Attachment D

VISION ZERO COMMUNITY TOOLKIT

MARCH 2021 | VERSION 1.0

Montgomery Planning

Contents

What is Vision Zero?

Vision Zero is a proven approach to transportation safety, focused on preventing roadway-related deaths and severe injuries. Vision Zero represents a fundamental change in how we plan and design our roads, shifting from a focus on maximizing motor vehicle efficiency to ensuring that our roads are safe regardless of whether travel is by car, bus, bicycle or foot. Vision Zero recognizes that people will sometimes make mistakes and that our roads should be designed to ensure those inevitable mistakes do not result in severe injuries or fatalities.

Vision Zero in Montgomery County

Through its 2016 resolution, Montgomery County committed to eliminating traffic fatalities and severe injuries. In 2017, the County Executive released an initial two-year action plan of activities to advance the county toward Vision Zero. Upon completion of the two-year action plan, the county began preparing a ten-year action plan to eliminate traffic fatalities and severe injuries by 2030.

Vision Zero Community Toolkit

This Vision Zero Community Toolkit presents design treatments known to reduce crashes involving motor vehicles, bicyclists, and pedestrians. The toolkit outlines how each treatment addresses safety and the expected reduction in crashes associated with the treatment. It describes the applicable locations for each treatment and the estimated cost for implementing each treatment.

Safety Objectives

The toolkit's crash reduction treatments are designed to achieve the following primary safety objectives:

- Reduce speeds
- Reduce pedestrian crossing widths
- Increase frequency of safer crossings for pedestrians and bicyclists
- Increase visibility
- Increase motor vehicle stopping for pedestrians
- Separate pedestrians, bicyclists, and motor vehicles on higher speed or busier roads
- Reduce lane or roadway departures by motor vehicles on rural roads

The table below summarizes the safety objectives associated with each of the treatments included in the toolkit.

Treatment	Reduce Speeds	Safer Crossings	Increase Visibility	Mode Separation	Rural Road Safety
Advance Stop Lines		•	•		
Advisory Bike Lanes	•			•	
Automated Enforcement	•	•			•
Bicycle Crossings		•	•	•	
Bike Boxes		•	•	•	
Buffered Bike Lanes				•	
Chicanes/Roadway Curvature	•				
Conventional Bike Lanes				•	
Corner Radius Reduction	•	•	•		
Crossing Islands	•	•	•	•	
Curb Extensions/Bulb Outs	•	•	•	•	
Floating Transit Islands				•	
Gateway Treatments		•	•		
Hardened Centerlines and Turn Wedges	•	•	•		
High-Visibility Crosswalks		•	•		
Leading Bicycle Intervals and Leading Pedestrian Intervals		•	•		
Lighting		•	•		
Mini-Roundabouts	•	•			
Neighborhood Slow Zones	•	•			
Neighborhood Yield Streets	•	•			
No Turn on Red		•		•	
Off-Street Trails				•	
Parking Restrictions at Crossing Locations/ Daylighting		•	•		
Pedestrian Hybrid Beacons (PHB)		•	•	•	•

Treatment	Reduce Speeds	Safer Crossings	Increase Visibility	Mode Separation	Rural Road Safety
Posted Speed Limit (Target Speeds and School Speed Zones)	•	•			•
Protected Crossing Spacing for Managing Conflicts	•	•	•	•	•
Protected Intersections	•	•	•	•	
Protected Signal Phases		•		•	•
Raised Crossings	•	•	•		
Raised Medians	•	•	•		•
Rectangular Rapid Flashing Beacons (RRFB)		•	•		
Road Diets and Lane Width Reductions	•	•	•		•
Road Improvements at Curves					•
Roundabouts	•	•	•		•
Separated Bike Lanes				•	
Shared Streets	•				
Shoulders				•	•
Sidepaths				•	
Signal Timing and Pedestrian Recall		•			
Speed Humps, Tables, and Cushions	•				
Tree Buffer	•			•	

Which treatments are effective?

Researchers have estimated the reduction in crashes that can be achieved by implementing many roadway safety treatments. Where research has shown a reduction in crashes for a given treatment, that is noted in the toolkit. Crash reduction estimates do not exist for all treatments, but other research and data gathered from prior use can provide an indication of safety benefits.

Multiple treatments at the same location often have complementary benefits. Caution and engineering judgement should be exercised when extrapolating the safety impact in these cases.

According to the Federal Highway Administration.[1]

- A crash reduction estimate should be regarded as a generic guide of safety effectiveness.
- Environmental, traffic volume, traffic mix, geometric, and operational conditions may affect the safety impact of a treatment.
- Engineers must exercise judgement and consider these factors to ensure that a treatment applies to the conditions.

Where should treatments be applied?

Roadways throughout the county have different characteristics. Based on the number of lanes, daily vehicles, travel speeds, and other factors, different safety treatments may be appropriate on different roadways. In addition, some treatments are generally applied along segments, while others improve safety at intersections.

Montgomery County is currently developing a Complete Streets Design Guide, which assigns each county roadway a street type based on the roadway's surrounding context and transportation function for all travel modes. The table below summarizes the applicable locations, including both location type and street type, associated with each of the treatments included in the toolkit.

Treatment	Location Type				Street Type*											
	Along Segment	Midblock Crossing	Signalized Intersection	Unsignalized Intersection	Downtown Boulevards	Downtown Streets	Boulevards	Town Center Boulevards	Town Center Streets	Neighborhood Connectors	Neighborhood Streets	Neighborhood Yield Streets	Industrial Streets	Country Connectors	Country Roads	Major Highways
Advance Stop Lines		•		•	•	•	•	•	•	•	•	•	•	•	•	•
Advisory Bike Lanes	•										•	•				
Automated Enforcement	•		•		•	•	•	•	•	•	•		•	•	•	•
Bicycle Crossings		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bike Boxes			•		•	•	•	•	•	•	•	•	•	•	•	
Buffered Bike Lanes	•					•		•	•	•	•		•			
Chicanes/Roadway Curvature	•				•	•	•	•	•	•	•	•	•	•	•	
Conventional Bike Lanes	•					•			•	•	•		•			
Corner Radius Reduction			•	•	•	•	•	•	•	•	•	•	•	•	•	
Crossing Islands		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Curb Extensions/Bulb Outs			•	•	•	•	•	•	•	•	•	•	•	•	•	
Floating Transit Islands	•				•	•	•	•	•	•						
Gateway Treatments		•		•	•	•	•	•	•	•	•	•	•	•		
Hardened Centerlines and Turn Wedges		•	•	•	•	•	•	•	•	•	•					
High-Visibility Crosswalks		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Leading Bicycle Intervals and Leading Pedestrian Intervals			•		•	•	•	•	•							
Lighting	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Mini-Roundabouts				•							•	•				
Neighborhood Slow Zones	•									•	•	•				
Neighborhood Yield Streets	•											•				
No Turn on Red			•		•	•	•									•

Treatment	Location Type				Street Type*											
	Along Segment	Midblock Crossing	Signalized Intersection	Unsignalized Intersection	Downtown Boulevards	Downtown Streets	Boulevards	Town Center Boulevards	Town Center Streets	Neighborhood Connectors	Neighborhood Streets	Neighborhood Yield Streets	Industrial Streets	Country Connectors	Country Roads	Major Highways
Off-Street Trails																
Parking Restrictions at Crossing		•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Pedestrian Hybrid Beacons (PHB)		•			•	•	•	•	•	•	•	•	•	•	•	
Posted Speed Limit (Target Speeds and School Speed Zones)					•	•	•	•	•	•	•	•	•	•	•	•
Protected Crossing Spacing for Managing Conflicts	•	•			•	•	•	•	•	•	•	•	•	•	•	•
Protected Intersections			•	•	•	•	•	•	•	•	•	•	•	•	•	
Protected Signal Phases			•		•	•	•	•	•	•	•	•	•	•	•	•
Raised Crossings		•	•	•		•			•	•	•	•				
Raised Medians	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•
Rectangular Rapid Flashing Beacons		•			•	•			•	•	•	•				
Road Diets and Lane Width Reductions	•				•	•	•	•	•	•	•	•	•	•	•	•
Road Improvements at Curves	•													•	•	•
Roundabouts			•	•	•	•	•	•	•	•	•		•	•	•	•
Separated Bike Lanes	•				•	•		•	•				•			
Shared Streets	•					•										
Shoulders	•													•	•	•
Sidepaths	•						•			•			•	•	•	•
Signal Timing and Pedestrian Recall			•		•	•	•	•	•	•	•	•	•	•	•	•
Speed Humps, Tables, and Cushions	•				•	•		•	•	•	•	•	•			
Tree Buffer	•				•	•	•	•	•	•	•	•	•	•	•	•

*For definitions of the street types, see the Montgomery County Complete Streets Design Guide.

