Appendix B

Bicycle Facility Toolbox

APPENDIX B
BICYCLE FACILITY TOOLBOX

The Bicycle Facility Toolbox is a supplement to COS Bikes!, the Colorado Springs Bike Master Plan. The Toolbox was developed to guide the City and its partners in selecting and designing appropriate bicycle facilities. The Toolbox is research-based and uses nationally-accepted best practices, including the following standards and guidelines:

+ *A Policy on Geometric Design of Highways and Streets*, 6th Edition (AASHTO, 2011)
+ *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA, 2009)
+ *Guide for the Development of Bicycle Facilities* (AASHTO, 2012)
+ *CDOT Roadway Design Guide*, Chapter 14 (Colorado Department of Transportation, 2015)
+ *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts* (FHWA, 2016)
+ *Separated Bike Lane Planning and Design Guide* (FHWA, 2015)
+ *Highway Capacity Manual* (HCM) (Transportation Reseach Board, 2010)
+ *Urban Bikeway Design Guide* (NACTO, 2014)

This Toolbox provides general design considerations for bikeway implementation, and the City should use it when implementing the Vision Network in COS Bikes! The Toolbox includes design elements and facility types anticipated to be used in Colorado Springs, however, it is not all-inclusive. This document is not a design standard, and should not be used as such. Application of guidance provided in this document requires the use of engineering judgment. The design considerations for each treatment are intended to inform a future update to the City of Colorado Springs Engineering Criteria Manual.

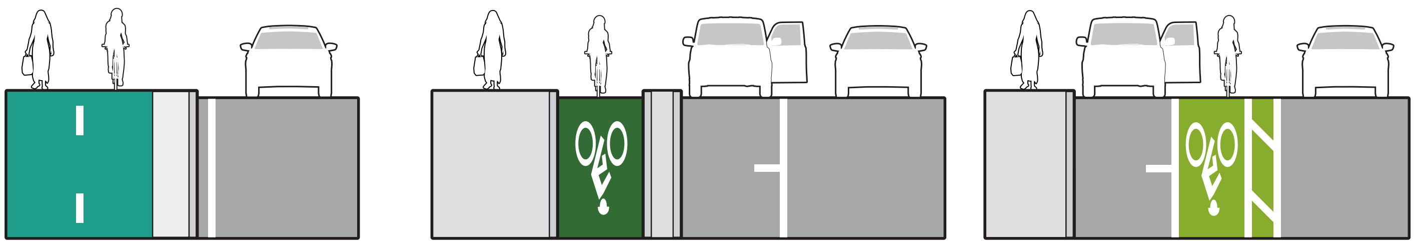
Cover photo: Bicycle Colorado Springs

TABLE OF CONTENTS

BICYCLE FACILITY TYPES

BICYCLE FACILITY OVERVIEW

Shared Use Path SUP | Separated Bike Lane SBL | Buffered Bike Lane BBL



MOST COMFORTABLE

TYPICAL APPLICATION *

Shared use paths can generally be considered on any road with one or more of the following characteristics:

+ Total traffic lanes: 3 or more lanes
+ Posted speed limit: 30 mph or greater
+ Average Daily Traffic: 9,000 vehicles or more
+ Parking turnover: frequent
+ Bike lane obstruction: likely to be frequent
+ Streets that are designated as truck or bus routes

Shared use paths may be preferable to separated bike lanes in low density areas where pedestrians volumes are anticipated to be fewer than 200 people per hour on the path.

Separated bike lanes can generally be considered on any road with one or more of the following characteristics:

+ Total traffic lanes: 3 or more lanes
+ Posted speed limit: 30 mph or more
+ Average Daily Traffic: 7,500 vehicles or more
+ Parking turnover: frequent
+ Bike lane obstruction: likely to be frequent
+ Streets that are designated as truck or bus routes

Preferred in higher density areas, adjacent to commercial and mixed-use development, and near major transit stations or locations where observed or anticipated pedestrian volumes will be higher.

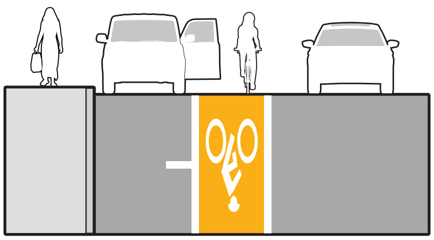
Buffered bike lanes can generally be considered on any road with one or more of the following characteristics:

+ Total traffic lanes: 3 or fewer lanes
+ Posted speed limit: 30 mph or lower
+ Average Daily Traffic: 7,500 vehicles or fewer
+ Parking turnover: infrequent.
+ Bike lane obstruction: likely to be infrequent
+ Where a separated bike lane or sidepath is infeasible or not desirable due to cost, lack of public support, etc.
+ Buffer may be located on the parking lane side of the bike lane, the travel lane side of the bike lane, or on both sides of the bike lane.

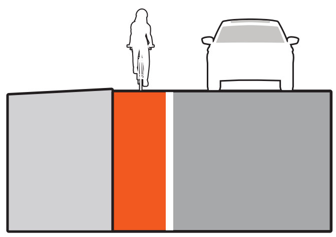
* References to adjacent traffic speeds and volumes are based on the appropriateness of these bicycle facility types for use by the "Interested but Concerned" bicyclist (see page 4). These thresholds are appropriate where the community goal is to encourage greater ridership among those who are most comfortable riding in bicycle facilities that are separated from motor vehicle traffic.

BICYCLE FACILITY OVERVIEW

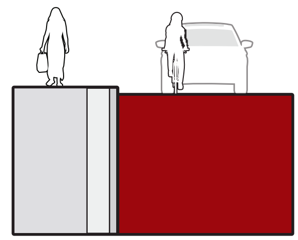
Bike Lane BL



Shoulder Bikeway SB



Shared Roadway SR



LEAST COMFORTABLE

TYPICAL APPLICATION *

Bike Lane

Conventional bike lanes can generally be considered on any road with one or more of the following characteristics:

- Total traffic lanes: 3 or fewer lanes
- Posted speed limit: 30 mph or lower
- Average Daily Traffic: 7,500 vehicles or fewer
- Parking turnover: infrequent
- Bike lane obstruction: likely to be infrequent
- Where a separated bike lane or sidepath is infeasible or not desirable

Shoulder Bikeway

Shoulder bike lanes can generally be considered on any road without on-street parking and one or more of the following characteristics:

- Total traffic lanes: 3 or fewer lanes
- Average Daily Traffic: 7,500 vehicles or fewer
- Shoulder obstruction: likely to be infrequent
- Where a separated bike lane or sidepath is infeasible or not desirable

The minimum width of a shoulder bikeway is 4' (exclusive of the gutter if one exists). Wider shoulders should be provided on streets or roads with average daily traffic higher than 3,500 vehicles.

Shared Roadway

Shared roadways can be considered on any road with no on-street parking and one or more of the following characteristics:

- Total traffic lanes: 3 or fewer lanes
- Posted speed limit: 25 mph or lower
- Average Daily Traffic: 3,000 vehicles or fewer
- Where a separated bike lane or sidepath is infeasible or not desirable

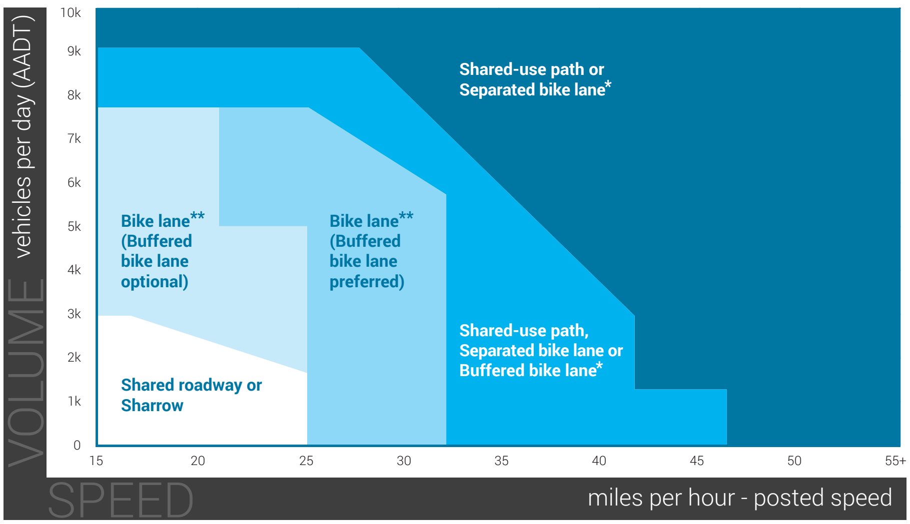
* References to adjacent traffic speeds and volumes are based on the appropriateness of these bicycle facility types for use the "Interested but Concerned" bicyclist (see page 4). These thresholds are appropriate where the community goal is to encourage greater ridership among those who are most comfortable riding in bicycle facilities that are separated from motor vehicle traffic.

BICYCLE FACILITY SELECTION

The City of Colorado Springs Traffic Criteria Manual includes bicycle facility guidance (pages 39 through 41). The Bicycle Facility Toolbox proposes the following bicycle facility types, based on national design standards and best practices, which include a broad range of facility options. Bicycle facility selection is primarily influenced by traffic volume and speed, however, engineering judgement is needed to properly consider other relevant factors, such as the presence of conflict points.

Designing for “Interested but Concerned” and “Enthused and Confident” Bicyclists

“Interested but concerned” bicyclists prefer physical separation as traffic volumes and speeds increase. The bikeway facility selection chart below identifies bikeway facilities that improve operating environment for this bicyclist type at different roadway speeds and traffic volumes. The “enthused and confident” bicyclist will also prefer bikeway treatments noted in this chart. Selecting facility types based on this chart is recommended in order to serve the largest share of the population and increase bicycling in Colorado Springs.

