## Solano Active Transportation

#### Appendices

C: Pedestrian and Bicycle Design Treatments Toolkit

## SOLANO ACTIVE TRANSPORTATION PLAN TREATMENT TOOLKIT - DRAFT





October 2018

**TOOLE** DESIGN

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## INTRODUCTION

The purpose of the toolkit is to provide an array of options to engineers, planners, and community members. It is primarily developed to provide an overview of the possible facility recommendations that could be proposed in the Plan. It provides a description of the treatments, their application, and considerations for their use in various contexts. The toolkit is not intended to take the place of design standards prepared by the Solano Transportation Authority or Caltrans.

Key principles assumed in the toolkit are that:

- + The bicycling and walking networks should accommodate people of all ages and abilities.
- + Bicycle travel on all streets should be safe, continuous, direct, and convenient.
- + The pedestrian network should not only be safe, but also attractive and dignified.

## **SECTION 1: NATIONAL STANDARDS & RESOURCES**

The bicycle facilities and amenities included in this toolkit are based on the recommendations from the following state and national standards and resources:



#### **Federal Highway** Administration (FHWA)

Separated Bike Lane Planning and Design Guide, 2015

#### **California Department of Transportation (Caltrans)**

Highway Design Manual, 2006

#### **California Department of Transportation (Caltrans) Class IV Bikeway Guidance**

(Separated Bikeways/Cycle Tracks), 2018



#### **California Department of Transportation (Caltrans)**

Manual on Uniform Traffic Control Devices, 2014



#### **Massachusetts Department of** Transportation (MassDOT)

Separated Bike Lane Planning & Design Guide, 2016



#### National Association of City Transportation Officials (NACTO)

Urban Street Design Guide, 2013 Transit Street Design Guide, 2017 Urban Bikeway Design Guide, 2012

#### Guide for the Development of **Bicucle Facilities** 2012 • Fourth Edition



#### **American Association of State Highway and Transportation Officials (AASHTO)**

Guide for the Development of Bicycle Facilities, 2012 Will be updated with a new edition in 2018

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## SECTION 1: NATIONAL STANDARDS & RESOURCES

The pedestrian facilities and amenities included in this toolkit are based on the recommendations from the following state and national standards and resources:



**United States Access Board** 

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way, 2015 Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines

UNITED STATES ACCESS BOARD

United States Access Board

Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, 2004



Federal Highway Administration (FHWA)

Manual on Uniform Traffic Control Devices, 2009



Federal Highway Administration (FHWA)

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations, 2005



Federal Highway Administration (FHWA)

Safe Transportation for Every Pedestrian Page Intentionally left Blank

## SECTION 2: BICYCLE TREATMENTS



## **POTENTIAL BICYCLE USERS**

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#### **Types of Cyclists**

The figure below illustrates a typical range of cyclists. Estimates show the greatest percentage of the population-approximately 51%-fall into the "Interested but Concerned" category. The "Interested but Concerned" are most comfortable cycling separated from motorized vehicles. On the other end of the spectrum, roughly 4% of the population is "Strong and Fearless", comfortable sharing the road with motorized vehicles. In the middle, approximately 5% are "Enthusiastic and Confident", comfortable cycling for short distances with motorized vehicles. The remaining portion of the population falls under the category of "Non-Bicyclists", uncomfortable bicycling in any condition, have no interest in bicycling, or are physically unable to bicycle. See pages 9-10, Bikeway Facilities Selection Chart, to determine which facility types best serve the different types of cyclists.

#### Who are they?

00 0x

A mother and daughter who enjoy Saturday rides to the park along the Alamo Creek Bike Path that runs near their house. Concern over crossing a busy road prevents them from riding together to elementary school during the

### Who are they?

A 45-year-old father of two who was just diagnosed with pre-diabetes. His doctor encouraged him to be more active, so he's been thinking about commuting to work by bike. As a motorist, he feels uncomfortable passing bicyclists, so he isn't sure he'd feel comfortable as a bicyclist sharing the road with cars.

#### Who are they?

A worker who just started a new job at Kaiser Permenente. He enjoys riding as long as he stays on guiet streets or the sidewalk. He'd like to be able to ride to more destinations, but he's uncomfortable crossing busy roads and intersections along the way.



#### REFERENCES

· Speed thresholds based on Level of Traffic Stress. "Interested but Concerned" riders are sensitive to increases in volume or speed. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

## **POTENTIAL BICYCLE USERS**



#### Who are they?

A woman who rides her bike downtown every morning to run errands. She prefers to ride on neighborhood streets, but doesn't mind riding the last few blocks on a busy street since there's a bike lane.

#### Who are they?

A lower-income resident who rides a biσ cycle to save money for other household expenses. He's comfortable riding on Tabor Avenue because it has bike lanes.



#### Who are they?

an

Strong

A recent Solano Community College grad who can't wait to hit the road this weekend for a 100-mile ride on his brand new road bike. He helped pay his way through college as a bike messenger, and loves the rush that he gets from racing.

#### **HIGHER STRESS** TOLERANCE

## **BICYCLE FACILITY SELECTION**

#### Designing for Interested but Concerned and Enthusiastic 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 the operating environment for this bicyclist type at different roadway speeds and traffic volumes. The "enthusiastic and confident" bicyclist will also prefer bikeway treatments noted in this chart. If a community's goal is to increase bicycling, it is appropriate to select facility types based on this chart.



Source: AASHTO Guide for the Development of Bicycle Facilities, 5th Edition (expected publication 2019).

\* 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.

#### FACILITY DETAILS:

- Physically separated facility:
  - Separated bike lane or shared-use path, separated from traffic by parking, posts, curb, etc.
  - For two-way facility: 10 to 12 ft preferred, 8 ft minimum
- Bike lane: 5 to 7 ft
- Buffered bike lane: 8 to 9 ft total

#### **CHART REFERENCES**

- Transitions are based on a shift in the 2010 Highway Capacity Manual (HCM 2010) bike Level of Service (LOS) 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 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. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

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## **BICYCLE FACILITY SELECTION**

#### **Shoulder Widths for Rural Roadways**

When selecting a minimum shoulder width to accommodate bicyclists, the decision should be based on traffic volumes and posted speeds in the rural context. For the purposes of determining the appropriate shoulder width, it is assumed that posted speeds are approximately the same as operating speeds. If operating speeds differ from posted speeds, then operating speed should be used instead of posted speed.



#### Notes

- 1 This chart assumes the project involves reconstruction or retrofit in constrained conditions. For new construction, follow recommended shoulder widths in the AASHTO Green Book.
- 2 A separated shared use pathway is a suitable alternative to providing paved shoulders.
- 3 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.
- 4 If the percentage of heavy vehicles is greater than 10%, consider providing a widel shoulder or a separated pathway.

#### **CHART REFERENCE**

- Transitions are based on a snitt in the 2010 Highway Capacity Manual (HCM 2010) Dike Level of Service (LOS) 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 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. Source: Dill, J. McNeil, N. "Revisiting the Four Types of Cyclists: Findings from a National Survey" Transportation Research Board 95th Annual Meeting, 2016.