- Systemic Treatments

- Systemic treatment implementation is a common Vision Zero approach that identifies many locations for rapid application of safety measures designed to avert severe and fatal crashes.

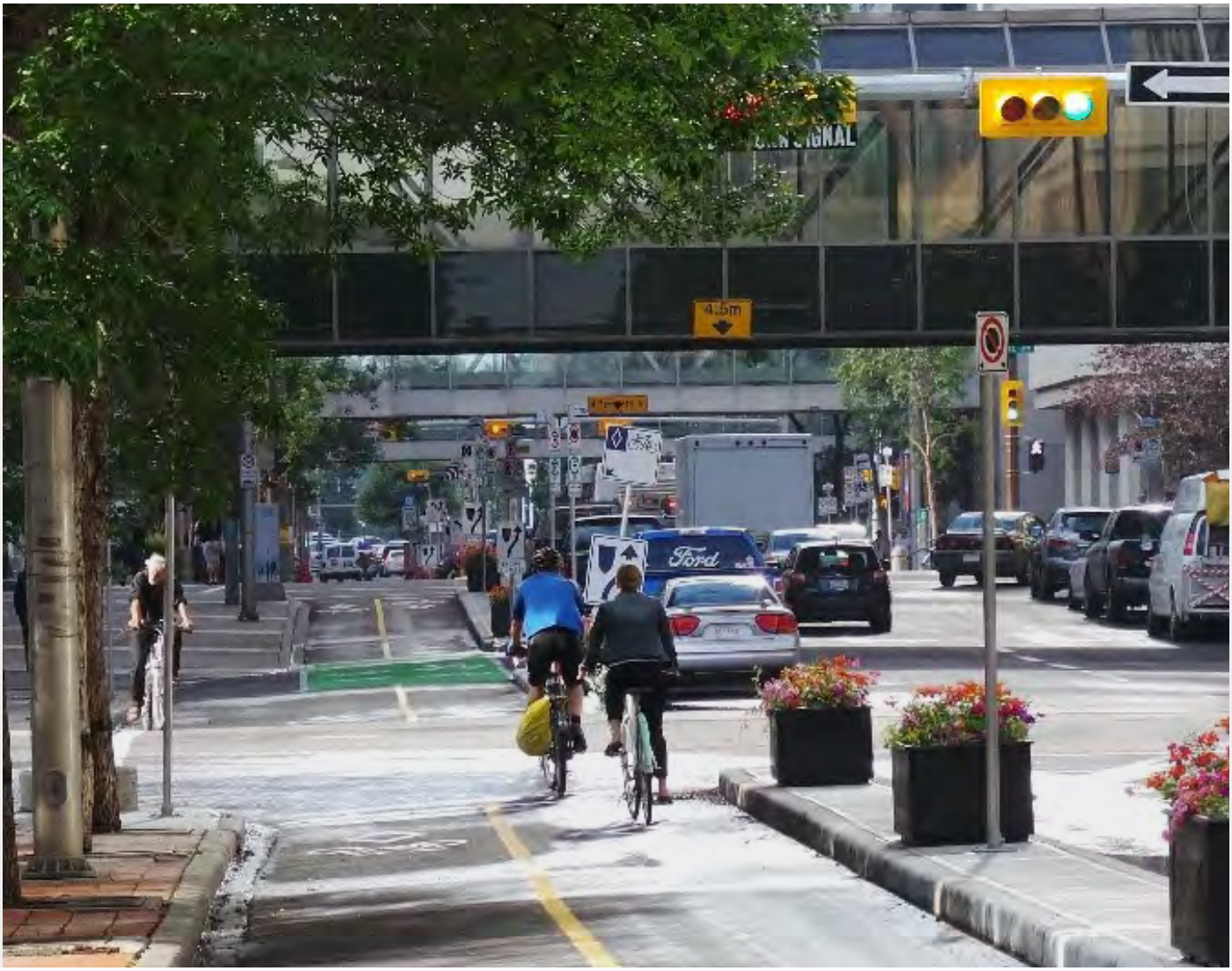
- Systemic treatments are often discussed in contrast with spot treatments:

- **Systemic treatments** can be implemented at many locations throughout the county and are generally considered well-suited for widespread implementation as a result of their safety effectiveness, cost effectiveness, and feasibility for implementation at multiple locations. Some systemic treatments can be implemented with limited study and design, such as high-visibility crosswalks and curb extensions created with paint, bollards, and turn wedges.

- **Spot safety treatments** use traditional site-based analysis at a specific location. Some examples include bike boxes, chicanes, and gateway treatments.

- Some treatments may be useful in both spot and systemic safety improvement approaches.

> The systemic approach to safety involves widely implemented improvements based on high-risk roadway features correlated with specific severe crash types. The approach provides a more comprehensive method for safety planning and implementation that supplements and complements traditional site analysis. The approach also helps agencies broaden their traffic safety efforts and consider risk as well as crash history when identifying where to make low-cost safety improvements.[2]



Source: City of Calgary Bike Program.

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ADVANCE STOP LINES

Purpose

Increase the likelihood that motorists stop for pedestrians and bicyclists at uncontrolled crossings by making the crossings more visible.

Description

Pavement markings placed between 20 and 50 feet in advance of uncontrolled crossings.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

Advance stop markings are an option at many uncontrolled or unsignalized crossings, including:

- At intersection and midblock crossings
- Uncontrolled multi-lane crossings, with at least two lanes in one direction[3]

Applicable Street Types

All street types.

Safety Benefits

- Increases visibility of crossing bicyclists and pedestrians to motorists.
- May increase driver stopping for pedestrians.
- May reduce multiple threat crashes.
- Reduces conflicts between pedestrians and motorists.
- May reduce conflicts between bicyclists and motorists.
- May increase effectiveness of other safety treatments, such as when paired with "Stop Here for Pedestrian" signs.

Expected Crash Reduction

25 percent for vehicle-pedestrian crashes.[4]

Design Guidance

- Place on all approaches to the uncontrolled crossing.
- Mark crossing with high-visibility crosswalk markings.
- Install pedestrian warning signs (MUTCD W11-1, W11-2, W11-15, or S1-1).[5]
- Restrict parking within 20 to 50 feet of the crosswalk to improve visibility.
- Use markings in conjunction with an appropriate regulatory sign (e.g. Stop Here for Pedestrians MUTCD R1-5 series).[6]

Considerations

- Motorists may ignore markings placed too far in advance of the crosswalk.
- Use a regulatory sign with the advanced stop markings to aid with compliance.

Systemic Safety Potential

Potential for systemic implementation at all uncontrolled marked crossings of roadways with at least four lanes and posted speeds of at least 30 mph.

Additional Information

- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- Manual on Uniform Traffic Control Devices

ADVISORY BIKE LANES

Purpose

Allow motorists to temporarily enter bike lane to provide sufficient space for oncoming traffic to safely pass.