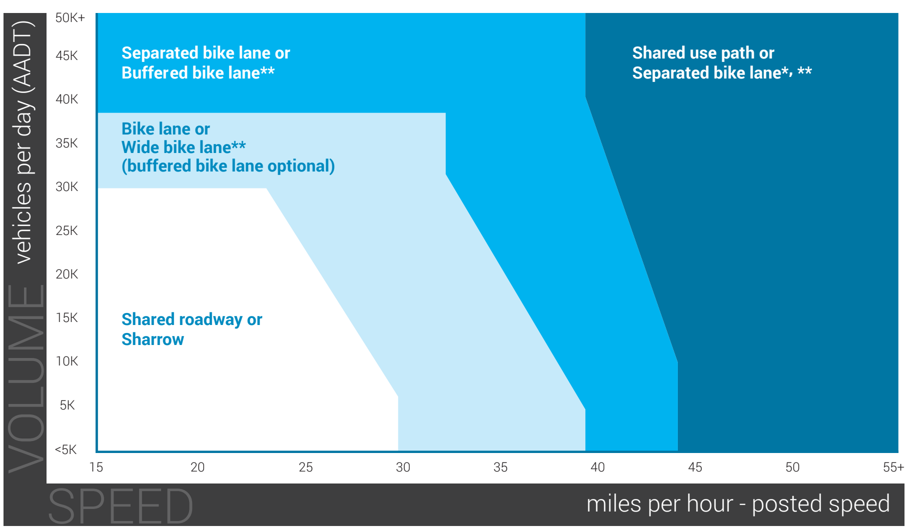


* To determine whether to provide a shared-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

** Can use a shoulder bikeway as necessary

Designing for “Strong and Fearless” Bicyclists

“Strong and fearless” bicyclists have a greater tolerance and willingness to operate with higher motor vehicle traffic volumes and speeds. The bikeway facility selection chart below identifies bikeway facilities that improve the operating environment for this bicyclist type at different roadway speeds and traffic volumes. The “enthused and confident” bicyclist may tolerate bikeway treatments based on this chart for limited distances, while “interested but concerned” bicyclists may not.



* To determine whether to provide a shared-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

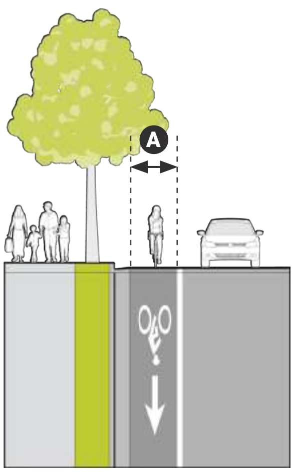
** Can use a shoulder bikeway as necessary

CHART REFERENCES

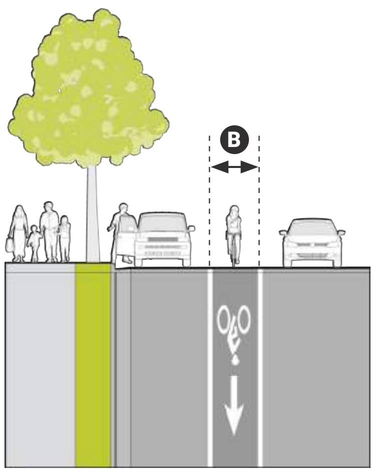
+ Transitions are based on a shift in the Highway Capacity Manual (HCM) Bike Level of Service (BLOS) from A to B (assuming no parking, 12 ft outside travel lane, 6 ft bike lane, 8 ft buffered bike lane). This roughly translates to a BLOS C to D transition with on-street parking (8 ft parking lane).
+ Speed thresholds based on Level of Traffic Stress. “Interested but Concerned” riders are sensitive to increases in volume or speed, based on Dill’s research, Categorizing Cyclists: What Do We Know? Insights from Portland, OR on the four types of cyclists.

BIKE LANES

Bicycle lanes provide an exclusive space for bicyclists in the roadway. Bicycle lanes are established through the use of lines and symbols on the roadway surface. Bicycle lanes are for one-way travel and are normally provided in both directions on two-way streets and/or on one side of a one-way street. Bicyclists are not required to remain in a bicycle lane when traveling on a street and may leave the bicycle lane as necessary to avoid debris, make turns, pass other bicyclists, or to properly position themselves for other necessary movements. Bicycle lanes may only be used temporarily by vehicles accessing parking spaces and entering and exiting driveways and alleys. Stopping, standing, and parking in bike lanes is prohibited.



Bike Lane Adjacent to Curb



Bike Lane Adjacent to Parking

GUIDANCE

A The minimum width of a bike lane adjacent to a curb is 5 feet exclusive of a gutter (4 feet in highly-constrained locations); a desirable width is 6 feet.

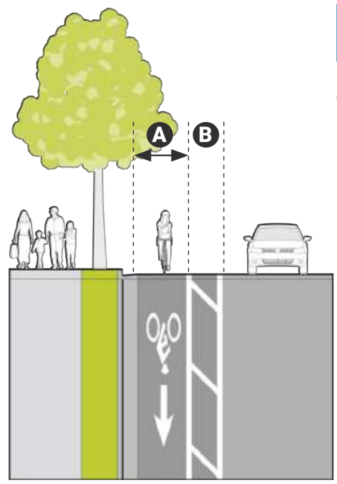
B The minimum width of a bike lane adjacent to parking is 5 feet; a desirable width is 6 feet.

CONSIDERATIONS

- Typically installed by reallocating existing street space.
- Can be used on one-way or two-way streets.
- Contra-flow bicycle lanes may be used to allow two-way bicycle travel on streets designated for one-way motor vehicle travel to improve bicycle network connectivity.
- Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.
- Wider bike lanes or buffered bike lanes are preferable at locations with high parking turnover.
- Along some transit routes, buses may need to pull into the bike lane to access bus stops along the curb. At these locations, a variety of design options may be used, such as delineating the bike lane with a dotted line or constructing a floating bus stop.

BUFFERED BIKE LANES

Buffered bicycle lanes are created by painting or otherwise creating a flush buffer zone between a bicycle lane and the adjacent travel lane. While buffers are typically used between bicycle lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bicycle lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles.



Buffered Bike Lane Adjacent to Curb

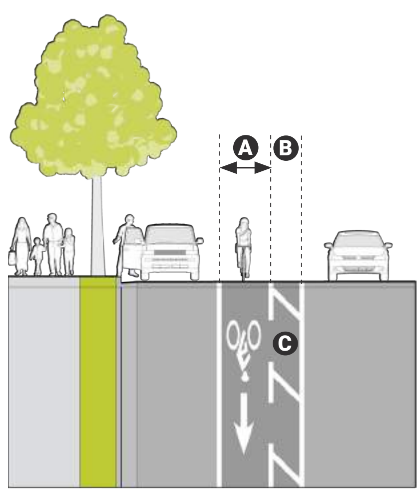
GUIDANCE

A The minimum width of a buffered bike lane adjacent to parking or a curb is 4 feet exclusive of gutter (if present); a desirable width is 6 feet.

B The minimum buffer width is 18 inches. There is no maximum width. Diagonal cross hatching should be used for buffers <3 feet in width. Chevron cross hatching should be used for buffers >3 feet in width.

CONSIDERATIONS

- Typically installed by reallocating existing street space.
- Can be used on one-way or two-way streets.



Buffered Bike Lane Adjacent to Parking

- Where there is 7 feet of roadway width available for a bicycle lane, a buffered bike lane should be installed instead of a conventional bike lane. The preferred configuration is **A** a 5-foot or wider bike lane and **B** an 18-inch or wider buffer.
- Buffered bike lanes allow bicyclists to ride side-by-side or to pass slower-moving bicyclists.

C Buffers are to be broken where curbside parking is present to allow cars to cross the bike lane.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

NACTO Urban Bikeway Design Guide (2014)

CDOT Roadway Design Guide, Chapter 14 (2015)

SEPARATED BIKE LANES

Separated Bike Lanes (also known as protected bike lanes or cycletracks) are an exclusive bikeway facility type that combines the user experience of a sidepath with the on-street infrastructure of a conventional bike lane. They are physically separated from motor vehicle traffic and distinct from the sidewalk. Separated Bike Lanes are more attractive to a wider range of bicyclists than striped bikeways on higher volume and higher speed roads. They eliminate the risk of a bicyclist being hit by an opening car door and prevent motor vehicles from driving, stopping or waiting in the bikeway. They also provide greater comfort to pedestrians by separating them from bicyclists operating at higher speeds.

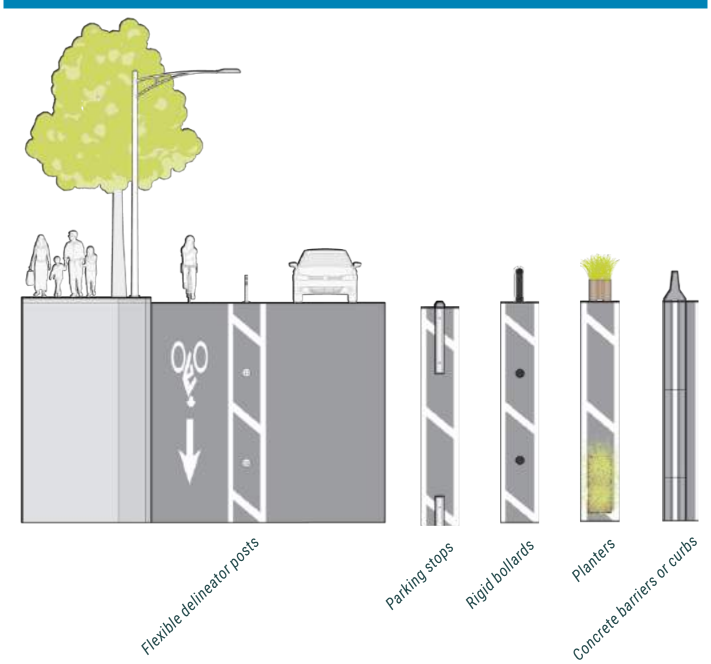
GUIDANCE

Separated bike lanes can provide different levels of separation:

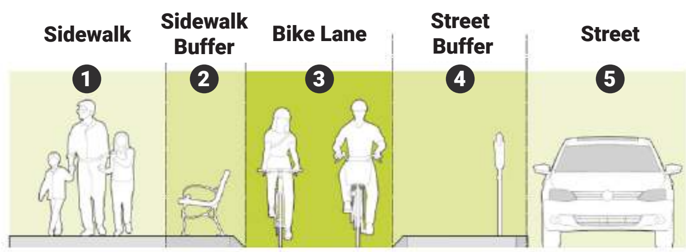
+ Separated bike lanes with only flexible delineator posts ("flex posts") offer the least separation from traffic and are appropriate as interim solution.
+ Separated bike lanes that are raised with a wider buffer from traffic provide the greatest level of separation from traffic, but will often require road reconstruction.
+ Separated bike lanes that are protected from traffic by a row of on-street parking offer a high degree of separation.