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## **BICYCLE FACILITY TYPES**



## **MULTI-USE PATHS (CLASS I)**

A multi-use path is a two-way facility physically separated from motor vehicle traffic and used by bicyclists, pedestrians, and other non-motorized users. Multi-use paths are often located in an independent alignment, such as a greenbelt or abandoned railroad. However, they are also regularly constructed along roadways; often bicyclists and pedestrians will have increased interactions with motor vehicles at driveways and intersections on these "multi-use paths."

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. Another example would be when the path is shared by multiple user types such as roller bladers, skateboarders, or dogs on leashes. By widening the path to provide space to accommodate passing movements, conflicts can be reduced.



Multi-use path with combined pedestrian and bicycle traffic

Bike path with adjacent pedestrian path

#### APPLICATION

• Many people express a strong preference for the separation between bicycle and motor vehicle traffic provided by paths when compared to on-street bikeways. Multi-use paths 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. However, multi-use paths may present increased conflicts between path users and motor vehicles at intersections and driveway crossings. Conflicts can be reduced by minimizing the number of driveway and street crossings present along a path and otherwise providing high-visibility crossing treatments.

AASHTO. Guide for the Development of Bicycle Facilities. 2012. FHWA. Achieving Multimodal Networks. 2016. FHWA. Shared-Use Path Level of Service Calculator. 2006. Manual on Uniform Traffic Control Devices. 2009.

#### CONSIDERATIONS

- Typical path width shall be 12 feet wide with 3 foot shoulders on each side. This width allows users to pass one another with minimal conflict.
- Path clearances are an important element in path design and reducing user conflicts. Vertical objects close to the path edge can endanger users and reduce the comfortable usable width of the path. Along the path, vertical objects should be set back at least two feet from the edge of the path. Path shoulders may also reduce conflicts by providing space for users who step off the path to rest, allowing users to pass one another, or providing space for viewpoints.
- A path may benefit from the separation of users by user speed, type, or direction. When separating users, consider the path width and paving material preferred by each user.
- When accommodating moderate to high volumes of horse back riders, it is recommended to provide a separated unpaved equestrian/jogger path. Six feet of clearance and separation is recommended between the multi-use path and the bridle path. Elevation change between the multiuse path and the bridle path can also be considered.

## **SEPARATED BIKE LANES (CLASS IV)**

Separated bike lanes are an exclusive bikeway facility type that combines the user experience of a multi-use path with the on-street infrastructure of a conventional bike lane. They are physically separated from motor vehicle traffic and distinct from the sidewalk.



One-way sidewalk-level separated bike lane



separated bike lane



One-way street-level separated bike lane

#### APPLICATION

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

- + Traffic lanes: 3 lanes or greater.
- + Posted speed limit: 30 mph or more.
- + Traffic: 6,000 vehicles per day or greater.
- + On-Street parking turnover: frequent.
- + Bike lane obstruction: likely to be frequent.
- + Streets that are designated as truck or bus routes.

Separated bike lanes are preferred over multi-use paths in higher density areas, commercial and mixed-use development, and near major transit stations or locations where pedestrian volumes are anticipated to exceed 200 people per hour on a shared use path.

#### CONSIDERATIONS

- 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.
- Choice of one- or two-way facility should be based on connectivity, bicyclist desire lines, roadway configuration, and potential intersection conflicts. Generally, one-way facilities are preferred.

REFERENCES

Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2018. Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2015. FHWA. Separated Bike Lane Planning and Design Guide. 2015. MassDOT. Separated Bike Lane Planning and Design Guide. 2015. NACTO. Urban Bikeway Design Guide. 2nd Edition.

## **BUFFERED BIKE LANES (CLASS II)**

Buffered bike lanes are created by painting or otherwise creating a flush buffer zone between a bike lane and the adjacent travel lane. While buffers are typically used between bike lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bike 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 a curb

#### APPLICATION

Place buffered or unbuffered bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day.



Buffered bike lane adjacent to parking

#### CONSIDERATIONS

- + Typically installed by reallocating existing street space.
- + Can be used on one-way or two-way streets.
- + Consider placing buffer next to parking lane where there is commercial or metered 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.
- Buffered bike lanes allow bicyclists to ride side by side or to pass slower moving bicyclists.
- Preferable to a conventional bike lanes when used as a contra-flow bike lane on one-way streets.
- Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.

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

NACTO. Urban Bikeway Design Guide. 2nd Edition.

Portland State University, Center for Transportation Studies. Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT. 2011.

## **BIKE LANES (CLASS II)**

Bike lanes provide an exclusive space for bicyclists in the roadway. Bike lanes are established through the use of lines and symbols on the roadway surface. Bike lanes are for one-way travel and are normally provided in both directions on two-way streets or on one side of a one-way street. Bicyclists are not required to remain in a bike lane when traveling on a street and may leave the bike lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements.



Bike lane adjacent to parking



Bike lane with door zone marking

#### APPLICATION

Place bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day.

#### CONSIDERATIONS

- + Typically installed by reallocating existing street space.
- + Can be used on one-way or two-way streets.
- Contra-flow bike lanes may be used to allow two-way bicycle travel on streets designated for one-way travel for motorists to improve bicycle network connectivity.
- Consider placing bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day.
- 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.
- Bike 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.

AASHTO. Guide for the Development of Bicycle Facilities. 2012. NACTO. Urban Bikeway Design Guide. 2nd Edition. SOLANO ACTIVE TRANSPORTATION PLAN- TREATMENT TOOLKIT

## **BICYCLE BOULEVARD (CLASS III)**

Bicycle boulevards are applied on quiet streets, often through residential neighborhoods. These treatments are designed to prioritize bicycle through-travel, while calming motor vehicle traffic and maintaining relatively low motor vehicle volumes. Treatments vary depending on context, but often include elements of traffic calming, including traffic diverters, speed attenuators such as speed humps or chicanes, pavement markings, and signs. Bicycle boulevards are also known as neighborhood greenways, neighborhood bikeways, among other locally-preferred terms.



#### APPLICATION

Bicycle boulevards can generally be considered on any road with one or more of the following characteristics:

- + 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.
- Where these traffic characteristics are not already present, traffic calming and traffic diversion measures should be implemented to reach these desired thresholds.

AASHTO. Guide for the Development of Bicycle Facilities. 2012. Fundamentals of Bicycle Boulevard Planning & Design. 2009. Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Bikeway Design Guide. 2012.

#### 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.
- Stop signs or traffic signals should be placed along the bicycle boulevard in a way that prioritizes the bicycle movement, minimizing stops and delays for bicyclists whenever possible.
- Communities should begin by implementing bicycle boulevard treatments on one pilot corridor to measure the impacts and gain community support. The pilot program should include before-and-after crash studies, motor vehicle counts, and bicyclist counts on both the bicycle boulevard and parallel streets. Findings from the pilot program can be used to justify bicycle boulevard treatments on other neighborhood streets.
- Additional treatments for major street crossings may be needed, such as median refuge islands, rectangular rapid flashing beacons, bicycle signals, and HAWK or half signals.