Description

Dashed bike lanes on narrow, un-laned residential roads.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Roadways with one or two travel lanes.
- Streets with speed limits of 30 mph or lower.
- Streets with infrequent parking turnover.
- Where vehicle volumes are fewer than 6,000 vehicles per day (fewer than 4,000 daily vehicles preferred).
- Advisory bike lanes are not appropriate on designated truck or bus routes.

Applicable Street Types

- Neighborhood Street
- Neighborhood Yield Street

Safety Benefits

- Provides designated space for bicyclists.
- Allows vehicles to safely pass when necessary.
- May have a speed reduction effect on motor vehicles.[7]

Expected Crash Reduction

A crash reduction rate has not yet been determined. As of 2017, there was only one known bicycle crash involving advisory bike lanes. [8]

Design Guidance

The minimum width of an advisory bike lane is 5 feet adjacent to parking, or 4 feet curb-adjacent exclusive of gutter. A desirable width is 6 feet.

The minimum width of the un-laned motorist space should be 12 feet between the bike lanes. The maximum width is 18 feet.

Considerations

- Requires FHWA permission to experiment.
- For use on streets too narrow for both bike lanes and normal-width travel lanes.

- Motorists must yield to oncoming motor vehicles by pulling into the bike lane.
- This treatment should only be used on streets with greater than 60 percent continuous daytime parking occupancy. Where parking occupancy is continuously less than 50 percent, consolidate the parking to one side of the street.
- A two-way traffic warning sign (W6-3) may increase motorists' understanding of the intended two-way operation of the street.
- The combined bike lanes and un-laned travel area must meet the minimum requirements set out by the fire code.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- Alta Planning and Design (2017) Advisory Bike Lanes in North America
- FHWA Bikeway Selection Guide

AUTOMATED ENFORCEMENT

Purpose

Reduce serious injuries and fatalities caused by red light running and speeding.

Description

Systems that automatically issue fines for running red lights or speeding.

Estimated Cost

$ $$ **$$$** $$$$

Applicable Locations

Automated speed enforcement is currently allowed in:

- School zones.
- Residential areas with a speed limit of 35 mph or lower.
- Any work zone on expressways and controlled access highways where the speed limit is 45 mph or higher.

Red light cameras are most applicable in:

- School zones.
- Intersections with a history of red light running or crashes.
- Areas that would be hazardous for police to stop vehicles.

Applicable Street Types

All street types.

Safety Benefits

- Reduced red light running.
- Reduced speeding.
- Reductions in right angle crashes at intersections.
- Reductions in speeding-related crashes outside peak traffic flow times.

Expected Crash Reduction

16 to 25 percent for all injury crashes from red light cameras[9] and speed cameras.[10]

Design Guidance

- Mounted cameras record images of vehicles that speed or run red lights.
- Red light automated enforcement is recommended for intersections with previously observed red light running.
- Install signage warning motorists in advance of the first red light or speed camera on a corridor.

- Place speed cameras in school zones away from traffic signals, stop signs, yield signs, freeway ramps, curves with advisory speeds, or established speed transition zones.
- Contract with a firm that specializes in these systems for installation and administration.
- A law enforcement officer must verify the violation and sign the citation.

Considerations

- Legal authority is necessary to use automated red light or speeding enforcement.
- Six months after automated speed enforcement began in Montgomery County, 62% of drivers supported the program.[11]
- Public education about the safety benefits of automated enforcement may increase support for the programs.

Systemic Safety Potential

Fixed red light cameras are most effective at intersections with high total volumes, higher entering volumes on the main road, longer green cycle lengths, and protected left turn phases.

Additional Information

- MDOT Guidelines for Automated Speed Enforcement Systems in School Zones
- FHWA Red Light Camera Systems Operational Guidelines
- NHTSA Countermeasures that Work

BICYCLE CROSSING

Purpose

Provide designated crossing space for bicyclists and alert cars that bicyclists may be crossing at that location.

Description

Marked crossings specifically for bicycles.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

Where bike lanes (separated, conventional, etc.) cross intersections.

Applicable Street Types

All street types.

Safety Benefits

- Reduce conflict between bicyclists and pedestrians.
- Alert motorists to watch for crossing bicyclists.

Expected Crash Reduction

An estimated crash reduction has not yet been determined for bicycle crossings.

Design Guidance

- Should be separate from pedestrian crossings.
- Supplement with green-colored pavement for contrast.

Considerations

- At signalized intersections, consider alongside implementation of a bicycle signal.

Systemic Safety Potential

Potential for systemic safety application at signalized intersections along roadways with a sidepath, separated bike lanes, buffered bike lanes, or conventional bike lanes.

Additional Information

- NACTO Urban Bikeway Design Guide

BIKE BOXES

Purpose

Provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase.

Description

A designated area at the head of a traffic lane at a signalized intersection.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- Where through-bicyclists and right-turning vehicles conflict at signalized intersections.
- Where a bicycle lane does not continue across an intersection.

Applicable Street Types

All street types except Major Highways.

Safety Benefits

- Enhances visibility of bicyclists for motorists.
- Reduces conflict between bicyclists and motorists.

Expected Crash Increase

No crash reduction found.[12] One study noted a 100 percent increase in crashes during initial implementation of bike boxes.[13]

Design Guidance

- Bike boxes are primarily installed at signalized intersections.
- Bike boxes should be a minimum of 10 feet deep from the stop bar.
- A bike box should only extend across one travel lane. Bike boxes should not be used to facilitate bicycle left turns. A two-stage turn queue box is the preferred method of accommodating left turns.
- Green pavement can be used within the bicycle box to deter motor vehicles from encroaching.
- At least 50 feet of bicycle lane should connect the approach leg of the intersection to the bike box so bicyclists do not have to weave between queueing motor vehicles to access it.

Considerations

- Bicyclists waiting in front of stopped motorists gain a head start by being 10-15 feet in front of stopped vehicles. This head start can be extended with a leading bicycle and/or pedestrian phase.
- Motorists should be discouraged from merging into the bicycle lane with a solid bicycle lane line to ensure bicyclists can enter the bike box.
- At locations where there are high volumes of turning traffic or frequent conflicts between turning motorists and bicyclists during stale green portions of the signal phase, it may be advisable to consider a right turn lane or separate phasing to mitigate conflicts in lieu of or in addition to a bike box.

Additional Information

- Fehr and Peers (2018) Safety Efficacy Confidence Levels for Pedestrian & Bicycle Treatments
- NACTO Urban Bikeway Design Guide

Systemic Safety Potential

Best suited as a spot treatment.

BUFFERED BIKE LANES

Purpose

To increase the comfort of bicyclists by increasing the distance between the bike lane and travel or parking lanes.

Description

Conventional bike lanes paired with a designated buffer space separating the bike lane from the adjacent motor vehicle travel lane and/or parking lane.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Roadways with three or fewer travel lanes.
- Streets with speed limits of 30 mph or lower.
- Streets with infrequent parking turnover.
- Where vehicle volumes are fewer than 9,000 vehicles per day.
- Buffered bike lanes are appropriate where a separated bike lane or sidepath is infeasible or undesirable.

Applicable Street Types

- Downtown Street
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Industrial Street
- Other streets as determined by the Bicycle Master Plan

Safety Benefits

Increases distance between motor vehicles and bicyclists.

Expected Crash Reduction

A crash reduction rate has not yet been determined.

Design Guidance

- Minimum buffered bike lane width, exclusive of buffer, is 4 feet with a parking-adjacent buffer and 5 feet with a travel-lane-adjacent buffer or where bike lane is adjacent to curb. Desirable width is 6 feet.
- Buffers should be broken along curbside parking to allow cars to cross the bike lane.
- Minimum buffer width is 2 feet. There is no maximum. Diagonal crosshatching should be used for buffers less than 3 feet wide. Chevron crosshatching should be used for buffers greater than 3 feet.