In constrained environments, reductions should be made to the street and vehicle space before narrowing sidewalks and other spaces allocated to pedestrians. This reduction can include decreasing the number of travel lanes, narrowing existing lanes or adjusting on-street parking.

OPTIONS FOR SEPARATION MATERIALS (IN-STREET SEPARATED BIKE LANES)



SEPARATED BIKE LANE ZONES



1. The sidewalk should not be narrowed beyond the minimum necessary to accommodate pedestrian demand.

2. The sidewalk buffer is desirable, but not required. The sidewalk buffer zone separates the bike lane from the sidewalk, communicating each as distinct spaces. By separating people walking and bicycling, encroachment into these spaces is minimized and the safety and comfort is enhanced for both users.

3. The width of the bike lane zone should be determined by the peak hour volume of users. Separated bike lanes generally attract a wider spectrum of bicyclists, some of whom operate at slower speeds, such as children or seniors. Because the elements used to separate the bike lane from the adjacent motor vehicle lane include some vertical component, bicyclists usually do not have the option to pass each other by moving out of the separated bike lane. The bike lane zone should therefore be sufficiently wide to enable passing maneuvers between bicyclists.
    - The bike lane width should be at least 6.5 feet for one-way bike lanes and 8 feet for two-way bikeways, to ensure bicyclists can safely pass each other.
    - A minimum shy distance of 1 foot should be provided between any vertical objects in the sidewalk or street buffer and the bike lane.

4. The street buffer is required and should provide separation from the street with vertical objects or a median. The street buffer can consist of parked cars, vertical delineators, raised medians, landscaped medians, and a variety of other elements. The buffer should be at least 2 feet wide at midblock locations and should be between 6 feet and 20 feet at intersections to provide maximum safety benefits. Intersections must be designed with consideration of potential conflicts with motor vehicle traffic. Where the buffer is reduced below 6 feet, a raised bicycle crossing or signal phase separation should be considered.

5. Travel lanes and parking should be narrowed to the minimum widths in constrained corridors.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

NACTO Urban Bikeway Design Guide (2014)

MassDOT Separated Bike Lane Planning and Design Guide (2015)

FHWA Separated Bike Lane Planning and Design Guide (2015)

SEPARATED BIKE LANES

Separated bike lanes may be located at sidewalk level, street level, or at an elevation intermediate to the sidewalk and street. Separated bike lanes are physically separated from motor vehicles and pedestrians by vertical and horizontal elements.

GUIDANCE

Sidewalk-level bike lanes:

+ May encourage pedestrian and bicyclist encroachment unless discouraged with a continuous sidewalk buffer.
+ Requires no transition for raised bicycle crossings at driveways, alleys or streets.
+ May provide level landing areas for parking, loading or bus stops along the street buffer.
+ May reduce maintenance needs by prohibiting debris build up from roadway runoff. May simplify snow plowing operations.

Intermediate-level bike lanes:

+ Preserve separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Ensures a detectable edge is provided for people with vision impairments.
+ May reduce maintenance needs by prohibiting debris build up from roadway runoff. May complicate snow plowing operations.
+ May require careful consideration of drainage design and in some cases may require catch basins to manage bike lane runoff.

Street-level bike lanes:

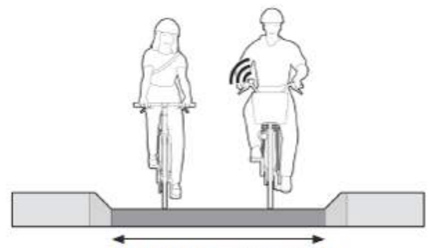
+ Preserve separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Ensures a detectable edge is provided for people with vision disabilities.
+ May increase maintenance needs to remove debris from roadway runoff unless street buffer is raised. May complicate snow plowing operations.
+ May require careful consideration of drainage design and in some cases may require catch basins to manage bike lane runoff.

CONSIDERATIONS

+ Implementing separated bike lanes may require removal of on-street parking or other visual obstructions in some locations for safety reasons. Parking removal can be of particular importance at intersections, where clear sight triangles should be maintained for bicyclists as well as motorists.
+ Clear approach space should be preserved along intersection and driveway approaches so that (in the case of right-side separated bike lanes) right-turning motorists can see and react to bicyclists on their right approaching the same crossing.

ONE-WAY SEPARATED BIKE LANES

+ The recommended minimum width of a one-way separated bicycle lane is:

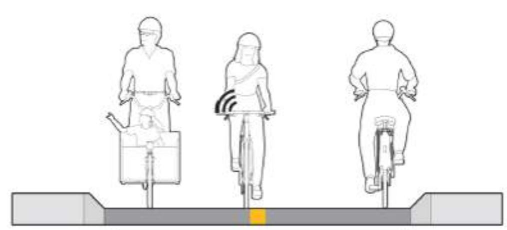


Same Direction Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	6.5	5.0
150-750	8.0	6.5
>750	10.0	8.0

+ A constrained bicycle lane width of 4 feet (one-way only) may be used for short distances to navigate around transit stops, accessible parking spaces, or other obstacles.

TWO-WAY SEPARATED BIKE LANES

The recommended minimum width of a two-way separated bicycle lane is:



Bidirectional Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	10.0	8.0
150-400	11.0	10.0
>400	14.0	11.0

SHARED LANE MARKINGS

Shared lane markings (or "sharrows") are pavement markings that denote shared bicycle and motor vehicle travel lanes. The markings are two chevrons positioned above a bicycle symbol, placed where the bicyclist is anticipated to operate. In general, this is a design solution that should only be used in locations with low traffic speeds and volumes as part of a signed route or bicycle boulevard.

GUIDANCE

- Intended for use only on streets with posted speed limits of up to 25 mph and traffic volumes of less than 3,000 vehicles per day. Maximum posted speed of street: 35 mph.
- May be used as a temporary solution on constrained streets with up to 10,000 vehicles per day until a more appropriate bikeway facility can be implemented. Maximum posted speed of street: 35 mph.
- Intended for use on lanes up to 14' wide (up to 13' preferred). For lanes 15' wide or greater, stripe a 4' bike lane instead of using shared lane markings.
- The marking's centerline must be at least 4' from curb or edge of pavement where parking is prohibited.
- The marking's centerline must be at least 11' from curb where parking is permitted, so that it is outside the door zone of parked vehicles.
- For narrow lanes (11' or less), it may be desirable to center shared lane markings along the centerline of the outside travel lane.
- May be used as interim treatments to fill gaps between bike lanes or other dedicated facilities for short segments where there are space constraints.
- Typically supplemented by signs, especially Bikes May Use Full Lane (R4-11).

BICYCLE BOULEVARDS

Bicycle boulevards incorporate traffic calming treatments with the primary goal of prioritizing bicycle through-travel, while discouraging motor vehicle traffic and maintaining relatively low motor vehicle speeds. These treatments are typically applied on quiet streets, often through residential neighborhoods. Treatments vary depending on context, but often include traffic diverters, speed attenuators such as speed humps or chicanes, pavement markings, and signs.

CONSIDERATIONS

Many cities already have signed bike routes along neighborhood streets that provide an alternative to traveling on high-volume, high-speed arterials. Applying bicycle boulevard treatments to these routes makes them more suitable for bicyclists of all abilities and can reduce crashes as well.

Stop signs or traffic signals should be placed along the bicycle boulevard in a way that prioritizes the bicycle movement, minimizing stops for bicyclists whenever possible.

Additional treatments for major street crossings may be needed, such as median refuge islands, rapid flash beacons, bicycle signals, pedestrian hybrid beacons, or half signals.

GUIDANCE

- Maximum Average Daily Traffic (ADT): 3,000
- Preferred ADT: up to 1,000
- Target speeds for motor vehicle traffic are typically around 20 mph; there should be a maximum 15 mph speed differential between bicyclists and vehicles.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (2009)
Fundamentals of Bicycle Boulevard Planning & Design (2009)
CDOT Roadway Design Guide, Chapter 14 (2015)

SHARED USE PATHS

A shared use path is a two-way facility physically separated from motor vehicle traffic and used by bicyclists, pedestrians, and other non-motorized users. Shared use paths, also referred to as trails, are often located in an independent alignment, such as a greenbelt or abandoned railroad.

CONSIDERATIONS

- Path width should be determined based on three main characteristics: the number of users, the types of users, and the differences in their speeds. For example, a path that is used by higher-speed bicyclists and children walking to school may experience conflicts due to their difference in speeds. By widening the path to provide space to accommodate passing movements, conflicts can be reduced.
- On hard surfaces it can be useful to include soft surface parallel paths which are preferred by some users, such as runners.

GUIDANCE

- Due to the fact that nearly all shared use paths are used by pedestrians, they must be designed to be accessible, per the Americans with Disabilities Act (ADA).
- Widths as narrow as 8 feet are acceptable for short distances under physical constraints. Warning signs should be considered at these locations.
- In locations with heavy volumes or a high proportion of pedestrians, widths exceeding 10 feet are recommended. A minimum of 11 feet is required for users to pass with a user traveling in the other direction. It may be beneficial to separate bicyclists from pedestrians by constructing parallel paths for each mode.
- Paths must be designed according to state and national standards. This includes establishing a design speed (typically 18 mph) and designing path geometry accordingly. Consult the AASHTO *Guide for the Development of Bicycle Facilities* for guidance on geometry, clearances, traffic control, railings, drainage, and pavement design.
- Path clearances are an important element in path design and reducing user conflicts. Along the path, vertical objects should be set back at least two feet from the edge of the path.

SIDEPATHS

A shared use path constructed parallel to and within the right-of-way of a roadway is referred to as a sidepath. Often bicyclists and pedestrians will have increased interactions with motor vehicles at driveways and intersections on these sidepaths compared to a shared use path in an independant alignment.