## **RURAL BICYCLE ROUTE (CLASS III)**

In many cases, rural routes should provide shoulders to accommodate bicyclists. Shoulders are portions of the roadway that accommodate stopped or parked vehicles, emergency use, bicycles, motor scooters and pedestrians where sidewalks do not exist. This type of facility is applicable in rural areas where dedicated bikeways either will not fit on the street or would not be appropriate given the surrounding context.



APPLICATION

- Shoulder width should be at least 4 feet if the roadway is curbless and there are no vertical obstructions. If curbs or vertical obstructions are present, shoulder width should be 5 feet minimum exclusive of the gutter if present.
- Shoulders should be wider on roads with high levels of bicycle traffic to accommodate bicyclist passing and facilitate side-by-side bicycling.
- When posted speed limits or 85th percentile speeds exceed 50 mph and/or if heavy vehicles frequently use the road, shoulders should exceed minimum widths to enhance bicyclist comfort.
- The width of a shoulder with rumble strips should be measured from the rightmost side of the rumble strip. Periodic gaps should be provided to allow bicyclists to move across the strip pattern.
- + Edge line rumble strips can provide additional bicyclist space on paved shoulders.



#### CONSIDERATIONS

For roads that are unable to provide consistent and standard size bikeable shoulders in both directions, prioritize:

- The uphill direction on hilly roads to reduce conflicts between slow-moving bicyclists and fast-moving motor vehicles.
- + The inside of a horizontal curve and/or the downgrade of a vertical curve where sight distance is restricted.
- Paved shoulders should be considered on roadways popular with recreational bicyclists that have significant motor vehicle traffic during periods when recreational bicycling is known to occur.
- Bicyclists will not use a shoulder if it is covered in gravel, glass and other road debris, so regular street sweeping is important.
- In rural areas, paved shoulders can also provide space for pedestrians on roadways without sidewalks. In situations where a shoulder is intended for pedestrian use, it must meet Americans with Disabilities Act requirements to the maximum extent possible

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities (2012). FHWA. Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

## **ADVISORY BIKE LANES (CLASS III)**

Advisory bicycle lanes (ABLs) are used to create narrow streets where bicyclists are provided priority movement and motorists are compelled to yield to bicyclists as well as drivers approaching in the opposing direction. ABLs use dotted lane lines, allowing motorists to enter them to yield and are designed using dimensions based on conventional bicycle lanes. ABLs are reserved for use on low-volume, low-speed streets.



Advisory bike lane without parking



Advisory bike lane with parking

#### APPLICATION

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

- + Traffic lanes: 2 lanes or less
- + Posted speed limit: 25 mph or less
- + Traffic: 3,000 vehicles per day or less
- + On-street parking turnover: infrequent

#### CONSIDERATIONS

- + Treatment requires FHWA permission to experiment.
- + For use on streets too narrow for bike lanes and normal width travel lanes.
- To reduce motorist speeds, and to encourage yielding, the unmarked space between the two advisory bike lanes should be no wider than 18 feet.
- This treatment should only be used on streets with >60% continuous daytime parking occupancy.
- Where parking occupancy is continuously <50%, it is preferable to consolidate it to one side of the street or remove it.
- + A Two-Way Traffic warning sign (W6-3) may increase motorists understanding of the intended two-way operation of the street.

REFERENCE

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

 $http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/dashed_bike_lanes.cfm$ 

## **BICYCLE INTERSECTION DESIGN & SPOT TREATMENTS**



### **BIKE BOXES**

A bike box provides dedicated space between the crosswalk and vehicle stop line where bicyclists can wait during the red light at signalized intersections. The bike 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 left turning maneuvers at the intersection, and provide more queuing space for multiple bicyclists than that provided by a typical bike lane.



#### APPLICATION

 Applicable wherever a bike route requires a left turn at a signalized intersection or there is a desire for bicyclists to enter and clear the intersection ahead of vehicle traffic.

#### CONSIDERATIONS

- In locations with high volumes of turning movements by bicyclists, a bike box should be used to allow bicyclists to shift towards the desired side of the travel way. Depending on the position of the bike lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.
- In locations where motor vehicles can continue straight or cross through a right-side bike lane while turning right, the bike box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning vehicle. When a bike box is implemented in front of a vehicle lane that previously allowed right turns on red, the right turn on red movement must be restricted using signage and enforcement once a bike box is installed.
- A bicycle box should only extend across one travel lane. Bicycle boxes should not be used to facilitate bicycle left turns. A two-stage turn queue box is the preferred method of accommodating left turns."

FHWA. Separated Bike Lane Planning and Design Guide. 2015. MassDOT. Separated Bike Lane Planning & Design Guide. 2016. NACTO. Urban Bikeway Design Guide - Bike Boxes. 2012.

REFEREN

## **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 only appropriate 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.
- + This type of conflict marking is not commonly used in California.

#### **GUIDANCE**

- 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.
- 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

REFERENCES

- 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.

FHWA. Separated Bike Lane Planning and Design Guide. 2015. MassDOT. Separated Bike Lane Planning and Design Guide. 2015. NACTO. Urban Bikeway Design Guide. 2012.



## **TWO-STAGE TURN BOX**

The two-stage turn box designates a space for bicyclists to wait while performing a two-stage turn across a street at a location outside the path of traffic. Two-stage turn queue boxes may be used with any type of bicycle facility. A two-stage turn queue box should be considered where separated bike lanes are continued up to an intersection and a protected intersection is not provided.



#### APPLICATION

 Two stage turn boxes are applicable at locations where a left turn movement is expected by bicyclists. These are preferred where a bicyclist would have to cross over more than one lane of traffic to make a left turn or in-street rail tracks (e.g. streetcar).

#### CONSIDERATIONS

- + This treatment has been granted interim approval by FHWA and Caltrans.
- Two-stage turn 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 (the crosswalk location may need to be adjusted), in a 'jughandle' configuration within a sidewalk, or at the tail end of a parking lane or a median island.
- + A minimum width of 10 feet is recommended for the box.
- + A minimum depth of 6.5 feet is recommended for the box.
- + Dashed bike lane extension markings may be used to indicate the path of travel across the intersection.

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

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

## SEPARATED BIKE LANES AT INTERSECTIONS

Separated bike lanes provide an exclusive travel way for bicyclists alongside roadways that is separate from motor vehicle travel lanes, parking lanes, and sidewalks. Separated bike lane designs at intersections should manage conflicts with turning vehicles and increase visibility for all users.



#### APPLICATION

- At major intersections where space is available, protected intersection designs are preferred because they are intuitive and comfortable, provide clear right-of-way assignment, promote predictability of movement, and allow eye contact between motorists, bicyclists, and pedestrians.
- Corner refuge islands allow the bike lane to be physically separated up to the intersection crossing point where potential conflicts with turning motorists can be controlled more easily. It serves an important purpose in protecting the bicyclist from right-turning motor vehicle traffic.

#### CONSIDERATIONS

- All intersection designs should provide adequate sight distance. Recessed crossings should be considered at all intersection crossings: streets, driveways or alleys. The recessed crossing creates space for motorist yielding before crossing the bike facility."
- The operation of one-way separated bike lanes is similar to the normal vehicle operations, which simplifies signal operations.
- Where two-way separated bike lanes are installed on one side of the street, the contra-flow direction of bicycle travel introduces an unexpected movement at the intersection and requires more complex signal operations.