Considerations

- Consider placing buffer next to parking lane where there is high turnover parking.
- Consider placing buffer next to travel lane where speeds are 30 mph or faster, or when traffic volume exceeds 6,000 vehicles per day.
- Preferable to conventional bike lanes when used as a contra-flow bike lane on one-way streets.
- Can be used on one-way or two-way streets.
- Where there is 7 feet of roadway width available, a buffered bike lane should be installed instead of a conventional bike lane.
- If there is sufficient width and a separated bike lane is not being considered, buffers may be installed on both sides of the bike lane.
- Allow bicyclists to ride side-by-side or to pass slower moving bicyclists.
- Research has documented buffered bike lanes increase safety and the perception of safety.

Systemic Safety Potential

Best suited as a spot treatment. Should be implemented along corridors identified in the Bicycle Master Plan and where identified as the default bikeway treatment in the Complete Streets Design Guide.

Additional Information

- Berkeley Bicycle Plan Appendix F: Bicycle Facility Design Toolbox
- FHWA Bikeway Selection Guide

CHICANES/ ROADWAY CURVATURE

Purpose

Slow motor vehicles speeds by diverting the path of travel.

Description

Horizontal treatments to restrict vehicle movement and reduce speeds. Chicanes are often made of curb extensions or islands that create "S" curves along a roadway.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

Most effective at midblock locations.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street
- Industrial Street
- County Connector
- County Road

Safety Benefits

- Improves speed limit compliance.
- Certain designs increase the amount of sidewalk width, buffer width, or both on corridors.

Expected Crash Reduction

An estimate has not yet been determined; initial research indicates this treatment may be effective at increasing driver yielding and improving pedestrian safety. [14]

Design Guidance

- Interim treatments use striping and flex posts.
- Permanent treatments use curb extensions or islands and may include vegetation.
- Maintain sight lines by landscaping chicanes with lower shrubs and plants.
- Multiple treatments may be placed on alternating sides of the roadway.
- Drainage and utility location should be considered when implementing.

- Additional signing or pavement markings may be needed to ensure drivers are aware of the bend in the roadway.

Considerations

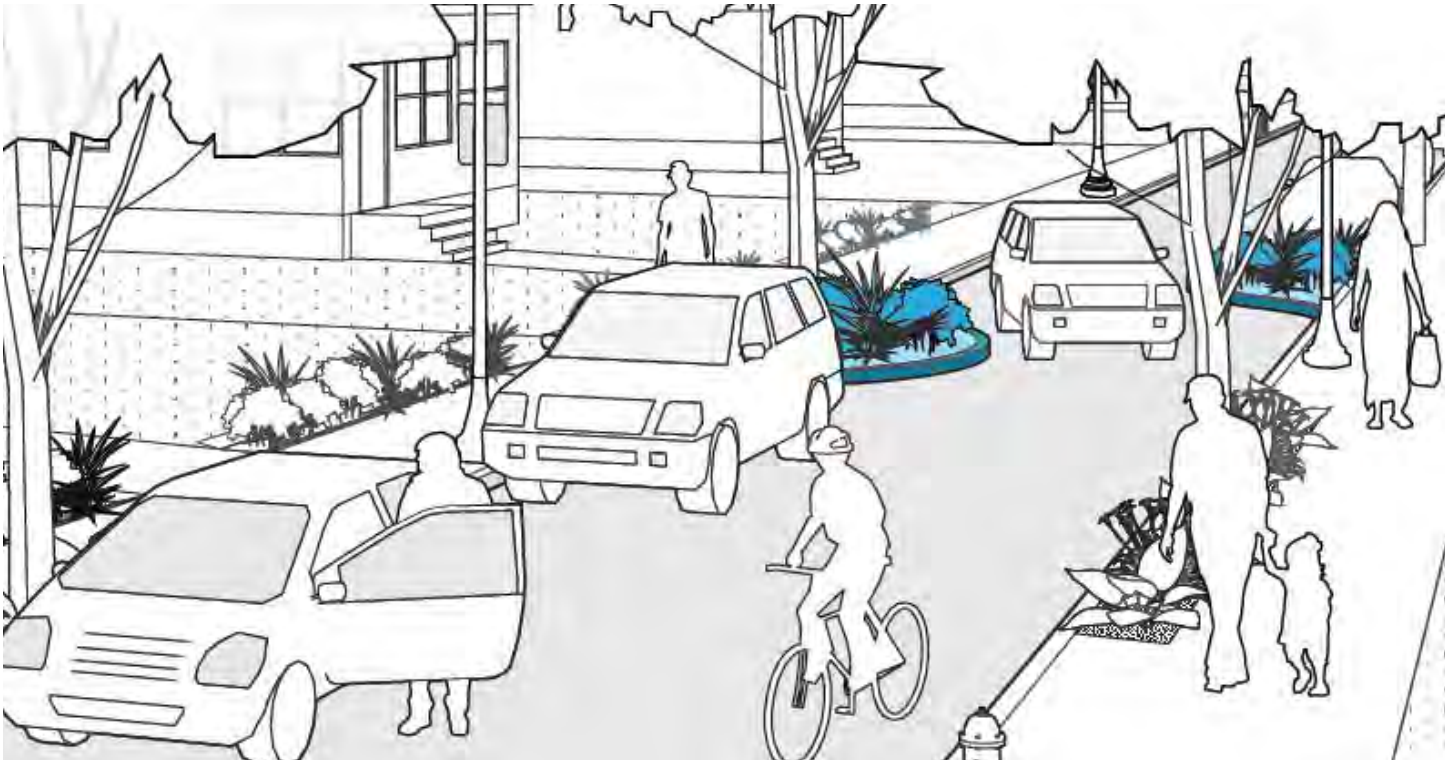
- Vehicles and bicyclists must carefully maneuver around fixed objects. Traffic may be slowed when vehicles attempt to pass bicyclists.
- If drainage impacts are a concern, curb extensions may be designed as edge islands with a 1–2-foot gap from the curb (see top right image).
- Mini-roundabouts should be considered at intersections of local roads.
- May reduce on-street parking depending on the design.
- Emergency vehicle access must be maintained.

Systemic Safety Potential

- Best suited as a spot treatment.

Additional Information

- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
- NACTO Urban Street Design Guide



CONVENTIONAL BIKE LANES

Purpose

To designate road space for bicyclists separate from motor vehicles.

Description

A portion of a street designated for the exclusive use of bicycles and distinguished from traffic lanes by striping, signing, and pavement markings.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Roadways with three or fewer travel lanes.
- Streets with speed limits of 30 mph or lower.
- Streets with infrequent parking turnover.
- Where vehicle volumes are fewer than 9,000 vehicles per day.
- Conventional bike lanes are appropriate where a separated bike lane or sidepath is infeasible or undesirable.

Applicable Street Types

- Downtown Street
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Industrial Street
- Other streets as determined by the Bicycle Master Plan

Safety Benefits

Spatially separates bicyclists from motor vehicles.

Expected Crash Reduction

Reports vary; anywhere from 5-53 percent.[15]

Design Guidance

- The minimum width of a bike lane adjacent to parking is 5 feet, a desirable width is 6 feet.
- The minimum width of a bike lane adjacent to a curb is 5 feet exclusive of a gutter, a desirable width is 6 feet.
- Parking Ts or hatch marks can highlight the vehicle door zone on constrained corridors with high parking turnover to guide bicyclists away from doors.
- See the NACTO and AASHTO design guides for more information on bike lane widths.

Considerations

- Typically installed by reallocating 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 one-way streets for motorists, improving 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 preferred at locations with high parking turnover.

Systemic Safety Potential

Best suited as a spot treatment. Should be implemented along corridors identified in the Bicycle Master Plan and where identified as the default bikeway treatment in the Complete Streets Design Guide.

Additional Information

- AASHTO Guide for the Development of Bicycle Facilities
- FHWA Bikeway Selection Guide
- NACTO Urban Bikeway Design Guide

CORNER RADIUS REDUCTION

Purpose

Reduce motor vehicle turning speeds, reduce pedestrian crossing distances, increase pedestrian visibility, and expand waiting areas for pedestrians crossing.