CONSIDERATIONS

- According to the American Association of State Highway and Transportation Officials (AASHTO), "Shared use paths should not be used to preclude on-road bicycle facilities, but rather to supplement a network of on-road bike lanes, shared roadways, bicycle boulevards, and paved shoulders." In some situations, it may be appropriate to provide an on-road bikeway in addition to a sidepath along the same roadway, such as frequently heavy pedestrian activity on the sidepath.
- Many people express a strong preference for the separation between bicycle and motor vehicle traffic provided by paths when compared to on-street bikeways. Sidepaths may be desirable along high volume or high speed roadways, where accommodating the targeted type of bicyclist within the roadway in a safe and comfortable way is impractical.
- Sidepaths are most appropriate where driveways and intersections are limited. In areas with high concentrations of driveways and intersections, on-street accommodations (including bike lanes, buffered bike lanes, and separated bike lanes) are preferred because they are proven to be safer.
- Special attention must be given to the design of intersections between sidepaths and streets, driveways, and alleys. Treatments such as proper signage, pavement markings, and other elements could be needed to ensure that bicyclists remain visible to drivers.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

CDOT Roadway Design Guide, Chapter 14 (2015)

Manual on Uniform Traffic Control Devices (2009)

CROW Design Manual for Bicycle Traffic (2007)

PAVED SHOULDERS

Paved shoulders provide a range of benefits: they reduce motor vehicle crashes, reduce long-term roadway maintenance, ease short-term maintenance such as snow plowing, and provide space for bicyclists and pedestrians (although paved shoulders typically do not meet accessibility requirements for pedestrians). Paved shoulders are typically reserved for rural road cross-sections.

CONSIDERATIONS

Where 4-foot or wider paved shoulders exist already, it is acceptable or even desirable to mark them as bike lanes in various circumstances, such as to provide continuity between other bikeways. If paved shoulders are marked as bike lanes, they need to also be designed as bike lanes at intersections. Where a roadway does not have paved shoulders already, paved shoulders can be retrofitted to the existing shoulder when the road is resurfaced or reconstructed. In some instances, adequate shoulder width can be provided by narrowing travel lanes to 11 feet.

Reducing travel lane width on existing roads—also known as a "lane diet"—is one way to increase paved shoulder width.

There are several situations in which additional shoulder width should be provided, including motor vehicle speeds exceeding 50 mph, moderate to heavy volumes of traffic, and above-average bicycle or pedestrian use.

The placement of rumble strips may significantly degrade the functionality of paved shoulders for bicyclists. Rumble strips should be placed as close to the lane edge line as practicable and four feet of usable space should be provided for bicyclists. Where rumble strips are present, gaps of at least 12' should be provided every 40-60'.

GUIDANCE

Benefits

+ Provide separated space for bicyclists and can be used by pedestrians.
+ Reduce run-off-road motor vehicle crashes.
+ Reduce pavement edge deterioration and accommodate maintenance vehicles.
+ Provide emergency refuge for public safety vehicles and disabled vehicles.
+ Provide space for large agricultural equipment.

Challenges

+ May not provide a comfortable experience for all bicyclists when used on high-speed roads.
+ May not facilitate through-intersection bicycle movement unless designed as bike lanes through intersections.
+ For pedestrians, paved shoulders do not meet accessibility requirements.

Design Criteria

+ Minimum width: 4 feet (5 feet if adjacent to curb or guardrail)
+ Preferred minimum width based on user type and traffic volume:

Minimum Paved Shoulder Widths

	Strong and Fearless	Interested but Concerned and Enthused and Confident
Under 1,500 ADT	--	4'
1,500-3,000 ADT	4'	4'
Over 3,500 ADT	6'	Sidepath recommended*
Over 7,500 ADT	Sidepath recommended*	Sidepath recommended*

* Sidepath recommended in addition to paved shoulders, which should be provided by default on roads with these traffic volumes in order to reduce run-off-road crashes, improve roadway maintenance, and provide additional space for more confident bicyclists.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

AASHTO Policy on Geometric Design of Highways and Streets (2013)

CDOT Roadway Design Guide, Chapter 14 (2015)

Manual on Uniform Traffic Control Devices (2009)

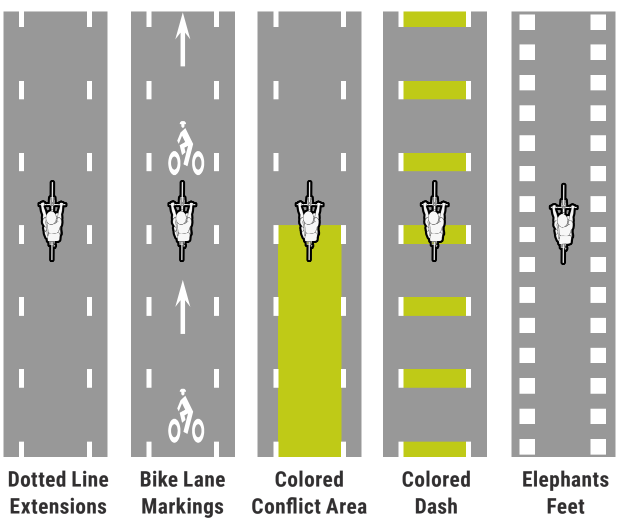
BICYCLE INTERSECTION DESIGN AND SPOT TREATMENTS

CONFLICT AREAS

Conflict area markings are intersection pavement markings designed to improve visibility, alert all roadway users of expected behaviors, and reduce conflicts with turning vehicles.

CONSIDERATIONS

- The appropriate treatment for conflict areas can depend on the desired emphasis and visibility. Dotted lane lines may be sufficient for guiding bicyclists through intersections; however, consider providing enhanced markings with green pavement and/or symbols at complex intersections or at intersections with safety concerns.
- Symbol placement within intersections should consider vehicle wheel paths and minimize maintenance needs associated with wheel wear.
- Driveways with higher volumes may require additional pavement markings and signage.
- Consideration should be given to using intersection conflict markings as spot treatments or standard intersection treatments. A corridor-wide treatment can maintain consistency; however, spot treatments can be used to highlight conflict locations.

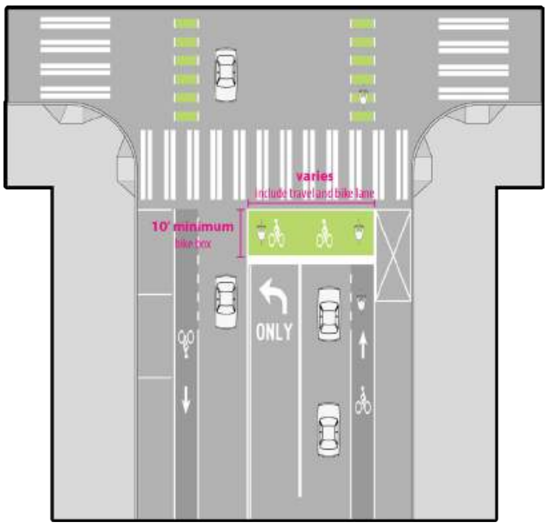


GUIDANCE

- The width of conflict area markings should be as wide as the bike lanes on either side of the intersection.
- Dotted white lane lanes should conform to the latest edition of the MUTCD. These can be used through different types of intersections based on engineering judgment.
- A variety of pavement marking symbols can enhance intersection treatments to guide bicyclists and warn of potential conflicts.
- Green pavement markings can be used along the length of a corridor or in select conflict locations.

BIKE BOXES

A bicycle box provides dedicated space between the crosswalk and vehicle stop line where bicyclists can wait during the red light at signalized intersections. The bicycle box allows a bicyclist to take a position in front of motor vehicles at the intersection, which improves visibility and motorist awareness, and allows bicyclists to "claim the lane" if desired. Bike boxes aid bicyclists in making turning maneuvers at the intersection, and provide more queuing space for multiple bicyclists than that provided by a typical bicycle lane.



CONSIDERATIONS

In locations with high volumes of turning movements by bicyclists, a bicycle box should be used to allow bicyclists to shift towards the desired side of the travel way. Depending on the position of the bicycle lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.

Where motor vehicles can continue straight or cross through a right-side bicycle lane to turn right, the bicycle box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning. When a bicycle box is implemented in front of a vehicle lane that previously allowed right turn on red, the right turn on red movement must be restricted using signage and enforcement following installation of the bike box.

Colorado Springs has historically not used bike boxes. This intersection tool may be a longer-term spot treatment where appropriate conditions exist.

GUIDANCE

+ Bicycle boxes are typically painted green and are a minimum of 10' in depth and are the width of the entire travel lane(s).
+ Bicycle box design should be supplemented with appropriate signage according to the latest version of the MUTCD.
+ Bicycle box design should include appropriate signalization adjustment in determining the minimum green time.
+ Where right-turn lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane.

TWO-STAGE TURN QUEUE BOXES

A two-stage turn queue box should be considered where bike lanes are continued to an intersection and a protected intersection is not provided. The two-stage turn queue box designates a space for bicyclists to wait outside the path of traffic while performing a two-stage turn across a street.

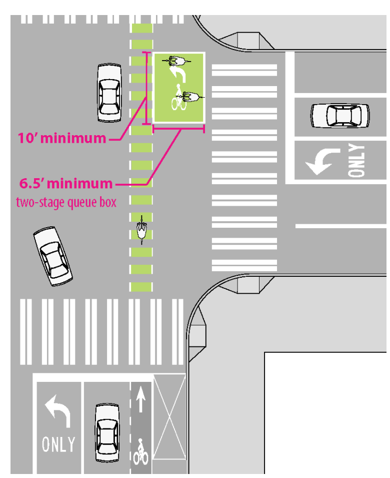
CONSIDERATIONS

Use of a two-stage turn queue box requires FHWA permission to experiment.

Two-stage turn queue box dimensions will vary based on the street operating conditions, the presence or absence of a parking lane, traffic volumes and speeds, and available street space. The turn box may be placed in a variety of locations including in front of the pedestrian crossing (crosswalk location may need to be adjusted), in a 'jug-handle' configuration within a sidewalk, or at the tail end of a parking lane or a median island.

GUIDANCE

+ A minimum width of 10 feet is recommended.
+ A minimum depth of 6.5 feet is recommended.
+ Dashed bike lane extension markings may be used to indicate the path of travel across the intersection.
+ NO TURN ON RED (R10-11) restrictions should be used to prevent vehicles from entering the queuing area.
+ The box should consist of a green box outlined with solid white lines supplemented with a bicycle symbol and a turn arrow to emphasize the crossing direction.