Bicycle Facilities and the Manual on Uniform Traffic Control Devices. FHWA. Separated Bike Lane Planning and Design Guide. 2015. NACTO. Urban Bikeway Design Guide. 2012.

## SEPARATED BIKE LANES AT ROUNDABOUTS

When separated bike lanes are provided at roundabouts, they should be continuous around the intersection and parallel to the sidewalk. Separated bike lanes should generally follow the contour of the circular intersection.



#### APPLICATION

 Separated bike lanes are applicable at all roundabouts. This treatment reduces conflict and places bicyclists in more predictable and visible positions.

MassDOT. Separated Bike Lane Planning & Design Guide. 2016.

#### CONSIDERATIONS

At crossing locations of multi-lane roundabouts or roundabouts where the exit geometry will result in faster exiting speeds by motorists (thus reducing the likelihood that they will yield to bicyclists and pedestrians), additional measures should be considered to induce yielding such as providing an actuated device such as a Rectangular Rapid Flashing Beacon or Pedestrian Hybrid Beacon.

- + The bicycle crossing should be immediately adjacent to and parallel with the pedestrian crossing, and both should be at the same elevation.
- The separated bike lane approach to the bicycle crossing should result in bicyclists arriving at the queuing area at a perpendicular angle to approaching motorists.
- + Consider providing supplemental yield lines at roundabout exits to indicate priority at these crossings.
- The decision of whether to use yield control or stop control at the bicycle crossing should be based on available sight distance.
- + Channelizing islands are preferred to maintain separation between bicyclists and pedestrians, but may be eliminated if different surface materials are used.

FREN

## **CONFLICT AREA MARKING**

Intersection pavement markings are designed to improve visibility, alert all roadway users of expected behaviors, and to reduce conflicts with turning vehicles. They may be used with any Class II or Class IV bike lane across driveways, through intersections, or in separated bike lane mixing zones.



Colored Dash



#### APPLICATION

- A variety of pavement marking symbols can enhance intersection treatments to guide bicyclists and warn of potential conflicts.
- Green pavement markings may be applied in a solid or dashed pattern within a dashed bicycle lane to indicate conflict areas and where merging maneuvers are permitted, such as across intersections, driveways, and at STOP or YIELD-controlled cross-streets.
- Dashed 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 documented conflicts and safety concerns.

#### CONSIDERATIONS

- + Symbol placement within intersections should consider vehicle wheel paths to minimize maintenance.
- + Driveways with higher volumes may require additional pavement markings and signage.
- Consideration should be given to using intersection pavement 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.

AASHTO Guide for the Development of Bicycle Facilities. 2012.
Caltrans. Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2018.
FHWA Memorandum – Interim Approval for Optional Use of Green Colored Pavement for Bike Lane. 2011.
FHWA. Separated Bike Lane Guide.
Manual on Uniform Traffic Control Devices. 2009.

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NACTO. Urban Bikeway Design Guide. 2012.

## DRIVEWAYS

Most bicycle facilities will need to cross streets, driveways, or alleys at multiple locations along a corridor. At these locations, the crossings should be designed to 1) delineate a preferred path for people bicycling through the intersection and 2) to encourage driver yielding behavior, where applicable. Bicycle crossings may be supplemented with green pavement, yield lines, and/or regulatory signs.



#### APPLICATION

+ Whenever a bicycle lane intersects with a high traffic driveway special treatment should be taken to reduce conflict.

### FHWA. Separated Bike Lane Planning and Design Guide. 2015. MassDOT. Separated Bike Lane Planning & Design Guide. 2016.

#### CONSIDERATIONS

- Supplemental yield lines, otherwise known as shark's teeth, can be used to indicate priority for people bicycling and may be used in advance of unsignalized crossings at driveways, at signalized intersections where motorists may turn across a bicycle crossing during a concurrent phase, and in advance of bicycle crossings located within roundabouts.
- Raised bicycle crossings further promote driver yielding behavior by slowing their speed before the crossing and increasing visibility of people bicycling.
- The bicycle crossing should be a minimum of 6 feet wide for one-way travel and 10 feet wide for two-way travel, as measured from the outer edge of the elephant's feet. Bicycle lane symbol markings should be avoided in bicycle crossings. Directional arrows are preferred within twoway bicycle crossings. Two-way crossings should also be indicated with warning signage for drivers entering and exiting the driveway.
- Dashed green-colored pavement may be used in the bicycle crossing to increase the visibility of the crossing where permitted conflicts occur. Green color may be desirable at crossings where concurrent vehicle crossing movements are allowed and where sightlines are constrained, or where motor vehicle turning speeds exceed 10 mph.

## **TRUCK APRONS**

In locations where large vehicles make occasional turns, designers can consider mountable truck aprons. Mountable truck aprons deter passenger vehicles from making higher-speed turns, yet accommodate the occasional large vehicle without encroachment or off-tracking into pedestrian waiting areas. Mountable truck aprons should be visually distinct from the adjacent travel lane and sidewalk.



#### **APPLICATION**

- Mountable truck aprons are a solution that can reduce turning speeds for passenger vehicles while accommodating the offtracking of larger vehicles where a larger corner radius is necessary.
- While bicyclist and pedestrian safety is negatively impacted by wide crossings, bicyclists and pedestrians are also at risk if the curb radius is too small. Curb radii that are too small for large vehicles to navigate can result in the rear wheels of a truck tracking over queuing areas at the corner. Maintenance problems are also caused when trucks must regularly drive over street corners to make turns.

#### CONSIDERATIONS

- Mountable truck aprons are part of the traveled way and as such should be designed to discourage pedestrian or bicycle refuge.
- Bicycle stop bars, detectable warning panels, traffic signal equipment and other intersection features must be located behind the mountable surface area.
- + The mountable surface should be visually distinct from the adjacent travel lane, sidewalk and separated bike lane.
- The heights of mountable areas and curbs should be no more than 3 inches above the travel lane to accommodate lowboy trailers.

FHWA. Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts. 2016. MassDOT Separated Bike Lane Planning & Design Guide. 2016. Page Intentionally left Blank

## FACILITY IMPLEMENTATION STRATEGIES



## 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.



APPLICATION

- 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 recommended on 4-lane undivided arterial roadways, but may be considered where speeds are 30 mph or less and truck use is low

#### 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.

#### AASHTO. Green Book. 2011.

FHWA. Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

## LANE RECONFIGURATION (ROAD DIET)

Road diets are the reconfiguration of one or more travel lanes to calm traffic and provide space for bicycle lanes, turn lanes, streetscapes, wider sidewalks, and other purposes. Four- to three-lane conversions are the most common road diet, however, there are numerous types (e.g., three- to two-lanes, or five- to three-lanes).



Typical 4-lane road with onstreet parking

Three-lane road diet (with center two-way left-turn lane), with on-street parking and separated bicycle lanes



#### APPLICATION

 Lane reconfiguration is a great tool for reducing collisions and injuries, improving pedestrian crossings and providing designated space for bicyclists. Road diets improve safety as they reduce conflict points and lead to fewer and less severe collisions.

