10. ONLY FOR USE IN AREAS REQUIRING REMOVAL FOR LARGE EVENTS.

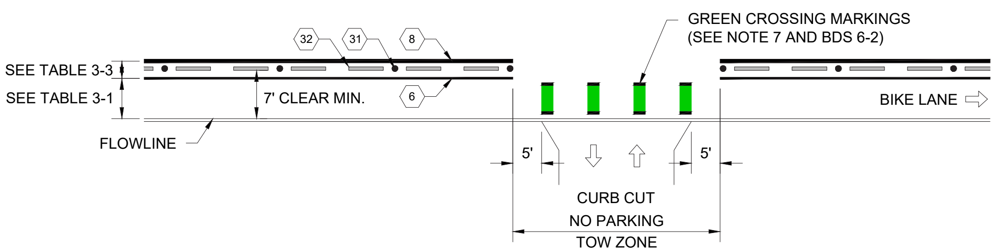
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER STREET-LEVEL PROTECTED BIKE LANE BUFFER DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-1



CAST-IN-PLACE CONCRETE PARKING PROTECTED BIKE LANE



PAINT & POST PARKING PROTECTED BIKE LANE



PAINT & POST PROTECTED BIKE LANE
(CONCRETE CURB SIMILAR)

LEGEND:

- (6) 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (8) 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (31) 36" WHITE FLEXIBLE DELINEATOR POST
- (32) 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

TABLE 3-6: APPROACH CLEAR SPACE

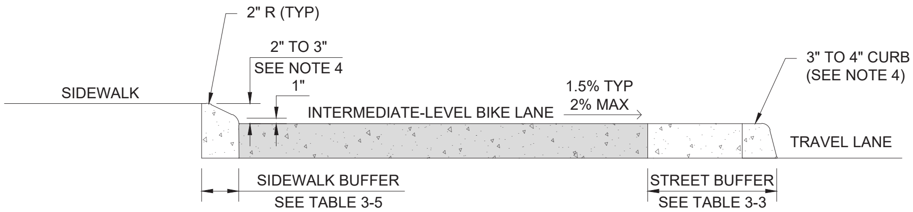
EFFECTIVE VEHICLE TURNING RADIUS	VEHICULAR TURNING SPEED	APPROACH CLEAR SPACE
< 18 FT**	< 10 MPH*	20 FT
18 FT**	10 MPH	40 FT
25 FT	15 MPH	50 FT
30 FT	20 MPH	60 FT
> 50 FT	25 MPH	70 FT

* STOP CONTROLLED INTERSECTIONS AND MOST LOW VOLUME DRIVEWAYS AND ALLEYS
** PREFERRED TURNING RADIUS

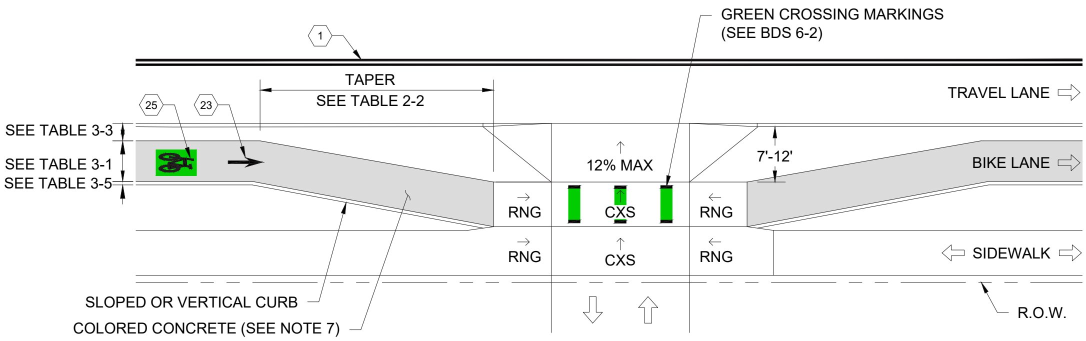
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. USE TABLE 3-6 TO IDENTIFY APPROPRIATE APPROACH CLEAR SPACE (ACS) FOR DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
4. IN CONSTRAINED LOCATIONS THE APPROACH CLEAR SPACE MAY BE MEASURED FROM EDGE OF DRIVEWAY.
5. IN CONSTRAINED LOCATIONS THE FAR-SIDE BUFFER TANGENT MAY BE REDUCED TO 5'.
6. SEE TABLE 3-4 FOR STREET BUFFER VERTICAL OBJECT CONSIDERATIONS.
7. SEE TABLE 3-7 FOR DRIVEWAY TREATMENTS.
8. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
9. FOR CONTRAFLOW PROTECTED BIKE LANES, THE BUFFER STRIPING, FLEXIBLE DELINEATOR POSTS, AND CURB STRIPING SHOULD BE YELLOW.
10. TYPE OF BIKEWAY PROTECTION ELEMENT TO USED IN DESIGN MUST BE CONFIRMED WITH DOTI PM AT CONCEPT LEVEL. OTHER FORMS OF PROTECTION MAY BE USED IF APPROVED BY DOTI.

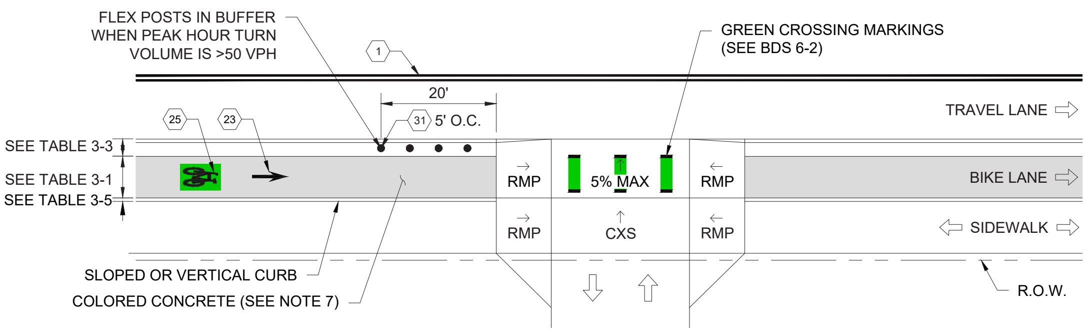
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER STREET-LEVEL PROTECTED BIKE LANE MARKING DETAIL AT DRIVEWAY / CURB CUT	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-2



INTERMEDIATE LEVEL BIKE LANE CROSS-SECTION DETAIL



INTERMEDIATE LEVEL BIKE LANE



INTERMEDIATE LEVEL BIKE LANE (CONSTRAINED)

LEGEND:

- (1) 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- (23) WHITE STRAIGHT BIKE ARROW MARKING
- (25) GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- (31) 36" WHITE FLEXIBLE DELINEATOR POST

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

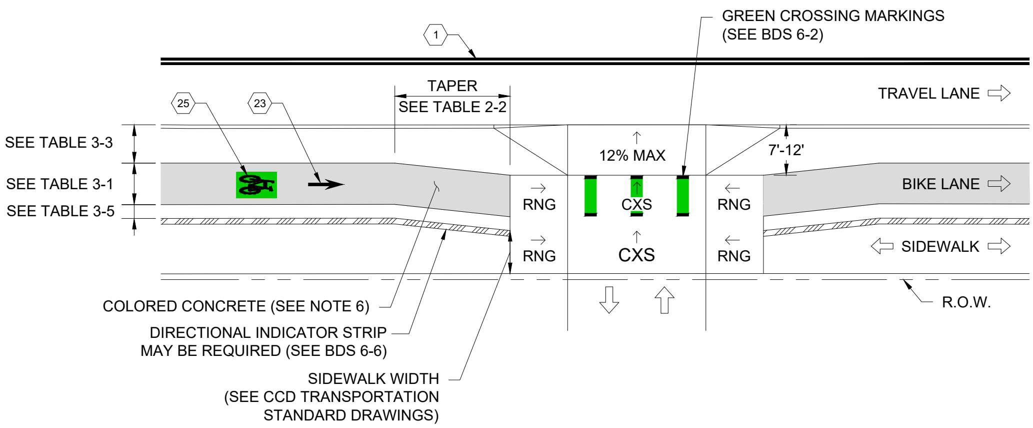
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

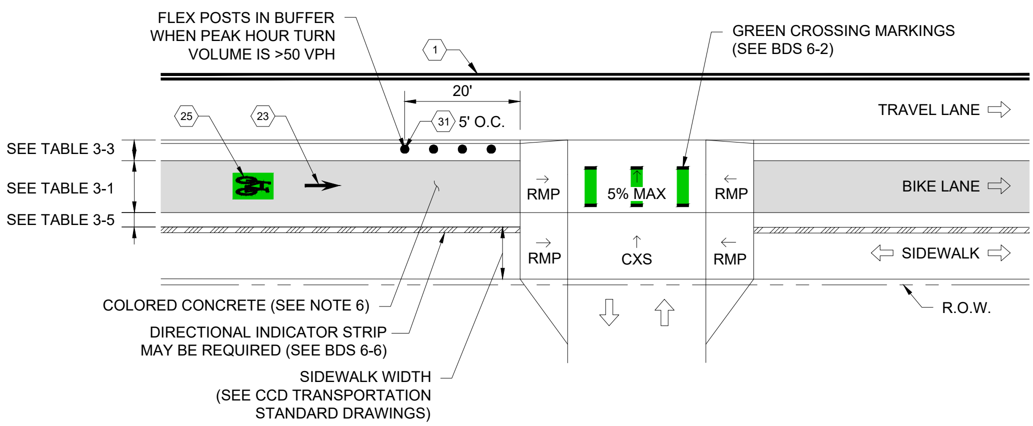
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. MINIMUM COMBINED HEIGHT OF INTERMEDIATE BIKE LANE AND SIDEWALK SHALL BE 6".
5. DETAILS DO NOT INCLUDE ALL INFORMATION NEEDED FOR CONSTRUCTION, SEE CCD STD DWG 6.0, 6.1, AND 6.2 FOR CURB CUT DETAILS AND SPECIFICATIONS.
6. FOR STANDARD COMMERCIAL AND MULTI-FAMILY CURB CUTS, INCLUDE 5' APPROACH WIDENING, AS SHOWN IN CCD STD DWG 6.1.
7. BIKE LANE SHALL BE INTEGRALLY COLORED WITH COLOR PEWTER 860.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER INTERMEDIATE-LEVEL PROTECTED BIKE LANE AT STANDARD RESIDENTIAL CURB CUT	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-3



SIDEWALK LEVEL PROTECTED BIKE LANE



SIDEWALK LEVEL PROTECTED BIKE LANE (CONSTRAINED)

LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 23 — WHITE STRAIGHT BIKE ARROW MARKING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

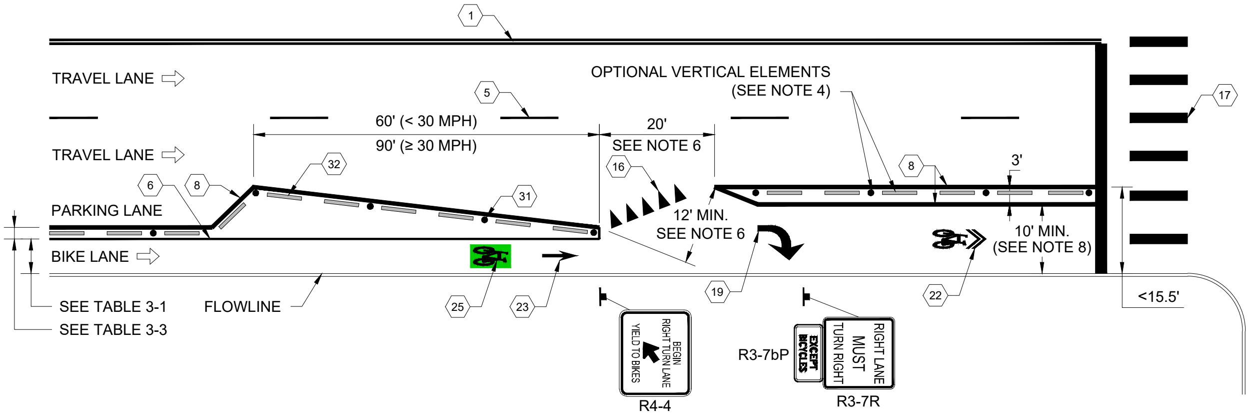
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

NOTES:

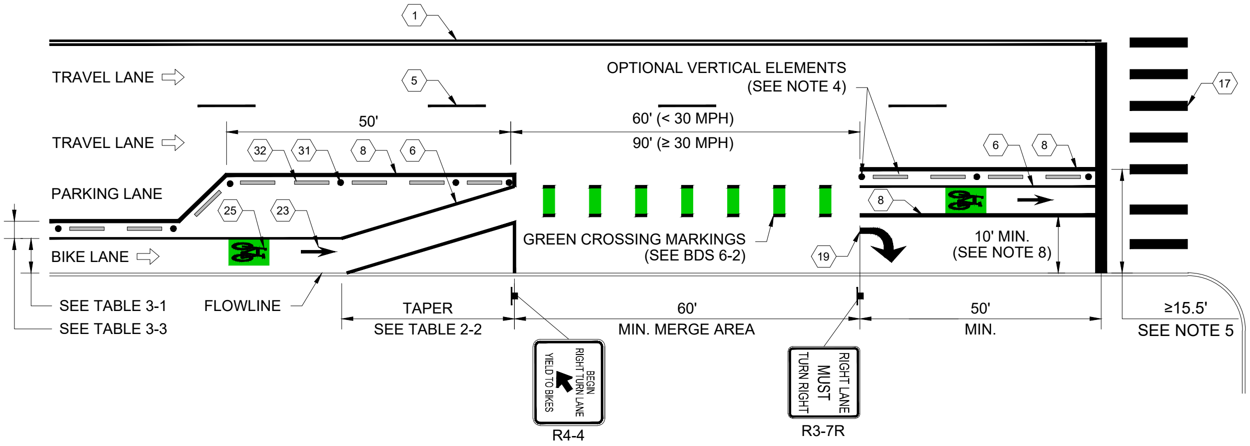
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. DETAILS DO NOT INCLUDE ALL INFORMATION NEEDED FOR CONSTRUCTION, SEE CCD STD DWG 6.0, 6.1, AND 6.2 FOR CURB CUT DETAILS AND SPECIFICATIONS.
5. FOR STANDARD COMMERCIAL AND MULTI-FAMILY CURB CUTS, INCLUDE 5' APPROACH WIDENING, AS SHOWN IN CCD STD DWG 6.1.
6. BIKE LANE SHALL BE INTEGRALLY COLORED WITH COLOR PEWTER 860.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER SIDEWALK-LEVEL PROTECTED BIKE LANE AT STANDARD RESIDENTIAL CURB CUT	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-4



MIXING ZONE TREATMENT

(CONSTRAINED CONDITIONS ONLY)



LATERAL SHIFT TREATMENT

LEGEND:

- 1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 16 WHITE YIELD LINE 24"X36" WITH 4" TO 12" SEPARATION
- 17 18"X10' WHITE CROSSWALK BAR
- 19 WHITE TURN ARROW MARKING
- 22 WHITE SHARED LANE MARKING SYMBOL
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

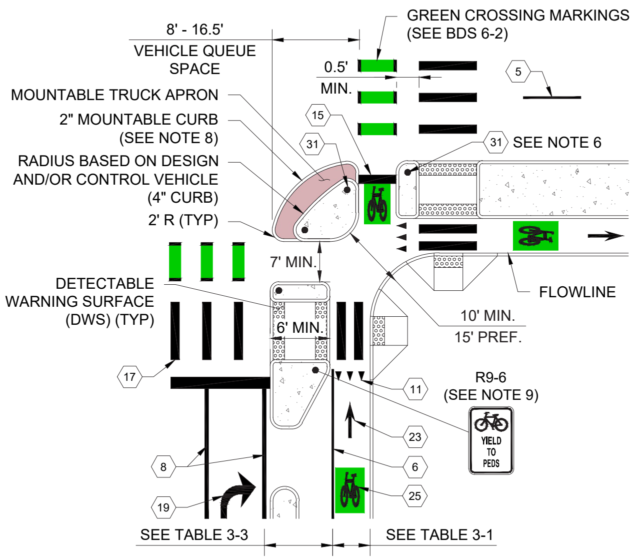
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

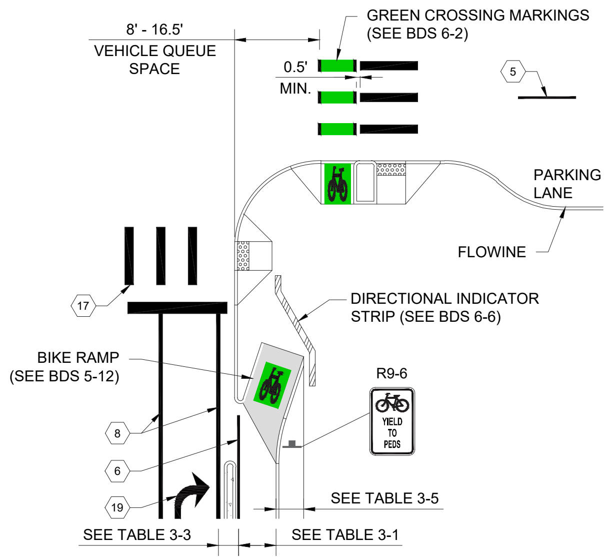
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. VERTICAL ELEMENTS MAY BE EXCLUDED OR MODIFIED AS NEEDED TO ACCOMMODATE TRUCK AND/OR TRANSIT VEHICLES.
5. IF THE RIGHT TURN VOLUME IS >150 VPH, USE THE BIKE LANE AND HIGH VOLUME RIGHT TURN LANE LAYOUT DETAIL ON BDS 2-4.
6. 25' AND 15' MINIMUM WHERE ANY BUS VOLUME IS ANTICIPATED.
7. STRAIGHT BIKE ARROWS SHALL BE INCLUDED ON DESIGN PLANS FOR CONTRAFLOW BIKE LANES, PROTECTED BIKE LANES, WHEN THE BIKE LANE IS INSTALLED ON A ONE-WAY STREET, AND WHEN A BIKE LANE IS LOCATED ON AN INTERSECTION APPROACH BETWEEN VEHICULAR TRAVEL LANES.
8. 10' MINIMUM, EXCLUDING GUTTER PAN.

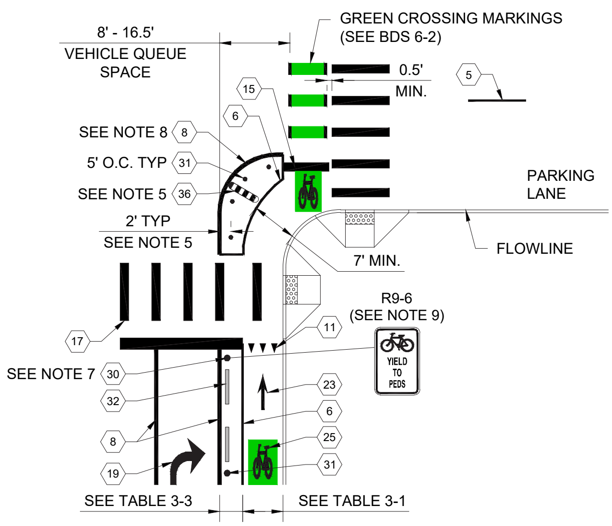
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TURN LANE AND MIXING ZONE TREATMENT DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-5



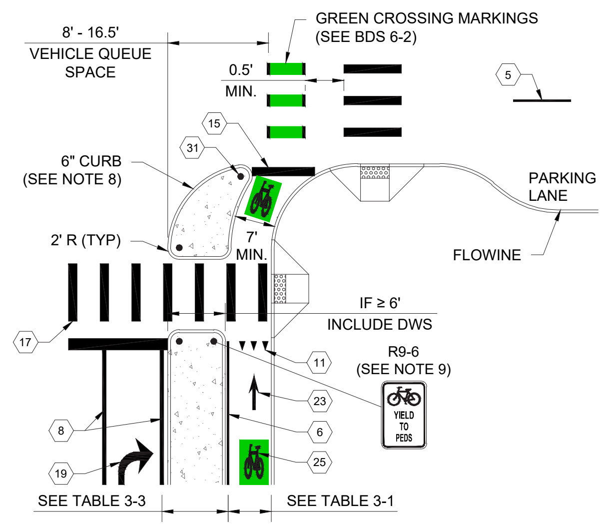
TRUCK APRON WITH INTERSECTING BICYCLE FACILITY



PROTECTED CORNER TREATMENT - SIDEWALK-LEVEL



PROTECTED CORNER TREATMENT - PAINT AND POST



PROTECTED CORNER TREATMENT - CONCRETE

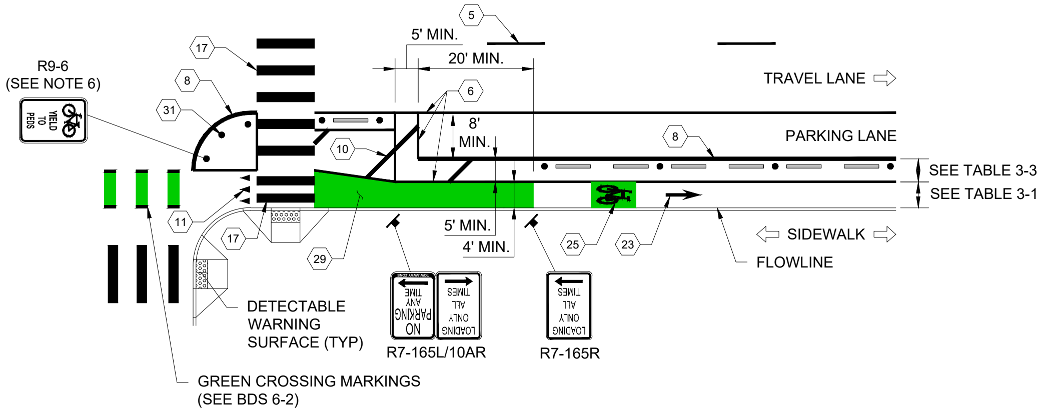
LEGEND:

- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 11 WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- 15 18" WHITE ADVANCED STOP BAR
- 17 18"X10' WHITE CROSSWALK BAR
- 19 WHITE TURN ARROW MARKING
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 30 36" YELLOW FLEXIBLE DELINEATOR POST
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES
- 36 2" TO 3" MAX HIGH RUBBER SPEED BUMP, BLACK AND WHITE

NOTES:

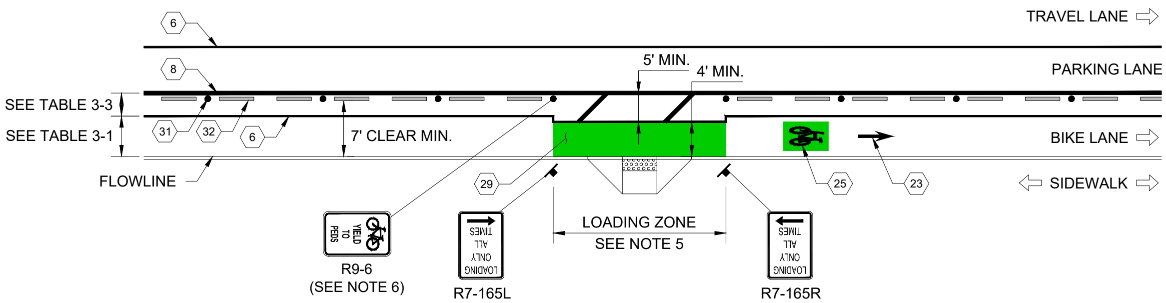
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SIZE AND SHAPE OF CORNER TREATMENTS ARE DEPENDENT ON INTERSECTION CHARACTERISTICS.
5. CORNER RUBBER SPEED BUMP TO BE INSTALLED WHEN THE DESIGN AND/OR CONTROL VEHICLE TURNING PATH REQUIRES FLEXIBLE DELINEATOR POSTS TO BE INSTALLED FURTHER THAN 2' BEHIND THE EDGE LINE STRIPE.
6. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
7. YELLOW FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED PRIOR TO TURN WEDGES WITH RUBBER SPEED BUMPS.
8. RADIUS BASED ON MANAGED VEHICLE. STANDARD RADIUS IS 15', BUT MAY BE REDUCED TO 10' ON TWO-WAY STREETS PER TURNING TEMPLATES, AND 5' ON ONE-WAY STREETS ON CORNERS WHERE THERE ARE NO RIGHT TURN MOVEMENTS.
9. R9-6 SIGN TO BE PLASTIC AND INSTALLED ON FLEXIBLE DELINEATOR POST.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER PROTECTED CORNER TREATMENT DETAILS	STD DWG NO. BDS 3-6



LOADING ZONE AT PARKING PROTECTED BIKE LANE - FAR-SIDE

(PREFERRED DESIGN)



LOADING ZONE AT PARKING PROTECTED BIKE LANE - MID-BLOCK

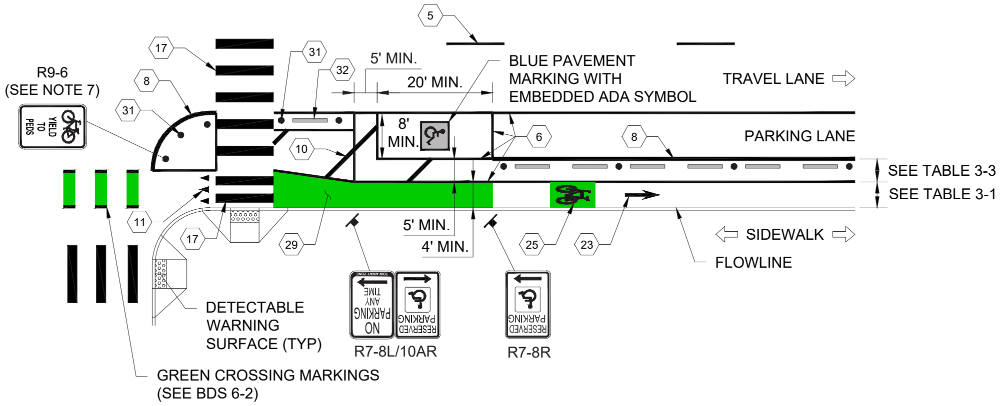
LEGEND:

- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 11 WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- 17 18"X10' WHITE CROSSWALK BAR
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

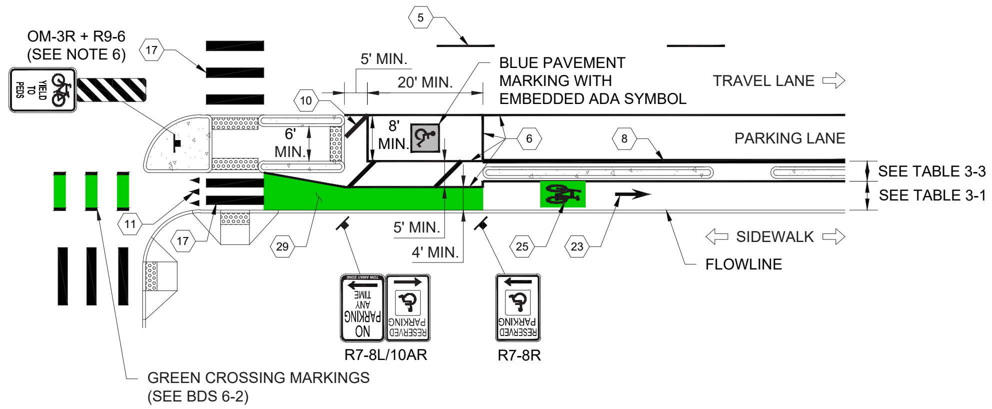
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE BDS 3-6 FOR PROTECTED CORNER TREATMENT DETAILS.
5. IT IS PREFERRED TO RELOCATE EXISTING MID-BLOCK LOADING ZONES TO THE END OF THE BLOCK TO CONNECT WITH EXISTING ADA RAMPS. IF RELOCATION IS NOT POSSIBLE, LOADING ZONES MAY REQUIRE ADA COMPLIANT IMPROVEMENTS AT THE EXISTING CURB.
6. R9-6 SIGN TO BE PLASTIC AND INSTALLED ON FLEXIBLE DELINEATOR POST.

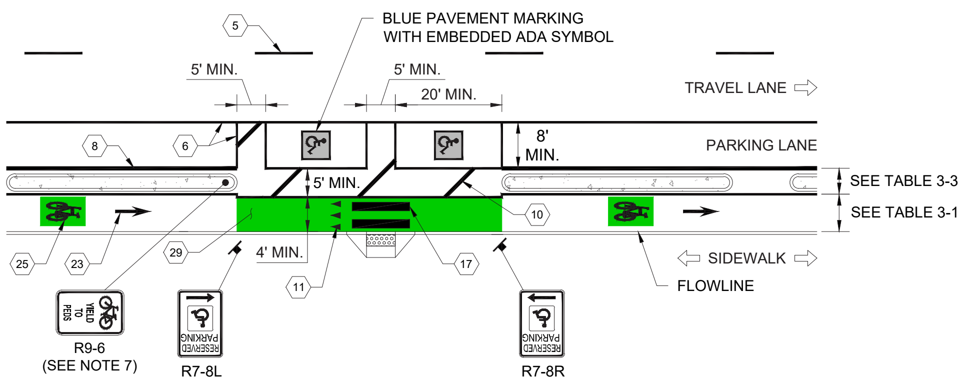
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER LOADING ZONE AT PROTECTED BIKE LANE DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 3-7



FAR-SIDE ACCESSIBLE PARKING SPACE PAINT AND POST



FAR-SIDE ACCESSIBLE PARKING SPACE CONCRETE



MID-BLOCK ACCESSIBLE PARKING SPACE

LEGEND:

- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 11 WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- 17 18"X10' WHITE CROSSWALK BAR
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE BDS 3-6 FOR PROTECTED CORNER TREATMENT DETAILS.
5. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
6. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.
7. R9-6 SIGN TO BE PLASTIC AND INSTALLED ON FLEXIBLE DELINEATOR POST.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER ACCESSIBLE PARKING SPACE DETAILS	STD DWG NO. BDS 3-8

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4. NEIGHBORHOOD BIKEWAYS

Neighborhood bikeways, also known as bicycle boulevards in many other cities, are low-volume and low-speed streets that have been modified to enhance bicyclist safety and comfort through design treatments such as speed and/or volume reduction features, pavement markings, signage, and street crossing treatments. These facilities, along with protected bike lanes and trails, make up the backbone of Denver's high-comfort network, where *Interested but Concerned* riders typically feel most comfortable riding.