REFERENCES

NACTO Urban Bikeway Design Guide (2014)

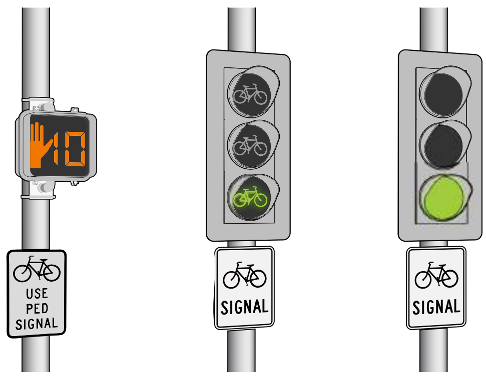
MassDOT Separated Bike Lane Planning and Design Guide (2015)

FHWA Separated Bike Lane Planning and Design Guide (2015)

FHWA Bicycle Facilities and the Manual on Uniform Traffic Control Devices - Two-Stage Turn Box (2015)

BICYCLE SIGNALS, DETECTION, ACTUATION

Bicyclists have unique needs at signalized intersections. Bicycle movements may be controlled by the same indications that control motor vehicle movements, by pedestrian signals, or by bicycle-specific traffic signals. The introduction of separated bike lanes creates situations that may require leading or protected phases for bicycle traffic, or place bicyclists outside the cone of vision of existing signal equipment. In these situations, provision of signals for bicycle traffic will be required.



CONSIDERATIONS

- Bicycle-specific signals may be appropriate to provide additional guidance or separate phasing for bicyclists per the AASHTO *Guide for the Development of Bicycle Facilities*.
- It may be desirable to install advanced bicycle detection on the intersection approach to extend the phase, or to prompt the phase and allow for continuous bicycle through movements.
- Video detection, microwave and infrared detection can be an alternative to loop detectors.
- Another strategy in signal timing is coordinating signals to provide a "green wave", such that bicycles will receive a green indication and not be required to stop.

GUIDANCE

- Set loop detectors to the highest sensitivity level possible without detecting vehicles in adjacent lanes and field check. Type D and type Q loops are preferred for detecting bicyclists.
- Install bicycle detector pavement markings and signs per the MUTCD, AASHTO *Guide for the Development of Bicycle Facilities*, and the NACTO *Urban Bikeway Design Guide*.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

NACTO Urban Bikeway Design Guide (2014)

Manual on Uniform Traffic Control Devices (2009)

BICYCLE BOULEVARD CROSSING TREATMENTS

While the street segments of a bicycle boulevard or other traffic-calmed street may be generally comfortable for bicyclists without significant improvement, major street crossings must be addressed to provide safe, convenient and comfortable travel along the entire route. Treatments can provide waiting space for bicyclists and control cross traffic.

Pedestrian hybrid signal

Offset intersection treatment using two-way separated bike lane (from NACTO)

CONSIDERATIONS

- Adjustments to traffic control such as a pedestrian hybrid beacon or stop sign adjustments may necessitate a traffic study.
- Numerous treatments exist to accommodate offset intersection crossings for bicyclists, and the full range of design treatments should be considered in these situations. These treatments include left turn queue boxes, two-way center left turn lanes (optionally designed solely for bicyclists), median left turn pockets and short sidepath segments.

GUIDANCE

Intersections along a bicycle boulevard route may need treatment in the following situations:

- Unsignalized crossings of arterial or collector streets with high traffic volumes and speeds.
- Offset intersections where the bicycle boulevard route makes two turns in short succession.

Offset intersections are locations where two segments of a connection do not directly align where they meet another street. These configurations are most challenging for bicyclists when offset local streets serving as bike routes or bike boulevards intersect with larger collector or arterial streets. Design solutions should include techniques to separate bicycle and motorist movements and create staged crossings if necessary. Selection of a suitable treatment at an offset intersection depends on the speed and volume of traffic on the intersecting street and whether the offset legs make the bike boulevard jog to the left or to the right. Treatments are context-sensitive, but may include:

- Two-stage turn queue boxes placed in on-street parking lanes
- Center left-turn lanes specially designed to accommodate the movements needed by bicyclists to connect from one leg to the other. These lanes also serve as refuges while bicyclists wait for gaps in traffic.
- Signal phasing for the bicycle movement at signalized locations
- A pair of one-way separated bike lanes
- A two-way separated bike lane
- Raised median islands with bicycle accommodations
- Contra-flow bike lanes if the intersecting street is one-way

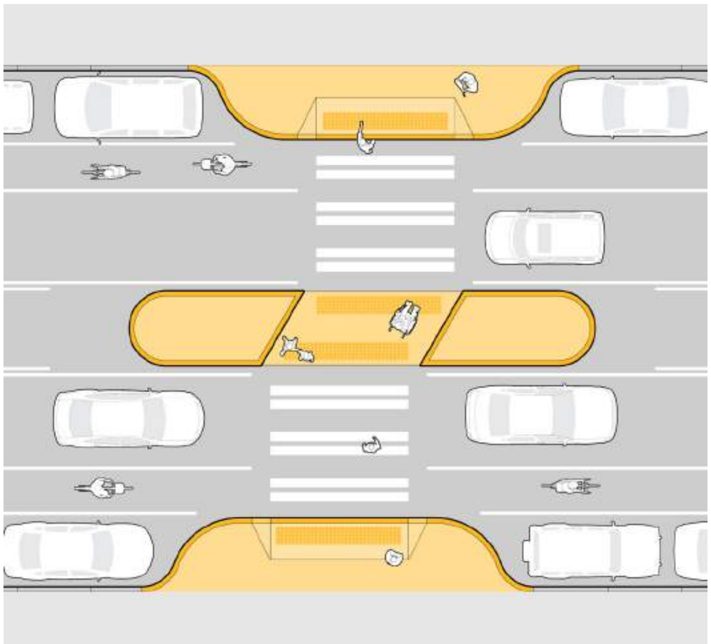
See the NACTO *Urban Bikeway Design Guide* for more detail.

REFERENCES

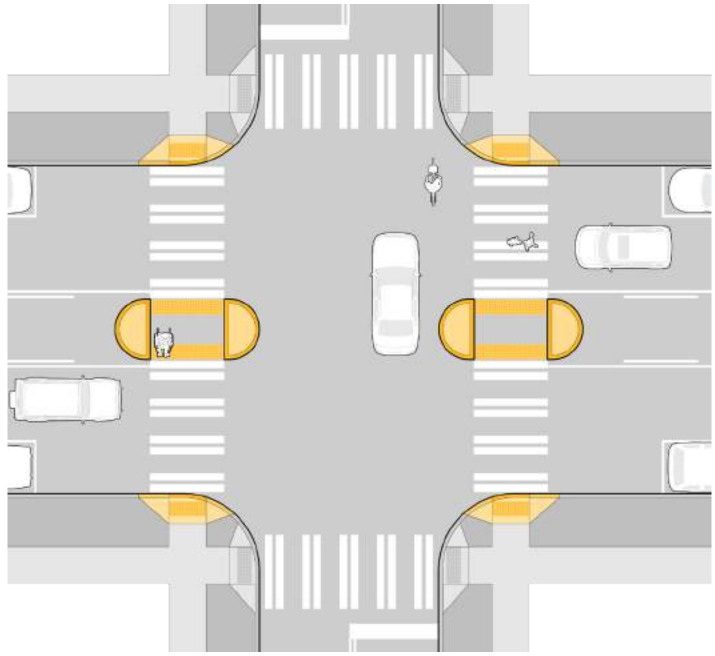
AASHTO Guide for the Development of Bicycle Facilities
CDOT Roadway Design Guide, Chapter 14 (2015)
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (2009)

CROSSING ISLANDS

Crossing islands are raised islands that provide pedestrians and bicyclists with a refuge and allow multi-stage crossings of wide streets. They can be located mid-block or at intersections and along the centerline of a street, as roundabout splitter islands, or as "pork chop" islands where right-turn slip lanes are present.



Mid-block Crossing Island with Curb Extensions



Intersection Crossing Islands (Left Turns Prohibited)

CONSIDERATIONS

+ There are two primary types of crossing islands. The first type provides a cut-through of the island, keeping pedestrians at street-grade. The second type ramps pedestrians up above street grade and may present challenges to constructing accessible curb ramps unless they are more than 17' wide (accommodating for ramp width and landing area).
+ Crossing islands should be considered where crossing distances are greater than 50 feet. For long distances, islands can allow multi-stage crossings, which in turn allow shorter signal phases.
+ Crossing islands can be coupled with other traffic calming features, such as partial diverters and curb extensions at mid-block and intersection locations.
+ At mid-block crossings where width is available, islands should be designed with a stagger, or in a "Z" pattern, encouraging pedestrians within the median to face oncoming traffic before crossing.
+ Advance rumble strips can increase driver awareness of upcoming crossings.

GUIDANCE

+ Minimum width: 6 feet
+ Preferred Width: 10 feet (to accommodate bicyclists with trailers and wheelchair users)
+ Cut-through openings should equal the width of the crosswalk. Cut-throughs may be wider in order to allow the clearing of debris and snow, but should not encourage motor vehicles to use the space for U-turns.
+ Curb ramps with truncated dome detectable warnings and 5'x5' landing areas are required.
+ A "nose" that extends past the crosswalk is not required, but is recommended to protect people waiting on the crossing island and to slow turning drivers.
+ Vegetation and other aesthetic treatments may be incorporated, but must not obscure visibility.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

NACTO Urban Bikeway Design Guide (2014)

Manual on Uniform Traffic Control Devices (2009)

MIXING ZONES

A mixing zone requires turning motorists to merge across a separated bike lane at a defined location in advance of an intersection. Unlike a standard bike lane, where a motorist can merge across at any point, a mixing zone design limits bicyclists' exposure to motor vehicles by defining a limited merge area for the turning motorist. Mixing zones are compatible only with one-way separated bike lanes.