Description

Reduced corner radius by changing the curb line or using temporary materials such as paint and bollards. Motorists will generally reduce their speed to navigate a sharper turn.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Corner radius reduction can be applied to intersections in an urban, suburban, or rural context.
- Intersections with low truck volumes can also make use of corner radius reduction.

Applicable Street Types

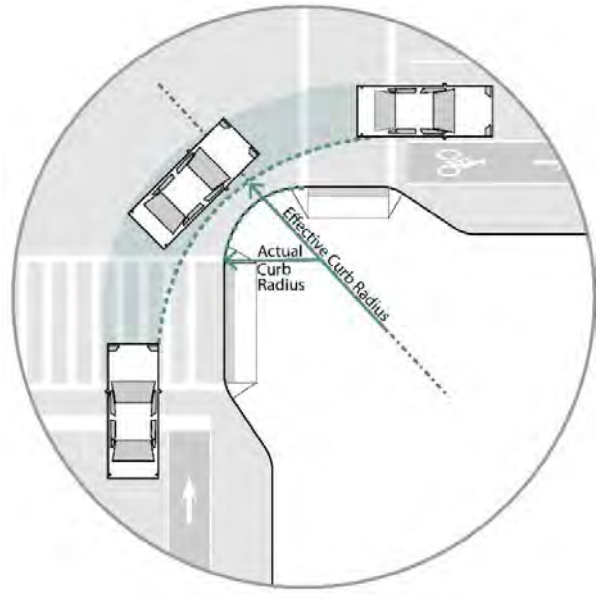
All street types.

Safety Benefits

- Reduce turning motor vehicle speeds.
- May reduce the risk of pedestrians in collisions with right-turn vehicles.
- Reduce crossing distance for pedestrians and thus reduces pedestrian exposure.
- A reduced crossing distance may allow for shorter traffic signal cycle lengths, increasing compliance.[16]

Expected Crash Reduction

Initial research indicates curb radius reduction may reduce turning speeds, which can increase motor vehicle yielding to crossing pedestrians and reduce the severity of crashes.[17]



Design Guidance

- Implementation should tailor design to the largest design vehicle size that frequently uses the intersection. This effective turning radius should determine actual curb radius.
- See the Montgomery County Complete Streets Design Guidelines and Montgomery County Bill 33-13 for recommended curb radius dimensions and design vehicle designation.
- Install with curb ramps and high-visibility crosswalk markings. Corner radius reduction allows for better placement of curb ramps and crosswalks.
- Mountable truck aprons can be implemented to encourage a smaller effective radius for passenger cars or small trucks, while accommodating larger vehicles as well.

Considerations

- The corner radius should make intersections as compact as possible while accommodating large vehicles that frequent the intersection.
- Corner radii that are too small may encourage motor vehicles to drive over the curb and onto sidewalks and bikeways.
- In some instances large vehicles may encroach on the opposing travel lane when turning. See Montgomery County Complete Streets Design Guidelines for specific guidance on allowable encroachment.

CROSSING ISLANDS

Purpose

Protect pedestrians and bicyclists crossing by slowing motor vehicle speeds, increasing motor vehicle yielding, increasing pedestrian visibility, providing a pedestrian waiting area, and allowing two-stage crossings for slower pedestrians.

Description

Median crossing islands have a cut-out area for pedestrian and bicyclist refuge and are used as a supplement to a crosswalk. Also known as pedestrian refuge islands or raised refuge islands.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Crossings at the midblock or at intersections.
- Most beneficial at uncontrolled crossings, multi-lane roads, wide signalized crossings, or complex intersections.
- On roads with two or more lanes of through traffic.
- Roads with insufficient gaps in traffic.
- Roads with high pedestrian crossing volumes.

Applicable Street Types

All street types.

Safety Benefits

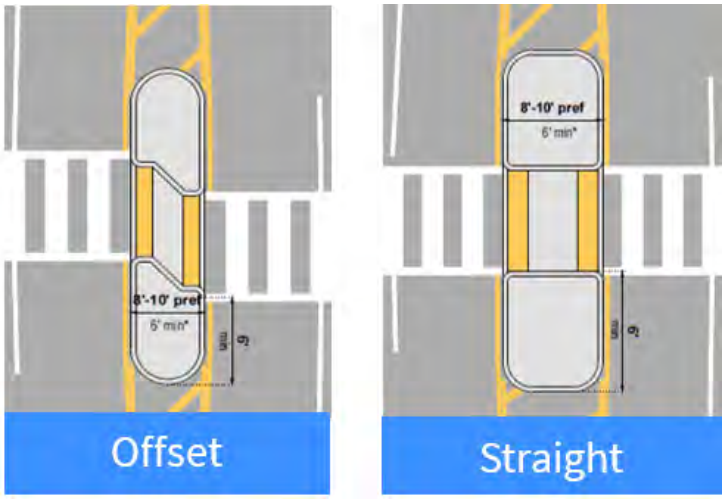
- Reduces maximum distance and time pedestrians exposed to crash risk.
- Allow pedestrians to cross the street one direction of travel or fewer lanes at a time.
- Ease crossing for slower pedestrians (e.g. youth, elderly, and disabled).
- Provide space for additional lighting at the crossing.
- May slow motorist through speed.
- May slow motorists turning left.

Expected Crash Reduction

32 percent for vehicle-pedestrian crashes.[18]

Design Guidance

- Median crossing islands should be a minimum of 6 feet wide. To provide bicyclist refuge or for high pedestrian volumes, crossing islands should be a minimum of 8 feet wide. The refuge is ideally 40 feet long.
- Ramps or island cut-throughs are required for accessibility. They should be the full width of the crosswalk, 5 feet minimum.



- All medians at intersections should have a "nose" which extends past the crosswalk. The nose protects people waiting on the median and slows turning drivers.
- At mid-block locations:
    - Install advance stop lines on multi-lane approaches.
    - Install with applicable warning sign (MUTCD W11-1, W11-2, W11-15, or S1-1).[19]
    - On multi-lane approaches, place "Stop Here for Pedestrians" or "Yield Here to Pedestrians" signs (MUTCD R1-5 series).[20]
- Mark with a high-visibility crosswalk.

Considerations

- Pedestrians may get caught on the crossing island if motorists do not yield or signal timing is too short.
- Crossing islands at intersections may restrict left turning.
- Curb extensions can be built along with crossing islands to restrict on-street parking and reduce crossing distance.
- Temporary crossing islands can be constructed with temporary curbing or flex posts.

Systemic Safety Potential

Potential for systemic safety application at mid-block crossings and at intersections along corridors with poor motor vehicle yielding, operating speeds over 30 mph, or motor vehicle volumes above 9,000 vehicles per day.

Additional Information

- Chapter 8 of Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide
- Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations

CURB EXTENSIONS/ BULB OUTS

Purpose

Shorten crossing distances and increase pedestrian comfort and visibility.

Description

Also called bulb outs or neck downs, curb extensions extend a section of sidewalk into the roadway at intersections and other crossing locations.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Curb extensions can make crossings safer and more comfortable everywhere from a mid-block crosswalk to a large signalized intersection.
- Curb extensions can be built in all-day parking lanes or wide shoulders.
- Transitions to lower-speed areas.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street
- Industrial Street
- Country Connectors
- Country Roads

Safety Benefits (see graphic on next page)

1. Shorten crossing distance.
2. Increase visibility between drivers and pedestrians.
3. Crosswalk is more noticeable to drivers.
4. Narrow the roadway to slow through speeds.
5. Reduce vehicular turning speed.
6. Add space for ADA curb ramps aligned with crosswalk.
7. Create physical barrier from parking encroachment on crosswalk.