Neighborhood bikeways generally support through bicycle travel while discouraging non-local cut-through traffic for motorists. In order to distinguish neighborhood bikeways from regular streets, shared lane pavement markings and neighborhood bikeway signage should be installed to alert motor vehicle drivers that they are on a street that is likely to be used by bicyclists of all ages and abilities.

Short sections of neighborhood bikeways may be designed with a higher degree of protection from moving vehicles to manage localized conflicts between modes. When designing those sections, designers should follow the design principles outlined in Volume 1 of the Manual.

Basis of Design

Manage Motor Vehicle Speeds and Volumes

On neighborhood bikeways, bicyclists operate on a shared roadway with motor vehicles. For this reason, it is critical to manage the frequency of motor vehicle passing events and the speed at which motor vehicles travel along the roadway. Bicyclist comfort decreases with more frequent and faster passing events, and the potential crash severity increases with higher motor vehicle speeds.

To ensure neighborhood bikeways provide a low-stress experience that appeals to all bicyclists, the performance thresholds for motor vehicle volumes and speeds shown in Table 4-1 should be met. Note that these preferred and acceptable speed and volume thresholds reflect the **anticipated post-implementation** condition, or the threshold for when additional improvements are recommended on existing neighborhood bikeways. The maximum values should be used as guidance to determine when a neighborhood bikeway should be considered given pre-implementation speed and volume data on any given street. See the Neighborhood Bikeway Corridor Evaluation section for what to do when the thresholds are not met.

	Peak Hourly Traffic Volume (veh/hr)*	Average Daily Traffic Volume (ADT)	Measured 95th Percentile Speed (mph)
Preferred	≤ 50	≤ 1,000	≤ 15
Acceptable	51 - 100	1,001 - 2,000	16 - 20
Maximum	301 - 450	2,001 - 3,000	21 - 25

*Peak hour traffic volumes are especially important on low-volume streets with large peak traffic generators, such as schools.

Table 4-1: Neighborhood Bikeway Motor Vehicle Thresholds

Designers should strive for the “preferred” and “acceptable” volume and operating speed ranges and consider additional traffic calming or diversion when parameters exceed the “acceptable” levels.

This chapter details the types of traffic calming and diversion measures that may be used to attain these thresholds. This chapter also provides guidance on applying intersection treatments designed to improve the safety of street crossings. The *Complete Streets Design Standards* also include more information on applying traffic calming treatments.

Prioritize Bikeways at Local Street Crossings

Longer distance bicycling on neighborhood bikeways should be as efficient as bicycling on parallel collector or arterial roadways that prioritize long distance vehicle travel. It is therefore desirable to avoid unnecessary stopping or circuitous routing. Designers should prioritize bicyclist mobility along a neighborhood bikeway by modifying intersection traffic control as necessary and feasible. Refer to this chapter’s Design Elements, Minor Street Crossings section for more information on measures like STOP sign flips and removals.

Accommodate Bikeways at Major Crossings

When a neighborhood bikeway reaches a major street, the intersection’s existing condition is typically stop-controlled on the neighborhood street and uncontrolled on the major street, which can result in difficult and uncomfortable crossings for bicyclists. For this reason, the designer should consider crossing improvements at all major streets. This chapter’s Major Street Crossing Treatments section should be consulted for the selection of the appropriate crossing improvement, which is based on the motor vehicle volumes and speeds along the major street. These crossings may also be opportunities to consider traffic diversion measures such as continuous medians or forced turn islands. These treatments may accomplish multiple goals, including improving crossings for pedestrians and bicyclists; decreasing through motor vehicle traffic on the bikeway; and eliminating vehicle crashes associated with through- or left-turning traffic.

Neighborhood Bikeway Corridor Evaluation

Candidate neighborhood bikeway corridors were initially identified in Denver Moves: Bikes, which identified lower volume streets providing desired bicycle connectivity between and within neighborhoods. Secondary considerations in selecting the routes included major street crossing opportunities and challenges, connections to key destinations, connectivity within the emerging low-stress bikeway network, creating parallel alternatives to higher volume collectors and arterials, and proximity to major commercial corridors.

Once a project progresses to the concept design phase the planner and/or designer must:

1. Assess the feasibility of the neighborhood bikeway;
2. Decide on a traffic calming implementation approach;
3. Develop a concept design; and
4. Evaluate the neighborhood bikeway's performance after implementation, if necessary.

This section of the Manual describes each of these steps.

Feasibility Assessment

At the corridor level, the designer must verify route feasibility, per fundamental thresholds identified in Volume 1, before proceeding with a concept design. The designer should determine whether or not it seems feasible to achieve the preferred and acceptable vehicle speed and volume thresholds in Table 4-1 after project implementation. General steps to take when evaluating feasibility of a neighborhood bikeway are as follows:

1. Document street crossings and their traffic control. If there are uncontrolled crossings of arterial roadways that cannot be upgraded, consider moving the bikeway to a nearby parallel route with controlled crossings.

    a. The nearby parallel route should be direct. Research has shown that ridership will decrease when a route increases the bicycle trip length by more than 30%, notwithstanding topography[3]. The planner or designer may modify the route as needed to meet the overall goal of the project while reducing out-of-direction travel.

2. Measure vehicle speeds and volumes throughout the corridor during peak and non-peak periods. Select data collection locations that are near schools, parks, major streets, and other trip generators.
3. Analyze crash data for all modes along the corridor using the most recent five years of data. Vehicle crash data should include crashes resulting in fatalities or serious injuries only. All bicyclist and pedestrian crash data should be analyzed.
4. Conduct a field visit to identify other safety issues and document existing conditions of the corridor. Reach out to community members to gather their input on safety and livability concerns that could be remedied through bikeway design.
5. Map the existing conditions collected in steps 1-4 to evaluate patterns.
6. Compare existing volumes and speeds to the performance goals to determine the design approach. A combination of volume and speed management treatments may be necessary depending on the results of traffic analysis. The concept design should consider ways to reduce vehicle speeds and volumes, reduce crossing distances, and creates a comfortable condition for people walking and bicycling.

3. Broach, J., Dill, J., and J., Gliebe. Where Do Cyclists Ride? A Route Choice Model Developed with Revealed Preference GPS Data

TREATMENT	VOLUME MANAGEMENT	SPEED MANAGEMENT
HORIZONTAL DEFLECTION		
Curb Extension	—	○
One-Lane Pinch Points	—	◒
Traffic Circles	—	●
Median Islands	—	◒
VERTICAL DEFLECTION		
Speed Cushions	◒	●
Raised Crosswalks	◒	●
TRAFFIC DIVERTERS		
Signs and Markings	○	—
Diagonal Diverter	●	◒
Refuge Island Diverter	●	—
Forced Turn	●	◒

POTENTIAL EFFECTIVENESS

● High

◒ Medium

○ Low

— None

Table 4-2: Traffic Calming and Diversion Effectiveness

Traffic Calming Implementation Approach

During the concept design phase, designers should evaluate roadway segments that do not meet desired neighborhood bikeway performance goals and develop a plan to mitigate them via traffic calming or by reassessing the appropriate facility type. Traffic calming can be in the form of traffic volume management (hard diversion) or speed management (soft diversion). Soft diversion happens when the speed management treatments installed may result in drivers choosing another parallel street to use due to the slower nature of the street. Speed management techniques should be applied every 250’-400’ to be most effective.

Table 4-2 includes guidance for which traffic calming measures are most effective, and this chapter’s Design Elements section has information on how to apply these treatments. Designers should take the steps on the following page to determine the most appropriate speed and volume management techniques for each corridor.

VOLUME MANAGEMENT

1. Identify locations that exceed acceptable volume levels, per Table 4-1. These locations will require traffic volume management. To determine the feasibility and type of traffic volume management, the designer should:

    a. Evaluate the street network to see if traffic diversion is viable. Determine the potential access impacts that may result from diversion.

    b. Assess the impact on intersecting and parallel streets. If traffic diversion is expected to increase traffic volumes on intersecting or parallel local streets by more than 1,000 vehicles per day, traffic calming may be needed on the adjacent street(s) as well.

    c. Assess major (arterial) intersections with safety issues to determine whether treatments that restrict through vehicular traffic (major street refuge islands or forced turns) are feasible.

    d. Assess non-arterial crossings that generate traffic and determine whether measures such as diagonal diverters or forced turns are viable.

    e. Determine the level of community support and refine as needed.

    f. If traffic diversion is not acceptable at a major street crossing, progressively assess intersections closest to the major intersection to apply forced turns.

2. When traffic volumes exceed acceptable thresholds in Table 4-1 and the options previously presented are not expected to mitigate the issue, determine whether a conventional bike lane, buffered bike lane, protected bike lane, or shared-use path are viable following the bikeway selection guidance in Volume 1.

3. If the options previously presented are not expected to mitigate traffic to acceptable levels, identify an alternate route for the bikeway that has more desirable characteristics.

4. If diverters are proposed, regardless of existing speeds, include effective traffic calming every 250’ - 400’ to mitigate potential for vehicle speeds to increase with lower volumes after diversion is installed.

SPEED MANAGEMENT

1. Identify roadway segments with speeding issues (where the 95th percentile speed exceeds the goal) or where STOP signs are recommended for reorientation and consider adding the following mid-block and intersection treatments. Note that a combination of intersection and mid-block treatments will be most effective. Intersection treatments alone, particularly curb extensions, have lower effectiveness at slowing vehicle speeds.

    a. Traffic circles

    b. Raised crosswalks at intersections

    c. Median Islands

    d. Curb extensions

    e. Raised crosswalks at logical mid-block crossings connecting to locations like parks and schools

    f. Speed cushions

    g. One-lane pinch points

2. Verify that the overall distance between traffic calming measures, all-way stop-controlled intersections, and major controlled street crossings will result in relatively uniform motorist operating speeds by ensuring that these features are placed every 250 feet to 400 feet depending on block lengths, presence of alleys, and other roadway characteristics.

4. Parkhill, Margaret, et al. “Updated Guidelines for the Design and Application of Speed Humps.”

Roadway Width	Parking on Both Sides	Parking on One Side	No Parking
Less than 32 feet	Use a bi-directional shared lane marking in the center of the roadway	Use a shared lane marking, placed in the center of each travel lane, a minimum of 12 feet from curb on parked side; 4 feet from the non-parked side	Use a shared lane marking in both directions, placed in the center of each travel lane, a minimum of 4 feet from the curb face
32 feet or greater	Use a shared lane marking in both directions, placed in the center of each travel lane, a minimum of 12 feet from the curb face	Use a shared lane marking, placed in the center of each travel lane, a minimum of 12 feet from curb on parked side; 4 feet from the non-parked side	Not likely to occur

Note: The designer should use a bi-directional shared lane marking instead of two standard shared lane markings when the shared lane markings would be placed less than 10 feet (on center) from each other.

Table 4-3: Shared Lane Marking Placement

Concept Design

The concept design for the corridor should incorporate any needed traffic calming elements to achieve the neighborhood bikeway speed and volume goals. The plan should also identify other needed treatments, including:

1. Identify ways to prioritize bicyclists at local street crossings. When traveling along a neighborhood bikeway, a person bicycling should not be required to stop frequently.

Identify the major street crossings that need safety improvements to create a low-stress crossing following Denver's *Uncontrolled Pedestrian Crossing Guidelines* (UPCG) and recommend appropriate treatments.

2. Develop a concept design that includes all recommended treatments and neighborhood bikeway signs and markings.

Project Evaluation

If a corridor needs substantial volume or speed management to meet performance goals, the City should evaluate its performance over time to ensure that the installed design treatments are operating as intended. The City should measure motor vehicle speeds and volumes at key corridor locations and compare them against performance goals. The measurements should be taken a minimum of six months after construction to ensure that travel behavior has normalized. If the goals have not been met, the City should install additional volume or speed management features or modify existing treatments.

Design Elements

This section describes how to apply various design elements, including signs and pavement markings, traffic calming and diversion, and major street crossing upgrades to neighborhood bikeways.

Neighborhood Bikeway Signs and Markings

WAYFINDING SIGNS

The design of neighborhood bikeways should integrate Denver's custom neighborhood bikeway branding signs. Please refer to the *Denver Bicycle Wayfinding Guidelines* for information on how to apply wayfinding to neighborhood bikeways.

WARNING SIGNS

Warning signs, such as W11-15 signs, should be used at major street crossings in conjunction with other crossing treatments identified in this chapter's Major Street Crossing Treatments section.

PAVEMENT MARKINGS

Shared lane markings on neighborhood bikeways should be laterally placed (measured from the center of the marking) following the guidelines in Table 4-3. The markings should be placed following the guidelines below.

- On the far side of all intersections, 50 feet from the flare of the ADA ramp or tangent of the corner curb radius, whichever is farther from the intersection. Bi-directional markings should be 50' farside of all intersections.

- On the near side of all signalized intersections and all intersections with an arterial street, 20 feet from the flare of the ADA ramp or tangent of the corner curb radius, whichever is farther from the intersection. This also applies to shared lane markings with directional indication.

- Mid-block if the block is more than 500 feet.

- Mid-block if the horizontal or vertical curve of the street obstructs the view of a downstream intersection.

At locations where a neighborhood bikeway turns, the neighborhood bikeway marking with directional arrows may be used (Standard Drawing BDS 2-1).

If a centerline is present on streets designated as a neighborhood bikeway, designers should consider removing them. Centerlines have been found to increase motorist operating speeds and increase close passing of bicyclists—two behaviors that are not desirable on neighborhood bikeways.

CONTRAFLOW BIKE LANES

On low-volume one-way roads that would benefit from two-way bicycle traffic to maintain connections in the bike network, a contraflow bike lane can be appropriate. See Standard Drawing BDS 4-8 for details on designing a contraflow bike lane along a neighborhood bikeway corridor.

Traffic Calming and Diversion

Managing motor vehicle volumes and speeds are only necessary for creating a neighborhood bikeway when vehicle volumes and speeds exceed the thresholds identified in Table 4-1.

To determine the appropriate types and placement of traffic calming and diversion measures, the designer should consider how each measure might influence traffic volumes or traffic speeds. One treatment at a spot location is not as impactful as a carefully planned network of traffic calming devices along a neighborhood bikeway. The use of these devices is context-sensitive and engineering judgment should be used in design. The use of horizontal and vertical deflection should be thoughtfully considered where traffic volumes and speeds exceed thresholds. Table 4-2 offers a high-level assessment of the effectiveness of each treatment described in the following sections. Traffic calming considerations—in addition to volume management and speed management—include crash mitigation, opportunities for placemaking and green infrastructure, emergency vehicle access, and roadway maintenance.

Horizontal Deflection

The following treatments represent types of horizontal deflection, which can be used to manage motor vehicle speeds along a neighborhood bikeway route. Horizontal deflection is also a form of "soft diversion," as it can make the route less desirable for through travel by motorists.

Figure 4-1: Curb Extensions on Byron Pl in Denver

CURB EXTENSIONS

On streets with on-street parking or wide travel lanes, curb extensions can be used to extend the sidewalk or curb line into the parking lane, which reduces the effective street width at the intersection. Curb extensions can reduce crossing distance for pedestrians and cyclists, slow turning motorists, improve sight distance for all road users, and prevent parked cars from encroaching into the crosswalk area. Curb extensions should not interfere with bicycle lanes. Where appropriate and where space is available, bicycle parking corrals may be installed in curb extensions. See Chapter 6 for details on designing bicycle parking in curb extensions. Designers must consider stormwater drainage impact and maintaining accessibility for people using mobility devices in these designs.

ONE-LANE PINCH POINTS

Curb extensions can be used at mid-block locations to narrow a roadway to one travel lane to create a pinch point, which requires approaching motorists to yield. A warning sign (ROAD NARROWS) should be used upstream of the pinch point. Pinch points work best on streets wider than 32 feet, unless there is only parking on one side of the street. Pinch points may provide the opportunity to add street trees or green infrastructure; a mature tree canopy can also have a traffic calming effect.

MEDIAN ISLANDS

A median island may be used at mid-block and intersection locations along a neighborhood bikeway to narrow motor vehicle lanes and create a small shift in the path of travel for roadway users. They may also be used at intersection approaches in lieu of curb extensions where storm drain or ADA issues prohibit the use of curb extensions. Medians may provide the opportunity to add green infrastructure or pedestrian refuges as well.

GREEN STORMWATER INFRASTRUCTURE CONSIDERATIONS

Curb extensions (as well as those used for pinch points and chicanes) and median islands provide an opportunity to incorporate green stormwater infrastructure along a neighborhood bikeway. Denver's *Ultra-Urban Green Infrastructure Guidelines* and the *Green Continuum* provide detailed design guidelines on incorporating green infrastructure in various spaces in the public right-of-way (e.g., planters, curb extensions, green gutters, green alleys and tree trenches/pits). Consult the Division of Green Infrastructure's heat and water quality maps to determine the appropriate level of green infrastructure that is recommended for each project. Implementing green infrastructure with bicycle infrastructure can create a more comfortable environment by providing shade, mitigating urban heat, and reducing flooding.

NEIGHBORHOOD TRAFFIC CIRCLES

Neighborhood traffic circles are used to slow vehicle approach speeds at intersections. On neighborhood bikeways, the approaches for all legs of the intersection should be yield controlled. Traffic circles may be used where a neighborhood bikeway turns, or in other situations where intersection traffic calming is needed. Do not use traffic circles in locations where there are diagonal (apex) curb ramps or where the design vehicle path encroaches into the centerline of a valley gutter. In these situations, other traffic calming treatments such as curb extensions or median islands may work better.

Traffic circles should be designed to slow passenger vehicles while still allowing occasional access for larger vehicles. The circle may be designed to be fully mountable for larger vehicles. At some local street intersections, it may be desirable to restrict turns by larger vehicles. Implementation of traffic circles in isolation may not result in desired reduction in vehicular speed. In general, traffic circles intended to slow traffic should be accompanied by mid-block vertical deflection and other traffic calming devices to ensure that drivers do not speed in between the circles.

The design of the traffic circle is a function of the street width and the curb return radius on the intersecting side streets, as shown in the Figure 4-2 and Table 4-4. On wider streets, adding curb extensions alongside traffic circles can help to enforce horizontal deflection and better slow vehicle speeds.

The center island may be designed using permanent or interim materials. For permanent traffic circles, a mountable concrete curb may be used to allow larger vehicles to make left-turns around the center island. For interim material circles, a mountable engineered rubber curb with a yellow stripe may be used. Designers should check the turning envelope of the design and control vehicles to ensure that signs or other objects placed in the center island are outside the wheel path of those vehicles. Standard Drawing BDS 4-2 shows the design details for a neighborhood traffic circle.

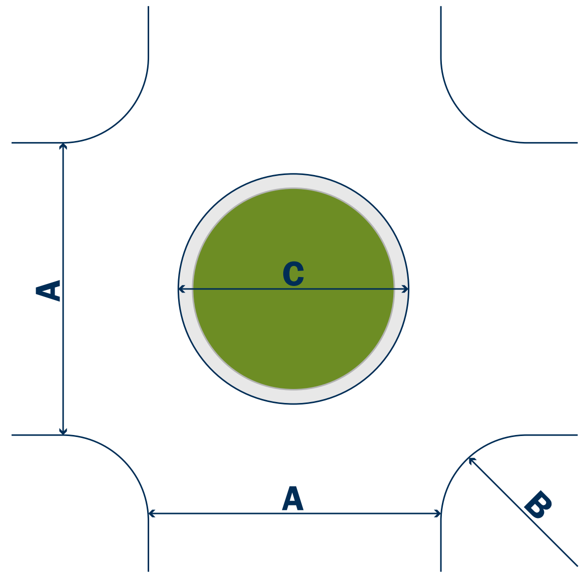


Figure 4-2: Layout of Typical Traffic Circle

A (street width)*	B (curb return radius)	C (center island diameter)
20 feet	15 feet 20 feet 25 feet	9 feet 11 feet 12 feet
25 feet	15 feet 20 feet 25 feet	15 feet 16 feet 18 feet
30 feet **	10 feet 15 feet 20 feet 25 feet	19 feet 20 feet 22 feet 24 feet
36 feet **	10 feet 15 feet 20 feet 25 feet	26 feet 27 feet 29 feet 33 feet
40 feet **	10 feet 15 feet 20 feet 25 feet	30 feet 32 feet 34 feet 38 feet

*Where the intersecting streets have differing widths, or where the intersecting streets are offset, an oval-shaped center island can be used; curb extensions may also be used to narrow one of the intersecting streets.

** On streets wide enough to accommodate parking, designers may need to add interim or permanent curb extension treatments to enforce horizontal deflection of the approach vehicular path. This is especially critical when parking utilization is low.

Table 4-4: Dimensions for Traffic Circles

Figure 4-3: Speed Cushions

Vertical Deflection

Vertical deflection treatments, which include speed cushions and raised crosswalks, are effective means of controlling the speed of motor vehicles along a neighborhood bikeway. They are also a form of "soft diversion," as they may make the corridor less desirable to motorists, thereby reducing motor vehicle volumes.

Speed cushions should be used at mid-block locations, while raised crosswalks can be found both mid-block and at intersections with higher volume streets. Vertical deflection treatments are typically constructed out of asphalt or concrete. Interim materials, such as engineered rubber speed cushions, should be used with caution due to potential snow maintenance issues. W17-1 warning signs should accompany any vertical deflection to alert drivers of the upcoming device.

Speed cushions are designed to have minimal impact on fire truck access. The cushions are placed side-by-side and spaced 2 feet apart to allow the tires of fire trucks to straddle the cushions, thus minimizing any impact on response times.

Vertical deflection treatments should be located so that they are not placed within 20 feet of driveways and alleys. They typically do not impact existing drainage infrastructure, as they match the existing grade of the roadway at a minimum distance of 2.5 feet from the face of the curb. The raised portion of a raised crosswalk should match the height of the sidewalk to allow for a smooth transition for people using mobility devices. If a raised crossing is not extended up to the existing curb height due to storm drain and maintenance issues, ADA compliant ramps are required with a maximum 5% counter slope with the raised crossing. Where roadway grades are steeper than 8%, vertical deflection is not appropriate.

Traffic Diversion

Traffic diversion can be used to reduce motor vehicle volumes along a neighborhood bikeway. Diverters can be located at local street intersections and at major street crossings and should be deployed with careful consideration of traffic impacts and in collaboration with the Denver Fire Department. Where on-street parking is present on both sides of the street, parking may need to be restricted near the diverter to allow for drivers of managed vehicles to turn around and park in the direction of travel.

Reducing motor vehicle traffic on any street can be controversial. It is important to engage with community members along a corridor prior to implementing speed and volume management interventions. Projects that reduce cut-through traffic and provide traffic calming are most successful when there is neighborhood buy-in. Some useful strategies when considering traffic diversion listed below. These strategies should only be considered when vehicle volumes are not severely high and/or the project encounters significant local access issues.

1. Implement “soft diversion,” such as traffic calming, first and measure how it affects vehicle volumes prior to implementing traffic diversion.

2. Implement traffic diversion with interim materials; monitor and adjust based on data collection.

3. Consider changing the bikeway type for segments that exceed the thresholds in Table 4-1. Appropriate bikeway types should be based on the Facility Selection Chart in Volume 1.

The following treatments can be considered for diverting traffic off of a neighborhood bikeway:

REGULATORY SIGNS

Motor vehicle traffic may be restricted through the use of mandatory turn signs (R3-1 and R3-2) or DO NOT ENTER signs (R5-1). These signs should be supplemented with pavement markings indicating the turn requirement. All signs should include an EXCEPT BICYCLES plaque to allow through movement of bicyclists. Signs and markings alone may not be effective at discouraging motor vehicle access.

REFUGE ISLAND DIVERTER

A raised median can be constructed to restrict through motor vehicle access while maintaining bicyclist and pedestrian access. The median can be designed to either restrict or allow left turns from the major street onto the neighborhood bikeway, depending on goals of the project and existing neighborhood bikeway volumes.

When used at crossings of major streets or roads with multiple travel lanes in each direction, such as along a collector or arterial roadway, it is preferable for the refuge median to be 10 feet wide to provide queuing space for bicyclists. At uncontrolled crossings of major streets, the crossing should be evaluated to confirm whether other treatments may be necessary. The median may be narrowed to a minimum of 6 feet at crossings of lower volume two-lane streets.

To provide space for bicyclists to pass through the median, there should be one median opening for each direction of bicycle travel. Each median opening should be a minimum of 5 feet wide, with a 6.5-foot width being preferable. Width of openings may be increased to 7 feet if needed for maintenance. The openings should be designed to allow emergency vehicles to cross while preventing motorists from crossing. All treatments should provide a separate accessible pedestrian route and crossing treatment based on Denver’s *Uncontrolled Pedestrian Crossing Guidelines*. Standard Drawing BDS 4-4 shows the design details of a refuge island on a major street.

DIAGONAL DIVERTER

Diagonal diverters prevent through motor vehicle movements in all directions at a street intersection, requiring motorists to turn left or right. These are typically installed at four-way intersections of local streets where the traffic volume on the neighborhood bikeway is higher than on the intersecting local street. Diagonal diverters require a physical barrier to restrict motor vehicle access and force drivers to turn off of the neighborhood bikeway. Diagonal diverters may be constructed with curb extensions with drainage channels at the curb. For interim conditions, pavement markings, flex posts and rubber curbs may be used instead. Standard Drawing BDS 4-5 shows the design details for a diagonal diverter on a local street intersection.

FORCED TURN

To reduce vehicular traffic volume on a neighborhood bikeway, a portion of a two-way neighborhood bikeway can be converted to one-way motor vehicle traffic by installing an island to force motorists to turn onto the side street rather than continuing through (Standard Drawing BDS 4-6). The median can be constructed using interim materials as a pilot project or using concrete. This design also restricts motorists from turning onto the neighborhood bikeway from the side street. If the design of the neighborhood bikeway includes installation of a new traffic signal to provide a safe bicycle crossing of a major street, designers should consider implementing a forced turn at the intersection to ensure that the new traffic signal does not induce additional vehicles on the neighborhood bikeway.

To mitigate conflicts with turning vehicles, the design should provide

- bicycle lanes between left and right-turning traffic where space is available, or
- a bike lane with a bike box or two-stage turn queue box to allow bicyclists to position themselves in front of stopped motor vehicles, or
- a leading bicycle interval to allow bicyclists to establish themselves in the intersection before the turning vehicles.

Large Vehicle Access

Traffic calming and diversion should be designed to accommodate the design vehicle and the occasional large vehicle (control vehicle). Refer to the *Complete Streets Design Standards* for information on which vehicle to use for the design and control vehicle.

Many types of vertical deflection can accommodate emergency vehicles by leaving gaps that match the wheel base for these larger vehicles and allow a flat navigable surface for people on bike. Smaller passenger vehicles should not be able to fit in the gap.

Minor Street Crossings

Where STOP signs are present along the route, designers should prioritize the neighborhood bikeway by flipping STOP signs to control the street that is not a bikeway. Where all-way stops exist, designers should evaluate whether the all-way stop control is still necessary or if the bikeway direction can be uncontrolled. Where there is existing stop control on the neighborhood bikeway and where flipping the STOP sign is determined to be infeasible, designers should consider a four-way stop or a traffic circle to enhance cyclist safety and priority. At locations where two neighborhood bikeways intersect, an all-way stop should be implemented.

For any STOP sign changes, designers should consider traffic patterns and neighborhood context associated with past STOP sign installation. Removing stop control along a neighborhood bikeway may make the corridor more desirable as a cut-through route for motorists or encourage higher motor vehicle operating speeds. For this reason, streets with existing volumes below the thresholds in Table 4-1 may benefit from the installation of traffic calming measures to discourage changes in existing traffic patterns.

Major Street Crossings

Neighborhood bikeways should ensure that major street crossings maintain the low stress nature of the facility. Major intersections are often the most uncomfortable and difficult parts of a neighborhood bikeway and additional consideration should be taken to design them so that they enhance safety and comfort of people walking and biking. Neighborhood bikeways should follow guidance outlined in the UPCG. The major street crossing treatment should be selected based on the motor vehicle speeds and volumes and the cross-section of the major street. The following section describes bicycle-specific additions or changes to the Geometric Treatments section of the UPCG.

LEVEL A

Level A treatments use a marked crossing and supplemental crossing signs to designate the crossing. If the bikeway type is modified to a bike lane or protected bike lane ahead of the major street crossing, bicycle crossing markings may also be used.

The sight distance for approaching motorists on the major street, and for bicyclists on the neighborhood bikeway, should be evaluated to determine whether roadway users have sufficient time to accommodate the stopping sight distance and judge gaps in traffic. Restriction of parking and removal of sight obstructions is necessary if adequate sight distance isn't provided. If the minimum sight distance can't be provided, advanced warning signs should be installed.