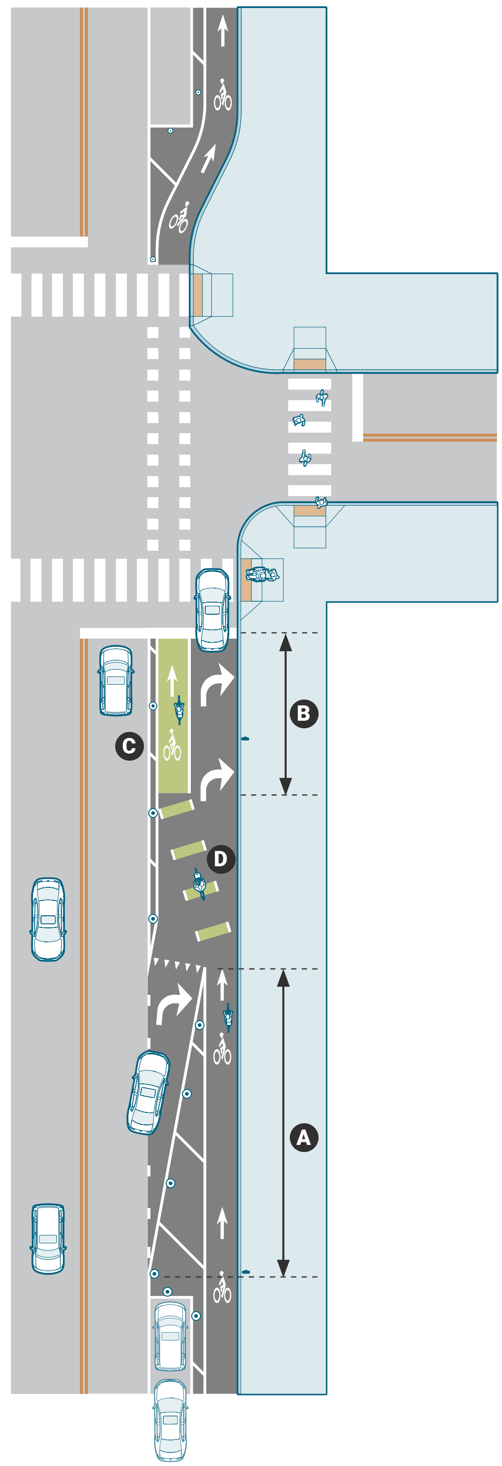
CONSIDERATIONS

Protected intersections are preferable to mixing zones. Mixing zones are generally appropriate as an interim solution or in situations where severe right-of-way constraints make it infeasible to provide a protected intersection.

Mixing zones are appropriate only on street segments with one-way separated bike lanes. They are not appropriate for two-way separated bike lanes due to the contra-flow bicycle movement.

GUIDANCE

- **A** Locate merge points where the entering speeds of motor vehicles will be 20 mph or less by (a) minimizing the length of the merge area and (b) locating the merge point as close as practical to the intersection.
- **B** Minimize the length of the storage portion of the turn lane
- **C** Provide a buffer and physical separation (e.g. flexible delineator posts) from the adjacent through lane after the merge area, if feasible.
- **D** Highlight the conflict area with green surface coloring and dashed bike lane markings, as necessary, or shared lane markings placed on a green box.
- + Provide a BEGIN RIGHT (or LEFT) TURN LANE YIELD TO BIKES sign (R4-4) at the beginning of the merge area.
- + Restrict parking within the merge area
- + At locations where raised separated bike lanes approach the intersection, the bike lane should transition to street elevation at the point where parking terminates.
- + Where posted speeds are 35 mph or higher, or at locations where it is necessary to provide storage for queued vehicles, it may be necessary to provide a deceleration/storage lane in advance of the merge point.



REFERENCES

NACTO Urban Bikeway Design Guide (2014)

MassDOT Separated Bike Lane Planning and Design Guide (2015)

FHWA Separated Bike Lane Planning and Design Guide (2015)

BICYCLE TREATMENTS AT INTERCHANGES

Many of the designs implemented at interchanges to improve motor vehicle capacity and driver safety can create significant challenges for bicyclists. On- and off-ramp configurations can be difficult for on-road bicyclists to traverse due to lack of visibility of approaching motorists, intersecting roadway angles, undefined areas created by lane merges, and the significant speed differential between bicyclists and motorists. Designs at these locations should seek to substantially reduce motorist speeds and maximize visibility between roadway users.

CONSIDERATIONS

The design of bicycle facilities through interchanges should consider the following principles:

+ Provide a highly visible and coherent bicycling route.

Reduce motor vehicle speeds

+ Reduce motor vehicle speeds to 25 mph or less where bicyclists cross a motorist's path.
+ Minimize or avoid the use of high-speed merging lanes and free-flow traffic movements. Minimize corner radii to slow turning speeds.

Maximize visibility between bicyclists and motorists

+ Provide bicycle crossings in conspicuous locations where there are clear sight lines between motorists and bicyclists, and which place bicyclists as perpendicular to conflicting motorists as possible.

Minimize the severity of conflicts where they cannot be eliminated

+ Separate movements in time through the use of traffic controls.
+ Minimize spatial exposure to conflicts with motorists by providing short crossings and physically separated bikeways.

Provide adequate signal timing for bicyclists to completely clear intersections before permitting conflicting movements

Minimize Conflicts with Pedestrians

+ Maximize visibility between bicyclists and pedestrians.

GUIDANCE

+ One way to accommodate on-road bicyclists at an ***on-ramp*** is to develop a right-turn lane prior to the point where the ramp diverges from the roadway.
+ A key consideration for accommodating on-road bicyclists at freeway ***off-ramps*** is to design the bike lane to intersect the on-ramp as close to a 90-degree angle as possible.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

Manual on Uniform Traffic Control Devices (2009)

BICYCLE TREATMENTS AT ROUNDABOUTS

Roundabouts are a popular design solution for intersections because they allow almost continuous flow of traffic through an intersection while generally reducing travel speeds and the number of conflicts points. As many bicyclists will not feel comfortable navigating roundabouts with vehicular traffic, especially multilane roundabouts, roundabouts should be designed to facilitate travel outside of the circular roadway, whether or not a separated facility is provided on the approaches.

CONSIDERATIONS

Access to Separated Bicycle Facilities (Separated Bike Lanes or Shared Use Paths)

+ Bicycle ramps should be used to allow on-road bicyclists to move from the roadway to an adjacent separated facility.
+ When shared use paths or separated bike lanes are provided at roundabouts, they should be continuous around the roadway.

On-Road Bicycle Travel Through Roundabouts

+ With typical on-road bicyclists traveling between 10 and 20 mph, roundabouts that are designed to maintain similar motor vehicle speeds can be comfortable for bicyclists. If designed appropriately, the geometric features of a roundabout (e.g., entry and exit radius, entry and exit width, splitter islands, circulatory roadway width, and inscribed circle diameter) can combine to maintain desired motor-vehicle speeds.

GUIDANCE

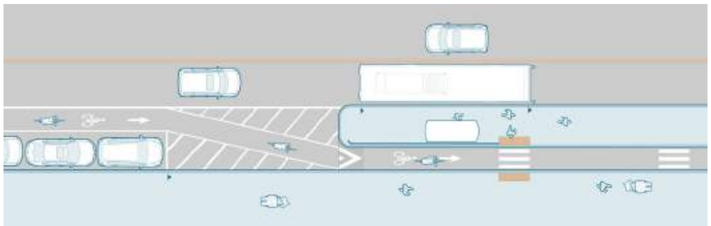
+ Single-lane roundabouts are much simpler for bicyclists than multilane roundabouts, since bicyclists do not need to change lanes, and motorists are less likely to cut off bicyclists when they exit the roundabout.
+ On-street bike lanes should be terminated in advance of roundabouts. The full-width bike lane should normally end at the bike ramp 100 ft before the edge of the circulatory roadway. Terminating the bike lane indicates to bicyclists to merge into the lane of traffic or to use the bike ramp to access a separated facility.

REFERENCES

CDOT Roadway Design Guide, Chapter 14 (2015)

BICYCLE FACILITIES AND TRANSIT STOPS

Because bike lanes and transit stops are both typically located on the right side of a street, it is common for conflicts to arise as transit vehicles cross over bike lanes to access and serve stops and then pull back into traffic. These crossover points create large conflict zones within the bike lane. When locating bike lanes near transit stops, the design should focus on identifying ways to separate these modes and reduce the risk of collision.



CONSIDERATIONS

+ Separated bike lanes are often a better solution than striped bike lanes for streets with transit stops.
+ Where implementation of separated bike lanes is not possible, striped bicycle lanes may be routed behind transit stops to create short sections of separated bike lanes where continuous separation is not feasible. This is often called a “floating bus stop.” Care should be taken to ensure all transit stops are accessible.
+ In situations where a bike lane cannot be routed behind the transit stop, bike lanes should be installed adjacent to the transit stop so that people riding bicycles can maneuver around a transit vehicle stopped to service the stop.
+ If the transit stop shares space with a right-turn lane, the mixing zone where buses and right-turning vehicles cross into the shared space should be clearly marked.

REFERENCES

NACTO Transit Street Design Guide (2012)

MassDOT Separated Bike Lane Planning & Design Guide (2016)

FHWA Separated Bike Lane Planning and Design Guide (2015)

SHARED USE PATH CROSSINGS

Shared use path crossings can be broadly categorized as mid-block, intersection (within the functional area of roadway intersections), or grade-separated. Design solutions should maximize visibility and provide appropriate traffic control based on the character of the roadway.

CONSIDERATIONS

+ Designing a mid-block crossing involves a number of variables, including anticipated mix and volume of path users, the speed and volume of motor vehicle traffic, the roadway configuration, the sight distance that can be achieved at the crossing location, and other factors.
+ High-visibility marked crosswalks are recommended at uncontrolled path–roadway intersections.
+ Crossing islands (or medians) are of particular benefit at path–roadway intersections with high motor vehicle volumes or speeds and long crossing distances.

GUIDANCE

At shared use path crossings, either the path or the street should be given priority. The MUTCD advises that in considering assignment of STOP or YIELD control at shared use path crossings, consideration should be given to

+ Relative speeds of shared use path and roadway users,
+ Relative volumes of shared use path and roadway traffic, and
+ Relative importance of shared use path and roadway.

The least restrictive control appropriate should be placed on lower-priotity approaches. Four-way stop control should not be used where shared use paths cross streets.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

CDOT Roadway Design Guide, Chapter 14 (2015)

Manual on Uniform Traffic Control Devices (2009)

TRANSITIONS BETWEEN FACILITY TYPES

Where a shared use path crosses or terminates at an existing road, it is important to integrate the path into the existing system of on-road bicycle facilities to accommodate bicyclists and into sidewalks to accommodate pedestrians and other path users. Care should be taken to properly design the terminus to transition the traffic into an effective merging or diverging situation. Appropriate signing is needed to warn and direct bicyclists, pedestrians and motorists at such transition areas.

CONSIDERATIONS

+ Each roadway crossing is also an access point, and should therefore be designed to facilitate movements of path users who either enter the path from the road, or plan to exit the path and use the roadway.
+ It is particularly important to ensure path users are provided with clear guidance to ensure they are going in the correct direction of travel when they exit the pathway and enter the roadway, and that they are provided with frequent opportunities to depart from the path as it comes within close proximity to, or connects with, the road network.