#### CONSIDERATIONS

- Four-lane streets with volumes less than 15,000 vehicles per day are generally good candidates for four- to threelane conversions.
- Four-lane streets with volumes between 15,000 to 20,000 vehicles per day may be good candidates for four- to threelane 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 five-lane (including two-way center turn lane) conversions. A traffic analysis is needed to determine feasibility.

Dr. Ata M. Kahn, P.E., ITE Journal, Washington, D.C. FHWA Road Diet Guide. 2014. NACTO Urban Street Design Guide .2013.

## **EVOLUTION OF A BIKE LANE**

Separated bike lanes have been implemented in many cases as low-cost retrofit projects (e.g. using flex posts and paint within the existing right-of-way). More permanent forms of separation, such as curb-protected bike lanes, cost more and are less flexible once implemented. A phased implementation approach, where "pilot" projects transition to permanent protected bike lanes may solve both of these problems, by implementing the facility slowly and troubleshooting before permanent materials and high costs are necessary.



#### CONSIDERATIONS

Lower-cost retrofits or demonstration projects allow for quick implementation, responsiveness to public perception and ongoing evaluation. Separation types for short-term separated bike lane designs often include non-permanent separation, such as flexible delineator posts, planters or parking stops. Pilot projects allow the agency to:

- Test the separated bike lane configuration for bicyclists and traffic operations
- + Evaluate public reaction, design performance, and safety effectiveness
- Make changes if necessary
- + Transition to permanent design

#### GUIDANCE

 Permanent separation designs provide a high level of protection and often have greater potential for placemaking, quality aesthetics, and integration with features such as green stormwater infrastructure. Agencies often implement permanent separation designs by leveraging private development (potentially through developer contribution), major capital construction, and including protected bike lanes in roadway reconstruction designs. Examples of permanent separation materials include rigid bollards, raised medians and grade-protected bike lanes at an intermediate or sidewalk level.

REFERENCES

FHWA. Separated Bike Lane Planning and Design Guide. 2015. NACTO. Urban Street Design Guide. 2013.

## **DEMONSTRATION PROJECTS**

Demonstration projects can be effective ways to introduce new infrastructure treatments and test alternative designs with minimal levels of investment. Typically, demonstration projects are planned with a definite life span (such as two weeks to three months) and usually occur during warm-weather months when bicycle ridership is highest. The planned duration of a demonstration determines the level of detail and needed durability of materials used.



This two-way separated bike lane was installed on S. Broadway in Denver as a demonstration project.

#### CONSIDERATIONS

Demonstration projects provide an opportunity for agencies to test various bicycle facility design configurations and gauge public acceptance of the installation. These types of projects should be implemented in areas with known bicycle activity, where the demonstration project is likely to seen frequent use by bicyclists.

Gathering public input on the project is an important step in the demonstration project process. Websites can be useful tools to solicit feedback through surveys or other interactive forums.

Temporary installations should be designed to be as attractive as possible in order to dissuade feedback based primarily on the aesthetics, rather than the merits, of the project.

#### GUIDANCE

- The bicycle facility design used in a demonstration project should closely resemble the design that would be implemented in a permanent installation. This consistency is important when gauging public support and setting community expectations.
- Many demonstration projects are constructed using temporary materials such as flex posts or moveable planter boxes. Using cost-efficient materials allows for easy modification during testing. If the design is later made permanent, materials such as concrete curbing or irrigated planter boxes may be used instead.

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## SUPPORTIVE AMENITIES



## **BICYCLE ROUTING / DESTINATION WAYFINDING**

Wayfinding is a highly visible way to improve bicycling in an area because it helps identify the best routes to destinations, helps people overcome a barrier of not knowing where to ride, and reminds motorists to anticipate the presence of bicyclists. A wayfinding system typically combines signage and pavement markings to guide bicyclists along preferred routes to destinations across the community, county, or region. The routes may or may not be numbered, named, or color-coded. Signs may also indicate distances or travel time to destinations. Similar wayfinding systems can be devised for pedestrian travel.



#### APPLICATION

- Basic bicycle route signs consist of a MUTCD-style "Bike Route" sign (D11-1 shown above) placed every half mile on a bike route and on the approach to bike routes at decision points. Unique numbered or named routes can be designated and can incorporate a route name or agency logos.
- Bike route signs can be supplemented with "fingerboard" panels showing destinations, directions, and distances (MUTCD D1 series, shown in photo).
- + Place directional signs on the near side of intersections and confirmation signs on the far side of intersections.



#### CONSIDERATIONS

A bicycle wayfinding protocol should coordinate with bicycle route maps and provide three general forms of guidance:

- Decision assemblies, which consist of Bike Route identification and optional destination fingerboards, placed at decision points where routes intersect or on the approaches to a designated bike route.
- + Turn assemblies, which consist of Bike Route panels and arrow plaques, placed where a designated bike route turns from one street to another.
- Confirmation assemblies, which consist of Bike Route panels and optional destination fingerboards, placed on the far side of intersections to confirm route choice and the distance (and optionally, time) to destinations.

Sign design can be customized to add distinct community branding, but the clarity and accuracy of the information must be the top priority.

Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Bikeway Design Guide. 2012.

## **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.



#### **APPLICATION**

- A stationary, or "standing", cyclist entering the intersection at the beginning of the green indication can typically be accommodated by increasing the minimum green time on an approach per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- A moving, or "rolling", bicyclist approaching the intersection towards the end of the phase can typically be accommodated by increases to the red times (change and clearance intervals) per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- 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.

#### CONSIDERATIONS

- Bicycle-specific signals may be appropriate to provide additional guidance or separate phasing for bicyclists per the 2012 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 alternate 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. Several cities including Portland, OR and San Francisco, CA have implemented "green waves" for bicycles.

AASHTO. Guide for the Development of Bicycle Facilities. 2012. Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Bikeway Design Guide. 2012.

## SHORT-TERM BICYCLE PARKING

Bicycle parking enhances the effectiveness of bicycle networks by providing locations for the secure storage of bicycles during a trip. Bicycle parking enables bicyclists to secure their bicycles while patronizing businesses, recreating, and going to work. Bicycle parking requires far less space than automobile parking-- in fact, 10 bicycles can typically park in the area needed for a single car.



#### **APPLICATION**

 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.



- Bicycle parking facility should not obstruct pedestrian traffic or interfering with the use of the pedestrian areas.
- Each parked bicycle should be accessible without moving another bicycle.
- + On-street bicycle parking is intended for short term use.
- Multiple types of racks exist, but all should adhere to guidance pictured above regarding providing two points of contact for bike frame to prevent bikes from falling.

REFERENCES

Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Street Design Guide. 2013.



## LONG-TERM BICYCLE PARKING

Long-term bicycle parking is intended to provide sheltered and secure bicycle storage for residents, employees and longterm visitors who are leaving their bicycles in a residential or commercial building for several hours or longer and therefore need their bicycles to be protected from vandalism, theft and the elements.