Consider reducing the speed limit and implementing traffic calming measures on the major street to improve yielding rates and reduce the severity of injury in the event of a crash. Regulatory signs that communicate the right-of-way (e.g., R10-15) and treatments designed to slow turning speeds (e.g., truck aprons, hardened centerlines) should be used to improve yielding rates.

Optimize the geometric design of the intersection and crossing to minimize exposure and maximize sight lines. The designer should consider the following: narrowing the lanes on the major street or removing travel lanes; using refuge islands to break the crossing into two stages or restricting turning motor vehicle movements at the intersections; or using curb extensions to daylight the intersection and slow turning speeds.

LEVEL B

As stated in Level A, consider strategies to reduce the speed of motorists on the major street.

Per Table 4 in the UPCG, at higher-volume or higher-speed crossings, a Rectangular Rapid Flashing Beacon (RRFB) may be warranted in addition to warning signs. Designers should use green bicycle crossing markings, a trail crossing warning sign W11-15P, and bicycle camera detection when RRFBs are used on neighborhood bikeways.

LEVEL C

Per Table 4 of the UPCG, crossing treatments that stop motor vehicle traffic on the major road may be warranted depending on the corridor speeds, volumes, roadway type, if there are insufficient gaps in traffic to cross the street, or sight distance is restricted. If the UPCG recommends Level C, designers should consider installing a traffic signal if warranted by the MUTCD.

Where active warnings, toucans, or PHB signals are installed, curbside push buttons or video detection for bicyclists should be used in lieu of pavement detectors to prevent motor vehicles from actuating the device. See Chapter 6 for further guidance on bicycle detection. Provide a minimum 30-foot no-parking zone on the side street where a PHB or RRFB push-button is installed.

Toucan Crossings

A toucan crossing requires traffic diversion to restrict left turns and through traffic from the minor street. This design should be considered for major crossings if it is not desirable to install a PHB or a full traffic signal. The toucan geometry forces motorists to turn right from the minor street while allowing bicyclists to proceed straight under signal protection. Standard Drawing BDS 4-7 shows the design details for a toucan crossing.

Full Signals

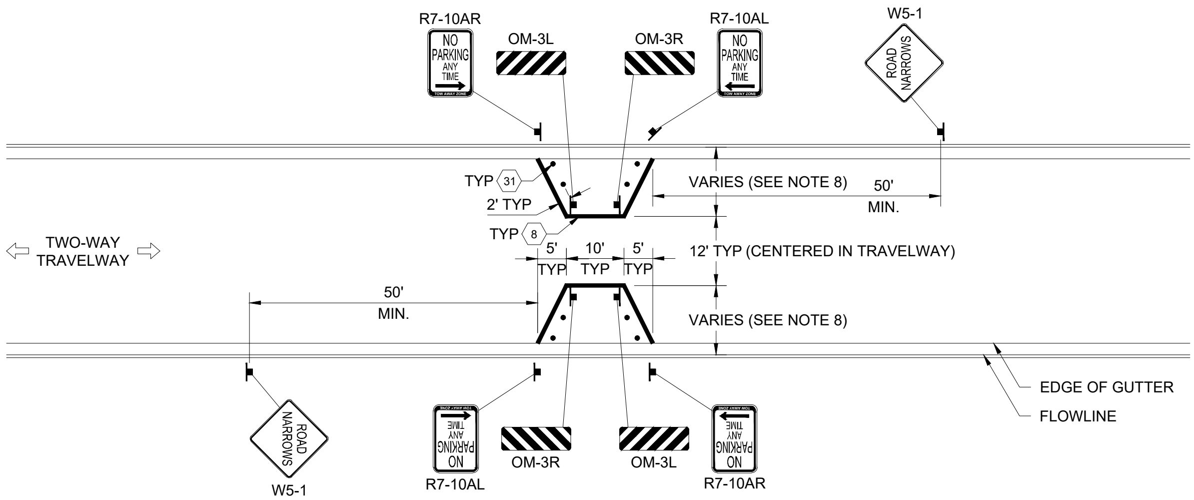
A full signal may be required to provide a comfortable crossing for neighborhood bikeway users. However, designers should be aware that a new traffic signal on a neighborhood bikeway may induce additional motor vehicle demand on the street. Traffic calming measures may need to be installed to reduce the induced demand effect of the new traffic signal.

Pedestrian Hybrid Beacon (PHB)

The use of a Pedestrian Hybrid Beacon (also called a High Intensity Activated Crosswalk or HAWK) signal should meet MUTCD traffic signal warrants and guidelines. This treatment is the least preferred option because it requires bicyclists to use the sidewalk, which is often inconvenient and increases potential for conflict with pedestrians.

Neighborhood Bikeway Standard Drawings

STANDARD DRAWING BDS 4-1	**Pinch Point Layout**
STANDARD DRAWING BDS 4-2	**Traffic Circle Layout - Asphalt**
STANDARD DRAWING BDS 4-3	**Asphalt Speed Cushion Detail**
STANDARD DRAWING BDS 4-4	**Refuge Island Diverter**
STANDARD DRAWING BDS 4-5	**Diagonal Diverter**
STANDARD DRAWING BDS 4-6	**Forced Turn**
STANDARD DRAWING BDS 4-7	**Toucan Signal**
STANDARD DRAWING BDS 4-8	**Contraflow Bike Lane Details**



PINCH POINT

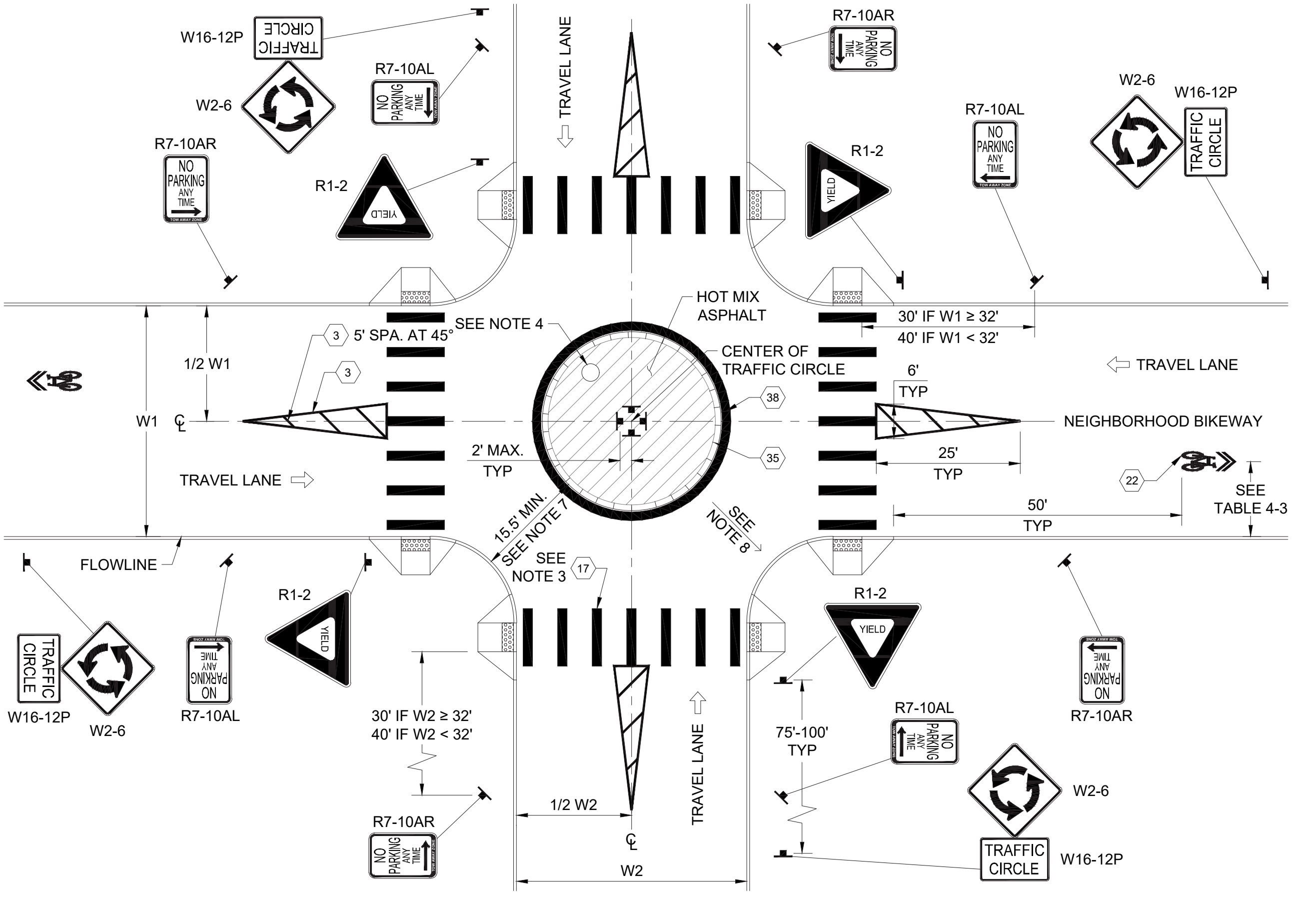
LEGEND:

- ⟨8⟩ 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- ⟨31⟩ 36" WHITE FLEXIBLE DELINEATOR POST

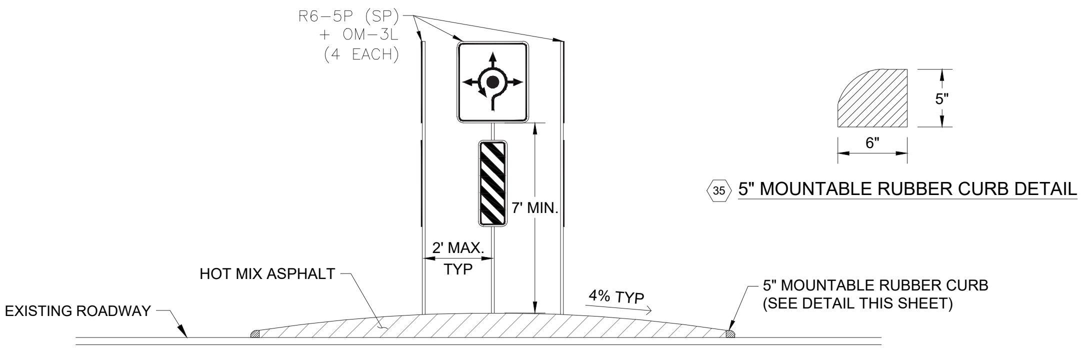
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. OM SIGNS SHOULD BE PLASTIC AND MOUNTED ON 36" WHITE FLEXIBLE DELINEATOR POSTS.
4. PINCH POINTS SHOULD NOT BE INSTALLED WITHIN 20' OF THE EDGE OF RESIDENTIAL DRIVEWAYS OR ALLEY CURB CUTS. TURNING TEMPLATES SHOULD BE EXECUTED FOR ALL CURB CUTS WHERE THE DESIGN VEHICLE IS LARGER THAN AN SU-30.
5. PINCH POINTS SHOULD NOT BE INSTALLED WITHIN 100' OF AN INTERSECTION.
6. PINCH POINTS SHALL NOT BE INSTALLED WITHIN 10' OF FIRE HYDRANTS.
7. PINCH POINTS SHALL NOT BE INSTALLED IN FRONT OF DRAINAGE INLETS.
8. IF LESS THAN 10' ON ROADWAY WITH PARKING, DESIGN SHOULD ONLY BE CONSIDERED IF PARKING UTILIZATION IS LOW, WITH DOTI APPROVAL.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER PINCH POINT LAYOUT	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-1



ASPHALT TRAFFIC CIRCLE - PLAN



ASPHALT TRAFFIC CIRCLE - CROSS SECTION

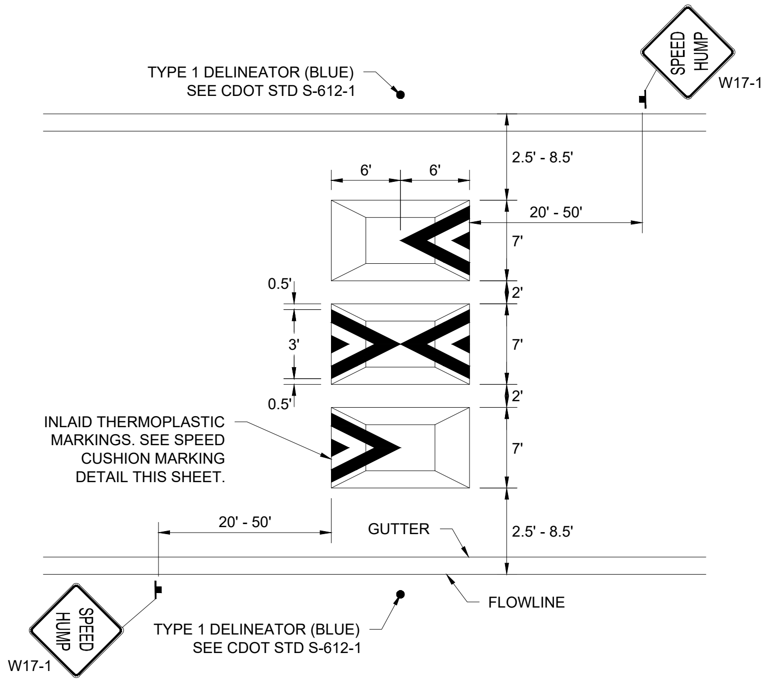
LEGEND:

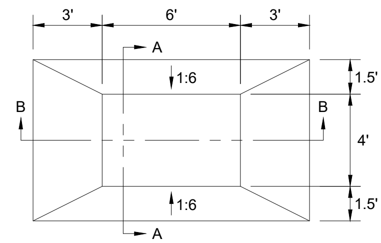
- 3 — 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- 17 — 18"X10' WHITE CROSSWALK BAR
- 22 — SHARED LANE MARKING SYMBOL
- 35 — 3' LONG, 5" HIGH MOUNTABLE RUBBER CURB WITH YELLOW STRIPES
- 38 — 18" SOLID YELLOW LINE

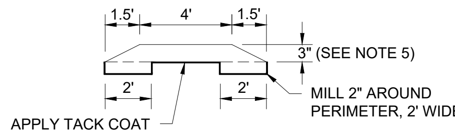
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. REFER TO TABLE 4-4 FOR CENTER ISLAND DIMENSION.
3. MARKED CROSSWALKS ARE WARRANTED WHEN RECEIVING RAMPS ARE PRESENT.
4. IF PRESENT, ADJUST EXISTING MANHOLE TO NEW ASPHALT GRADE AND INCLUDE MANHOLE RISER RINGS IN QUANTITIES.
5. TRAFFIC CIRCLES SHOULD NOT BE INSTALLED WITH DIAGONAL CURB RAMPS.
6. TRAFFIC CIRCLES SHOULD NOT BE INSTALLED WHERE THE PARALLEL DESIGN VEHICLE PATH ENCROACHES INTO THE CENTERLINE OF A VALLEY GUTTER.
7. IF A CORNER INLET IS PRESENT, INCREASE THIS DIMENSION BY 2 FEET.
8. MAXIMUM SLOPE IS 12% IN RETROFIT DESIGNS.
9. SEE TRANSPORTATION STANDARD DRAWINGS FOR CONCRETE DETAIL.

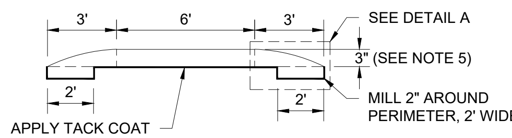
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRAFFIC CIRCLE LAYOUT - ASPHALT	STD DWG NO. BDS 4-2



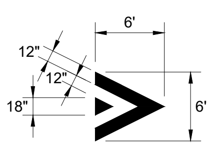




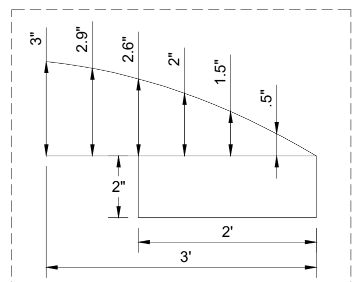
SECTION A-A



SECTION B-B



SPEED CUSHION MARKING DETAIL
(WHITE PREFORMED THERMOPLASTIC)



DETAIL A

NOTES:

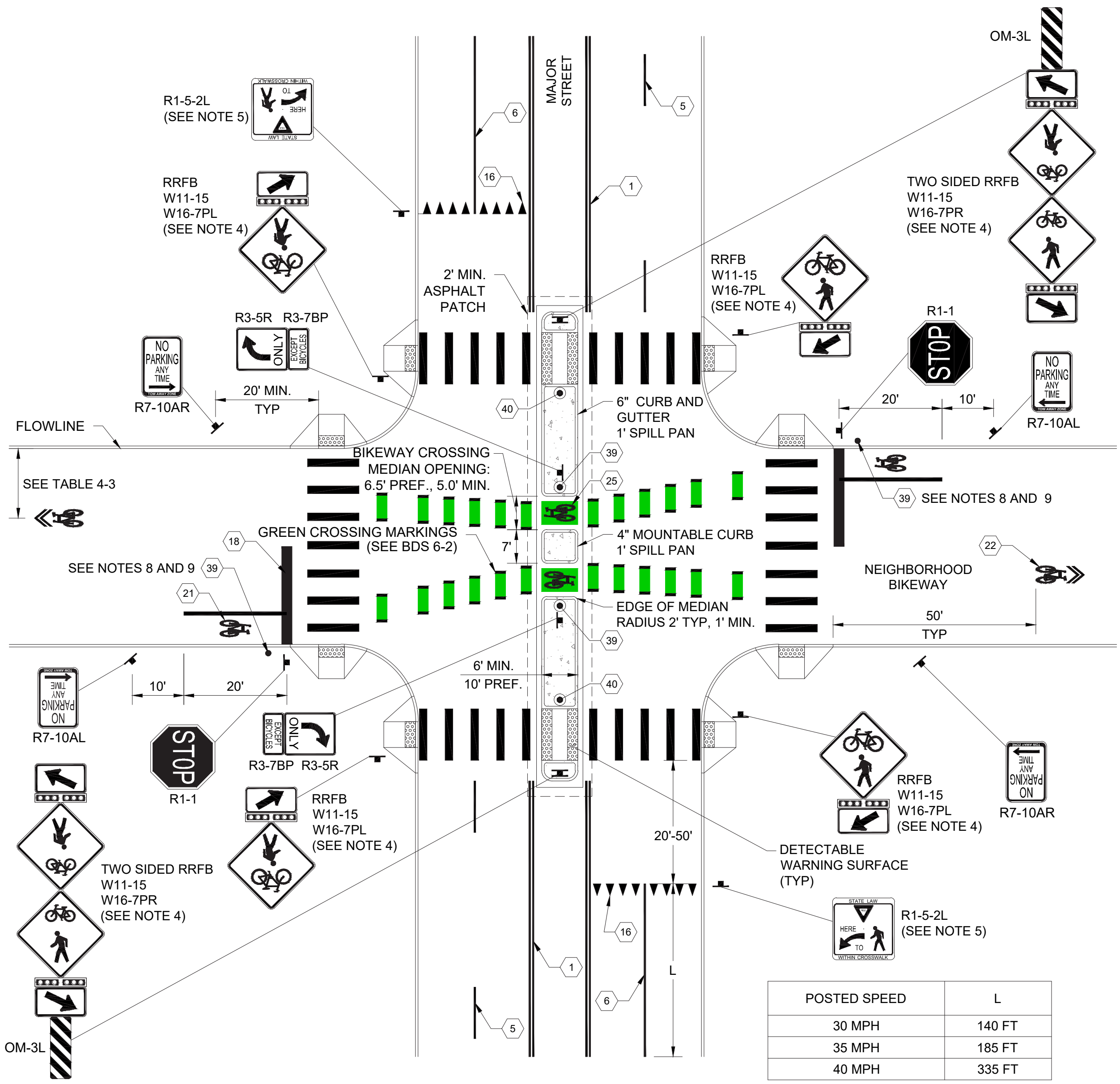
1. SPEED CUSHIONS SHALL NOT BE PLACED OVER MANHOLES, WATER VALVES, SURVEY MONUMENTS, OR ANY OTHER SURFACE INFRASTRUCTURE.
2. SPEED CUSHIONS SHALL NOT BE INSTALLED IN A LOCATION SUCH THAT DRAINAGE IS COMPROMISED.
3. SPEED CUSHIONS SHOULD NOT BE INSTALLED WITHIN 20' OF THE EDGE OF RESIDENTIAL DRIVEWAYS OR ALLEY CURB CUTS.
4. SPEED CUSHIONS SHOULD NOT BE INSTALLED WITHIN 100' OF AN INTERSECTION.
5. SPEED CUSHIONS ARE TO BE CONSTRUCTED BETWEEN 3" AND 3-1/2" IN HEIGHT. IF CONSTRUCTED OUTSIDE OF THIS RANGE, CONTRACTORS WILL BE REQUIRED TO MAKE CORRECTIONS. BECAUSE SOME SETTLEMENT IS NORMAL, IT IS PREFERABLE FOR THE INITIAL HEIGHT TO BE MID-RANGE.
6. SPEED CUSHIONS SHALL BE INSTALLED WITH SX(75) PG 64-22. TACK COAT SHALL BE APPLIED PRIOR TO APPLICATION OF ASPHALT.
7. CONTRACTOR MUST PROPERLY COMPACT SPEED CUSHIONS TO PRECLUDE EXCESSIVE SETTLEMENT.
8. THE CONTRACTOR SHALL PROVIDE VERIFICATION OF CROSS SECTION DIMENSIONS.
9. THE CONTRACTOR SHALL FURNISH AND MAINTAIN A FLASHING BARRICADE WITH WARNING SIGNAGE 50' MAX FROM EACH SPEED CUSHION LOCATION IN BOTH DIRECTIONS UNTIL ALL PERMANENT WARNING SIGNS AND PAVEMENT MARKINGS ARE INSTALLED FOR THE SPEED CUSHIONS.
10. ASPHALT APPLICATION SHOULD INCLUDE SEALANT AT THE EDGES PER SPEC 408.
11. APPROACH SLOPE SHALL BE PARABOLIC AND NOT STRAIGHT LINE, AS REFERENCED IN DETAIL A.
12. CONTRACTOR SHALL CONFIRM LAYOUT AND RECEIVE APPROVAL FROM CCD PROJECT MANAGER PRIOR TO COMMENCING WITH MILLING ACTIVITIES.
13. INCREASE DISTANCE BETWEEN CUSHIONS TO 3' MAX. IF CURB TO CURB WIDTH IS GREATER THAN 42'.

STANDARD QUANTITIES (3 CUSHIONS TOTAL)
FOR INFORMATION ONLY:

ITEM	UNIT	QUANTITY
MILLING (2")	SY	20
ASPHALT	CY	4.7
INLAID WHITE THERMOPLASTIC	SF	49
30W17-1 SIGNS	SF	12.5
2" TELESPAR TUBING	LF	25
TYPE 1 DELINEATOR (BLUE)	EA	2

PAYMENT FOR THE THREE SPEED CUSHIONS SHOULD BE PAID FOR AS ITEM NO. 403-34743 SPEED CUSHION BY EACH UNIT

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER ASPHALT SPEED CUSHION DETAIL	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-3



POSTED SPEED	L
30 MPH	140 FT
35 MPH	185 FT
40 MPH	335 FT

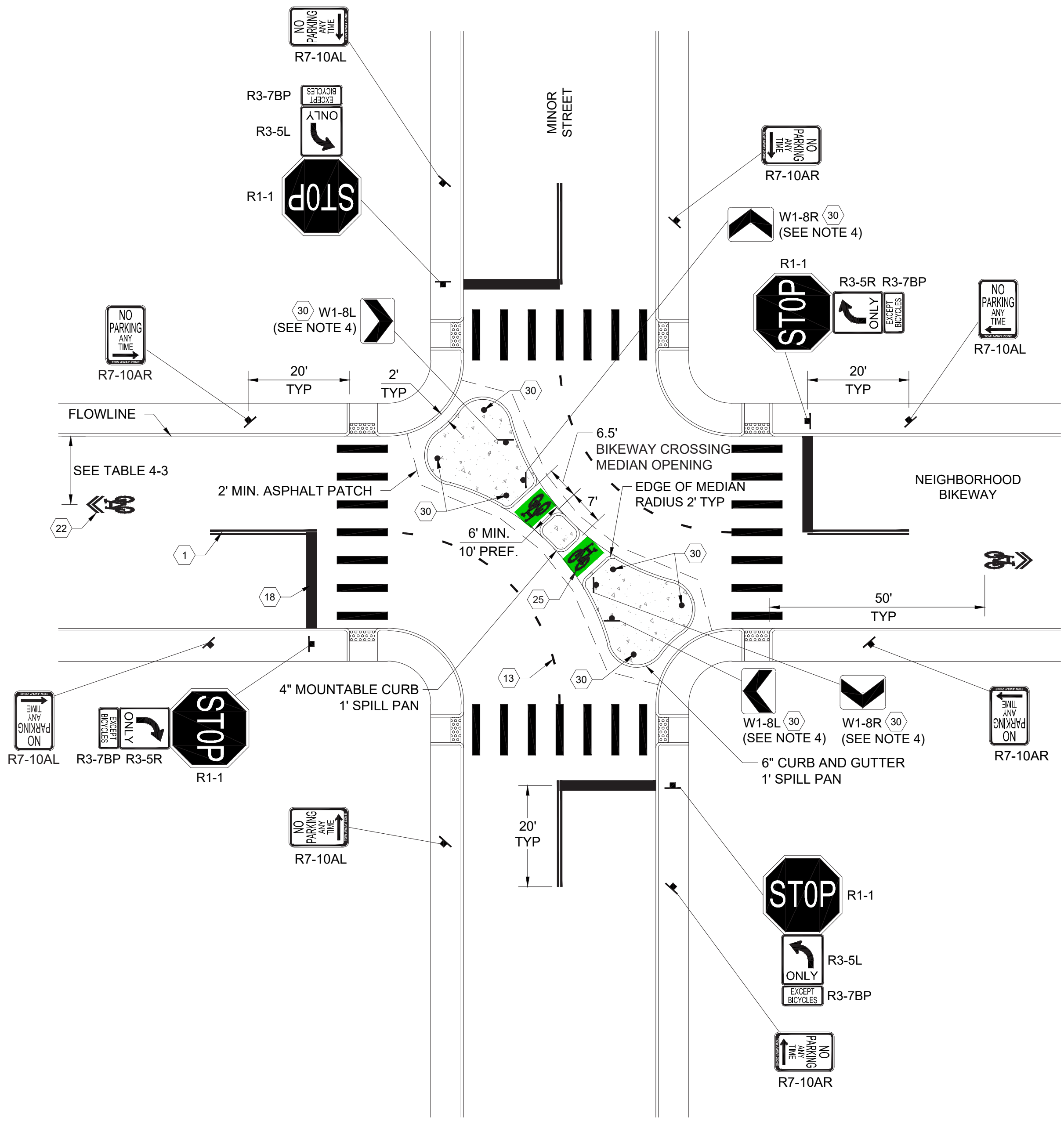
LEGEND:

- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 16 — WHITE YIELD LINE 24"X36" WITH 3" TO 12" SEPARATION
- 18 — 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 21 — BIKE SYMBOL MARKING
- 22 — WHITE SHARED LANE MARKING SYMBOL
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 39 — 6' PEDESTAL POLE WITH BICYCLIST PUSH BUTTON
- 40 — 6' PEDESTAL POLE WITH PEDESTRIAN PUSH BUTTON

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. REFER TO CCD UNCONTROLLED PEDESTRIAN CROSSING GUIDELINES TO DETERMINE WHICH LEVEL OF TREATMENT IS WARRANTED FOR ALL PEDESTRIAN CROSSINGS.
5. R1-5-2L REQUIRED ONLY AT MULTI-LANE APPROACHES.
6. SEE CCD STD DWG 4.2B FOR CURB DETAILS AND CCD STD DWG 12.0 FOR ASPHALT PATCH DETAIL.
7. SEE CCD STD DWGS 16.1.25.1 AND 16.1.25.2 FOR RRFB DETAILS.
8. CAMERA DETECTION IS PREFERRED FOR BIKEWAY RRFB DETECTION IF THE CAMERA CAN BE MOUNTED ON THE CORNER ADJACENT TO THE BIKEWAY APPROACH. SEE BDS 6-3 FOR RRFB CAMERA DETECTION SIGNING AND STRIPING DETAIL.
9. IF THE NEIGHBORHOOD BIKEWAY STREET GEOMETRY ALLOWS, IT IS PREFERRED TO INSTALL A MEDIAN FOR THE BICYCLIST PUSH BUTTON TO THE LEFT OF THE VEHICULAR TRAVEL LANE. SEE BDS 4-7 FOR DESIGN.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER REFUGE ISLAND DIVERTER	STD DWG NO. BDS 4-4