Path entrances serve as gateways, and typically offer a variety of amenities to accommodate pathway users transitioning from the road to the path system:

+ Informational kiosks, signs and bulletin boards - These elements should meet proposed PROWAG requirements for position, height and legibility of signs.
+ Bicycle parking
+ Vehicular parking - For major regional paths that attract people travelling longer distances, off-street parking can be beneficial.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

CDOT Roadway Design Guide, Chapter 14 (2015)

Manual on Uniform Traffic Control Devices (2009)

SUPPORTING ELEMENTS FOR BICYCLE FACILITIES

TRAFFIC CALMING

Traffic calming aims to slow the speeds of motorists to a "desired speed" (usually 20 mph or less for residential streets and 25 to 35 mph for collectors and minor arterials). The greatest benefit of traffic calming is increased safety and comfort for all users on and crossing the street. Compared with conventionally-designed streets, traffic calmed streets typically have fewer collisions and far fewer injuries and fatalities. These safety benefits are the result of slower speeds for motorists that result in greater driver awareness, shorter stopping distances, and less kinetic energy during a collision. Traffic calming treatments may use horizontal elements or vertical elements.

HORIZONTAL ELEMENTS

Horizontal traffic calming reduces speeds by narrowing lanes, which creates a sense of enclosure and additional friction between passing vehicles. Narrower conditions require more careful maneuvering around fixed objects and when passing bicyclists or oncoming automobile traffic. Some treatments may slow traffic by creating a yield situation where one driver must wait to pass.

Neighborhood traffic circle

CONSIDERATIONS

+ Horizontal traffic calming treatments must be designed to deflect motor vehicle traffic without forcing the bicycle path of travel to be directed into a merging motorist.
+ Neighborhood traffic circles should be considered at local street intersections to prioritize the through movement of bicyclists without enabling an increase in motorist speeds.

GUIDANCE

Horizontal traffic calming treatments can be appropriate along street segments or at intersections where width contributes to higher motor vehicle speeds. It can be particularly effective at locations where:

+ On-street parking is low-occupancy during most times of day.
+ There is desire to remove or decrease stop control at a minor intersection.

Horizontal treatments are most effective if they deflect motorists midblock (with chicanes) or within intersections (with neighborhood traffic circles).

REFERENCES

Fundamentals of Bicycle Boulevard Planning & Design (2009)

NACTO Urban Bikeway Design Guide (2014)

Portland's Neighborhood Greenway Assessment Report (2015)

CDOT Roadway Design Guide, Chapter 14 (2015)

VERTICAL ELEMENTS

Vertical traffic calming treatments compel motorists to slow speeds. By lowering the speed differential between bicyclists and motorists, safety and bicyclist comfort is increased. These treatments are typically used where other types of traffic controls are less frequent, such as along a segment where stop signs may have been removed to ease bicyclist travel.

Speed hump

CONSIDERATIONS

+ Typically, speed humps should extend the full width of the roadway and should be tapered to the gutter to accommodate drainage. Speed humps are not typically used on roads with rural cross-sections.
+ Speed humps and raised crosswalks impact bicyclist comfort. The approach profile should preferably be sinusoidal or flat.
+ Speed humps or speed cushions are not typically used on collector or arterial streets.

GUIDANCE

Vertical traffic calming will not be necessary on all traffic-calmed streets but should be considered on any street with the following characteristic:

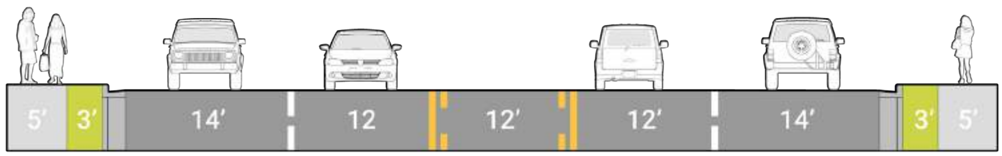
+ Locations with measured or observed speeding issues, with 50th percentile of traffic exceeding the posted limit.

Continuous devices, such as speed humps and raised crosswalks, are more effective to achieve slower speeds than speed cushions.

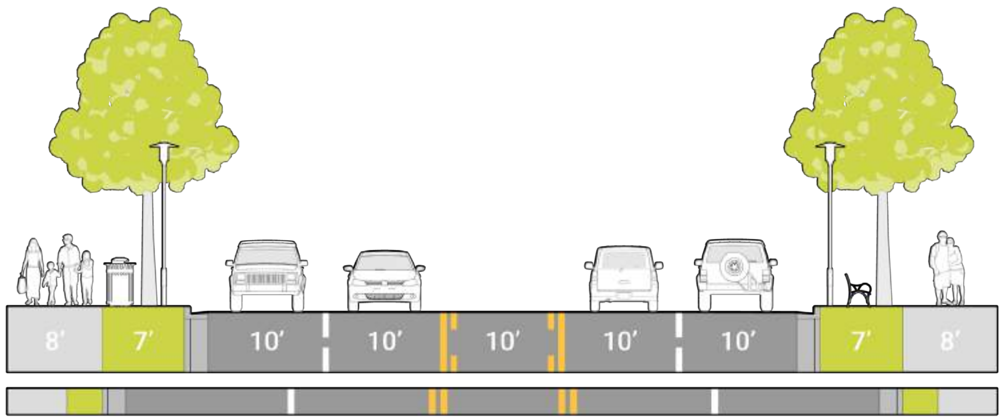
LANE DIETS AND LANE NARROWING

Lane narrowing can improve comfort and safety for vulnerable road users. Narrowing lanes creates space that can be reallocated to other modes, in the form of wider sidewalks, bike lanes, and buffers between cyclists, pedestrians and motor vehicles. Space can also be dedicated to plantings and amenity zones, and reduces crossing distances at intersections.

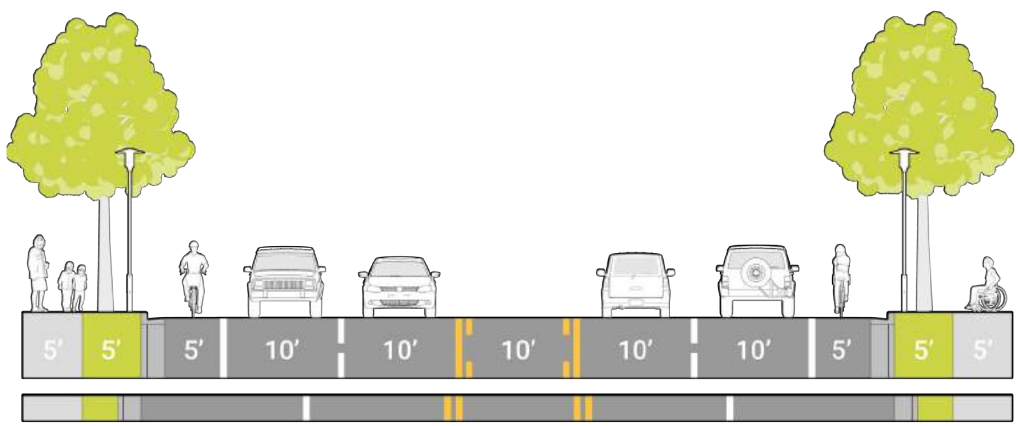
Roadway Before Narrowing



Narrowing Motor Vehicle Lanes to increase Sidewalk and Amenity Zones



Narrowing Motor Vehicle Lanes to increase Amenity Zone and add Bicycle Lanes



CONSIDERATIONS

Narrowing existing motor vehicle lanes may result in enough space to create separated bicycle lanes, widened sidewalks and buffers, or a combination of on-street bike lanes and enhancements to the pedestrian corridor.

Narrower lanes can contribute to lower operating speeds along the roadway, which may be appropriate in dense, walkable corridors.

GUIDANCE

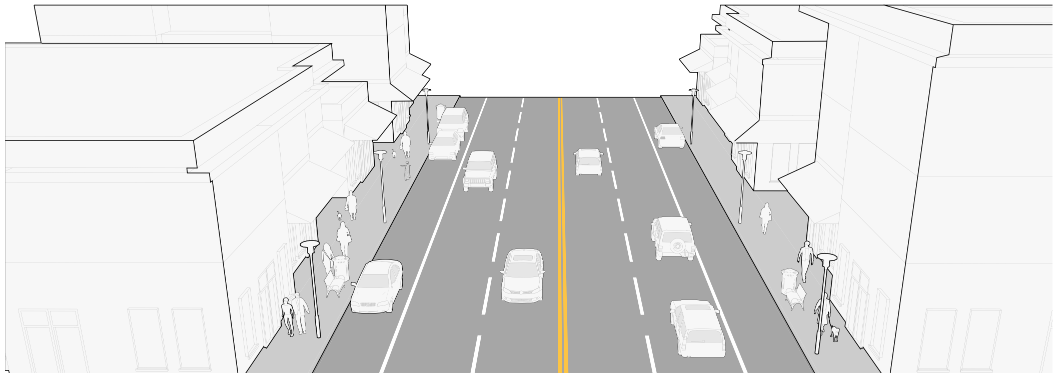
+ Motor vehicle travel lanes as narrow as 10 feet are allowed in low-speed environments (45 mph or less) according to the AASHTO Green Book.
+ 10-foot travel lanes are not appropriate on 4-lane undivided arterial roadways.

REFERENCES

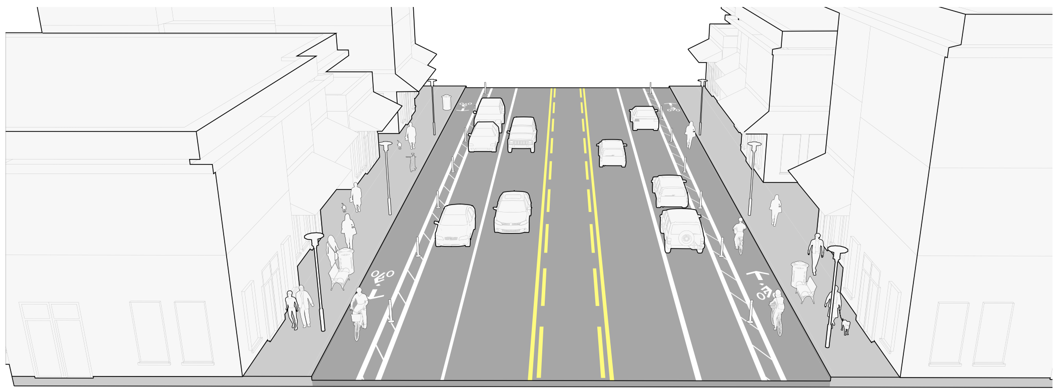
FHWA Achieving Multimodal Networks (2016)

ROAD DIETS AND LANE RECONFIGURATION

A road diet is a reduction in overall roadway width, typically accomplished by removing motor vehicle travel lanes. This strategy can be applied broadly to a wide variety of cross sections where one or more travel lanes are repurposed to provide more space for pedestrians and bicyclists. Road diets are most typically done on roadways with excess capacity where anticipated traffic volumes have not materialized to support the need for additional travel lanes.