#### APPLICATION

Lockers should be:

- + Clearly marked as a long-term bicycle parking space.
- + Located no lower than the first complete parking level below grade, and no higher than the first complete parking level above grade.
- Available and accessible to all building tenants during the buildings hours of operation and at all times for residents in residential contexts.
- + Located in a well-lit, visible location near the main entrance or elevators.
- Separated from vehicle parking by a barrier that minimizes the possibility of a parked bicycle being hit by a car.
- + Securely anchored.
- + Well-maintained and well lit.

Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Street Design Guide. 2013.

#### CONSIDERATIONS

A bicycle locker is a secure, locked box that stores a single bicycle and provides:

- + Highly secure bicycle storage in an enclosed box.
- Direct or indirect access to the street or sidewalk depending on whether it is located in a parking garage or at street level.
- + Varying amount of conflict with automobiles depending on whether it is located in a parking garage or at street level.
- Long-term bicycle parking can also be provided indoors. This can be located within businesses or offered as a locked public facility, accessible with the same key card technology as bicycle lockers.

## SECTION 3: PEDESTRIAN TREATMENTS



# PEDESTRIAN FACILITIES & AMENITIES



## **ELEMENTS OF A STREETSCAPE**

Sidewalks play a critical role in the character, function, enjoyment, and accessibility of neighborhoods, main streets, and other community destinations. In addition to providing space for pedestrians separated from motor vehicles, the space between property lines and curbs also accommodates street trees and other plantings, stormwater infrastructure, street lights, and bicycle racks. This section defines those zones and provides considerations for better activating the streetscape to enhance peoples' experiences.

#### ZONES

#### Frontage Zone:

The Frontage Zone is the area of sidewalk that immediately abuts buildings along the street. In residential areas, the Frontage Zone may be occupied by front porches, stoops, lawns, or other landscape elements that extend from the front door to the sidewalk edge. The Frontage Zone of commercial properties may include architectural features, outdoor displays, café seating, awnings, signage, etc. Frontage Zones may vary widely in width from just a few feet to several yards.

#### **Pedestrian Zone:**

Also known as the "walking zone," the Pedestrian Zone is the portion of the sidewalk space used for active travel. For it to function, it must be kept clear of any obstacles and be wide enough to comfortably accommodate expected pedestrian volumes (as anticipated by density and adjacent land use) including those using mobility assistance devices, pushing strollers, or pulling carts.

#### Amenity Zone:

The Amenity Zone, or "landscape zone," lies between the curb and the Pedestrian Zone. This area is occupied by fixtures such as street lights, trees, bicycle racks, parking meters, signposts, signal boxes, benches, trash and recycling receptacles, and other amenities. In commercial areas, it is typical for this zone to be hardscape pavement, pavers, or tree grates. In residential, or lower intensity areas, it is commonly a planted strip.

#### **CONSIDERATIONS**

- Vibrant street walls with active uses adjacent to the sidewalk are particularly valuable and are essential to Main Street contexts. Where an active use adjacent to the sidewalk is not feasible, visually engaging walls should be provided adjacent to the street.
- Outdoor dining opportunities contribute to a lively street environment and add economic value by enabling private commercial activity to spill into the public environment of the street. Sidewalk cafés are encouraged in Main Street contexts and other areas with commercial activity.
- Planting in the public right-of-way typically occurs in the Amenity Zone; however, this is not the only place that can accommodate planting. Wherever there is an opportunity for landscape features, street or development projects



Frontage, Pedestrian and Amenity Zones

should also look for opportunities to incorporate best management practices (BMPs), such as rain gardens. The preferred BMPs for use in the right-of-way are above-grade systems located within the sidewalk that treat stormwater runoff from adjacent roads and sidewalks.

- While there are some exceptions, most street furniture installation is installed in the Amenity Zone. For example, on occasion bicycle parking may be installed in the frontage zone if it is sufficiently wide enough to accommodate it. Regardless, street furniture should not impede movement in the Pedestrian Zone.
- Seating is most commonly located in the Amenity Zone of the street, but may also be placed in the Frontage Zone. Seating in the Amenity Zone should generally face away from the street and toward the sidewalk or be aligned perpendicular to the curb. Seating in the Frontage Zone should face the street.
- The Amenity Zone can also provide an emergency repository for snow cleared from streets and sidewalks, although snow storage should not impede access to or use of important mobility fixtures such as parking meters, bus stops, and curb ramps. Stormwater BMPs are commonly located in the Amenity Zone.

## **PREFERRED WIDTHS FOR SIDEWALK ZONES**

The width of the various sidewalk zones will vary given the street type, the available right-of-way, scale of the adjoining buildings and the intensity and type of uses expected along a particular street segment. A balanced approach for determining the sidewalk width should consider the character of the surrounding area and the anticipated pedestrian activities. For example, is the street lined with retail that encourages window shopping or does it connect a residential neighborhood to a commercial area where pedestrians frequently need to pass one another? Does the scale of the buildings and the character of the street indicate a need for a wider sidewalk?



Street Type	Frontage Zone	Pedestrian Zone	Amenity Zone	Preferred Total Width
	door swings, awnings, café seating, retail signage and displays, building projections	zone should be clear of any and all fixed obstacles; clear space for pedestrian travel only.	street lights and utility poles, street trees, bioyole racks, parking meters, transit stops, stormwater facilities, street furniture and signage	
Transit Station Areas	2 to 5 feet	6 to 15 feet	6 to 10 feet	14 to 30 feet
School Zones	2 to 6 feet	6 to 10 feet	6 to 10 feet	14 to 22 feet
Downtown/Urban Centers/Main Streets	2 to 6 feet	6 to 18 feet	6 to 10 feet	14 to 30 feet
Suburban Commercial	2 feet	6 to 8 feet	6 to 7 feet	14 to 17 feet
Suburban Areas/Residential Developments	2 feet	6 feet	5 to 7 feet	11 to 13 feet
Rural Areas	N/A	6 to 10 feet	5 to 10 feet	11 to 20 feet

#### CONSIDERATIONS

- In locations with severely constrained rights-of-way, it is possible to provide a narrower Frontage Zone and Pedestrian Zone. Sidewalk width is based on local context, therefore in retrofit locations where development is not occurring and where existing building are anticipated to remain, 5-foot-wide sidewalks may be adequate.
- Frontage Zones used for sidewalk cafés are a special condition and should generally be no less than 6 feet in width.
- + Where on-street parking is not present, the wider dimensions should be provided.

- + The provision of tree wells or landscape strip within the Amenity Zone will be based on the existing or planned character of the neighborhood.
- Sidewalk stormwater facilities (including rain gardens) require a minimum of 7 feet of width for the Amenity Zone. The final dimensions will be established based on the context of each landscape area. Where stormwater facilities are not provided in the Amenity Zone, this area may be at the lower end of the range.

NACTO. Urban Street Design Guide. 2013.

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

## **CURB RAMPS**

The transition for pedestrians from the sidewalk to the street is provided by a curb ramp. The designs of curb ramps are critical for all pedestrians, but particularly for people with disabilities. The ADA Standards require all pedestrian crossings be accessible to people with disabilities by providing curb ramps at intersections and midblock crossings as well as other locations where pedestrians can be expected to enter the street. Curb ramps also benefit people pushing strollers, grocery carts, suitcases, or bicycles.