Expected Crash Reduction

Initial research indicates this treatment may be effective at increasing driver yielding and improving pedestrian safety.[21]

Design Guidance

- Limit planting and street furniture height within curb extensions to preserve sight lines.
- Consider expanding curb extensions at bus stops to produce bus bulbs.
- Where curb extension installation on one side is infeasible or inappropriate (i.e., no parking lane), this should not preclude installation on the opposite side.
- Maximum length can vary to accommodate sight lines, manage stormwater, facilitate transit loading, or restrict parking. Minimum length is the width of the crosswalk.
- Designers should refer to the Montgomery County Bicycle Master Plan to ensure that curb extensions not preclude the implementation of the designated low stress network of bikeways.

Considerations

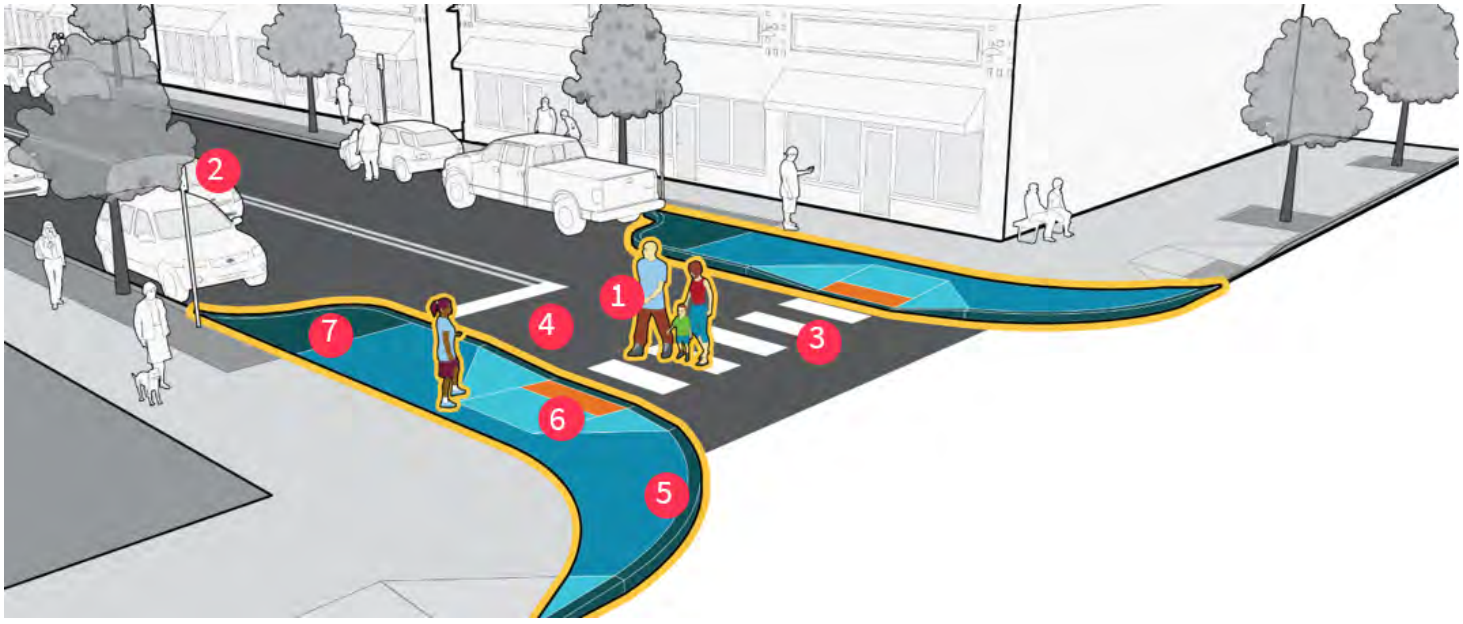
- If funding for permanent curb extension construction is unavailable, use lower cost alternatives, such as bollards, temporary curbs, planters, or paint and striping.
- Curb extensions should not extend into travel lanes or bicycle lanes. Generally designed with one foot of shy distance between the face of curb and the edge of travel lane.
- When designing the corner radius on a curb extension, consider the appropriate large vehicle turning path to prevent encroachment into the pedestrian space.
- Curb extensions can require modifications to or relocation of drainage structures. Consider drainage slots with solid surface plating at pedestrian crossings as an alternative.

Systemic Safety Potential

Spot treatment or systemic safety improvement. Consider at all locations with on-street parking.

Additional Information

- Montgomery County Complete Streets Design Guide
- NACTO Urban Street Design Guide
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations



FLOATING TRANSIT ISLANDS

Purpose

To eliminate the conflict between bicyclists traveling in bike lanes and transit vehicles that must pull into conventional bike lanes to load and unload passengers.

Description

A concrete island located between transit/traffic lanes and bike lanes where transit passengers board and alight transit vehicles.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

Where bike lanes (separated, conventional, etc.) run along a transit stop. This treatment is compatible with near-side, far-side and midblock transit stop locations.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector

Safety Benefits

Eliminates conflict between transit vehicles and bicyclists.

Expected Crash Reduction

A crash reduction rate has not yet been determined.

Design Guidance

- Provide a buffer of 6 to 12 inches between the transit shelter and the bike lane. This buffer is narrower than the shy distance normally used for vertical surfaces (2 feet), but this is okay for short distances in constrained spaces.
- Channelizing railings, planters or other treatments can be used to help direct people to the crossing location(s).
- Multiple pedestrian crossings are recommended, but not required.
- Provide a minimum 4-foot-wide walkway between the curb and the transit shelter.
- Minimum 8 feet of clear width at the location where the bus doors will open to accommodate people in wheelchairs.

Considerations

- The space between the bike lane and the sidewalk must have a detectable edge so pedestrians with vision

disabilities can distinguish between the two. The bike lane may be located at street level, intermediate level, or sidewalk level. The bike lane elevation can affect the treatment used and can itself be a treatment for creating the detectable edge. The following design treatments can help provide this tactile cue:

- Street furniture or other vertical objects.
- A curb.
- Curb height changes.
- Continuous low landscaping.
- A directional indicator (International Standard 23599) installed linearly on the sidewalk adjacent to the edge.