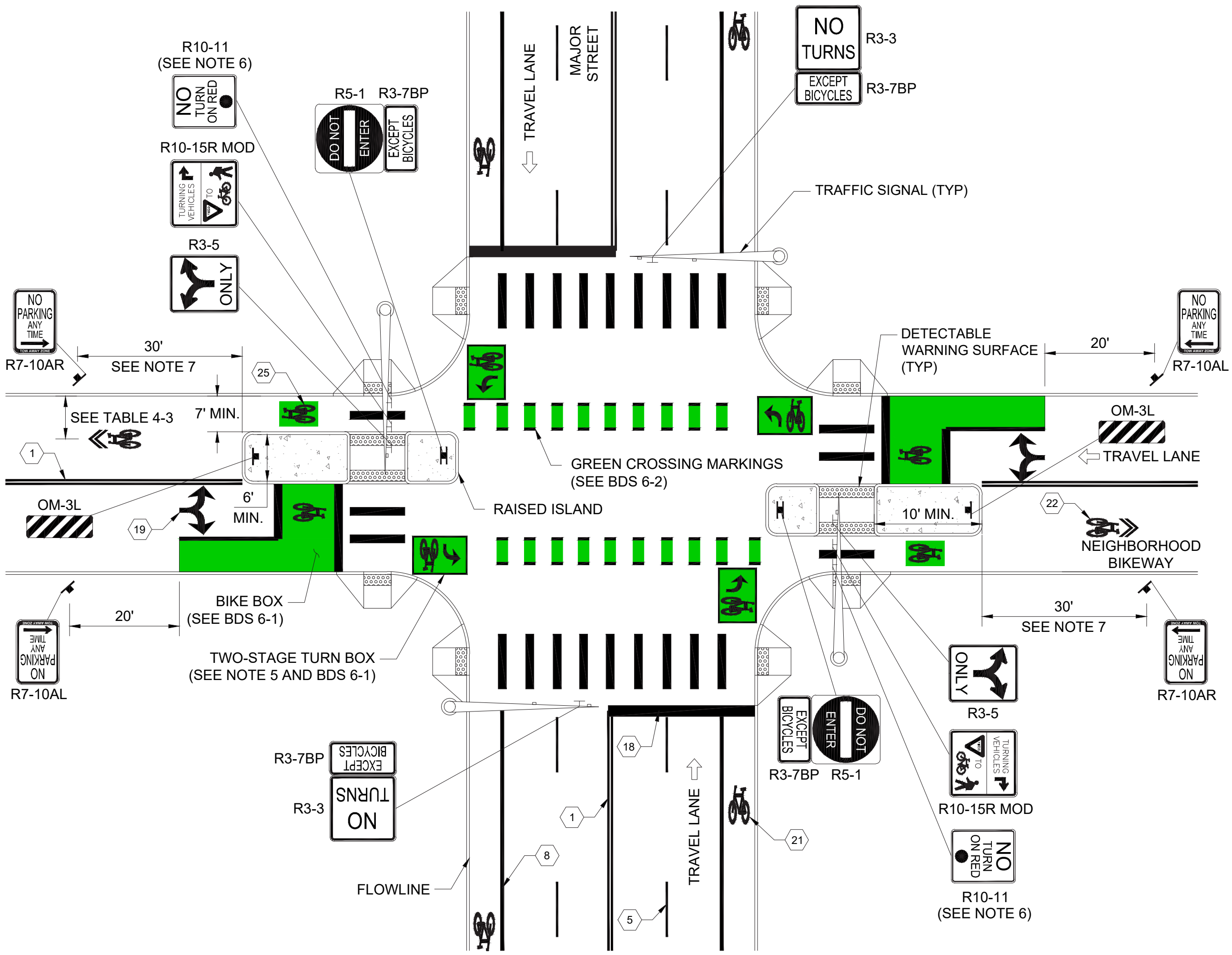
LEGEND:

- (1) 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- (13) 4" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
- (18) 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- (22) SHARED LANE MARKING SYMBOL
- (25) GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- (30) 36" YELLOW FLEXIBLE DELINEATOR POST

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. W1-8 SIGNS SHALL BE PLASTIC AND INSTALLED ON YELLOW FLEXIBLE DELINEATOR POSTS.
5. RELOCATE STREET NAME SIGNS TO SEPARATE POSTS.
6. SEE CCD STD DWG 4.2B FOR CURB DETAILS AND CCD STD DWG 12.0 FOR ASPHALT PATCH DETAIL.
7. COORDINATION WITH DFD IS REQUIRED IF FIRE HYDRANT ACCESS IS MODIFIED DUE TO DIAGONAL DIVERTER.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER DIAGONAL DIVERTER	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-5



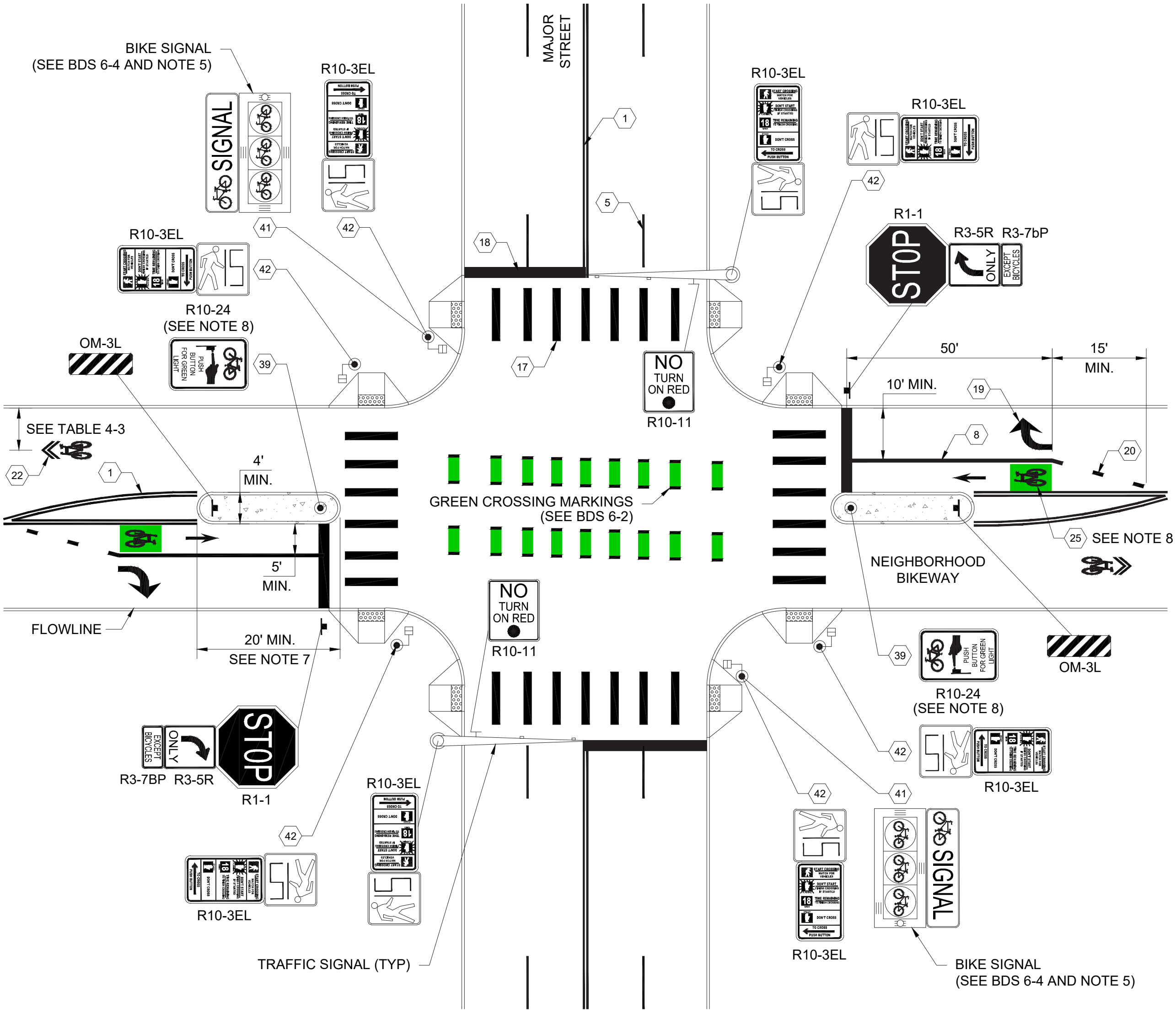
LEGEND:

1. 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
5. 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
8. 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
18. 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
19. WHITE TURN ARROW MARKING
21. WHITE BIKE SYMBOL MARKING
22. WHITE SHARED LANE MARKING SYMBOL
25. GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. ASSUMES SIGNALIZED INTERSECTION. MODIFICATIONS NEEDED FOR STOP CONTROLLED INTERSECTIONS.
3. SEE BDS 2-0 FOR GENERAL NOTES.
4. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
5. ADD TWO-STAGE TURN BOX IF INTERSECTING BIKEWAY ON MAJOR STREET IS PRESENT.
6. "NO TURN ON RED" SIGNS ARE REQUIRED WITH TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.
7. PARKING MAY NEED TO BE RESTRICTED FARTHER TO ALLOW MANAGED VEHICLES TO U-TURN TO PARK IN THE DIRECTION OF TRAVEL.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER FORCED TURN	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-6



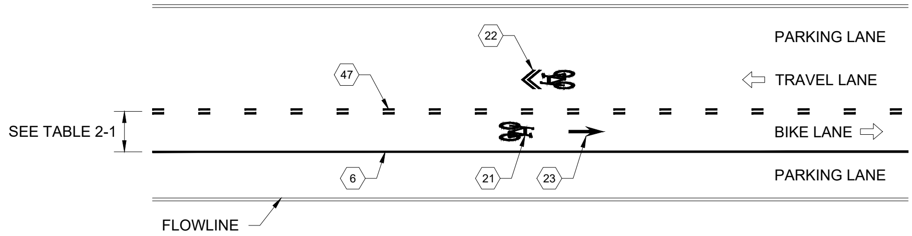
LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 17 — 18"X10' WHITE CROSSWALK BAR
- 18 — 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 19 — WHITE TURN ARROW MARKING
- 20 — 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 22 — WHITE SHARED LANE MARKING SYMBOL
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 39 — 6' PEDESTAL POLE WITH BICYCLIST PUSH BUTTON
- 41 — 15' PEDESTAL POLE WITH BICYCLE SIGNAL HEAD
- 42 — 15' PEDESTAL POLE WITH PEDESTRIAN SIGNAL HEAD AND PEDESTRIAN PUSH BUTTON

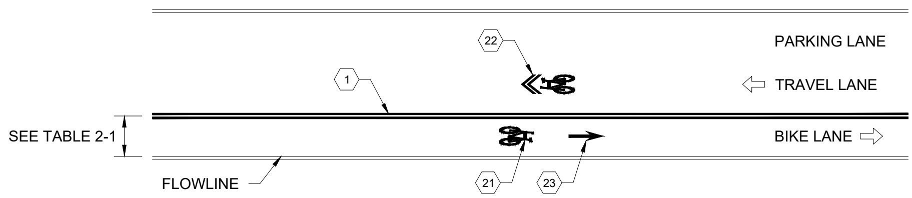
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. ADD TWO-STAGE TURN BOX IF INTERSECTING BIKEWAY ON MAJOR STREET IS PRESENT.
5. SUPPLEMENTAL NEARSIDE BICYCLE SIGNAL MAY BE REQUIRED. SEE CH. 6 FOR MORE INFORMATION.
6. DETAILS DO NOT INCLUDE ALL INFORMATION NEEDED FOR SIGNAL CONSTRUCTION. SEE CCD TRAFFIC SIGNAL, SIGN, AND PAVEMENT MARKING STANDARDS.
7. MINIMUM CURB TO CURB WIDTH TO CONSIDER INSTALLING A MEDIAN IS 40' .
8. IF CAMERA DETECTION IS USED IN LIEU OF A PUSH BUTTON, INSTALL R10-22 ON TELESPAR POST IN MEDIAN AND INSTALL WHITE BICYCLE DETECTION PAVEMENT MARKING.

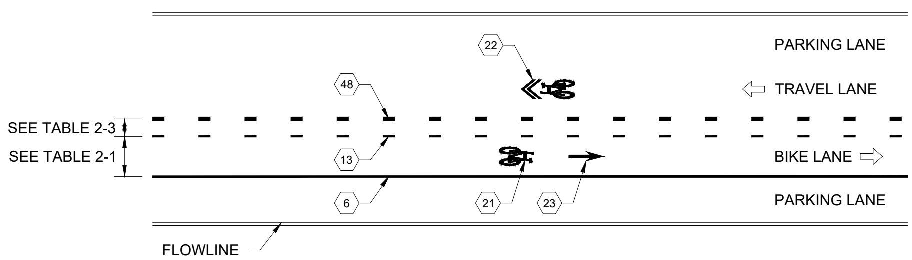
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TOUCAN SIGNAL	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-7



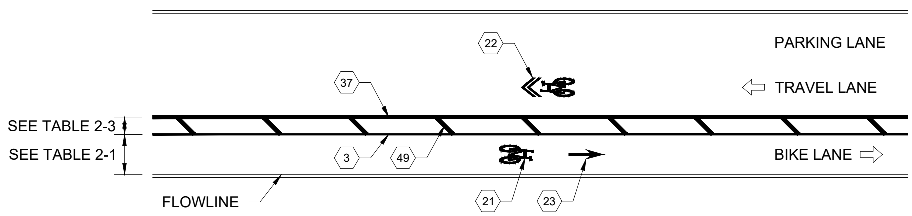
CONTRAFLOW BIKE LANE WITH PARKING



CONTRAFLOW BIKE LANE WITHOUT PARKING



BUFFERED CONTRAFLOW BIKE LANE WITH PARKING



BUFFERED CONTRAFLOW BIKE LANE WITHOUT PARKING

LEGEND:

- (1) 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- (3) 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- (6) 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (13) 4" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
- (21) WHITE BIKE SYMBOL MARKING
- (22) SHARED LANE MARKING
- (23) STRAIGHT BIKE ARROW MARKING
- (37) 8" SOLID YELLOW LINE
- (47) 4" DASHED DOUBLE YELLOW LINE, 2' DASH, 6' GAP, CENTERED WITH 4" SEPARATION
- (48) 8" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
- (49) 8" SOLID YELLOW 45° DIAGONAL CROSSHATCH AT 15' SPACING

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. DESIGN SHOWN IS ONLY APPLICABLE TO NEIGHBORHOOD BIKEWAYS. SEE CHAPTER 3 FOR CONTRAFLOW PROTECTED BIKE LANE DESIGN.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER CONTRAFLOW BIKE LANE DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 4-8

5. MULTIMODAL CONNECTIONS

This chapter provides design guidelines and standard drawings for situations where bikeways intersect with other modes or transition between different types of bicycle facilities.

Trail Crossings at Roadways

Trails are a crucial element of Denver's high-comfort bikeway network. Trail comfort can be degraded if roadway crossings are not designed well. Designers should reference the 2019 *Denver Moves: Pedestrian & Trails* plan for guidance on design elements related to trails, including cross-section requirements for various types of trails (e.g., regional, collector, or local trails). When trails cross a roadway, the crossing treatments should follow the guidance provided in this section and the *Uncontrolled Pedestrian Crossing Guidelines*.

Trails often cross roadways at mid-block or uncontrolled locations. Crossing improvements may be necessary depending on the roadway characteristics of the cross street. Designers should refer to the latest version of the UPCG to identify the level of crossing improvements that are appropriate for a crossing location.

The same principles for designing intersections apply to designing trail crossings. This includes creating a conspicuous crossing, providing adequate sight distances, designing the intersection and approaches with relatively flat grades, designing the intersection as close to a right angle as practical, and using speed reduction techniques where needed.

To assess which crossing approach (the trail or the street) should yield and which should stop, designers should evaluate relative volumes and facility hierarchy in the transportation network. After the decision has been made, the least restrictive control that is appropriate should be placed on the lower-priority approaches.

Speed should not be the sole factor used to determine priority, as it is sometimes appropriate to give priority to a high-volume trail crossing a low-volume street, or to a regional trail crossing a minor collector street. Where trails cross highway exits, coordinate with CDOT to implement speed management techniques. Sight triangles where shared-use paths cross a roadway should be calculated using the procedures detailed in the AASHTO Green Book.

Figure 5-1: Trail Crossing on S Zuni St

In addition to the guidance provided in the UPCG, trail crossing approaches should be designed to minimize conflict between trail and roadway users. Treatments that could be used to minimize conflict include pavement markings, signage, and appropriate sight lines to communicate the presence of the trail intersection.

The use of z-gates, bollards, or other physical obstructions within the trail to slow bicyclists or to force bicyclists to dismount is not appropriate approaching intersections. These treatments present a crash hazard for bicyclists and can create situations where bicyclists entering the trail are forced to queue into intersections while other users navigate through the obstructed area, increasing their exposure to collisions with motorists.

The entrance/exit of a trail at a roadway intersection should be at least the same width as the trail itself. If a splitter island is used, the combined trail widths on either side of the island should equal or exceed the width of the trail itself (see Standard Drawing BDS 5-1). Trails can be widened at locations where high volumes of trail users are expected, providing additional queuing space at the intersection. At constrained locations where it is not possible to widen both the trail approach and receiving lanes, the approach lane should be prioritized to be widened for trail users as they wait to cross the roadway.

A curb ramp or blended transition should be as wide as the trail, not including side flares of the curb ramp. The approach should provide a smooth transition between the trail and the roadway. The ramp should be accessible for individuals with disabilities. Detectable warning surfaces should be placed across the full width of the ramp at the edge of the roadway, even when there are separate bicycle and pedestrian ways within the trail.

A 5- to 10-foot radius from the trail to the roadway may be considered to facilitate turns for bicyclists, but this may complicate the provision of detectable warnings that extend the full width of the opening.

Where unauthorized motor vehicles entering the trail is a concern, the NO MOTOR VEHICLES (R5-10D) sign should be used. Bollards should not be used unless there is a documented history of unauthorized intrusion by motor vehicles. Bollards create a permanent obstacle to trail users that, when struck, can result in serious injury. Where bollards are used, they should follow the marking guidelines in AASHTO's *Guide for the Development of Bicycle Facilities.* Contact the DOTI project manager for the latest version of this document.

Standard Drawings BDS 5-2 and BDS 5-3 show a trail crossing at a stop-controlled intersection and with pedestrian hybrid beacon, respectively. Note that not all trail crossing treatments or traffic control priority options are shown in the standard drawings. Designers should refer to FHWA Achieving Multimodal Networks, the MUTCD, and Denver's UPCG for further guidance.

Bikeways within Transit Stops

Bus Stop Design Decision-Making

Bike and transit facility integration is a critical component of bikeway design. Designers must check early on whether a planned bike facility falls on an existing or planned bus route and coordinate with DOTI's Transit Team and RTD if so to identify any bus stop relocations and consolidations needed. New bus routes, planned service improvements, planned transit enhancements (such as Bus Rapid Transit or Bus Priority), are identified in *Denver Moves: Transit* and RTD's *System Optimization Plan*. This will ensure an appropriate level of design and investment to accomplish the vision for each street.

Streets with bike lanes, buffered bike lanes, and protected bike lanes that are along transit corridors should incorporate floating or raised bus stops that prioritize the movement of transit users and create high-quality facilities for people bicycling, walking, and taking transit unless budget or available right-of-way make that infeasible. Providing high-quality, separated facilities will help future-proof corridors, as bus frequencies may change and bike ridership may increase. Designers should also coordinate with DOTI's Transit Team to identify One Build opportunities, such as running a conduit to a floating bus stop so that it can accept a shelter or pedestrian light in the future.

Sometimes, constraints exist that make designing or implementing floating or raised bus islands more difficult. In situations where road geometry is the main constraint, use the dimensions for the constrained floating/raised bus stops in Table 5-2.

When budget is the main constraint, designers should prioritize floating bus islands in the following locations.

- Bus stops with frequencies of 15 minutes or less
- Bus stops along parking protected bike lanes, where taper length for buses would result in long stretches without any protection
- Along Bus Priority or Bus Rapid Transit routes

Floating Bus Stops

Bike lanes can be integrated with transit stops at mid-block, near-side, and far-side locations along high-frequency transit corridors. A protected bike lane should be routed behind the platform to minimize conflicts between transit patrons, transit vehicles, and bicyclists. Conventional bike lanes can be transitioned to protected bike lanes at bus stops for similar benefits. This recommended configuration—referred to as a "floating bus stop"—repurposes the street buffer into a dedicated passenger platform between the motor vehicle lane and the bike lane.

With this design, passengers must cross the bike lane when entering and exiting the platform. Designers should use the following principles to design floating bus stops:

- Platforms lengths should be determined based on the number of routes and types of buses accessing the stop. Stops that serve multiple frequent routes may warrant longer platforms to accommodate multiple buses at once. Buses shall allow for front and back door boarding and alighting. For standard buses, platforms should be at least 40 feet and for articulated buses, platforms should be at least 80 feet.

- Preserve the preferred front and back door boarding and alighting area (6 feet by 9 feet) within the floating transit platform, connecting to the pedestrian access route. 5 feet by 8 feet is the minimum dimension in constrained conditions. Preserve the minimum space required for standard recommended amenities based on bus stop typology identified in *Denver Moves: Transit.*

- Guide passengers across the bike lane at clearly marked locations. Two pedestrian crossings should be considered for bus islands that are 80 feet of longer. Channelizing railings, planters or other treatments can be used to help direct pedestrians, particularly those with vision impairments, to the crossing locations. Consider shy distances when placing vertical elements adjacent to the bike lane. Include "LOOK" markings on the pedestrian crossings to alert transit riders that bicyclists may be approaching.

- Provide clear direction to bicyclists to yield to pedestrians crossing the bike lane at crossings.

- Provide clear sight lines between pedestrians and bicyclists at expected crossing locations. If transit shelters are provided, ensure that the shelter structure or shelter advertising do not limit sight distances.

- Include design elements like transverse slow line markings and signage to reduce the operating speed of bicyclists as they approach the floating bus stop. These elements are especially necessary if the bike lane approach is downhill with a grade greater than 5%.

- Maintain an appropriate sidewalk width, typically wider than the minimum pedestrian access route.

- If necessary, narrow the bike lane along the bus stop to maintain an accessible sidewalk and platform in constrained areas (see Constrained Situations). However, if the bike lane is between two vertical curbs, a 7-foot clear distance will be required to allow for maintenance. If such space is not available, consider raising the bike lane to sidewalk level, with appropriate detectable edge design.

- Integrate the platform into the pedestrian crossing at the intersection for convenient access (see Accessibility section).

- Where a two-way protected bike lane is provided, a solid yellow center line should be located on the bikeway to discourage passing along the length of the platform. Clearly delineate direction of travel and yielding responsibilities, and alert pedestrians to the potentially unexpected contraflow bicycle movement.

- Consider raised crossings of side streets if a near-side bus stop diminishes motorist approach sight distance or increases the effective turning radius.

- Use green pavement marking within the bicycle lane for the length of the stop.

A far-side floating bus stop is the preferred configuration for all bus stops. Standard Drawing BDS 5-4 shows various design options based on bus platform requirements. The design also shows an option for a bicycle parking rack or corral at the stop.

Constrained Situations

There may be scenarios where a floating bus stop cannot be constructed according to the design guidance in this chapter because insufficient space is present along the corridor, or in specific locations. A constrained design is necessary in these instances. Before considering a constrained floating bus stop, the designer should ensure that the width of all roadway lanes (i.e., motor vehicle lanes, turn lanes, parking lanes, bicycle lanes) have been reduced to minimum values. Table 5-1 outlines tradeoffs and considerations for each bus stop type.

Constrained Design	Ranking	Considerations
Floating Bus Stop with Bike Lane (BDS 5-4)	Preferred	Use minimum bicycle lane widths to maintain separation and reduce conflict points through the bus stop.
Raised Bike Lane at Bus Stop (BDS 5-5)	Acceptable	Where minimum widths will not provide sufficient space for a bus platform, use this design instead.
Shared Bus/ Bike Lane at Bus Stop (BDS 5-6)	Acceptable	This treatment requires exclusive lanes for bicyclists and buses, which may be feasible at limited locations.
Curbside Bus Stop with Bike Lane (BDS 5-6, 5-7)	Not Preferred	This design is only acceptable where bus frequency and bicycle ridership are low.

Table 5-1: Bus Stop Design Tradeoffs at Constrained Locations

CONSTRAINED FLOATING BUS STOP

Where minimum values do not provide sufficient width for a standard floating bus stop, the designer may consider narrowing the bike lane width to the minimum values. A narrowed bike lane with a floating bus stop is still preferable to other options, as it reduces conflict points, creates consistency in design, and maintains a bus stop platform clear of the bicycle lane. Table 5-2 provides acceptable widths for the bike lane in this situation; however, this design requires a design variance. The presence and type of curb and the elevation of the bike lane affect the allowable minimum width.

	Between Vertical Curbs*	Adjacent to One Vertical Curb	Sidewalk-level
One-way	7 feet	4 feet	4 feet
Two-way	8.5 feet	8 feet	7.5 feet

*Between two vertical elements, a minimum width of 7 feet clear space is required for maintenance, unless a special agreement can be reached with the maintaining entity.

Table 5-2: Constrained Situation Minimum Bike Lane Widths

RAISED BIKE LANE BUS STOP

When the constrained floating bus stop is not feasible due to a lack of available right-of-way along the corridor, or in specific locations, a raised bike lane bus stop may be considered. The primary benefit to this design is that bicyclists are not required to share a lane with other vehicles (buses). The drawback is that boarding and alighting occurs within the bicycle lane, as there is not sufficient space to create a 9-foot platform (otherwise, a floating bus stop would be used). Operationally, bicyclists will need to yield at the upstream side of the raised bicycle lane when a bus is stopped and boarding and alighting is underway. When a bus is not present, transit riders will need to wait outside of the bicycle lane. Design considerations include:

- Maintain a 4-foot minimum “step-off” area between the curb and bicycle lane. Narrow the bicycle lane up to the widths in Table 5-2 to accommodate this space.
- Provide marked crosswalks, including detectable warning strips, to indicate where transit riders should cross to access bus doors.
- Provide signs and/or pavement markings to indicate where bicyclists are supposed to yield when a bus is present.
- Use green pavement marking within the bicycle lane for the length of the stop.

- Include design elements like transverse slow line markings and signage to reduce the operating speed of bicyclists as they approach the bus stop.
- Consider using additional pavement markings, such as "LOOK," to remind transit riders that bicycle riders may be approaching.
- Consider drainage impacts, which could require additional inlets that meet CCD Wastewater standards.

Standard Drawing BDS 5-5 shows the design detail for a raised bike lane at a bus stop.

SHARED BUS/BIKE LANE STOP

In a shared bus/bike lane stop design, a dedicated, curbside bus lane is identified as being exclusively for the use of buses and bicyclists. The lane is wide enough (15 foot minimum) to accommodate both a typical travel lane against the curb and provide sufficient space for a typical bicycle lane to the inside of the travel lane (see Standard Drawing BDS 5-6). The primary benefit of this design is that bicyclists have continuous space, with the ability to pass a stopped bus along the corridor, while only needing to share the roadway with buses and not regular motor vehicles. Note that in this design, motor vehicles turning right from the general purpose lane at a signalized intersection are required to be phase-separated from the bus/bike lane signal phase. This will likely require an exclusive right-turn lane for vehicles in addition to the general purpose through lane. The design of this alternative requires the following features:

- A continuous, dedicated curbside lane for the exclusive use of bicyclists and buses.
- A vertical buffer between the dedicated lane and the adjacent general purpose lanes.

CURBSIDE BUS STOP

The least preferred constrained design along a designated bikeway is a curbside bus stop. With this design, the separation between the motor vehicle lane and the bike lane is terminated prior to the bus stop, allowing the transit vehicle to pull to the curb. If the bus stop is planned to be used as a time-stop or buses dwell frequently, a curbside bus stop is not recommended.

When no parking is present, this design will require that a bicyclist either wait for the transit vehicle to complete boarding and alighting and re-enter the adjacent motor vehicle lane or merge into the adjacent motor vehicle lane and pass the stopped transit vehicle. When parking is present along the corridor, there may be sufficient space for a bicyclist to pass a stopped bus without merging into the adjacent motor vehicle lane; however, this maneuver may still be uncomfortable for many users and can cause high levels of bicyclist delay.

Other treatments, such as pavement markings, should be used to ensure that transit operators are aware of the presence of bicyclists and that bicyclists expect transit vehicles to fully encroach into the bike lane.

Standard Drawing BDS 5-7 shows the design detail for a curbside bus stop with a bike lane.

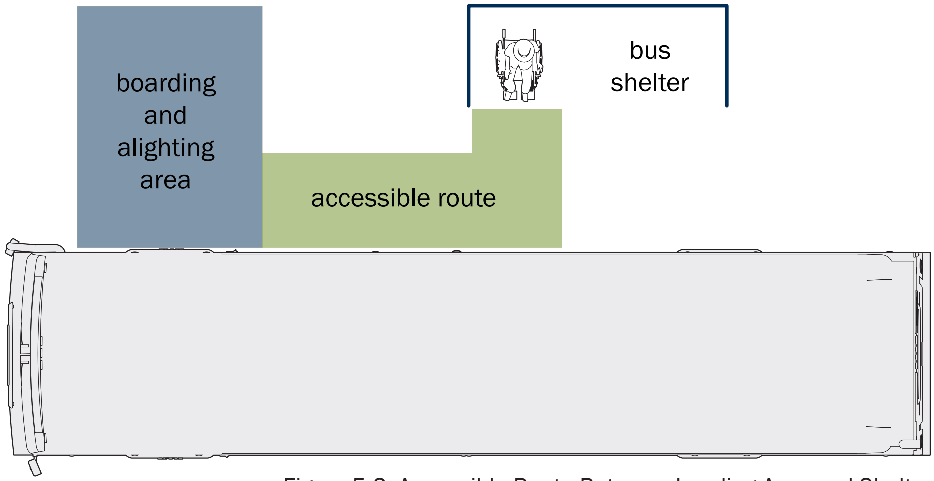


Figure 5-2: Accessible Route Between Landing Area and Shelter

Accessibility

All transit platforms must provide the following:

- A landing area with a minimum width of 6 feet along the curb and a minimum depth of 8 feet perpendicular to the curb (9 feet preferred). This landing area shall align with the front door of the bus when stopped for ramp deployment.
    - The platform should be a firm, stable surface, with a maximum 1.5% cross slope. Parallel to the roadway, the landing area should match the roadway running slope to the maximum extent practicable.
- A curb height between 4 and 8 inches to maximize the ability of the vehicle to deploy accessibility ramps to the platform.
- Accessible routes between the sidewalk, crosswalk, boarding and alighting zones, and transit shelters.
    - The accessible route must be clear of vertical obstructions. The accessible route must be a minimum width of 48 inches with a 60-inch width preferred (see Figure 5-2).