#### APPLICATION

+ At all intersections where pedestrians are permitted and expected to cross the street per ADA requirements.

#### CONSIDERATIONS

- Furnishing zones or terraces (the space between the curb and sidewalk) of 7' of width provide just enough space at intersections for curb ramps to gain sufficient elevation to a sidewalk.
- Separate curb ramps should be provided for each crosswalk at an intersection rather than a single ramp at a corner for both crosswalks. The separate curb ramps improve orientation for visually impaired pedestrians by directing them toward the correct crosswalk.
- Curb ramps are required to have landings. Landings provide a level area with a cross slope of 2% or less in any direction for wheelchair users to wait, maneuver into or out of a ramp, or bypass the ramp altogether. Landings should be 5' by 5' and shall, at a minimum, be 4' by 4'.
- + Consider providing wider curb ramps in areas of high pedestrian volumes and crossing activities.
- Flares are required when the surface adjacent to the ramp's sides is walkable, however, they are unnecessary when this space is occupied by a landscaped buffer. Excluding flares can also increase the overall capacity of a ramp in highpedestrian areas.

Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011. SOLANO ACTIVE TRANSPORTATION PLAN- TREATMENT TOOLKIT

## MARKED CROSSWALKS

Legal crosswalks exist at all locations where sidewalks meet the roadway, regardless of whether pavement markings are present. Drivers are legally required to yield to pedestrians at intersections, even when there are no pavement markings. Providing marked crosswalks communicates to drivers that pedestrians may be present, and helps guide pedestrians to locations where they should cross the street. In addition to pavement markings, crosswalks may include signals/beacons, warning signs, and raised platforms.



#### **APPLICATION**

- There are many different styles of marked crosswalk striping and some are more effective than others. Ladder and continental striping patterns are more visible to drivers.
- + Raised crossings can calm traffic and increase the visibility of pedestrians.

#### CONSIDERATIONS

- + Place marked crosswalks on all legs of signalized intersections, in school zones, and across streets with more than minimal levels of traffic.
- Marked crosswalks should be at least 10 feet wide or the width of the approaching sidewalk if it is greater. In areas of heavy pedestrian volumes (such as Transit Station Areas, School Zones, and Main Streets), marked crosswalks can be up to 25 feet wide.
- Stop lines at stop-controlled and signalized intersection approaches should be striped no less than 4 feet and no more than 30 feet from the edge of marked crosswalks.
- + For enhanced crossing treatments, refer to the section of this guide addressing Rectangular Rapid Flashing Beacons and HAWK Pedestrian Signals.
- Marked crosswalks should be oriented perpendicular to streets, minimizing crossing distances and therefore limiting the time that pedestrians are exposed.

ADA Accessibility Guidelines. 2004.

Manual on Uniform Traffic Control Devices. 2009.

- NACTO. Urban Street Design Guide. 2013.
- Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG). 2011.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines. 2005.

## **CORNERS AND CURB RADII**

Pedestrian safety and comfort is enhanced by smaller curb radii, which shorten crossing distances for pedestrians and reduce vehicle turning speeds. 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.





#### **APPLICATION**

- 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-foot 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 would include a 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. The maximum curb radii are shown below.

#### CONSIDERATIONS

- 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 offtracking into pedestrian areas. Mountable truck aprons should be visually distinct from the adjacent travel lane and sidewalk.

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## **CURB EXTENSIONS**

Curb extensions, also known as neckdowns, bulb-outs, or bump-outs, are created by extending the sidewalk at corners or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities. In addition to shortening crossing distances, curb extensions can be used to change the geometry of intersections resulting in smaller corner radii and slowing turning motor vehicles.



#### APPLICATION

- Curb extensions should be considered only where parking is present or where motor vehicle traffic deflection is provided through other curbside uses such as bicycle share stations or parklets. They cannot be installed where the curbside lane is a vehicle travel lane.
- Curb extensions are particularly valuable in locations with high volumes of pedestrian traffic, near schools, at unsignalized pedestrian crossings, or where there are demonstrated pedestrian safety issues.

#### CONSIDERATIONS

- + The turning needs of emergency and larger vehicles should be considered in curb extension design.
- Care should be taken to maintain direct routes across intersections by aligning pedestrian desire lines on either side of the sidewalk. Curb extensions often make this possible as they provide extra space for grade transitions.
- + Consider providing a 20' long curb extension to restrict parking within 20' of an intersection to enhance visibility.
- When curb extensions conflict with turning movements, reducing the width and/or length of the curb extension should be prioritized over elimination.
- Emergency access is often improved through the use of curb extensions because intersections are kept clear of parked cars.

AASHTO. Guide for the Development of Bicycle Facilities. 2012. NACTO. Urban Street Design Guide. 2013- Curb Extensions.

## **CROSSING ISLAND**

Crossing islands are raised islands that provide a pedestrian 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)

#### APPLICATION

- + Medians can provide a place of refuge for pedestrians, allowing them to cross one direction of traffic at a time.
- + On a local road with relatively low traffic speeds and volumes, placing a raised median or crossing island might be done for aesthetic considerations or special pedestrian crossing characteristics and volumes.
- + On a collector road with moderate-to-high traffic speeds and volumes, or on multi-lane roadways, a raised median or crossing island installation should be strongly considered.
- + Should a midblock crossing be provided along a multilane arterial, a raised median or crossing island and supplementary traffic control devices are desirable.

#### 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.

REFERENCES

NACTO. Urban Street Design Guide. 2013. Manual on Uniform Traffic Control Devices. 2009.

## **PEDESTRIAN SIGNALS**

Pedestrian signal heads display the three intervals of the pedestrian phase: (1) The Walk Interval, signified by the WALK indication (or the walking person symbol) alerts pedestrians to begin crossing the street. (2) The Pedestrian Change Interval, signified by the flashing DON'T WALK indication (or the flashing hand symbol accompanied by a countdown display) alerts pedestrians approaching the crosswalk that they should not begin crossing the street. (3) The Don't Walk Interval, signified by a steady DON'T WALK indication (or the steady upraised hand symbol) alerts pedestrians that they should not cross the street.

#### CONSIDERATIONS

One of primary challenges for traffic signal design is to minimize conflicts between motor vehicle and pedestrian movements. Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians. Traffic movements should be analyzed at intersections in order to utilize non-conflicting phases to implement one or more WALK intervals per cycle.

Signal design should also minimize the time that pedestrians must wait. Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (crossing against the signal) after waiting longer than 30 seconds.

Free-flowing right-turn lanes are discouraged at signalized intersections. Where they are present and unsignalized, the pedestrian signal and pushbutton should be located on the channelization ("pork chop") island. A yield or crosswalk warning sign should then be placed in advance of the crosswalk.