Typical 4-lane Road with on-street parking



Three-lane Road Diet (with center two-way left-turn lane), with on-street parking and separated bicycle lane

CONSIDERATIONS

The most common road diet configuration involves converting a four-lane road to three lanes: two travel lanes with a turn lane in the center of the roadway. The center turn lane at intersections often provides a great benefit to traffic congestion. A three-lane configuration with one lane in each direction and a center turn lane is often as productive (or more productive) than a four-lane configuration with two lanes in each direction and no dedicated turn lane.

The space gained for a center turn lane is often supplemented with painted, textured, or raised center islands. If considered during reconstruction, raised center islands may be incorporated in between intersections to provide improved pedestrian crossings, incorporate landscape elements and reduce travel speeds.

REFERENCES

FHWA Road Diet Informational Guide (2014)

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (2009)

GUIDANCE

+ Four-lane streets with volumes less than 15,000 vehicles per day are generally good candidates for four- to three-lane conversions.
+ Four-lane streets with volumes between 15,000 to 20,000 vehicles per day may be good candidates for four- to three-lane conversions. A traffic analysis is needed to determine feasibility.
+ Six-lane streets with volumes less than 35,000 vehicles per day may be good candidates for six- to four-lane (with center turn lane) conversions. A traffic analysis is needed to determine feasibility.

Roadway configurations with two travel lanes and a center turn lane can:

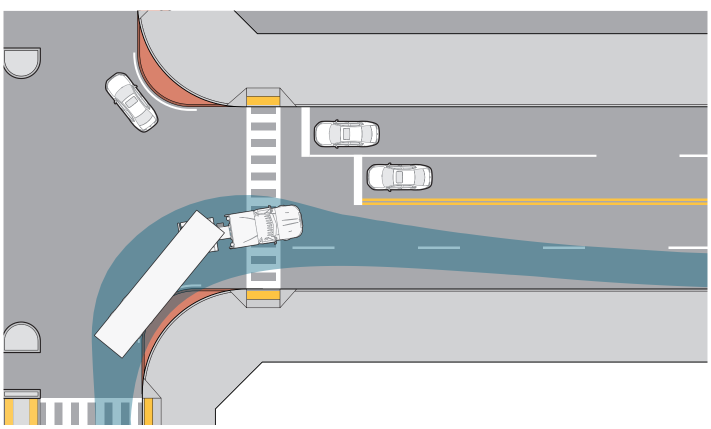
+ Discourage speeding and weaving.
+ Reduce the potential for rear end and side swipe collisions.
+ Improve sight distances for left-turning vehicles.
+ Reduce pedestrian crossing distances and exposure to motor vehicle traffic.

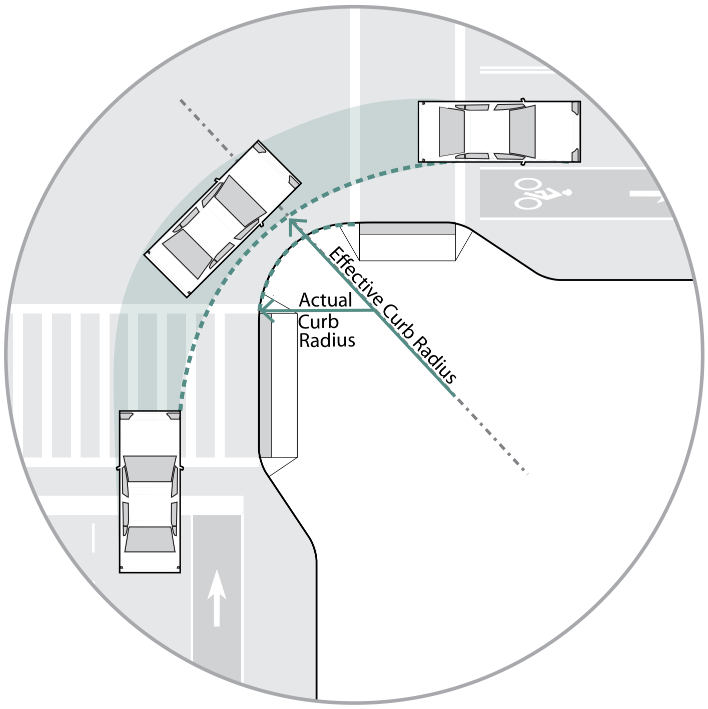
CORNERS & CURB RADII

Pedestrian safety and comfort is enhanced by smaller curb radii, which shorten crossing distances for pedestrians and reduce vehicle speeds in turn. However, streets must accommodate large turning vehicles, including school buses and transit vehicles. One of the most challenging aspects of intersection design is to determine methods of accommodating large vehicles while keeping intersections as compact as possible. This requires a great deal of design flexibility and engineering judgment, as each intersection is unique in terms of the angles of the approach and departure, the number of travel lanes, the presence of a median, and a number of other features that fundamentally impact corner design.

CONSIDERATIONS

- On-street parking and bicycle lanes may provide the larger effective radii to accommodate the appropriate design vehicle.
- At signalized intersections where additional space is needed to accommodate turning vehicles, consideration can be given to recessing the stop bar on the receiving street to enable the vehicle to use the entire width of the receiving roadway (encroaching on the opposing travel lane).
- A compound curve can be used to vary the actual curb radius over the length of the turn so that the radius is smaller as vehicles approach a crosswalk and larger when making the turn.
- In some cases where there are alternative access routes, it may be possible to restrict turning movements by large vehicles (via signage) at certain intersections and driveways to enable tighter curb radii. Turn restrictions and alternate access routes should be properly signed and locally approved.
- On low-volume (less than 4,000 vehicles per day), two-lane streets, corner design should assume that a large vehicle will use the entire width of the departing and receiving travel lanes, including the oncoming traffic lane.
- At signalized intersections, corner design should assume that a large vehicle will use the entire width of the receiving lanes on the intersecting street.
- In some cases, it may be possible to allow a large turning vehicle to encroach on the adjacent travel lane on the departure side (on multi-lane roads) to make the turn.
- Mountable truck aprons deter passenger vehicles from making higher-speed turns, but accommodate the occasional large vehicle without encroachment or off-tracking into pedestrian areas. Mountable truck aprons should be visually distinct from the adjacent travel lane and sidewalk.





GUIDANCE

- The design vehicle should be selected according to the types of vehicles using the intersection with considerations to relative volumes and frequencies. In most cases, the curb radii are based on a Single Unit vehicle with a 42' turning radius. If accommodations are needed for a larger design vehicle, a radius evaluation based on this larger vehicle would be required. Examples of typical turning templates include SU, WB-40, WB-50, WB-60 and WB-62.
- Intersection design should strive for the minimum curb radius that accommodates a frequent design vehicle.

Functional Classification	Local	Collector	Arterial
Local	15' (20')	20' (30')	25' (30')
Collector	20' (30')	25' (40')	30' (40')
Arterial	25' (30')	30' (40')	40' (50')

Note: xx' (xx') = minimum (maximum)

REFERENCES

City of Colorado Springs Traffic Criteria Manual (2010)

NACTO Urban Street Design Guide (2013)

BIKE PARKING

Bicycle parking enhances the usefulness of bicycle networks by providing locations for the secure storage of bicycles during a trip. Bicycle parking enables bicyclists to secure their bicycles while enjoying the offerings of a street or patronizing businesses and destinations in the city. Bicycle parking requires far less space than automobile parking-- in fact, 10 bicycles can typically park in the area needed for a single car. The most common means of providing bicycle parking is with bicycle racks and bicycle corrals.

CONSIDERATIONS

Bicycle parking consists of a rack that supports the bicycle upright and provides a secure place for locking. Bicycle racks should be permanently affixed to a paved surface. Movable bicycle racks are only appropriate for temporary use, such as at major community gatherings.

On-street bicycle parking is intended for short-term use. Bicyclists parking overnight should utilize off-street bicycle parking facilities. Bicyclists typically find a variety of fixed objects in the street to which they lock their bicycles. These include parking meters, tree well fences, lawn fences or other objects. These objects may satisfy the need for bicycle parking, but if this is the intent, they should be designed and located with this use specifically in mind. Otherwise, the use of such objects for parking may indicate insufficient or inappropriately located bicycle parking facilities.

GUIDANCE

+ Bicycle racks should provide two points of support for bicycles to prevent locked bicycles from falling over.
+ Bicycle rack footings can be mounted in soil, concrete, or asphalt, or mounted to stable surfaces using anchors.

REFERENCES

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (2009)

APBP Bicycle Parking Guidelines (2010)

APBP Essentials of Bike Parking: Selecting and Installing Bike Parking that Works (2015)

MAINTENANCE

Bicycle facilities require routine maintenance to ensure they provide safe bicycling conditions. Because they are typically located on the edge of the roadway, bicycle facilities are more likely to accumulate debris in all seasons. Maintenance activities should include removal of debris and snow, as well as regular reapplication of pavement markings.

CONSIDERATIONS

+ The development of a formal maintenance policy to guide maintenance activities can aid agencies in making cost-effective maintenance decisions. Having a formal policy for bicycle facility maintenance can also reduce an agency's exposure to liability, as long as an agency develops an appropriate program to implement the policy.
+ During the freeze/thaw cycles of the winter months, bike lanes are particularly susceptible to icing. As bicyclists may be prevented by the facility's design from exiting bike lanes, they may have no opportunity to avoid obstacles such as debris, obstructions, slippery surfaces, and pavement damage and defects.
+ Well-designed bikeways can reduce maintenance costs by ensuring bicycle facilities are well constructed and easily accessed by maintenance crews and equipment.
+ Local climate will affect maintenance activities significantly and should be taken into account when designing facilities and planning for their maintenance. Bicycle facility designs in Colorado should account for snow storage. Walls, buildings, trees, or other objects that cast shadows across bicycle facilities may require additional maintenance effort in winter to keep facilities free of ice and snow. These situations should be taken into account in the planning process.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities

FHWA Separated Bike Lane Planning and Design Guide (2015)