An accessible route connecting the boarding and alighting area to the shelter (if used) and the adjacent pedestrian facility is required for all bus stop configurations. When floating bus stops are located at an intersection, key design considerations include the effective turning radius of the design vehicle, the placement of the pedestrian curb ramps, and the crosswalks. It is important to design the accessible route to ensure pedestrians with vision disabilities cannot inadvertently walk into moving travel lanes.

Where directional curb ramps and a corner island are feasible at near-side or far-side stop locations, pedestrians may be directed to the intersection crosswalk from the platform, eliminating the need for an additional curb ramp at the sidewalk (Standard Drawing BDS 5-4). This can be accomplished by constructing a parallel pedestrian ramp that directs transit users to the crosswalk.

Where a corner island or directional curb ramps are not feasible due to turning vehicle design radius needs, it will be necessary to direct pedestrians from the platform to the sidewalk with a separate curb ramp. This will require installation of a new curb ramp within the sidewalk or a raised bicycle lane behind the platform (Standard Drawings BDS 5-4 and 5-5).

Bikeways Near Rail

Railroad tracks that interface with bikeways can be hazardous to bicycle and micromobility users. The following design considerations are important for bikeways located near tracks:

- Design the rail crossing to be between 60 and 90 degrees.
- Provide the best track surface treatment for bicyclists as practical.
- Provide firm, stable, and slip-resistant pavement.
- Reduce the flangeway width.
- Provide clear delineation with pavement markings that indicates to bicyclists where they should travel to cross railroad tracks at a 60- to 90-degree angle.
- Provide warning signs to alert bicyclists of the crossing.
- Provide adequate sight distances for approaching bicyclists to see the crossing and approaching trains.

Generally, there are two conditions for bikeways and rail interfaces: tracks located parallel to the bikeway, and tracks located crossing the bikeway.

Parallel Tracks

Tracks that are located parallel to a bikeway can be located in the street (e.g., streetcar) or adjacent to the roadway. These tracks are potentially hazardous to bicyclists, both when they travel parallel to the track and when they cross the track.

While traveling parallel to the track, a bicyclists' wheel may fall into the flangeway if they travel too close to the track. This can be an issue where bikeways are located in the street, in close proximity to rail tracks. In this case, the bikeway should be clearly delineated, and the distance between the bikeway and the track should be maximized.

Figure 5-3: Bicycle Facility Crossing Rail Line in Seattle, WA

Bicyclists may cross parallel tracks when turning onto or off of the corridor. When turning right, bicyclists should be encouraged (through pavement markings) to cross the track at an angle between 60 and 90 degrees. This reduces the chance of a bicycle wheel falling into the flangeway and the chance of a bicyclist slipping under wet conditions. If tracks are located to the left of the bikeway, bicyclists should be encouraged to use a two-stage turn box to turn left so that they cross the tracks at a 90-degree angle. Standard Drawing BDS 5-8 shows the design detail of a bikeway crossing parallel or skewed tracks.

Crossing Tracks

Railroad tracks that cross a street typically cross at an angle near 90 degrees. If the crossing angle is skewed, pavement markings should be used to help bicyclists understand the optimal path of travel for crossing. Standard Drawing BDS 5-8 shows the design details of a bikeway crossing turning over skewed tracks.

Figure 5-4: Transition from Conventional to Sidewalk-Level Bike Lane

Transition Between Facilities

Transitions between bikeways will be needed on most projects; either to facilitate a transition from one bikeway type to another or to be used at the end of a project to transition back to the existing conditions. The following considerations are important for applying transitions:

- Where conditions such as topography, street use, or available right-of-way would result in frequent transitions between bikeway types, every effort should be made to use a consistent, single treatment, or a parallel route should be considered.

- Where higher comfort bikeways (i.e., protected bike lanes, trails) transition to conventional bike lanes, or streets with no bicycle facilities, designers should consider how a bicyclist may exit the roadway. It is desirable to transition between the facilities on the far side of the intersection because maintaining protection through intersections is a key design principle.

- Transitions should be located where sight distance is not restricted, and ahead of pinch points, to allow bicyclists to receive advanced warning and sufficient time to make the transition.

Intersections provide natural opportunities to transition between bikeway types; this is especially true at fully controlled intersections. Bikeways should continue through the intersection, allowing the transition to occur on the far side of the intersection. In the case of high-comfort facilities, separation should continue through the intersection. See Standard Drawing BDS 5-9A and 5-9B for details on how a one-way protected bike lane can transition to two-way at an intersection. Standard Drawing BDS 5-10 shows a protected bike lane transitioning to a conventional bike lane or neighborhood bikeway, and BDS 5-11 shows a conventional bike lane transitioning to a neighborhood bikeway.

Ending the bikeway on the far-side also provide bicyclists the opportunity to pull over and wait to merge with general purpose traffic, or transition to the sidewalk if no bikeway continues. Designers should remember that a bicyclist may arrive at a signalized intersection with either a green or red light condition; the design of the transition should anticipate both conditions.

Long, straight sections of a bikeway also provide opportunities for transitions, as these locations provide good sight distance for all roadway users.

A park, plaza, or other destination where conditions are expected to change could also create an opportunity to transition to a different bikeway facility.

Transition Ramps to Raised Bike Lane

Transition ramps provide a bicycle-only connection between the street-level bikeway and raised bike lane. Standard Drawing BDS 5-12 provides guidance for designing such ramps. Transition ramps may be used to provide bicyclists the opportunity to use the sidewalk if a bikeway is ending or if there is a significant change in the comfort of the bikeway. Similarly, transition ramps may be common along neighborhood bikeways where they may be used to transition bicyclists from a shared street to a shared use path or protected bike lane at an offset intersection, or along a portion of the bikeway that has higher motor vehicle volumes.

Transition ramps should be designed so that they are not mistaken as pedestrian ramps. They should be designed to be wide enough to accommodate a variety of bicycle types (e.g., cargo bikes). Ramps should be 7 feet wide in order to accommodate snow clearing equipment. The slope of the ramp should be no greater than 8.3% and 7.8% is preferred. The slope of the roadway at the base of the ramp should be a maximum of 5%.

Similar to the construction of curb ramps, drainage should be considered when designing transition ramps to ensure that ponding does not occur.

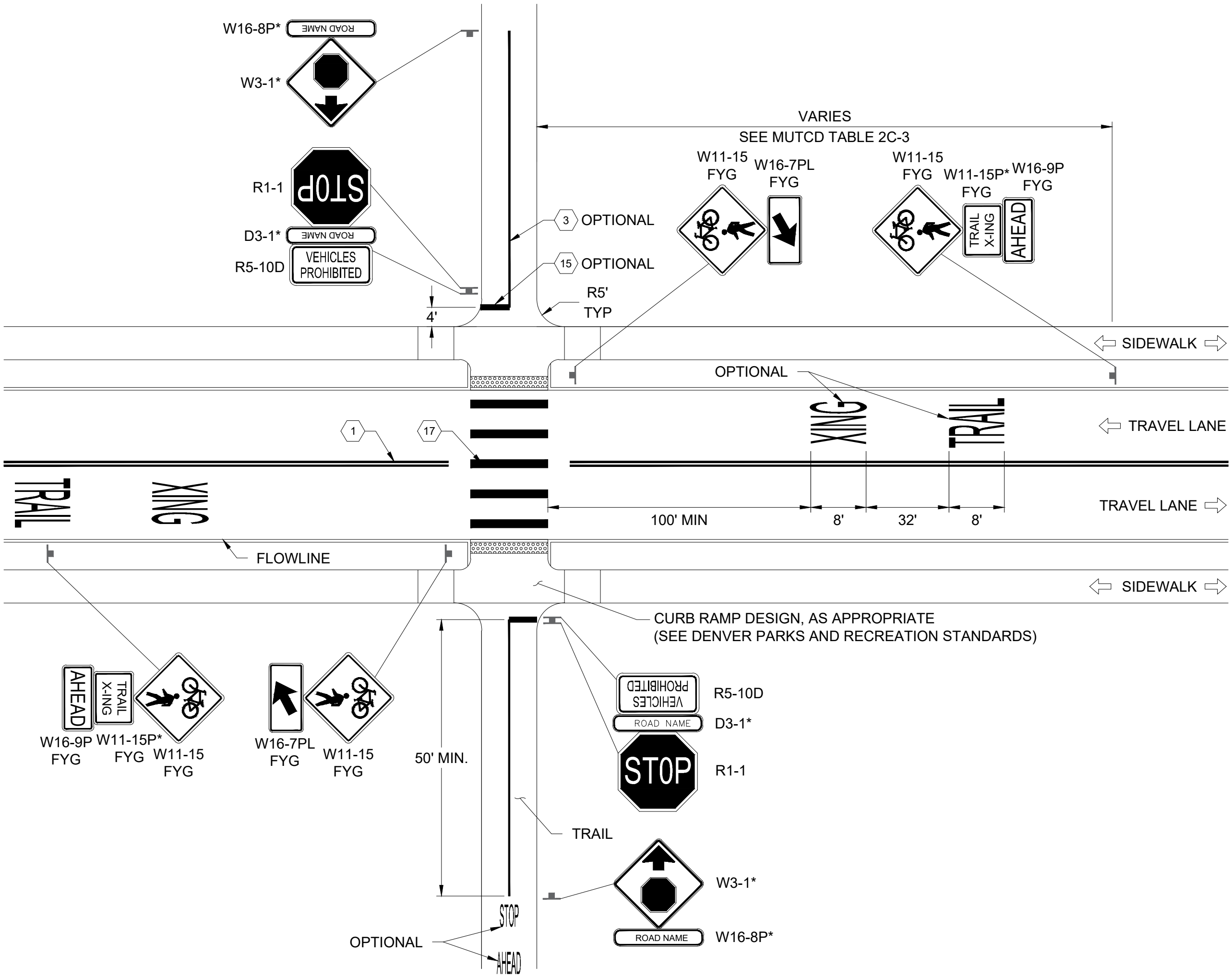
Transition ramps should be marked with pavement markings that indicate their exclusive use; this would typically include green pavement marking and bike lane symbols. A directional dot may be used where space is limited. A directional indicator strip may be used at the top of the ramp to communicate that the ramp is not intended for pedestrian use (see Chapter 6).

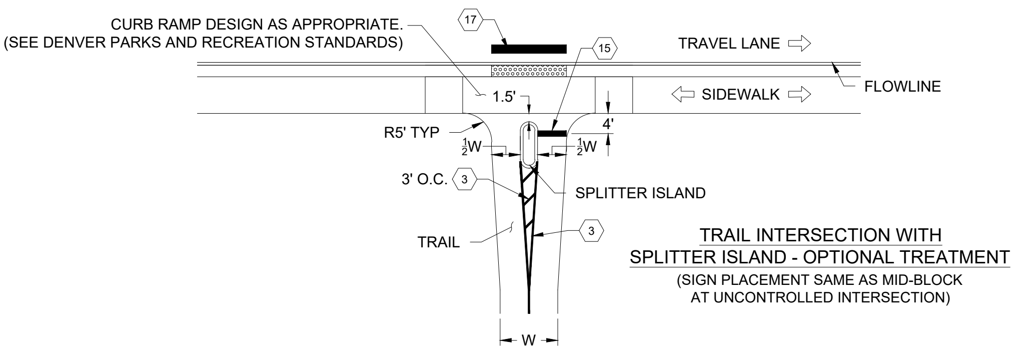
Beginning and Ending Bicycle Facilities

When a bikeway ends, bicyclists should be provided with advanced warning to indicate that they are approaching the end of the bikeway. At the beginning and end of a bike lane, the bike lane sign (R3-17) and accompanying plaque (R3-17-BG-P for “BEGINS” or R3-17BP for “ENDS”) shall be provided. When a bike lane ends, an additional sign should be located at least 100 feet in advance of the termination and should include a R3-17-5 “100 FT” plaque, such that a user has sufficient opportunity to transition to a different corridor, if desired. If there is not an existing bikeway corridor for bicyclists to transition to at the end of the bike lane, designers should consider what alternate route would be safest to direct bicyclists to use. Wayfinding signage may be used to direct users to nearby low-stress streets or streets with existing bicycle lanes.

Multimodal Connections Standard Drawings

STANDARD DRAWING BDS 5-1	**Trail Crossing at Mid-Block Uncontrolled Intersection**
STANDARD DRAWING BDS 5-2	**Trail Crossing at Stop-Controlled Intersection**
STANDARD DRAWING BDS 5-3	**Trail Crossing at Pedestrian Hybrid Beacon**
STANDARD DRAWING BDS 5-4	**Floating Bus Stop with Bike Lane**
STANDARD DRAWING BDS 5-5	**Raised Bike Lane at Bus Stop**
STANDARD DRAWING BDS 5-6	**Shared Bus/Bike Lane at Bus Stop and Curbside Bus Stop with Protected Bike Lane**
STANDARD DRAWING BDS 5-7	**Curbside Bus Stop with Bike Lane**
STANDARD DRAWING BDS 5-8	**Railroad Track Crossing Detail**
STANDARD DRAWING BDS 5-9A	**Transition from One-Way Protected Bike Lane to Two-Way Street-Level Protected Bike Lane**
STANDARD DRAWING BDS 5-9B	**Transition from One-Way Protected Bike Lane to Two-Way Sidewalk-Level Protected Bike Lane**
STANDARD DRAWING BDS 5-10	**Transition from Protected Bike Lane to Conventional Bike Lane or Neighborhood Bikeway**
STANDARD DRAWING BDS 5-11	**Transition from Conventional Bike Lane to Neighborhood Bikeway**
STANDARD DRAWING BDS 5-12	**Transition Ramp from Street-Level Bikeway to Sidewalk-Level Bikeway**





TRAIL INTERSECTION WITH
SPLITTER ISLAND - OPTIONAL TREATMENT
(SIGN PLACEMENT SAME AS MID-BLOCK AT UNCONTROLLED INTERSECTION)

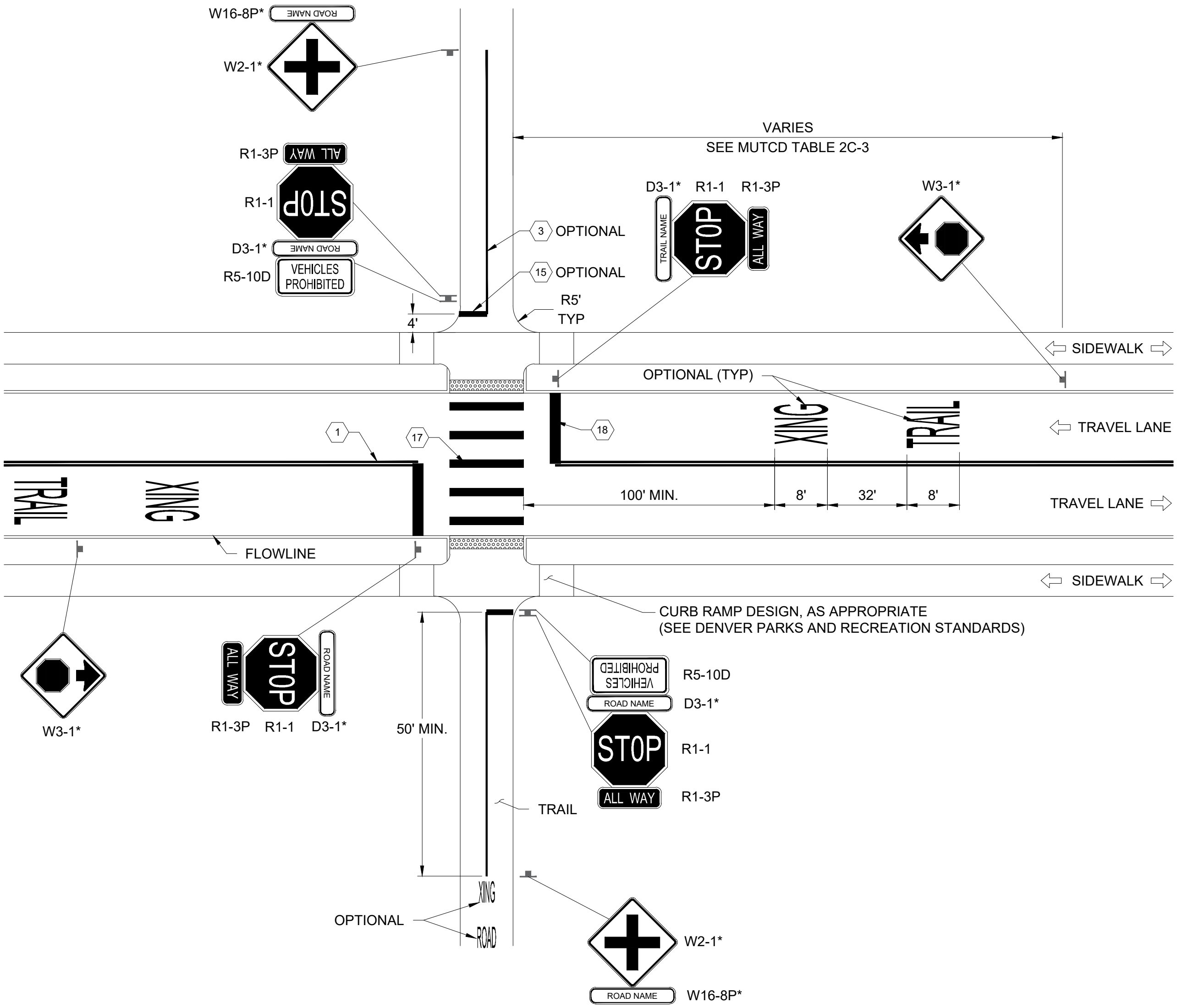
LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 3 — 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- 15 — 18" WHITE ADVANCED STOP BAR
- 17 — 18"X10' WHITE CROSSWALK BAR

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. WIDTH OF CROSSWALK MARKING AND RAMP TO MATCH TRAIL WIDTH.
4. * INDICATES SIGNS THAT ARE OPTIONAL, BUT RECOMMENDED.
5. COORDINATE PLACEMENT OF ALL SIGNS WITHIN DENVER PARKS PROPERTY WITH DENVER PARKS AND RECREATION.
6. REFER TO CCD UNCONTROLLED PEDESTRIAN CROSSING GUIDELINES TO DETERMINE WHICH LEVEL OF TREATMENT IS WARRANTED FOR ALL PEDESTRIAN CROSSINGS.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRAIL CROSSING AT MID-BLOCK UNCONTROLLED INTERSECTION	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-1



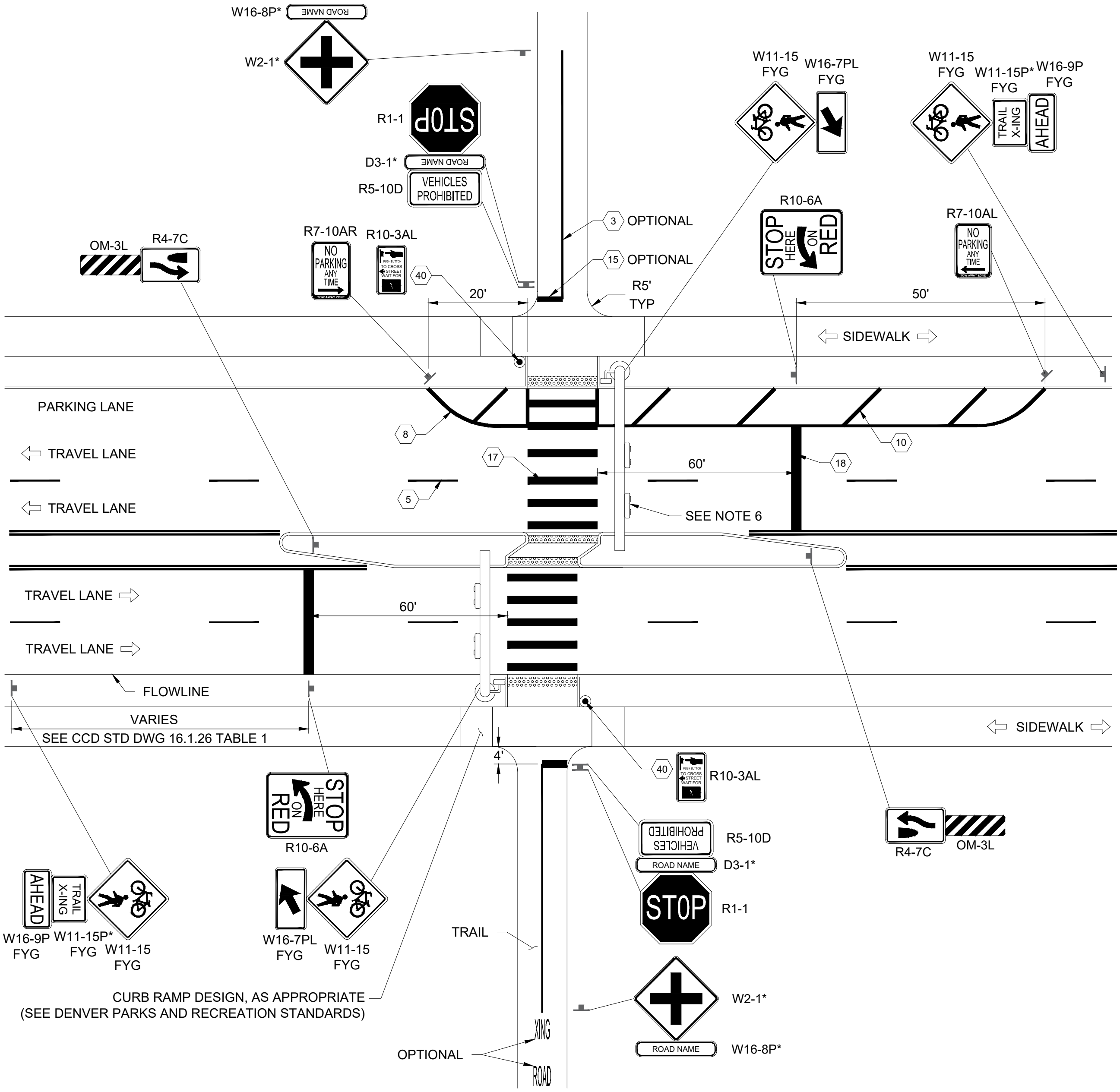
LEGEND:

1. 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
3. 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
15. 18" WHITE ADVANCED STOP BAR
17. 18"X10' WHITE CROSSWALK BAR
18. 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. WIDTH OF CROSSWALK MARKING AND RAMP TO MATCH TRAIL WIDTH.
4. * INDICATES SIGNS THAT ARE OPTIONAL, BUT RECOMMENDED.
5. COORDINATE PLACEMENT OF ALL SIGNS WITHIN DENVER PARKS PROPERTY WITH DENVER PARKS AND RECREATION.
6. SEE BDS 5-1 FOR OPTIONAL SPLITTER ISLAND DESIGN.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRAIL CROSSING AT STOP-CONTROLLED INTERSECTION	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-2



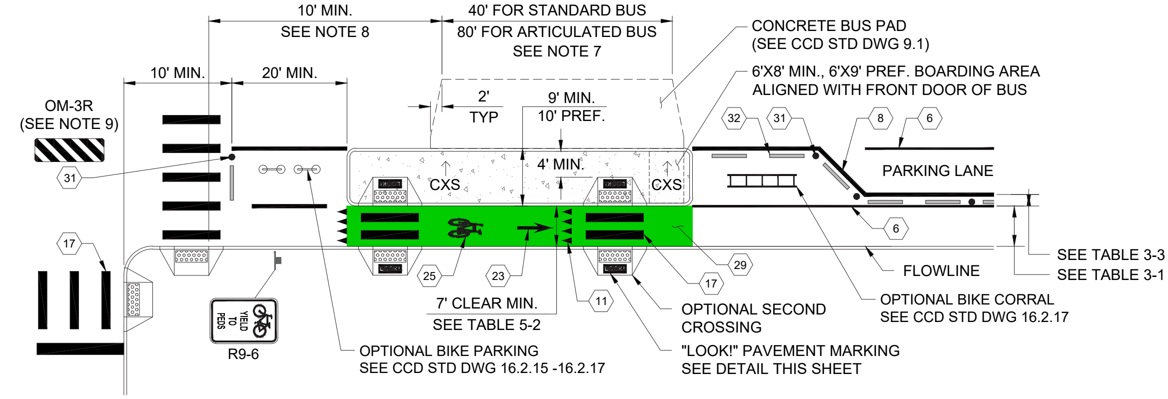
LEGEND:

- (1) 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- (3) 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- (8) 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (10) 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- (15) 18" WHITE ADVANCED STOP BAR
- (17) 18"X10' WHITE CROSSWALK BAR
- (18) 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- (40) 6' PEDESTAL POLE WITH PEDESTRIAN PUSH BUTTON

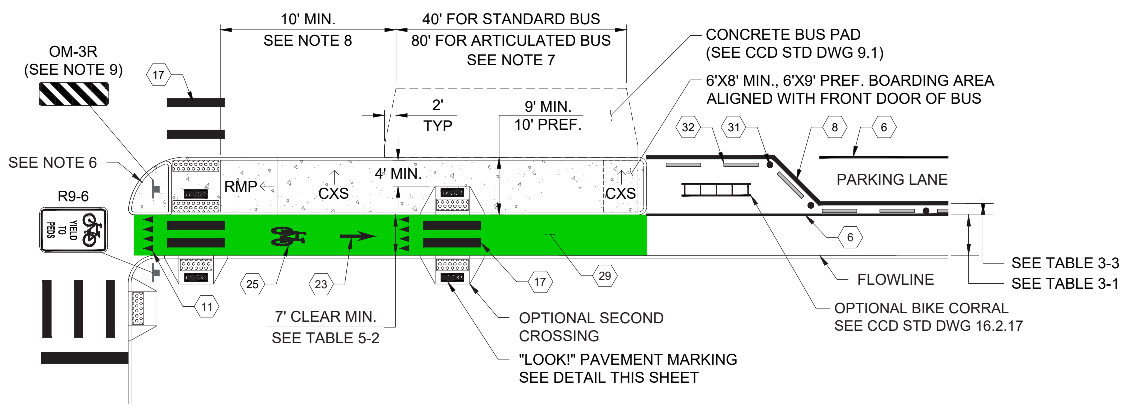
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. WIDTH OF CROSSWALK MARKING AND RAMP TO MATCH TRAIL WIDTH.
4. * INDICATED SIGNS THAT ARE OPTIONAL, BUT RECOMMENDED.
5. COORDINATE PLACEMENT OF ALL SIGNS WITHIN DENVER PARKS PROPERTY WITH DENVER PARKS AND RECREATION.
6. SEE CCD STD DWG 16.1.26 FOR PEDESTRIAN HYBRID BEACON DETAILS.
7. SEE BDS 5-1 FOR SPLITTER ISLAND DESIGN.
8. REFER TO CCD UNCONTROLLED PEDESTRIAN CROSSING GUIDELINES TO DETERMINE WHICH LEVEL OF TREATMENT IS WARRANTED FOR ALL PEDESTRIAN CROSSINGS.