#### **GUIDANCE: TIMING & ACTIVATION**

- Pedestrian signals should allocate enough time for pedestrians of all abilities to safely cross the roadway. The MUTCD specifies a pedestrian walking speed of 3.5 feet per second to account for an aging population. The pedestrian clearance time, which is the total time for the pedestrian change interval plus the buffer interval, is calculated using the pedestrian walking speed and the distance a pedestrian has to cross the street.
- Countdown pedestrian displays inform pedestrians of the amount of time in seconds that is available to safely cross during the flashing DON'T WALK (or upraised hand) interval. All pedestrian signal heads should contain a countdown display provided with the DON'T WALK (or upraised hand) indication.
- In areas with higher pedestrian activity, such as near transit stations, Main Streets, and school zones, push button actuators may not be appropriate. People should expect to get a pedestrian cycle at every signal phase, rather than having to push a button to call for a pedestrian phase.

Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Street Design Guide. 2013.

#### GUIDANCE: ACCESSIBLE PEDESTRIAN SIGNALS (APS)

Accessible pedestrian signals and accessible detectors are devices that communicate information in non-visual formats about the pedestrian phase to pedestrians with visual and/or hearing disabilities. APS and detectors may include features such as audible tones, speech messages, detectable arrow indications and/or vibrating surfaces.

- Pushbutton locator tones are used for locating the pedestrian pushbutton needed to actuate the WALK interval. Detectable arrows should be located on pushbuttons to point in the same direction as the crosswalk. At corners of signalized locations where two pushbuttons are present, they should be separated by at least 10'.
- Audible walk indications should have the same duration as the pedestrian walk indication unless the pedestrian signal rests during the pedestrian phase, in which case the audible indication should be provided in the first seven seconds of the Walk interval.
- For automatically-called pedestrian phases, pushbuttons can be used to activate accessible pedestrian signal features such as detectable arrow indications and/or speech messages.
- When new pedestrian signals are installed, APS with pushbuttons are required. For existing pedestrian signals, the APS and pedestrian pushbuttons should be provided when the signal controller and software are altered, or the signal head is replaced.

#### GUIDANCE: LEADING PEDESTRIAN INTERVAL (LPI)

The Leading Pedestrian Interval initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This signal timing technique allows pedestrians to enter the intersection prior to turning vehicles, increasing visibility between all modes.

- The LPI should be used at intersections with high volumes of pedestrians and conflicting turning vehicles and at locations with a large population of elderly or school children who tend to walk slower.
- + A lagging protected left arrow for vehicles should be provided to accommodate the LPI.

## **RECTANGULAR RAPID FLASHING BEACON**

At some uncontrolled crossings, particularly those with four or more lanes, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds and poor pedestrian visibility combine to create conditions in which very few drivers are compelled to yield. One type of device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs combine a pedestrian crossing sign with a bright flashing beacon that is activated only when a pedestrian is present.



#### APPLICATION

 RRFBs can be used when a signal is not warranted at an unsignalized crossing. They are not appropriate at intersections with signals or STOP signs.

#### CONSIDERATIONS

- RRFBs are considerably less expensive to install than mast arm-mounted signals. They can also be installed with solar power panels to eliminate the need for an external power source.
- RRFBs should be limited to locations with critical safety concerns, and should not be installed in locations with sight distance constraints that limit the driver's ability to view pedestrians on the approach to the crosswalk.
- + RRFBs should be used in conjunction with advance stop bars and signs.
- RRFBs are usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route crossings or locations where bike facilities cross roads at mid-block locations.

REFERENCES

Manual on Uniform Traffic Control Devices. 2009. NACTO. Urban Street Design Guide. 2013.

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations. 2005.

## **PEDESTRIAN-ACTIVATED BEACON**

Pedestrian-activated beacons, including the High-intensity Activated Crosswalk Beacon (HAWK), are a type of hybrid signal intended to allow pedestrians and bicyclists to stop traffic to cross high-volume arterial streets. This type of signal may be used in lieu of a full signal that meets any of the traffic signal control warrants in the MUTCD. It may also be used at locations which do not meet traffic signal warrants but where assistance is needed for pedestrians or bicyclists to cross a high-volume arterial street.



#### **APPLICATION**

- + The MUTCD recommends minimum volumes of 20 pedestrians or bicyclists an hour for major arterial crossings (volumes exceeding 2,000 vehicles/hour).
- + This type of device should be considered for all arterial crossings in a bicycle network and for path crossings if other engineering measures are found inadequate to create safe crossings.

#### CONSIDERATIONS

+ While this type of device is intended for pedestrians, it would be beneficial to retrofit it for bicyclists as the City of Portland, Oregon has, using bicycle detection and bicycle signal heads on major cycling networks. Depending upon the detection design, the agency implementing these devices may have the option to provide different clearance intervals for bicyclists and pedestrians. The provision of bicycle signal heads would require permission to experiment from FHWA.

Manual on Uniform Traffic Control Devices. 2009. REFEREN NACTO. Urban Street Design Guide. 2013. Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Location. 2005.

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## **TRANSIT STOPS**

Any marked or signed location where transit vehicles stop and service passenger boarding and alighting is a transit stop. The most basic transit stops have only a pole-mounted "header" sign indicating the transit provider and route(s). High frequency routes and higher volume stops generally have more passenger amenities such as benches, shelters, traveler information, trash receptacles, bicycle parking, and other features.



#### APPLICATION

+ Landing zones should be provided at all doors of the transit vehicle. Buses can vary in length and will have different door configurations. Landing zones should be designed in coordination with all transit providers.

#### CONSIDERATIONS

- Transit stops on urban streets are typically located at the natural curb line or on a bus bulb or transit island. Dedicated transit facilities may use medians. Transit operations, curbside uses, posted speed limits, traffic volumes, transit frequency and typical bus dwell time all influence location decisions for transit stops. See Transit Accommodations at Intersections for bus bulb design guidance.
- Transit stops may be located on the "near-side" of an intersection before a signal or cross street, on the "far-side" after a bus has passed through an intersection, or at a midblock location between intersections.
- Transit stop locations are determined based on a number of factors including intersection operations, bus routing, curbside conditions, transfer points, intersection geometry and sightlines, consideration of other street users, and major generators or destinations. The location of a transit stop can affect transit travel time, passenger safety, and roadway operations.
- Generally, transit agencies prefer far-side stops when traffic flows are heavy, where there are sight distance problems, and where buses turn left. Near-side located bus stops may be appropriate where traffic flow is lower or where transit riders can more easily transfer without crossing the street. Stops can also be placed mid-block where there are major passenger generators or where space next to an intersection is insufficient.
- Regardless of location, all transit stops must be ADA compliant, and should be safe, convenient, well-illuminated, and clearly visible. Transit stops should be connected to the larger pedestrian network with continuous sidewalks, curb ramps, and safe pedestrian crossings. Mid-block stops should provide access to mid-block crosswalks.
- + Bus bulbs may be considered where additional pedestrian space is needed or where it is challenging for transit vehicles to reenter traffic.
- Seating at or near transit stops can improve passenger comfort, as can shade in the form of street trees or awnings. Seating need not be a unique and dedicated element, but may include leaning rails, planters, ledges, or other street elements.

AASHTO. Guide for Geometric Design of Transit Facilities on Highways and Streets. 2014.

NACTO. Urban Street Design Guide. 2013.



## **TOOLE** DESIGN