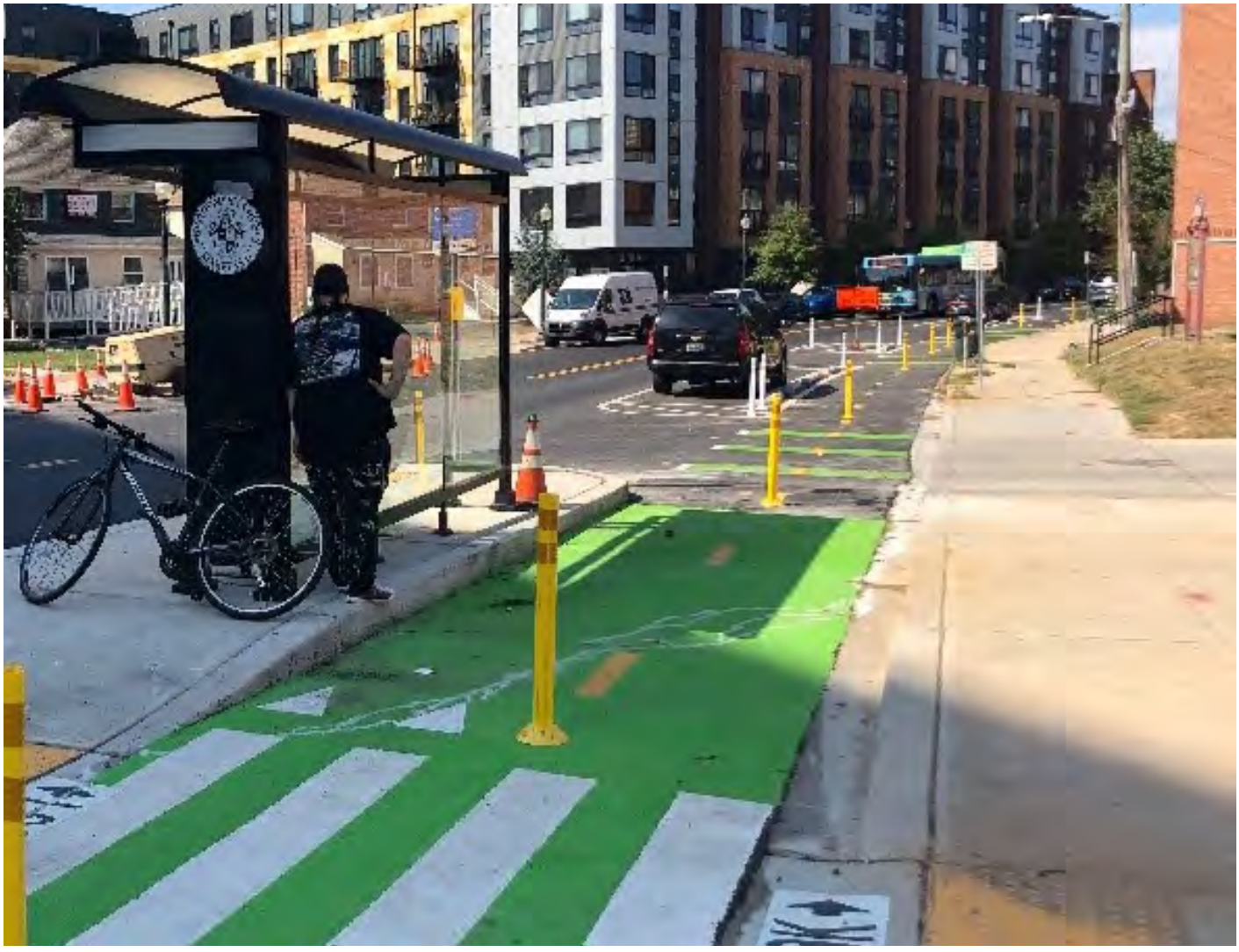
- Consider transit queuing and vehicle length to determine island length and pedestrian crossing placement.
- Ensure visibility between bicyclists and pedestrians for safety.
- Consider raised pedestrian crossings between the floating transit island and the sidewalk to prioritize pedestrians.

Systemic Safety Potential

Potential for systemic safety application at bus stops located along separated bike lanes. Best suited as a spot treatment along buffered bike lanes and conventional bike lanes.

Additional Information

- NACTO Transit Street Design Guide



GATEWAY TREATMENTS

Purpose

Reduce motor vehicle speeds and yielding at uncontrolled crosswalks.

Description

"Stop for Pedestrian" signs (MUTCD R1-6a) are placed on left and right sides of all travel lanes approaching a crosswalk to improve motorist awareness of pedestrians crossing.[22]

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

Gateway treatments are appropriate at uncontrolled crossings on streets with speed limits of:

- 30 mph or less.
- 35 mph and below 12,000 daily vehicles.

Not applicable on streets with speed limits of 40 mph and above.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street
- Industrial Street
- Country Connector

Safety Benefits

- Increase motorist yielding at uncontrolled crossings.
- May reduce delay for pedestrian crossings due to increased motorist yielding.
- Decreases vehicle speeds whether or not pedestrians are crossing.

Expected Crash Reduction

Initial research indicates gateway treatments may increase driver yielding and reduce vehicle speeds.[23]

Design Guidance

- All approaching travel lanes should have signs placed on both the left and right sides. Signs should be placed on center line, median, crossing island, lane line, or near the curb.
- Install with curb ramps and high-visibility crosswalk markings.
- On multi-lane approaches, install with advance stop/yield markings.
- Signs and delineators should be installed between 1.5 feet and 50 feet advance of the crosswalk. On multi-lane approaches, place Stop Here for Pedestrians signs (MUTCD R1-5 series).[24]
- Double-sided signs are recommended because they increase the likelihood that drivers will see a sign in heavy traffic.

Considerations

- Signs should not be placed within the crosswalk.
- More effective when gaps between signs are smaller.
- Edge line and curb line placement require FHWA permission to experiment.
- Placing signs farther back from crosswalks at intersections (e.g. 30 feet) can reduce sign damage.
- A refuge island and advance yield lines are recommended where daily vehicle volume is 12,000 or greater.

Systemic Safety Potential

Spot treatment. Can be applied to corridors with multiple uncontrolled crossings.

Additional Information

- User Guide for R1-6 Gateway Treatment for Pedestrian Crossings
- Manual on Uniform Traffic Control Devices

HARDENED CENTERLINES AND TURN WEDGES

Purpose

Reduce motor vehicle turning speed and increase motor vehicle yielding to pedestrians.

Description

Hardened centerlines are flexible delineators placed between opposing travel lanes. Turn wedges are raised curbs or flexible delineators and pavement markings on both sides of a crosswalk at an intersection.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Hardened centerlines can be installed at intersections of midblock crossing locations.
- Where left turning vehicles do not yield sufficiently.
- Turn wedges can be installed at corners of an intersection.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street

Safety Benefits

- Slow left-turning motor vehicles.
- Guide motor vehicles to wider turning angle for safer and more predictable turns.
- Increase visibility of pedestrians in crosswalk to turning motorists.
- Mitigate visibility issues caused by metal reinforcement between vehicle windshields and windows.

Expected Crash Reduction

46 percent for all crashes at raised medians.[25]

A crash reduction estimate has not been established for turn wedges.

Design Guidance

Hardened centerlines

- Raise centerline with flexible delineators and separators (e.g. Leitboy Bollard with Guide Curb separator).
- Install a rubber speed bump, mountable curb, or flexible delineators and separators along the centerline, on one or both sides of the crosswalk.

- Paint lane extensions through the intersection with yellow markings.
- Vertical elements should not be present in the crosswalk.

Turn wedges

- Have similar geometry and materials as a curb extension – typically placed in line with a parking lane. See curb extension treatment for design guidance.
- Reduce the effective turning radius for vehicles.

Considerations

- Can be constructed rapidly and inexpensively using paint and flexible bollards.
- The turning radius of trucks and buses should be considered when installing turn wedges.

Systemic Safety Potential

Both hardened centerlines and turn wedges slow left-turning vehicles. Potential for systemic implementation at intersections where turn speeds are high or motorists are not yielding.

Additional Information

- Chapter 8 of Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide
- Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- FHWA Proven Safety Countermeasures

HIGH-VISIBILITY CROSSWALKS

Purpose

Improves visibility of pedestrians to approaching motorists.

Description

High-visibility crosswalks use parallel markings that motorists see more easily compared with traditional crosswalk markings located perpendicular to the motor vehicle path of travel.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- High-visibility crosswalks are appropriate at all controlled intersections.
- Uncontrolled intersections should meet requirements in MUTCD Section 3B.18.

Applicable Street Types

All street types.

Safety Benefits

- Increase motorist awareness of crosswalk location.
- Reduce crashes between pedestrians, bicyclists, and motor vehicles.
- Designate pedestrian right-of-way, and may reduce pedestrian crossings at unmarked locations.[26]

Expected Crash Reduction

48 percent for vehicle-pedestrian crashes.[27]

Design Guidance

- Marking pattern should be continental: a series of wide stripes parallel to the travel lanes for the entire length of the crossing.
- Crosswalks should be a minimum of 10 feet wide. If the sidewalk or sidepath is wider than 10 feet, the crosswalk should match the width of the sidewalk or sidepath.
- Install with curb ramps.
- At signalized intersections, install a stop bar in advance of the crosswalk at least four feet from the nearest edge of the crosswalk.
- Parking should be restricted in advance of a crosswalk to provide adequate sight distance.

Considerations

- Crosswalk location should be convenient for pedestrian access.
- Width may be wider than 10 feet at crossings with high pedestrian or bicycling demand.