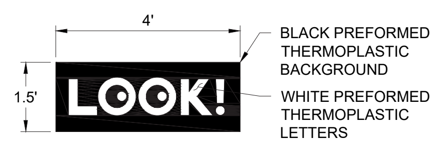
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRAIL CROSSING AT PEDESTRIAN HYBRID BEACON	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-3



FAR-SIDE FLOATING BUS STOP



FAR-SIDE FLOATING BUS STOP WITH PEDESTRIAN ISLAND



"LOOK!" PAVEMENT MARKING DETAIL

LEGEND:

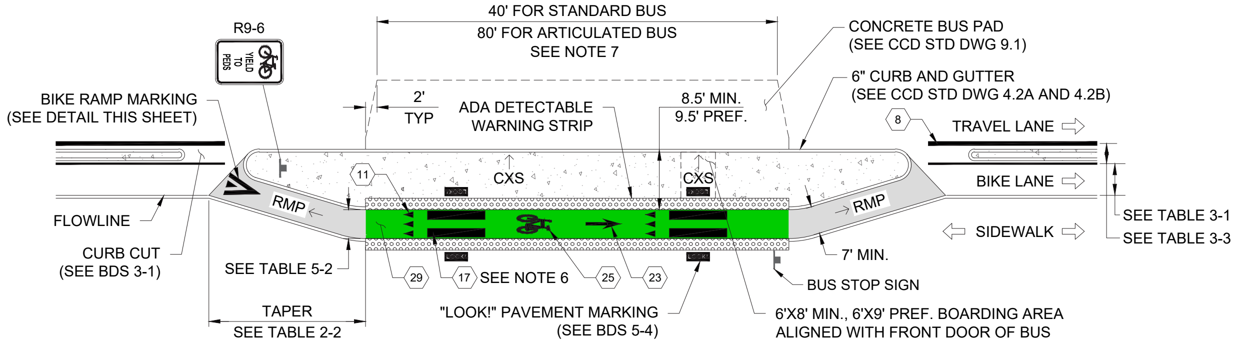
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 — 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 11 — WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- 17 — 18"X10' WHITE CROSSWALK BAR
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 23 — WHITE STRAIGHT BIKE ARROW MARKING
- 29 — GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

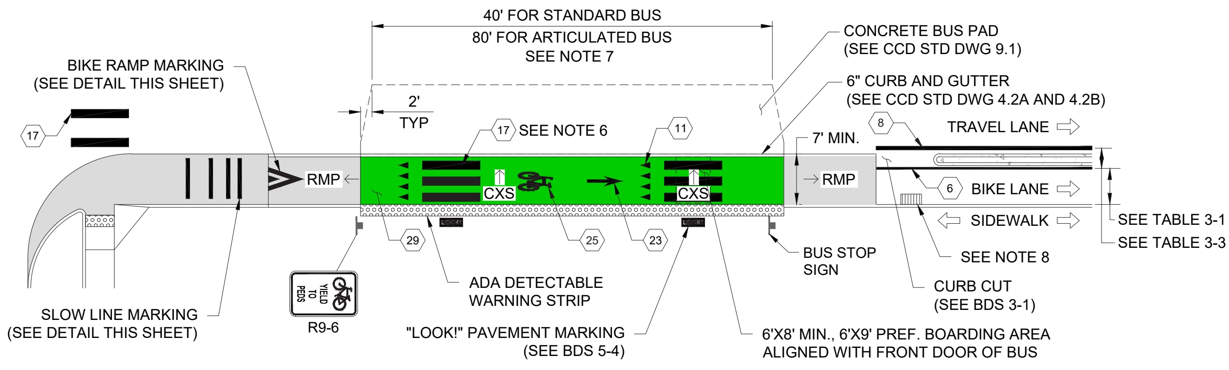
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE CCD STANDARD CURB RAMP DETAILS.
5. SEE CCD STD DWG 11.0 - 11.5 FOR INFORMATION ON CONCRETE PAVEMENT DESIGN, REINFORCEMENTS, AND JOINTS.
6. THE NOSE OF THE FLOATING BUS STOP MAY NEED TO BE DESIGNED AS A MOUNTABLE TRUCK APRON, DEPENDING ON INTERSECTION GEOMETRY.
7. FOR CONVENTIONAL OR BUFFERED BIKE LANES, LENGTH MAY BE REDUCED TO 30' FOR STANDARD BUS AND 50' FOR ARTICULATED BUS, WITH RTD APPROVAL.
8. IF BUS ISLAND LENGTH IS REDUCED PER NOTE 7, INCREASE THIS LENGTH TO 20' MIN. FOR STANDARD BUS AND 40' MIN. FOR ARTICULATED BUS.
9. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.

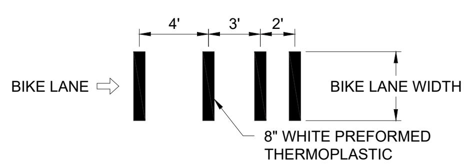
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER FLOATING BUS STOP WITH BIKE LANE	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-4



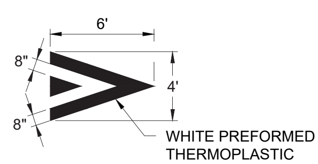
RAISED BIKE LANE AT BUS STOP



RAISED BIKE LANE AT BUS STOP (CONSTRAINED CONDITION ONLY)



SLOW LINE MARKING DETAIL



BIKE RAMP MARKING DETAIL

LEGEND:

- (6) 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (8) 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- (11) WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
- (17) 18" X 10' WHITE CROSSWALK BAR
- (23) WHITE STRAIGHT BIKE ARROW MARKING
- (25) GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- (29) GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

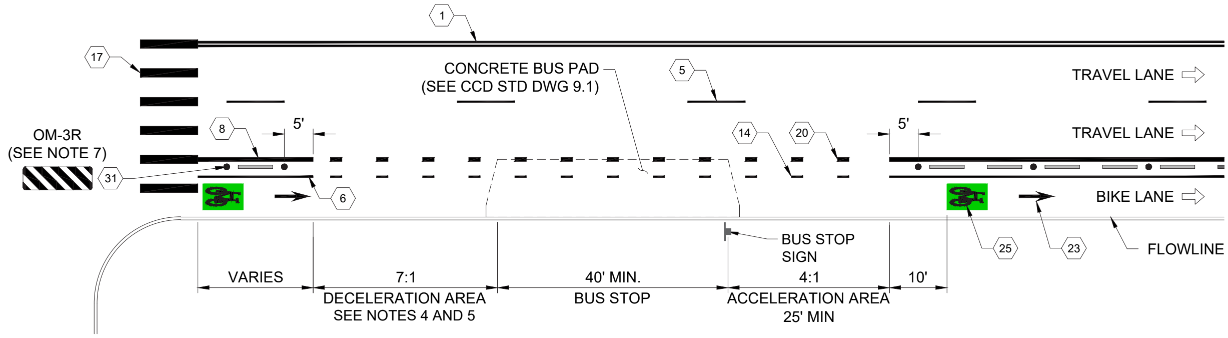
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

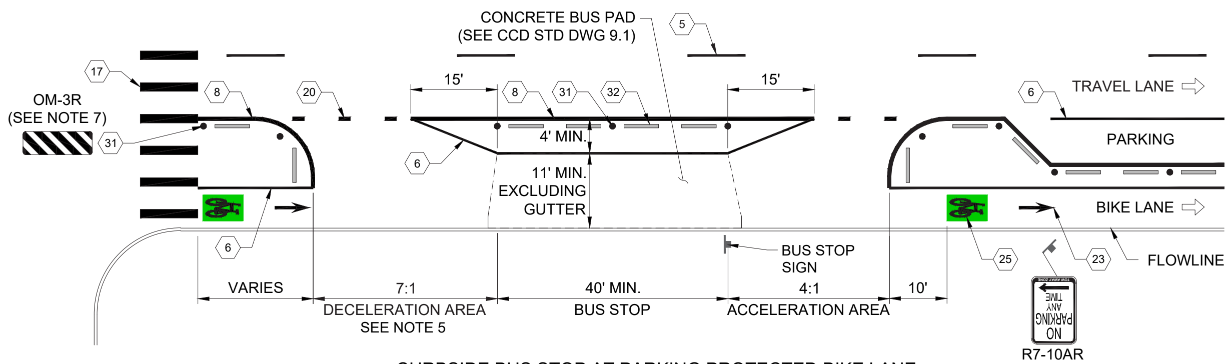
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE CCD STANDARD CURB RAMP DETAILS.
5. SEE CCD STD DWG 11.0 - 11.5 FOR INFORMATION ON CONCRETE PAVEMENT DESIGN, REINFORCEMENTS, AND JOINTS.
6. CROSSWALKS SHOULD ALIGN WITH BUS DOORS.
7. FOR CONVENTIONAL OR BUFFERED BIKE LANES, DIMENSIONS MAY BE REDUCED TO 30' FOR STANDARD BUS AND 50' FOR ARTICULATED BUS.
8. SUPPLEMENTAL DRAIN INLET MAY BE REQUIRED DEPENDING ON DRAINAGE STUDY. A SUPPLEMENTAL DRAIN INLET IS PREFERRED, BUT AN ADA COMPLIANT TRENCH DRAIN MAY BE INSTALLED IF APPROVED BY DOTI AND A MAINTENANCE AGREEMENT WITH A NON-CCD ENTITY IS ESTABLISHED. IF APPROVED, THE ADA COMPLIANT TRENCH DRAIN SHALL BE INCLUDED ALONG THE CURB LINE AS NEEDED TO MAINTAIN DRAINAGE FOR LENGTH OF RAISED CROSSING.
9. SIDEWALK-LEVEL BIKE LANE AND RAMP SHALL BE INTEGRALLY COLORED WITH COLOR PEWTER 860.

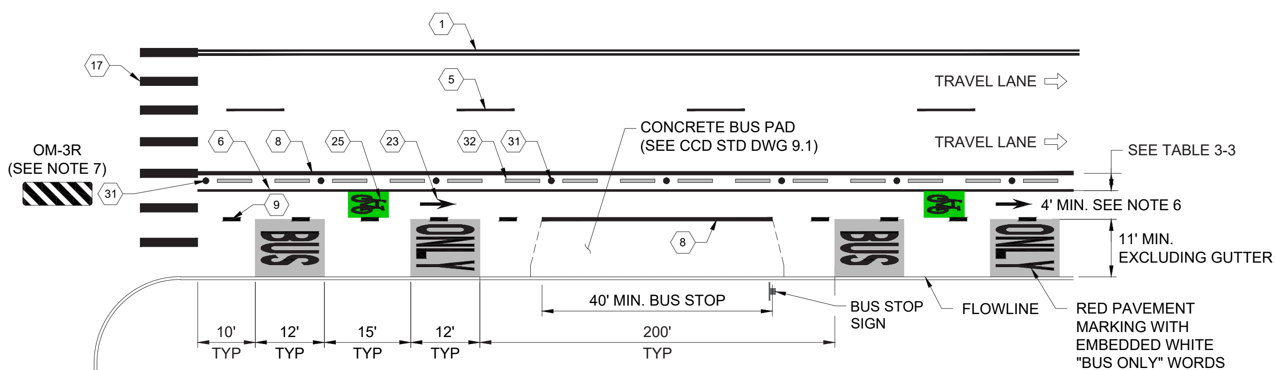
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER RAISED BIKE LANE AT BUS STOP	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-5



CURBSIDE BUS STOP WITH PROTECTED BIKE LANE



CURBSIDE BUS STOP AT PARKING PROTECTED BIKE LANE



SHARED BUS/BIKE LANE AT BUS STOP

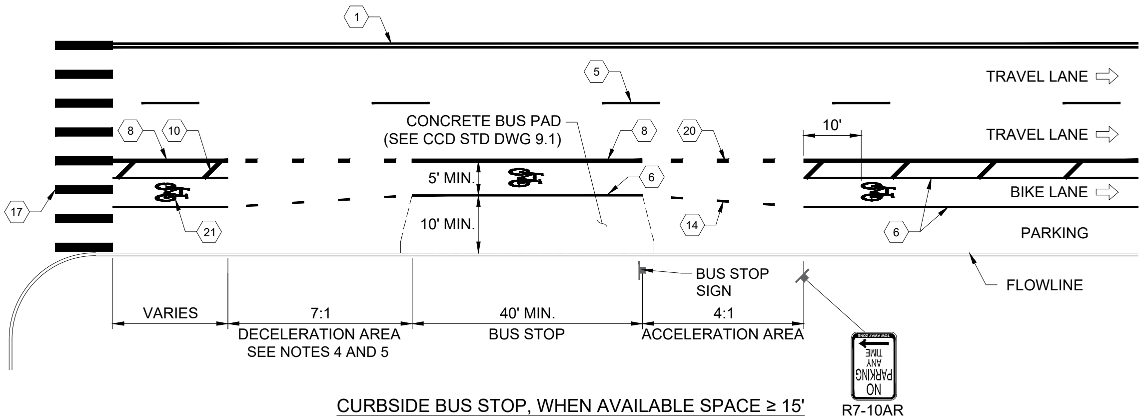
LEGEND:

- 1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 9 8" DASHED WHITE LINE, 3' DASH, 9' GAP
- 14 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 17 18"X10' WHITE CROSSWALK BAR
- 20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN
- 31 36" WHITE FLEXIBLE DELINEATOR POST
- 32 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

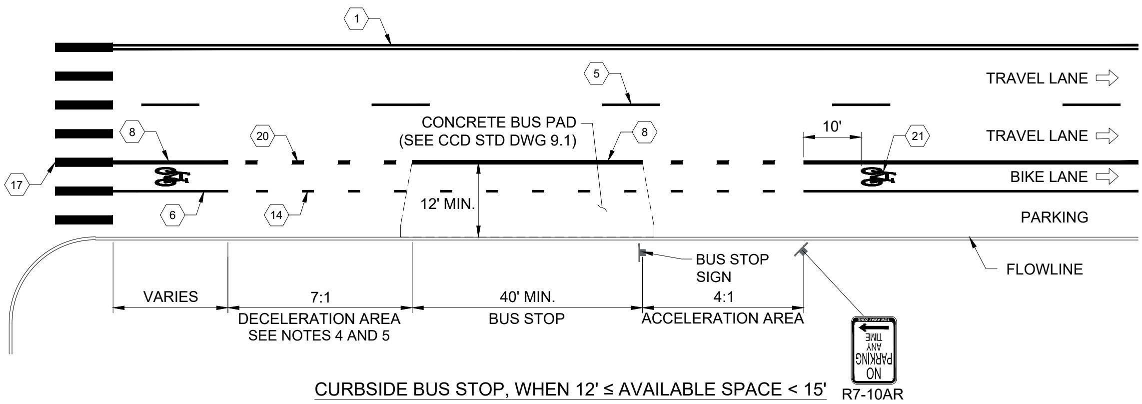
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. DECELERATION AREA ON THE FAR-SIDE OF THE INTERSECTION MAY BE ACCOMMODATED WITHIN THE INTERSECTION, IF NEEDED.
5. IN CONSTRAINED LOCATIONS, THE DECELERATION AREA MAY BE REDUCED TO 25' MIN. WITH RTD APPROVAL.
6. IF 5' OR GREATER, INSTALL 8" SOLID WHITE RIGHT EDGE LINE FOR FULL LENGTH OF SHARED BUS/BIKE LANE BETWEEN BIKE LANE AND BUS ONLY LANE.
7. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.

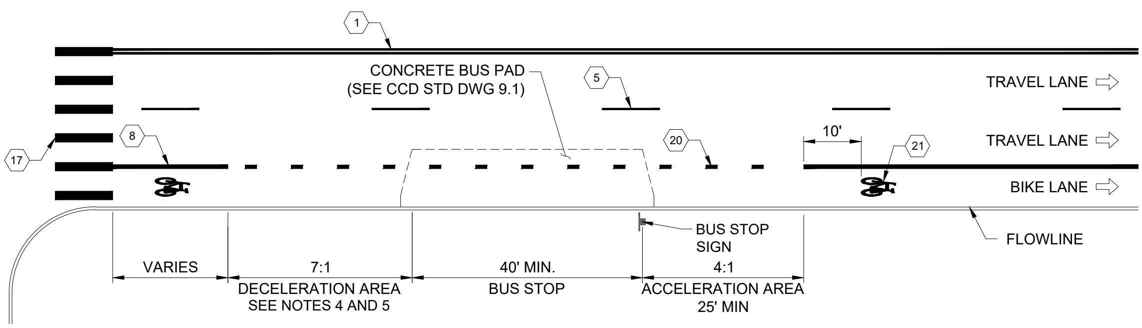
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER SHARED BUS/BIKE LANE AT BUS STOP AND CURBSIDE BUS STOP WITH PROTECTED BIKE LANE	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-6



CURBSIDE BUS STOP, WHEN AVAILABLE SPACE ≥ 15'



CURBSIDE BUS STOP, WHEN 12' ≤ AVAILABLE SPACE < 15'



CURBSIDE BUS STOP, WHEN AVAILABLE SPACE < 12'

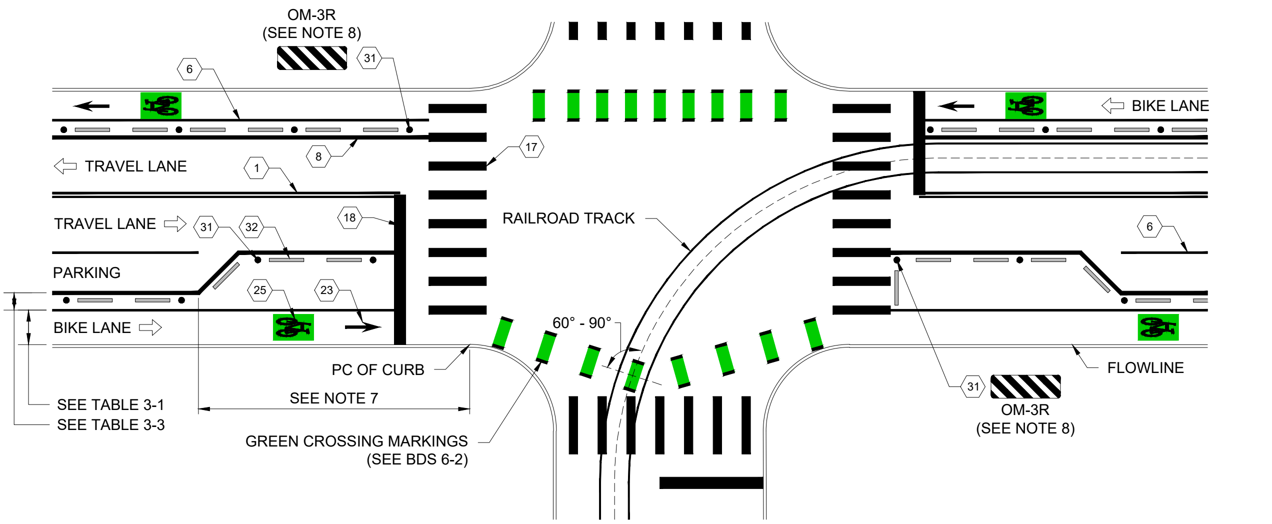
LEGEND:

- 1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 14 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 17 18"X10' WHITE CROSSWALK BAR
- 20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 21 WHITE BIKE SYMBOL MARKING

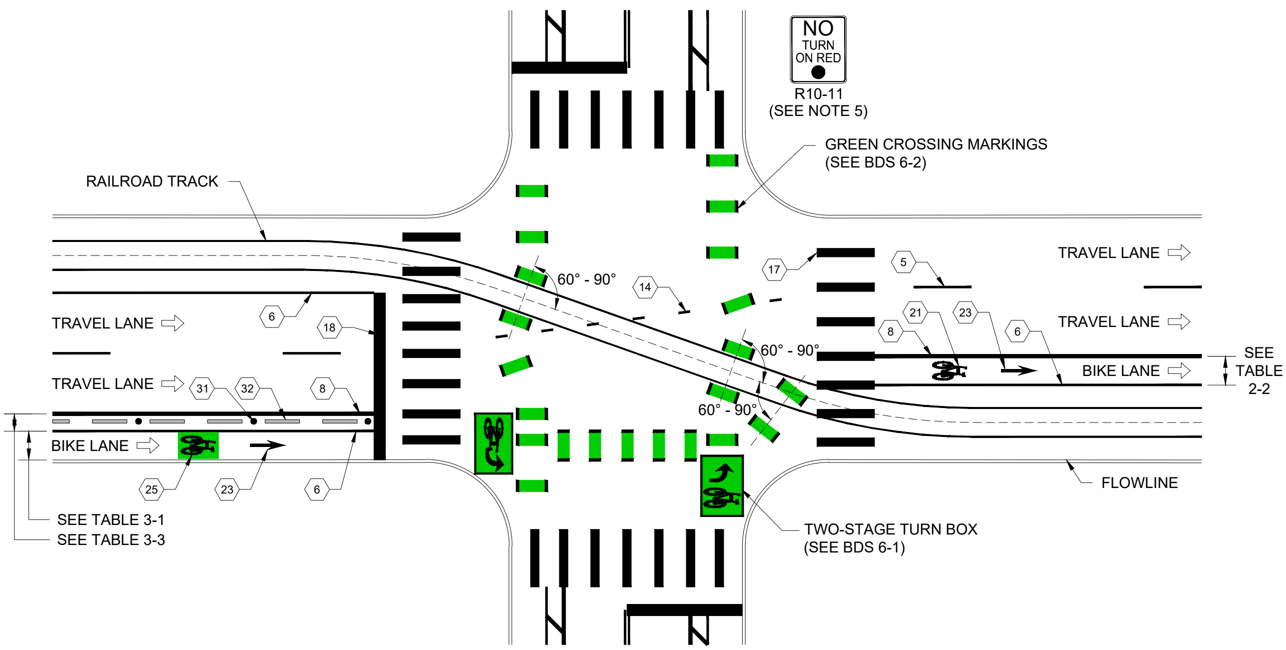
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. DECELERATION AREA ON THE FAR-SIDE OF THE INTERSECTION MAY BE ACCOMMODATED WITHIN THE INTERSECTION, IF NEEDED.
5. IN CONSTRAINED LOCATIONS, THE DECELERATION AREA MAY BE REDUCED TO 25' MIN. WITH RTD APPROVAL.
6. SEE PAGE 13 FOR GUIDANCE ON WHEN TO USE A STREET BUFFER VERSUS A PARKING BUFFER.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER CURBSIDE BUS STOP WITH BIKE LANE	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-7



BIKE FACILITY CROSSING TURNING TRACKS



BIKE FACILITY CROSSING SKEWED TRACKS

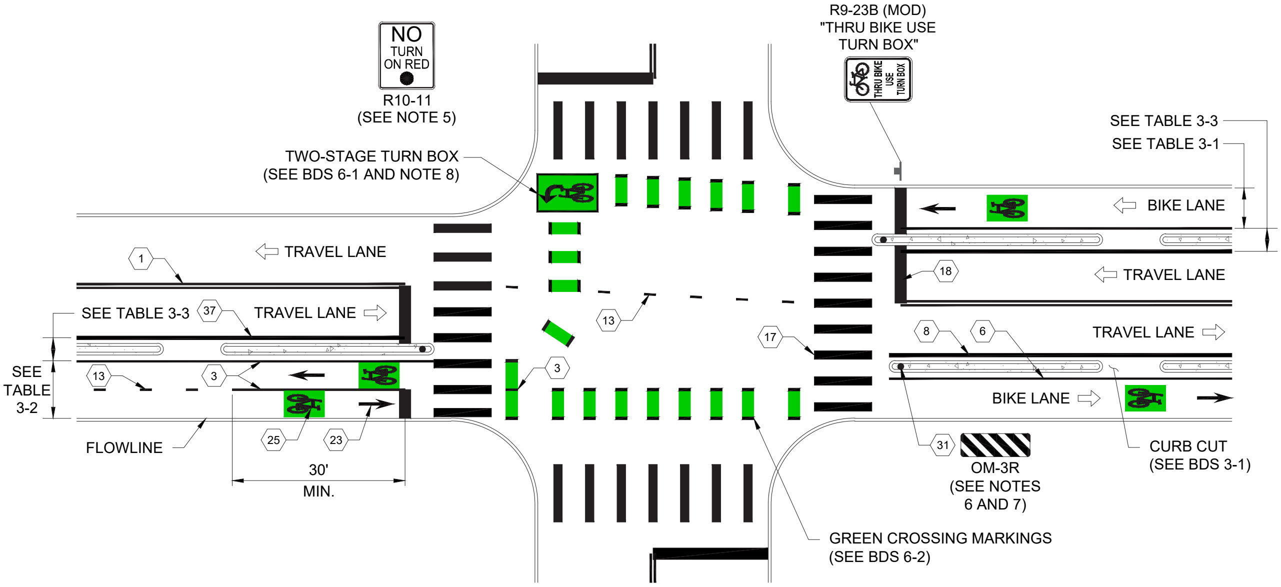
LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 14 — 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 17 — 18"X10' WHITE CROSSWALK BAR
- 18 — 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 21 — WHITE BIKE SYMBOL MARKING
- 23 — WHITE STRAIGHT BIKE ARROW MARKING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. THE SKEW ANGLE BETWEEN CENTERLINE OF RAIL TRACKS AND A BICYCLE FACILITY SHOULD BE BETWEEN 60 AND 90 DEGREES.
5. "NO TURN ON RED" SIGNS ARE REQUIRED WITH A TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.
6. ASSUMES SIGNALIZED INTERSECTION.
7. SEE TABLE 3-6 ON BDS 3-2 TO IDENTIFY APPROPRIATE APPROACH CLEAR SPACE.
8. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER RAILROAD TRACK CROSSING DETAIL	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-8



FROM ONE-WAY PROTECTED BIKE LANE
TO TWO-WAY STREET-LEVEL PROTECTED BIKE LANE

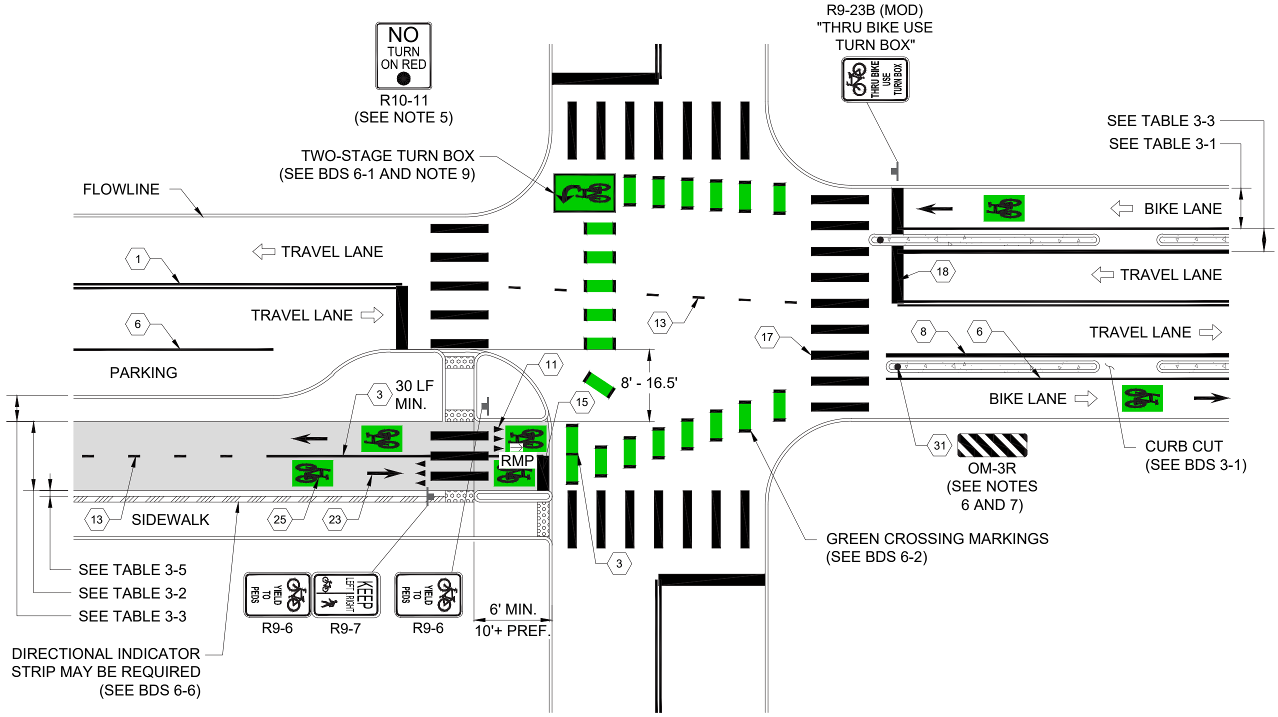
LEGEND:

- 1 — 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
- 3 — 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 13 — 4" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
- 15 — 18" WHITE ADVANCED STOP BAR
- 17 — 18"X10' WHITE CROSSWALK BAR
- 18 — 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 23 — WHITE STRAIGHT BIKE ARROW MARKING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 37 — 8" SOLID YELLOW LINE

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. ASSUMES SIGNALIZED INTERSECTION.
5. "NO TURN ON RED" SIGNS ARE REQUIRED WITH TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.
6. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
7. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.
8. IF BIKE SIGNAL IS INCLUDED, REMOVE TWO-STAGE TURN BOX AND ANGLE GREEN CROSSING MARKINGS DIRECTLY TO RECEIVING BIKE LANE.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRANSITION FROM ONE-WAY PROTECTED BIKE LANE TO TWO-WAY STREET-LEVEL PROTECTED BIKE LANE	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-9A



FROM ONE-WAY PROTECTED BIKE LANE
TO TWO-WAY SIDEWALK-LEVEL PROTECTED BIKE LANE

LEGEND:

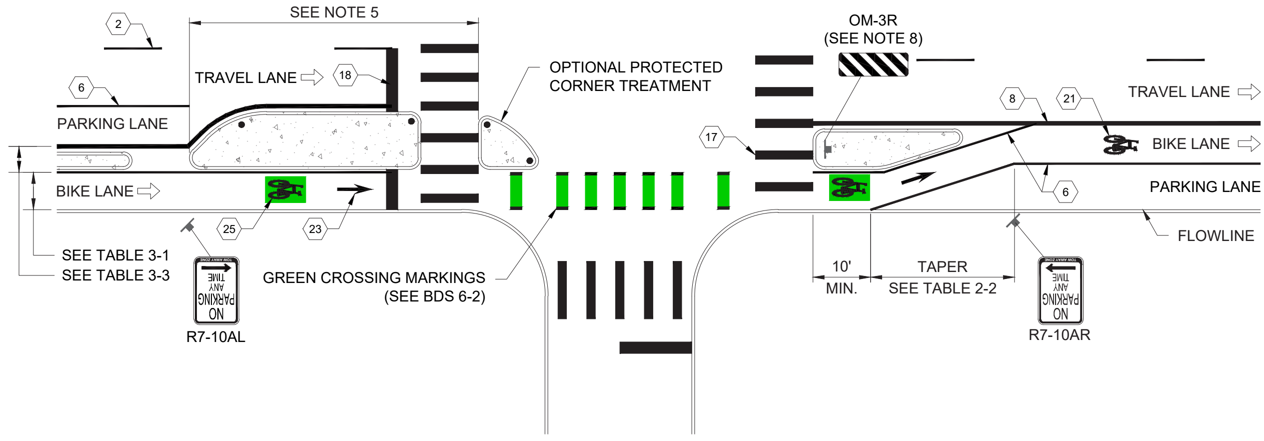
1. 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
3. 4" SOLID YELLOW TWO WAY LEFT EDGE LINE
6. 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
8. 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
11. WHITE YIELD LINE 12"X18" WITH 3" TO 12" SEPARATION
13. 4" DASHED YELLOW LINE, 2' DASH, 6' GAP, CENTERED
15. 18" WHITE ADVANCED STOP BAR
17. 18"X10' WHITE CROSSWALK BAR
18. 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
23. WHITE STRAIGHT BIKE ARROW MARKING
25. GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
31. 36" WHITE FLEXIBLE DELINEATOR POST
37. 8" SOLID YELLOW LINE

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

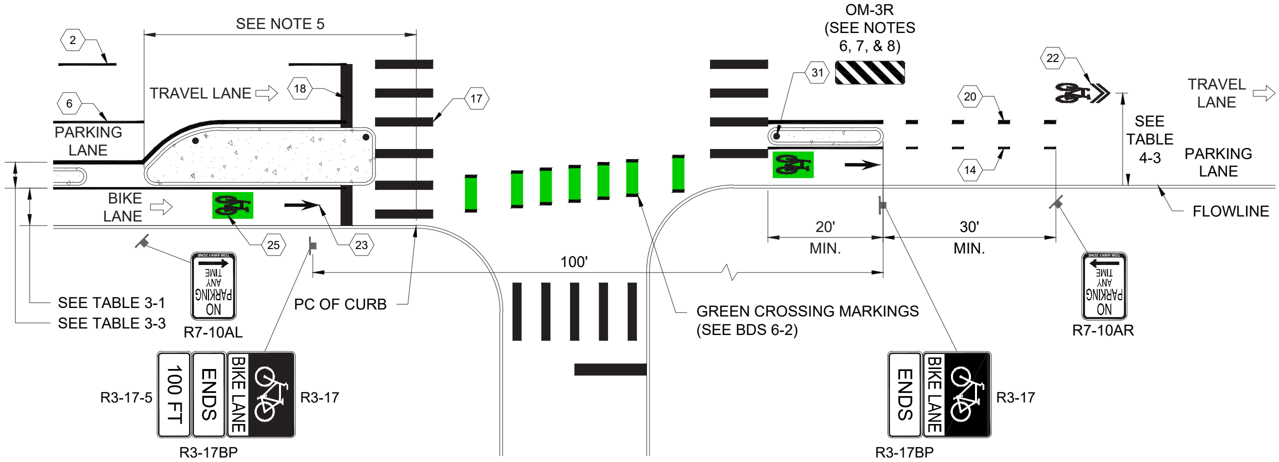
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. ASSUMES SIGNALIZED INTERSECTION.
5. "NO TURN ON RED" SIGNS ARE REQUIRED WITH TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.
6. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
7. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.
8. SIDEWALK-LEVEL BIKE LANE AND RAMP SHALL BE INTEGRALLY COLORED WITH COLOR PEWTER 860.
9. IF BIKE SIGNAL IS INCLUDED, REMOVE TWO-STAGE TURN BOX AND ANGLE GREEN CROSSING MARKINGS DIRECTLY TO RECEIVING BIKE LANE.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRANSITION FROM ONE-WAY PROTECTED BIKE LANE TO TWO-WAY SIDEWALK-LEVEL PROTECTED BIKE LANE	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-9B



FROM PROTECTED BIKE LANE TO CONVENTIONAL BIKE LANE



FROM PROTECTED BIKE LANE TO NEIGHBORHOOD BIKEWAY

LEGEND:

- 2 4" SKIP YELLOW CENTERLINE, 10' LINE, 30' GAP
- 6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 14 4" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 17 18"X10' WHITE CROSSWALK BAR
- 18 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 20 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 21 WHITE BIKE SYMBOL MARKING
- 22 WHITE SHARED LANE MARKING SYMBOL
- 23 WHITE STRAIGHT BIKE ARROW MARKING
- 25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 36" WHITE FLEXIBLE DELINEATOR POST

TABLE 2-2: SHIFTING TAPER	
PREFERRED	7:1
MINIMUM*	3:1

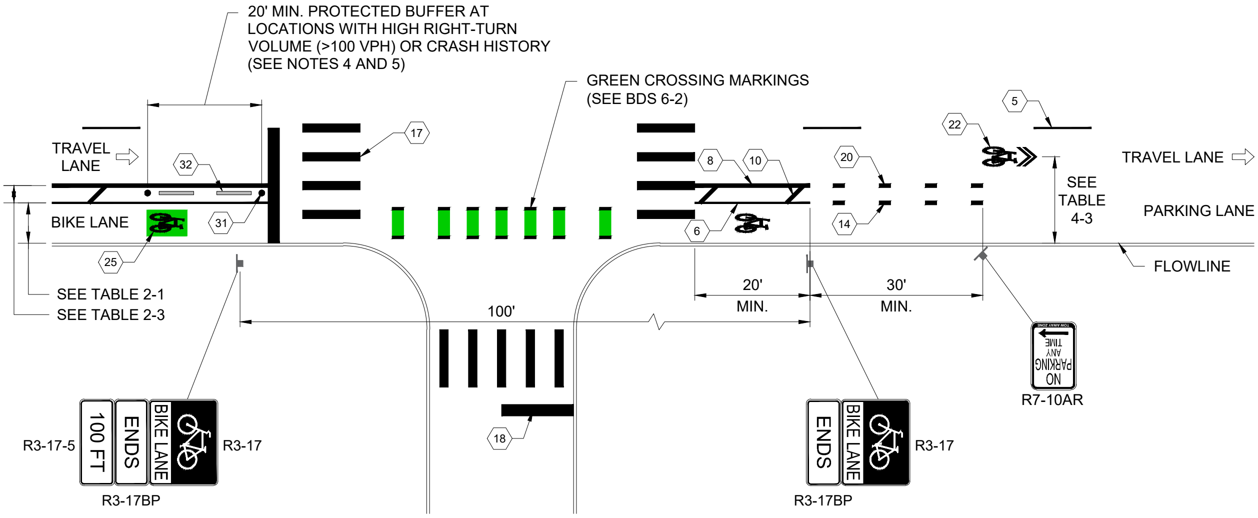
* ACCEPTABLE IN CONSTRAINED CONDITIONS WHERE ANTICIPATED OPERATING SPEED IS ≤ 13MPH

WHERE OPERATING SPEED IS ANTICIPATED TO BE >20MPH, TAPER LENGTH SHALL BE CALCULATED USING L=WS^2/60 (WHERE W = LATERAL OFFSET (FT), L = LONGITUDINAL LANE SHIFT (FT), S = BICYCLE OPERATING SPEED (MPH))

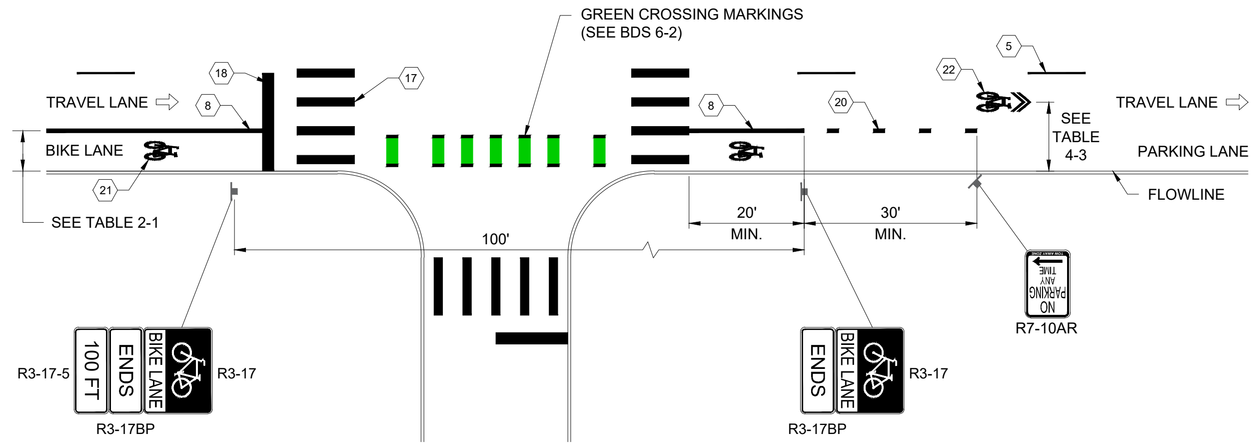
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. GEOMETRY SHOWN FOR PROTECTED CORNER TREATMENT DEPENDS ON INTERSECTION GEOMETRY.
5. USE TABLE 3-6 ON BDS 3-2 TO IDENTIFY APPROPRIATE APPROACH CLEAR SPACE.
6. FOR CONCRETE PROTECTED BIKE LANES, FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED BEFORE AND AFTER DRIVEWAYS, ALLEYS, AND INTERSECTIONS.
7. YELLOW FLEXIBLE DELINEATOR POSTS SHOULD BE INSTALLED PRIOR TO TURN WEDGES WITH RUBBER SPEED BUMPS.
8. FARSIDE OF INTERSECTIONS, IF A TURN WEDGE IS NOT INCLUDED, A PLASTIC OM-3R SIGN PANEL SHOULD BE INSTALLED ON A FLEXIBLE DELINEATOR POST. IF THE CONCRETE SECTION AT THE BEGINNING OF THE PROTECTED BIKE LANE IS AT LEAST 6' WIDE, INSTALL A METAL OM-3R SIGN ON A TELESPAR POST PER CCD STANDARDS.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRANSITION FROM PROTECTED BIKE LANE TO CONVENTIONAL BIKE LANE OR NEIGHBORHOOD BIKEWAY	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-10



FROM BUFFERED BIKE LANE
TO NEIGHBORHOOD BIKEWAY



FROM CONVENTIONAL BIKE LANE
TO NEIGHBORHOOD BIKEWAY

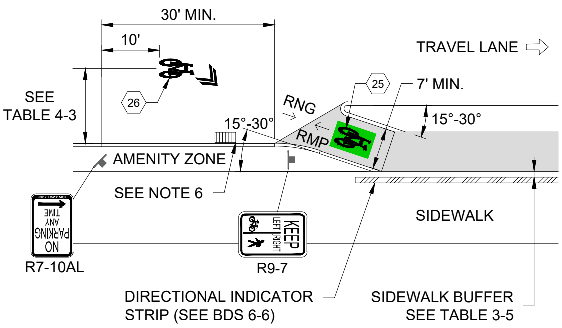
LEGEND:

- 5 — 4" SKIP WHITE LANE LINE, 10' LINE, 30' GAP
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 — 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 17 — 18"X10' WHITE CROSSWALK BAR
- 18 — 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
- 20 — 8" DASHED WHITE LINE, 2' DASH, 6' GAP, CENTERED
- 21 — WHITE BIKE SYMBOL MARKING
- 22 — WHITE SHARED LANE MARKING SYMBOL
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

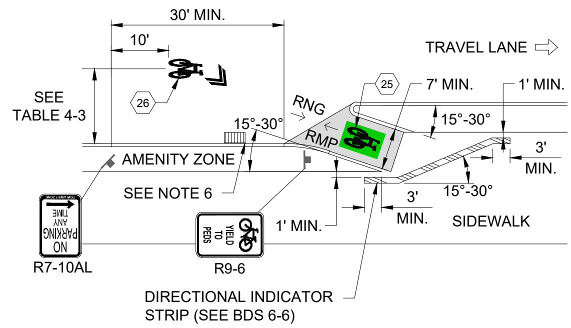
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE BDS 2-6 FOR PROTECTED BUFFER DESIGN AT NON-BUFFERED CONVENTIONAL BIKE LANE.
5. WHERE SPACE IS AVAILABLE, A TURN WEDGE SHOULD BE CONSIDERED AT INTERSECTIONS WITH HIGH RIGHT-TURN VOLUME (>100) OR CRASH HISTORY.

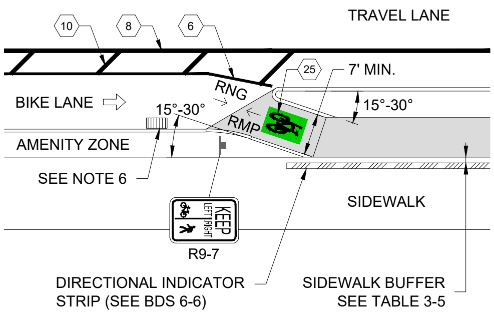
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRANSITION FROM CONVENTIONAL BIKE LANE TO NEIGHBORHOOD BIKEWAY	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 5-11



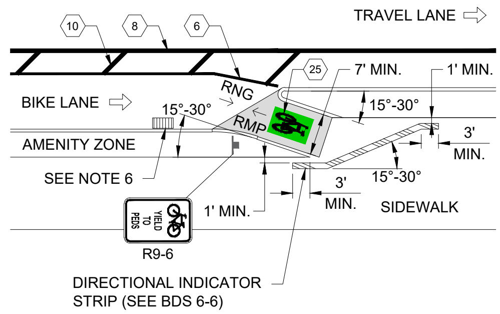
NEIGHBORHOOD BIKEWAY TO SIDEWALK LEVEL BIKE LANE



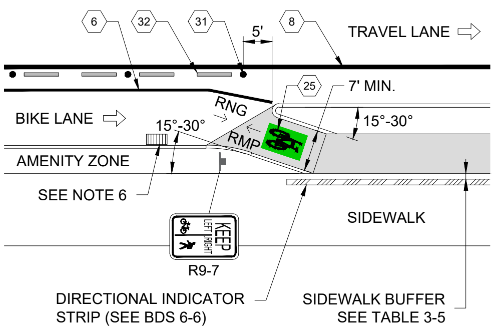
NEIGHBORHOOD BIKEWAY TO SHARED USE PATH



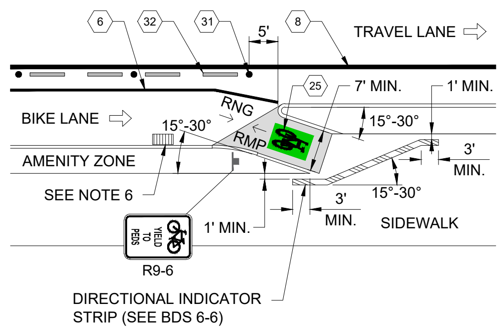
BUFFERED BIKE LANE TO SIDEWALK LEVEL BIKE LANE



BUFFERED BIKE LANE TO SHARED USE PATH



PROTECTED BIKE LANE TO SIDEWALK LEVEL BIKE LANE



PROTECTED BIKE LANE TO SHARED USE PATH

LEGEND:

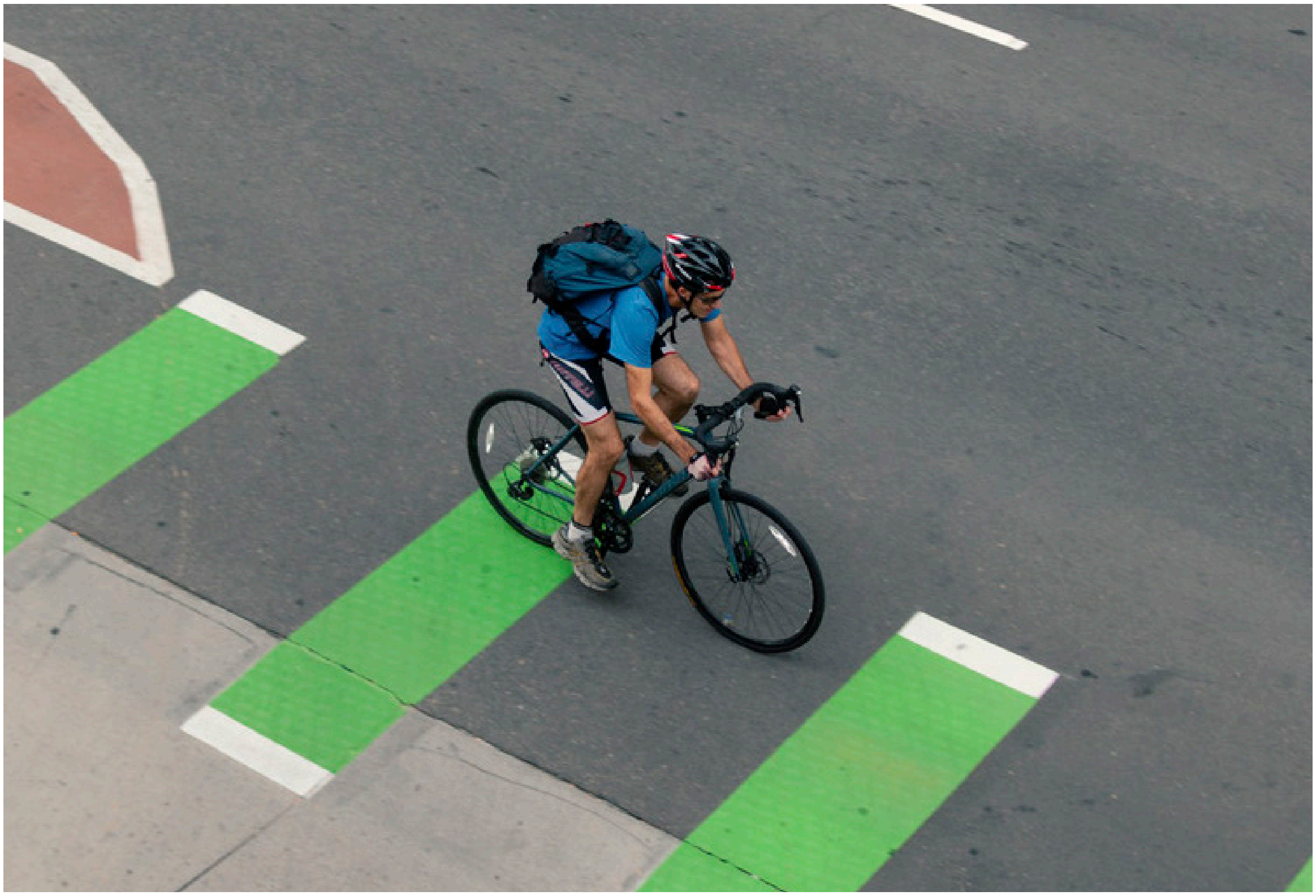
- 6 — 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 8 — 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
- 10 — 8" SOLID WHITE 45° DIAGONAL CROSSHATCH AT 15' SPACING
- 25 — GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
- 26 — WHITE SHARED LANE MARKING SYMBOL WITH DIRECTIONAL INDICATION
- 31 — 36" WHITE FLEXIBLE DELINEATOR POST
- 32 — 6' LONG, 4" HIGH ENGINEERED RUBBER CURB WITH WHITE STRIPES

ACCESSIBLE FLARE SLOPE (FLR) = 9.5% (10% MAX)
ACCESSIBLE RAMP SLOPE (RMP) = 7.8% (8.3% MAX)
ACCESSIBLE CROSS SLOPE (CXS) = 1.5% (2% MAX)
ACCESSIBLE RUNNING SLOPE (RNG) = 5% MAX

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. SEE BDS 2-2 FOR BUFFERED BIKE LANE MARKING DETAIL.
5. SEE BDS 3-1 FOR STREET LEVEL PROTECTED BIKE LANE BUFFER DETAILS.
6. SUPPLEMENTAL DRAIN INLET MAY BE REQUIRED DEPENDING ON DRAINAGE STUDY.
7. SIDEWALK-LEVEL BIKE LANE SHALL NOT ENCROACH INTO REQUIRED SIDEWALK WIDTH, SEE CCD TRANSPORTATION STANDARD DRAWINGS.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER TRANSITION RAMP FROM STREET LEVEL BIKEWAY TO SIDEWALK LEVEL BIKEWAY	STD DWG NO. BDS 5-12



6. DESIGN TOOLS

This chapter provides design guidelines and standard drawings for tools that enhance bicyclist user experience. These tools include pavement markings, bicycle signals and detection, bike parking, and more.

Intersection Pavement Markings

Two-Stage Turn Boxes

A two-stage turn is the act of a bicyclist turning left in stages at an intersection by continuing straight and crossing the intersecting street, then queuing on the side-street leg to cross the main street during a gap in traffic or upon receiving a green indication at a traffic signal. The two-stage turn box indicates the appropriate space for a bicyclist to queue on the side-street while waiting to cross the main street. Two-stage turns can be less stressful than merging into a vehicle travel lane, and is the preferred treatment to accommodate left-turn bicycle movements. Two-stage turns are also helpful to improve the angle of crossing where in-street railroad tracks are present.

Two-stage turn boxes should be installed when a bikeway intersects with another designated bikeway or when there is a major destination nearby that would require a left turn across vehicle traffic for bicyclists to access. They can also be useful tools for when a bikeway jogs to a perpendicular street.

At signalized intersections, two-stage turn boxes require a “NO TURN ON RED” (R10-11) sign for motor vehicles on the approach behind the turn box. Standard Drawing BDS 6-1 shows options for vertical and horizontal two-stage turn boxes with different arrow configurations, depending on the available space and desired bicyclist turn direction. Designers should place the box out of the way of “departing” through bike lane and travel lane, and in line with the “receiving” through bike lane. Typically, they are placed between bicycle crossing markings and marked crosswalks, but site-specific conditions may require engineering judgment to determine the best location of the bike box.

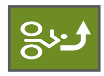
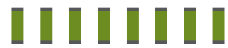
Bike Boxes

Bike boxes are designated areas for bicyclists to wait, located at a signalized intersection ahead of the stop bar for motor vehicles. Bike boxes can mitigate conflicts between bicyclists traveling straight or turning left and right-turning or through motorists. They also allow bicyclists to move to the front of the queue at a red light, reducing conflicts during the green signal phase; this is especially useful where bike lanes drop at the far side of an intersection.

Bike boxes should generally not be installed across more than one motor vehicle through lane. Bike boxes require a “NO TURN ON RED” (R10-11) sign for motor vehicles and a “STOP HERE ON RED” (R10-6) sign to indicate the stop location for motorists.

Generally, bike boxes and two-stage turn boxes should not be used at the same intersection approach. A bike box can provide the same function as a two-stage turn box and the designer should consider which type of box will be more useful based on the intersection characteristics and the predominant bicyclist movements. When the intent is to accommodate turning bicyclists, a two-stage turn box is preferred over a bike box, except at locations with high left-turning bicycle volume. In such a situation, bike boxes are preferred.

Standard Drawing BDS 6-1 shows the details for a standard bike box and two-stage turn boxes.

Intersection Type	Condition	Protected Bike Lane	Conventional/ Buffered Bike Lane	Neighborhood Bikeway
Signalized	Bikeway Extends Through Intersection			No Markings
	Bikeway Corridor Turns Left	 OR 	 OR 	 and 
Unsignalized	> 100 Turning VPH, High Crash Location, or Contraflow Bikeway			No Markings*
	All other locations		No Markings	No Markings
	Bikeway Corridor Turns Left			

*Additional treatment may be needed

Table 6-1: Bicycle Crossing and Intersection Markings

Advanced Bicycle Stop Bars

Advanced bicycle stop bars are additional stop bars that are placed downstream of a vehicle stop bar to help bicyclists establish themselves in front of vehicles at signalized intersections. This allows bicyclists to be seen more easily, reducing the probability of right-hook crashes. It also reduces the crossing distance for bicyclists and minimizes their exposure as they negotiate intersections. Advanced bicycle stop bars can only be implemented where adequate space is available between a 2-foot offset from the travel lane edge line of the cross street and the crosswalk of the approach. The preferred dimension for an advanced bicycle stop bar is 6 feet wide x 10 feet long. In constrained conditions, a 5-foot wide x 6-foot long space may be created. Ideally, advanced bicycle stop bars should be designed with the additional protection of a corner island or wedge. Designers should add a bicycle symbol with the advanced stop bar to clarify the use of the space. At locations where the volume of bicycles are anticipated to be more than approximately 75 bicycles per hour during the peak hour, designers may install a bike box in lieu of an advanced bicycle stop bar to accommodate the higher volume of bicyclists.

Standard Drawing BDS 6-1 includes details for an advanced stop bar.

Bicycle Crossings

Green bikeway crossing markings are used at both signalized and unsignalized intersections along protected bikeway corridors. For conventional and buffered bike lanes, green crossing markings should only be used at signalized intersections and unsignalized intersections with high turning volumes across the bike lane, at high crash locations, and for contraflow bikeways. Table 6-1 shows the locations where different types of bikeway crossing markings and bikeway turning markings should be used at intersections. The second type of bikeway crossing marking is a dashed marking, which are only used at driveways. Table 3-7 provides guidance for what types of bikeway crossing markings are required at different types of driveways.

Where two bikeways intersect and crossing markings need to be broken in one direction, the markings on the street with a lower ADT should be broken while the street with the higher ADT should remain continuous.

Standard Drawing BDS 6-2 shows details for bikeway crossing markings.

Bicycle Detection

Detection for bicyclists is necessary at signalized intersections if the signals are actuated, regardless of whether a bike signal is present. Although the preferred case is to have bicycle phase recall at signalized intersections, in locations where this is not desirable, the preferred method of detection is video detection cameras. The bicycle detection marking should be used to indicate to bicyclists where they should position themselves to be detected. This positioning may be within a bike lane or protected bike lane, or within a bike box or two-stage turn box. In locations with separate bicycle signal phases and bicycle signal heads, video detection can be used to actuate the green phase. Bicycle signal detection can also be used to actuate a vehicle signal head where bicycle phases are not present.

Designers should locate the video detection camera such that the bicycle detection zone is within the camera's field of view and detection distance. Designers should be aware that cameras with a wide field of view have a shorter detection zone. For example, some brands of video detection cameras with 90 degrees horizontal and 69 degrees vertical field of view only have about 6-100 feet of detection distance, while cameras with 32 degrees horizontal and 26 degrees vertical field of view have about 100-300 feet of detection distance. Designers should confirm the specifications of the video detection camera to ensure that bike detection zone is placed correctly.

A blue light indicator should be used to give bicyclists positive feedback that they have been detected at a traffic signal. Standard Drawing BDS 6-4 shows the detail for bicycle signals.

In some cases, video detection may not be feasible. This may be a common instance along neighborhood bikeways. In these cases, another method of detection at major road crossings along a neighborhood bikeway is a bicycle push button with "BIKE PUSH BUTTON FOR GREEN LIGHT" (R10-24) sign. Designers should follow TSD Standard Drawing 16.1.14 for Pedestal Mounted Pedestrian Push Button Pole and related details. Push buttons should be located adjacent to the curb so that a bicyclist is not required to leave the roadway to access the button.

Standard Drawing BDS 6-3 shows the detail for bike detection pavement markings.

Bicycle Signals

A bicycle signal provides a separate indication for bicyclists at a signalized intersection. Standard Drawing BDS 6-4 includes details for a bicycle signal. Bicycle signals are typically used in the following situations:

- Where the bikeway is a two-way protected bike lane.
- Where the bikeway is a one-way bike lane and the right-turn or left-turn motor vehicle movements in a shared through/turn lane across the protected bike lane exceed the thresholds in Figure 3-7.
- Where the bikeway is a one-way bike lane to the right of a right turn only lane or to the left of a left turn only lane.
- Where bicyclists' position in the bikeway does not allow them to see motor vehicles or the pedestrian signal.
- Where intersection complexity is such that signals are helpful, as determined by engineering judgment.

At signalized intersections where the turning volumes do not exceed thresholds in Figure 3-7, it is allowable to have a permissive conflict between bicyclists and turning motorists. Under this condition, the use of bicycle signal faces is not permitted. In this scenario, the designer may use a green ball indication with bike signal sign (R10-10b) as the bicycle signal.

The designer should pursue a Request to Experiment (RTE) with FHWA to use bicycle signal faces under conditions that are not currently allowable in the MUTCD in the following circumstances:

- Where some intersections along a corridor have signal phase separation and use a bicycle signal face, it may be desirable to provide bicycle signal faces at all intersections for consistency and added safety.
- Where a leading bicycle interval (LBI) is desired, it may be necessary to use a bicycle signal face to communicate the right-of-way. When a bicycle signal face is used for a LBI, continue to use the bicycle signal face for the remainder of the phase.
- Where it is desired to use a flashing yellow arrow for motor vehicles and a bicycle signal face to allow permissive turns across the bike lane.
- Where an all-pedestrian phase is proposed to run concurrently with a bicycle phase.

Layout

- The 8-inch or 12-inch bicycle signal face shall be positioned horizontally, with the RED BICYCLE, YELLOW BICYCLE, and GREEN BICYCLE signal indications in the same relative position to each other as specified for motor vehicles; a yellow backplate shall be used.
- The 4-inch bicycle signal face used for near-side bicycle signals shall be positioned vertically and the backplate may be omitted.

Size

- Bicycle signal indications may be 4, 8, or 12 inches in diameter.
- All signal indications in a bicycle signal face shall be the same size, including those that display arrows and those that display bicycle symbols.
- 4-inch signal indications shall only be used in supplemental, post-mounted, near-side bicycle signal faces. Near-side bicycle signal faces may alternatively be 8 inches in diameter.
- The primary bicycle signal face shall be located at the far side of the signal-controlled location. The far side bicycle signal face shall be 8 or 12 inches in diameter, unless the signal is located more than 120 feet from the stop bar, in which case a 12-inch diameter bicycle signal shall be used.

Placement

- When the primary bicycle signal face is located more than 120 feet from beyond the stop line, a supplemental near-side bicycle signal face is required. When more than 80 feet from the stop line, a supplemental near-side bicycle signal is recommended. When intersections are smaller and peak hour volumes of bicyclists are high, it may also be desirable to provide near-side signals.

- The designer should also consider the use of a near-side bicycle signal when the peak hour volume of bicyclists exceeds 150 bicyclists per hour.

- Bicycle signals should be separated vertically or horizontally by at least 3 feet from the nearest motor vehicle traffic signal face for the same approach.

Mounting Height

- The bottom of the signal housing of an 8-inch or 12-inch bicycle signal face that is not located over a roadway shall be a minimum of 7 feet above the sidewalk or ground. Where supplemental signing is installed below the bicycle signal face, the minimum mounting height to the bottom of the supplemental sign shall be 7 feet.

- The bottom of the signal housing of a near-side 4-inch bicycle signal face (post-mounted) shall be a minimum of 4 feet and a maximum of 7 feet above the sidewalk or ground.

Supplemental Signage

- The use of a bicycle signal requires a "[BICYCLE] SIGNAL" sign (R10-10b), installed immediately adjacent the signal.

- At signals with red, yellow, and green arrows, "RIGHT ON GREEN ARROW ONLY" R10-5A or "LEFT ON GREEN ARROW ONLY" R10-5 signs should be installed. At signals with red, yellow, and green ball indication, "NO RIGHT TURN ON RED" R10-11 signage should be installed.

Signal Phasing

The needs of all roadway users should be taken into account when designing signal timing and phasing. Where a bikeway is designed along a corridor with an existing all-way pedestrian phase, the designer may consider removing this phase. All-way pedestrian phases are not intended for bicyclists to use; however, the Colorado Safety Stop law allows bicyclists to treat red traffic signals like stop signs and proceed at red lights after coming to a complete stop if there is no oncoming traffic. Therefore, it is likely that most bicyclists would proceed through these intersections in conflict with pedestrians if a bikeway was implemented and the all-way pedestrian phase remained.

Where dedicated left-turn lanes exist (and can be controlled) and left-turn movements conflict with bicycle movements, the bicycle phase should operate on recall and the left-turn phase should be actuated.

GREEN WAVE

When bicycle volume is relatively high during peak hours (i.e., > 75 bicyclists per hour) along a corridor, designers should consider installing a bicycle green wave at all signalized intersections in the corridor at an appropriate bicycle design speed. Considerations for appropriate bicyclist design speeds, taking into account existing conditions and topography, can be found in Volume 1 of the Manual. This will reduce the number of stops for bicyclists and calm speeding vehicular traffic. However, designers should be aware that on corridors with a green wave, interaction between turning vehicles and bicyclists is likely to occur at higher speeds, especially if the green wave is installed at an approach with a steep downhill. For this reason, designers should provide adequate approach clear space to improve visibility of bicyclists. At intersections with high turning vehicle volumes, protected turn phases should be added to ensure safety of all users. When considering installation of a bicycle green wave, designers should consider impact on all users, including vehicular signal coordination on major cross-street corridors.

Figure 6-1: Bikeway Decision Sign

Figure 6-2: Directional Dots in Portland, OR

Bicycle Wayfinding

Wayfinding helps identify the best routes to key destinations, helps people overcome the barrier of not knowing where to ride, and reminds motorists to anticipate the presence of bicyclists, all of which make bicycling a more pleasant experience. A wayfinding system typically combines signage and pavement markings to guide bicyclists along preferred routes to destinations across the community, county, or region. Denver's signs also indicate distances to destinations.

Sign Types

Historically, Denver's bikeway wayfinding system relied on the D route system, which indicates to bicyclists that they are on one of many regional bike routes. These signs lack any information as to the destinations along the routes or where they may start and end. For this reason, the D route signs will be phased out and replaced with new route signs, which will be installed as a part of all future bikeway projects.

The current signage system has three sign types: neighborhood bikeway signs, Denver bikeways signs, and trail signs. Detailed information on sign design and placement can be found in Denver's *Bicycle Wayfinding Guidelines*.

Directional Dots

A directional dot is a wayfinding pavement marking that may be used along bikeways to indicate transitions between bikeway facility types that may not be intuitive. For example, a directional dot may be used to help users transition to a raised bike lane or to transition to a protected bike lane at an offset intersection. They may also be used to mark the distinction between a sidewalk-level bikeway and the pedestrian way. At intersection approaches, directional dots may guide bicyclists to a nearby PHB as well. Directional dots are typically only to be used in off-street conditions.

Directional dots are generally not appropriate to indicate turns along a neighborhood bikeway route. Instead, shared lane markings with directional indication (Standard Drawing BDS 2-1) should be used.

Standard Drawing BDS 6-5 shows the detail for directional dots.

Bicycle Parking

Bicycle parking, including stand-alone inverted U-racks and on-street bicycle corrals, enhances the usefulness of bicycle networks by providing locations for the secure short-term storage of bicycles during a trip. It enables bicyclists to secure their bicycles while enjoying the offerings of a street or patronizing businesses and destinations in Denver. Bicycle parking requires far less space than automobile parking—in fact, 10 bicycles can typically park in the area needed for a single car. In addition, bicycle corrals can be installed at intersections in place of a vehicle parking space or in bulbouts and large buffers to improve sight lines and visibility for people walking, bicycling, and driving cars. Designers should consult with DOTI's Bicycle Parking Program staff in the Curbside Management and Parking (CMP) group to identify locations where bicycle parking can be placed along new bikeway corridors. The CMP group also maintains additional details for bike corrals of various sizes for consideration, depending on available space. Bike parking designs should be reviewed and approved by DOTI's bicycle parking program within CMP. On-street bicycle parking should be considered for all bikeway projects, and included based DOTI's latest Corral Location Analysis Criteria.

Bike parking shall be installed per Standard Drawings 16.2.15 and 16.2.16 of the DOTI TSSMS.

Bicycle Counters

Bicycle volume data helps the City and County of Denver measure progress towards its goals. It is desirable to include bicycle counting infrastructure as part of any bikeway design project. Proximity to bicycle trip generators, as well as bicycle count technology install parameters should be used to determine the most appropriate count location along the project corridor. Bicycle permanent counters should generally be located where the data can be obtained with minimal error, e.g., at a mid-block location or on a physically-separated facility where interference from other users is minimal. The designer should consult CCD policies related to project evaluation and bicycle counting to determine the appropriate type of bicycle counting equipment to use.

Directional Indicator Strips

Directional indicator strips are tactile surfaces that can be installed parallel to the pedestrian path of travel to help pedestrians with vision impairments follow an accessible pathway or navigate a large open space. They are typically used where no curb, street furniture, or continuous landscape bed is present that would otherwise perform this function. Along bikeways, directional indicator strips shall be installed in the following situations:

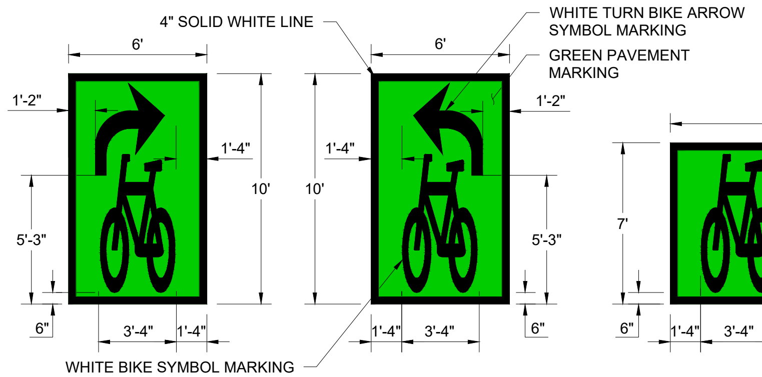
- Where the bikeway and the sidewalk are located at the same level and are parallel facilities with a minimum width sidewalk buffer.
- Where the bikeway changes to/from sidewalk-level, to indicate that the transition ramp is not intended for pedestrian use.
- To guide low-vision pedestrian to locations (indicated by detectable warning surfaces) where crossing the bikeway is preferred.

Directional indicator strips may be constructed of methyl methacrylate (MMA), pre-formed plastic plates, or tiles. The strips should be at least 12 inches wide, color should be "Federal Yellow," and should meet the tactile and contrast characteristics of ISO 23599. The ridges of the directional indicator strips should not be continuous to allow drainage to pass at various points (every 6 feet maximum).

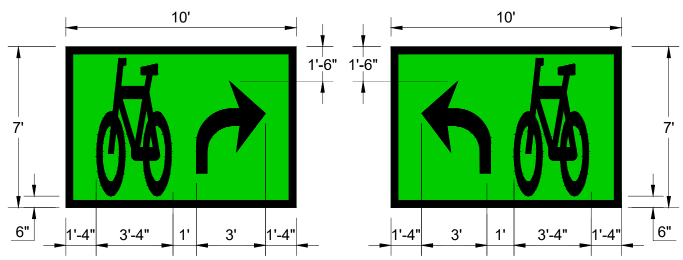
Since pedestrians with vision impairments walk on top of or follow the directional indicators with their cane swinging over the directional indicator, directional indicator strips shall not be placed directly on the boundary between the sidewalk and sidewalk-level bikeway. Directional Indicator strips should be installed in a linear fashion, at least 12 inches from the parallel edge of the bike lane, within the sidewalk.

Standard Drawing BDS 6-6 shows guidance for installing directional indicator strips.

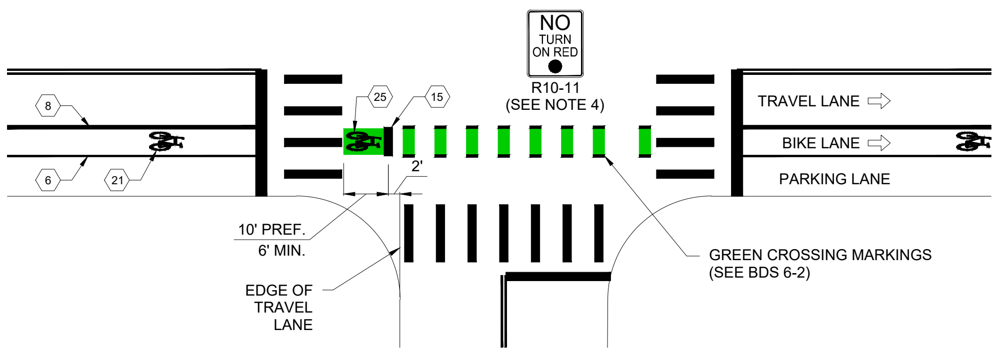
Bikeway Design Tools Standard Drawings



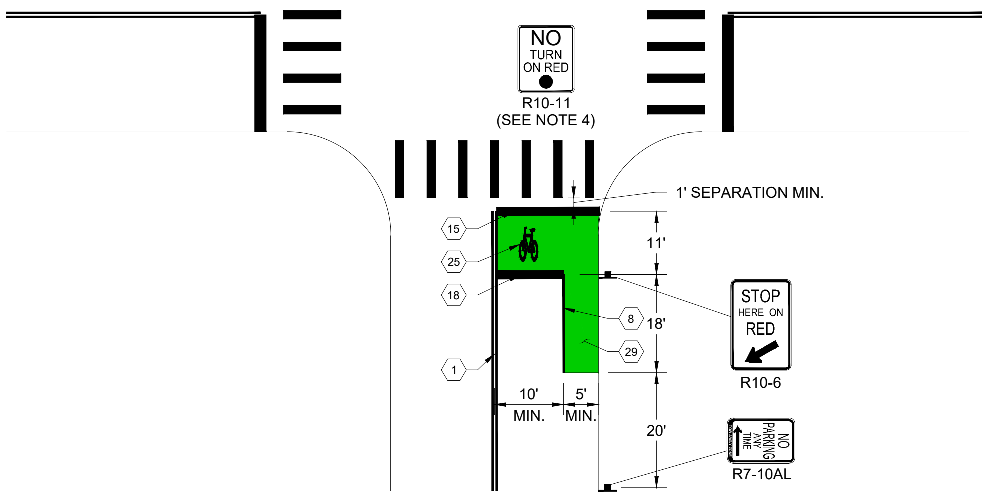
VERTICAL TWO-STAGE TURN BOX DETAILS



HORIZONTAL TWO-STAGE TURN BOX DETAILS



ADVANCED BIKE STOP BAR DETAIL
(SIGNALIZED INTERSECTIONS ONLY)



BIKE BOX DETAIL
(SIGNALIZED INTERSECTIONS ONLY)

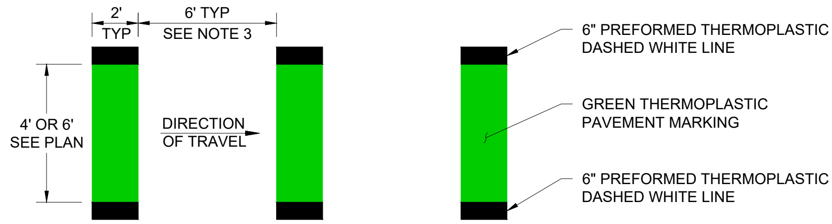
LEGEND:

1 4" DOUBLE YELLOW CENTERLINE WITH 4" SEPARATION
6 4" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
8 8" SOLID WHITE RIGHT EDGE LINE OR TURN LANE LINE
15 18" WHITE ADVANCED STOP BAR
18 24" WHITE STOP LINE, ONLY WHEN SHOWN ON PLANS
25 GREEN PAVEMENT MARKING WITH EMBEDDED WHITE BIKE SYMBOL
29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN

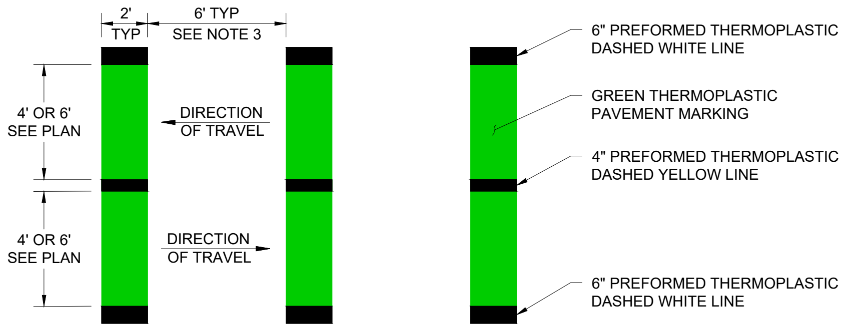
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 2-1 FOR BIKE SYMBOL DETAILS AND GREEN PAVEMENT MARKING USAGE.
4. "NO TURN ON RED" SIGNS ARE REQUIRED WITH TWO-STAGE TURN BOXES, ADVANCED BIKE STOP BARS, AND BIKE BOXES.

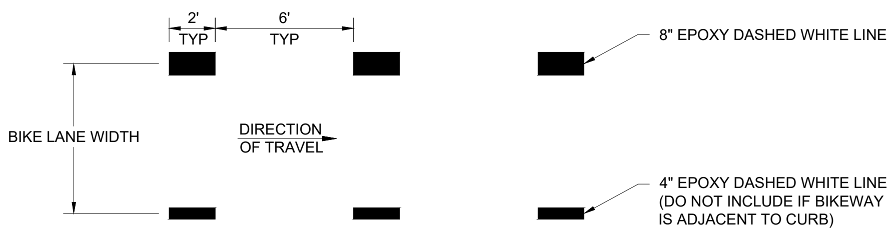
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE BOX, TWO-STAGE TURN BOX, AND ADVANCED BIKE STOP BAR DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 6-1



GREEN CROSSING MARKINGS (ONE-WAY FACILITY)



GREEN CROSSING MARKINGS (TWO-WAY FACILITY)

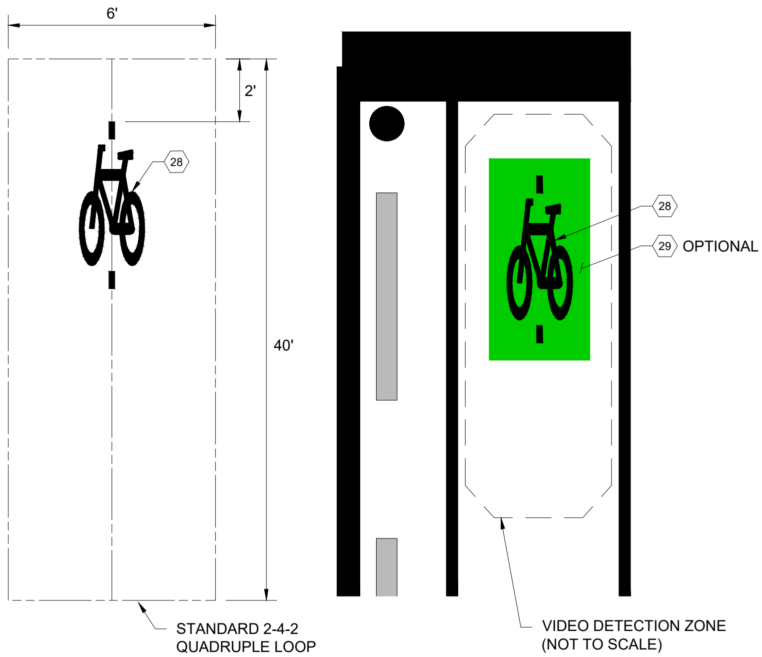


DASHED CROSSING MARKINGS

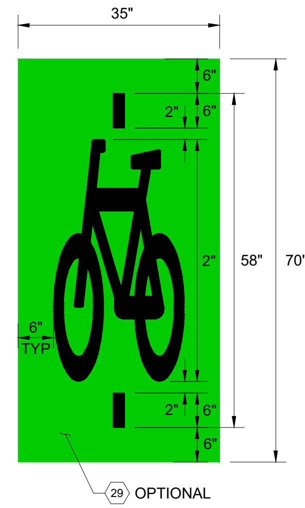
NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. WHEN ADJACENT TO A PEDESTRIAN CROSSWALK, GREEN CROSSING MARKINGS SHALL ALIGN WITH THE CROSSWALK MARKINGS.

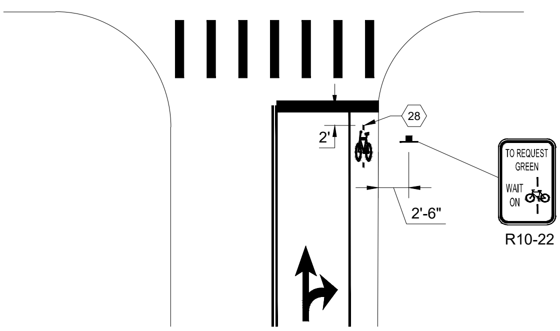
VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKEWAY CROSSING MARKING DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 6-2



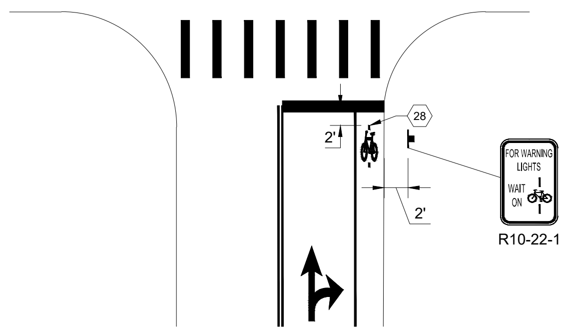
TYPICAL DETECTION PAVEMENT MARKING LOCATION



WHITE BIKE DETECTION PAVEMENT MARKING



TYPICAL PLACEMENT OF BIKE DETECTION MARKING
AND SIGN FOR CAMERA DETECTION SIGNAL



TYPICAL PLACEMENT OF BIKE DETECTION MARKING
AND SIGN FOR CAMERA DETECTION RRFB

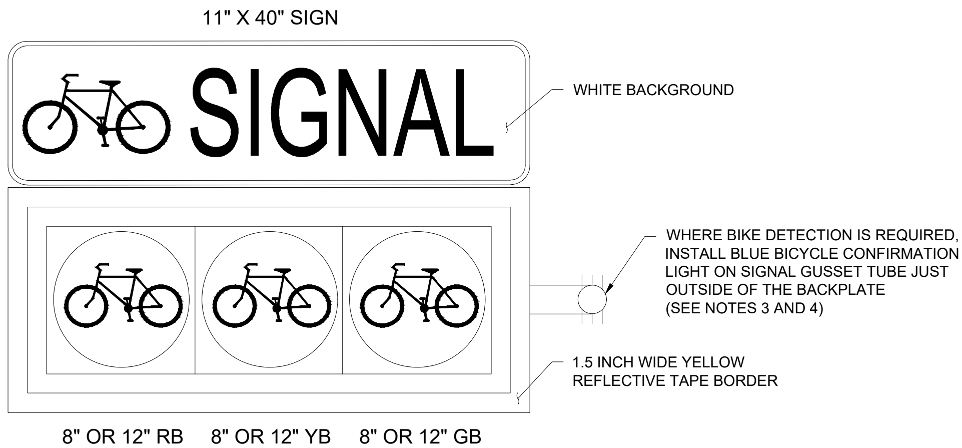
LEGEND:

- 28 WHITE BICYCLE DETECTION PAVEMENT MARKING
- 29 GREEN PAVEMENT MARKING, DIMENSIONS PER PLAN

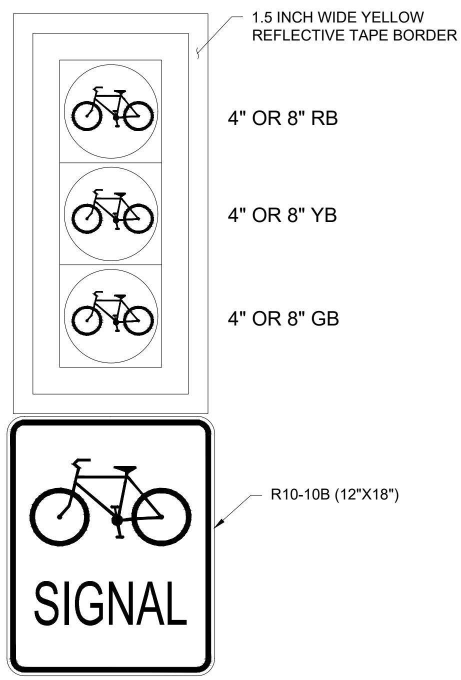
NOTES:

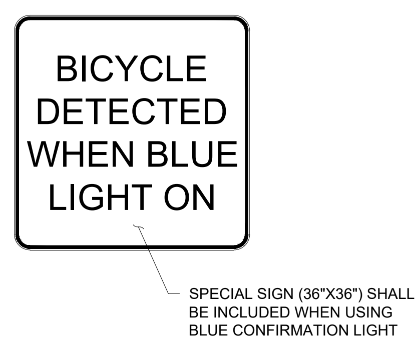
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. BIKE DETECTION PAVEMENT MARKING SHALL BE ACCOMPANIED BY R10-22 OR R10-22-1 SIGN.
4. LOOP AND VIDEO DETECTION DESIGN SHALL FOLLOW CCD STD DWG 16.1.5.1 - 16.1.5.2.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE DETECTION PAVEMENT MARKING DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 6-3



OVERHEAD-MOUNTED BICYCLE SIGNAL

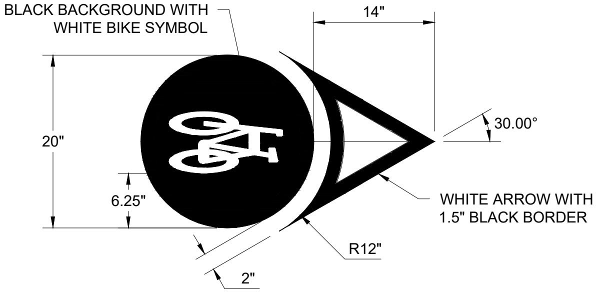




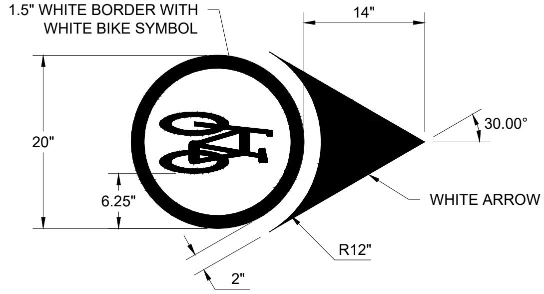
POST-MOUNTED BICYCLE SIGNAL
(SEE NOTE 5)

NOTES:
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. FHWA REQUEST TO EXPERIMENT APPROVAL REQUIRED.
4. WHEN INSTALLED, BLUE LIGHT SHALL HAVE A VIEW ANGLE OF 30 DEGREES AND TURN ON WHEN BICYCLE IS DETECTED.
5. 4" BIKE SIGNAL FACE SHALL ONLY BE USED ON SUPPLEMENTAL NEARSIDE BICYCLE SIGNALS AND THE BIKE SIGNAL SIGN SHOULD NOT BE INSTALLED WITH A 4" BIKE SIGNAL.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER BIKE SIGNAL DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 6-4



DIRECTIONAL DOT DETAIL
ON CONCRETE PAVEMENT
(PREFORMED THERMOPLASTIC)

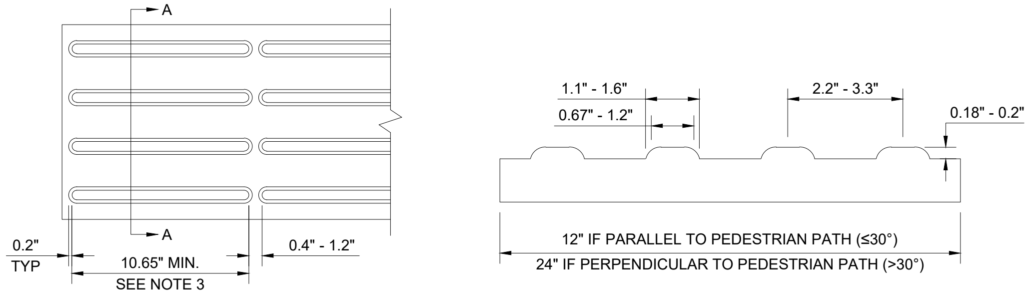


DIRECTIONAL DOT DETAIL
ON ASPHALT PAVEMENT
(PREFORMED THERMOPLASTIC)

NOTES:

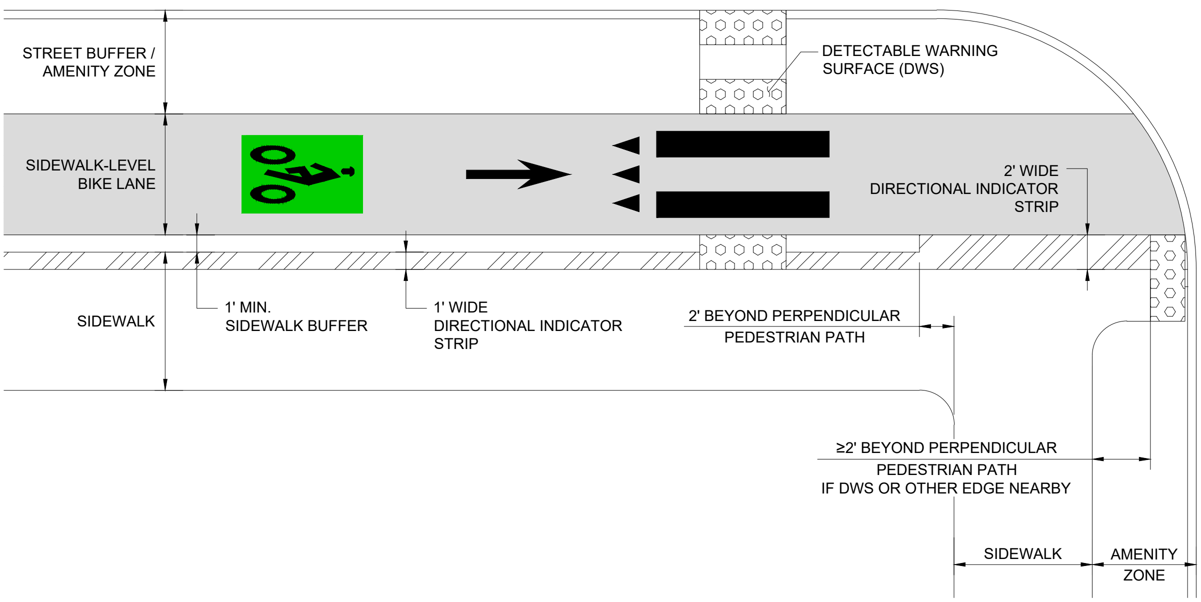
1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE CCD BICYCLE WAYFINDING GUIDELINES FOR WAYFINDING SIGN GUIDANCE AND DETAILS.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER DIRECTIONAL DOT DETAILS	STD DWG NO. BDS 6-5



PLAN

SECTION A-A



DIRECTIONAL INDICATOR STRIP AT SIDEWALK-LEVEL BIKEWAY
(SEE NOTE 3)

NOTES:

1. DESIGN PLANS SHOULD BE CONSULTED FOR VARIATIONS.
2. SEE BDS 2-0 FOR GENERAL NOTES.
3. SEE BDS 5-12 FOR DIRECTIONAL INDICATOR STRIP LAYOUT WHEN A STREET-LEVEL BIKEWAY TRANSITIONS WITH A RAMP TO A SIDEWALK-LEVEL BIKE LANE OR SHARED USE PATH.
4. SEE CCD TRANSPORTATION STANDARD DRAWINGS FOR REQUIRED SIDEWALK WIDTH.
5. THE RIDGES OF THE DIRECTIONAL INDICATOR STRIP SHOULD NOT BE CONTINUOUS, TO ALLOW DRAINAGE TO PASS AT VARIOUS POINTS. EVERY 6' MAX.
6. DETECTABLE DIRECTIONAL STRIP MUST BE COLOR "FEDERAL YELLOW" AND MEET THE TACTILE AND CONTRAST CHARACTERISTICS OF ISO 23599.
7. STRIP CENTERLINE MUST BE PARALLEL TO THE ALIGNMENT OF THE PEDESTRIAN ACCESS ROUTE.

VERSION 6 DATE: 9/12/24	CITY & COUNTY OF DENVER DIRECTIONAL INDICATOR STRIP DETAILS	DENVER THE MILE HIGH CITY	STD DWG NO. BDS 6-6