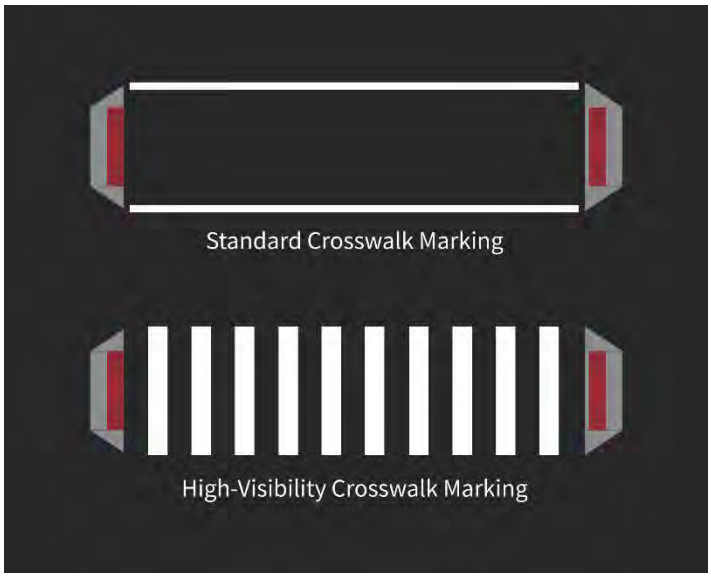
- Artistic crosswalks, with approval from MCDOT, may be installed in the center of the intersection to add a unique design feature.

Systemic Safety Potential

Apply as a systemic countermeasure at all controlled crossings. At uncontrolled crossings, apply in accordance with FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, Table 1.

Additional Information

- Manual on Uniform Traffic Control Devices
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations



LEADING BICYCLE INTERVALS AND LEADING PEDESTRIAN INTERVALS

Purpose

Extends crossing time for pedestrians and bicyclists at signalized intersections.

Description

Leading bicycle intervals (LBIs) or leading pedestrian intervals (LPIS) are adjustments to traffic signals to give bicyclists or pedestrians a three-to-seven-second head start before motorists enter the intersection.

Estimated Cost

$ | **$$** | $$$ | $$$$

Applicable Locations

LBIs are a treatment option at:

- Intersections with high bicycle volumes
- Intersections with separated bike lanes or contraflow bike lanes
- Intersections where shared-use paths or other bicycle routes cross a major, signalized intersection

LPIs are a treatment option at:

- Signalized intersections.
- Intersections with a significant number of turning vehicles and pedestrian volumes.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street

Safety Benefits

- Increase visibility of pedestrians and bicyclists.
- Increase motorist yielding.
- More crossing time provided for pedestrians and bicyclists.

Expected Crash Reduction

Thirteen percent for vehicle-pedestrian crashes.[28]

An estimated crash reduction has not yet been determined for LBIs.

Design Guidance

LBIs should be installed with:

- Bicycle Signal sign (MUTCD R10-10) if bicycle signal is present, otherwise, direct bicyclists to follow pedestrian signal (MUTCD R9-5). [29]
- "No Right Turn on Red" sign (MUTCD R10-11). [30]

LPIs should be installed with:

- High-visibility crosswalk markings, curb ramps, accessible pedestrian signals, and "No Right Turn on Red" sign (MUTCD R10-11). [31]

Considerations

- LBIs or LPIs can be provided actively or provided only when actuated. Active detection requires an accessible pushbutton.
- The length of LPIs or LBIs can be increased where pedestrian or bicyclist volumes are high.
- Right-turn-on-red rules may limit the effectiveness of LBIs and LPIs.
- LPI may be accompanied with an audible noise for visually-impaired pedestrians.

Systemic Safety Potential

LBIs are best as a spot treatment, or on corridors with high bicycle volumes and vehicle turning.

LPIs are suited for systemic use in areas with existing or planned pedestrian signals and high pedestrian and vehicle volumes.

Additional Information

- Pedestrian and Bicycle Information Center — Signals and Signs
- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System

LIGHTING

Purpose

Increase visibility for all road users at dusk and darkness, especially at crossings.

Description

Well-placed lighting improves visibility for all road users. Pedestrian-scale lighting illuminates sidewalks and crossings and light fixtures are shorter than roadway-scale light fixtures.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Controlled and uncontrolled intersections.
- On crossing approaches.
- Along sidewalks.
- Beneficial at intersections in areas with high volumes of pedestrians, such as commercial or retail areas.
- Near schools, parks, and recreation centers.
- On both sides of arterial streets.

Applicable Street Types

All street types.

Safety Benefits

- Improves visibility for all parties.
- May reduce crashes and injuries for all road users.
- May increase yielding and compliance with traffic control devices.
- Improves comfort levels.

Expected Crash Reduction

23 percent for injury crashes.[32]

Design Guidance

- Use 3000K shielded LED lights wherever possible.
- Lighting should be consistent and uniform.
- Consider placement of existing buildings and trees to reduce spillover.
- Install lighting to Illuminating Engineering Society and DarkSky guidelines.

Considerations

- Uniform lighting can suggest pedestrian use and create a sense of enclosure.
- Lighting should be provided on crosswalk approaches.

If a crossing has a crossing island, additional lighting may be provided.

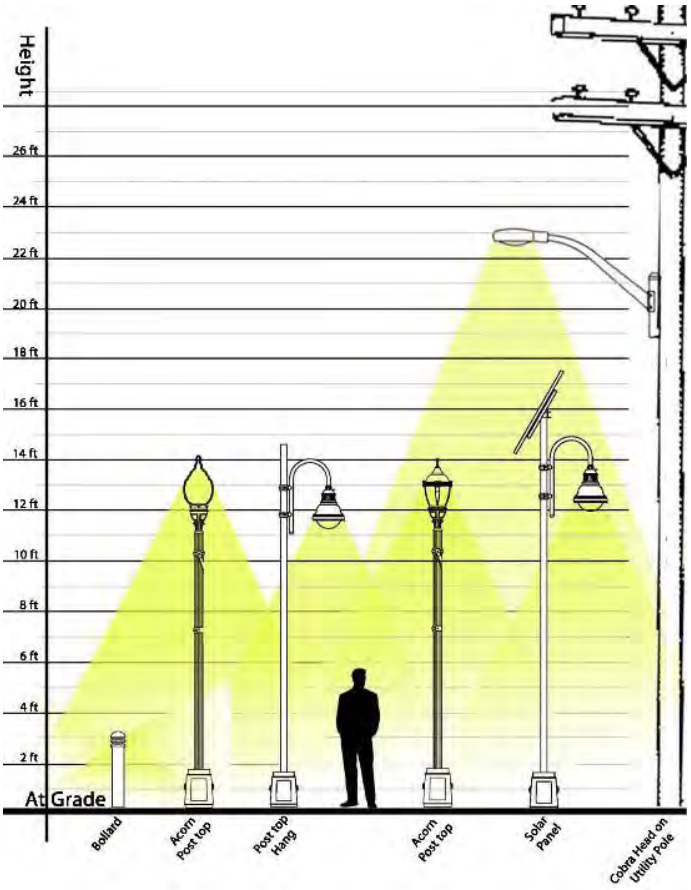
- Consider energy usage and environmental impacts.
- Consider quality and color of light.

Systemic Safety Potential

Potential for systemic safety application at all controlled and uncontrolled crossings.

Additional Information

- FHWA Lighting Handbook
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- ANSI/IES RP-8 Standard Practice for Roadway Lighting
- International DarkSky Association Outdoor Lighting Guidelines



MINI-ROUNDABOUTS

Purpose

Reduce traffic speeds at low-speed and low-volume intersections.

Description

Mini roundabouts, or mini traffic circles, are circular raised islands in the center of intersections.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Intersections with one travel lane in each direction.
- Roadways with posted speeds of 30 mph or lower.
- Residential streets.
- Neighborhood bikeways.
- Stop-controlled intersections with high delay.

Applicable Street Types

- Neighborhood Street
- Neighborhood Yield Street

Safety Benefits

- Reduces motor vehicle through speeds by forcing motorists to maneuver around the island.
- Eliminates left-turn crashes.
- Reduces right-turn speed.

Expected Crash Reduction

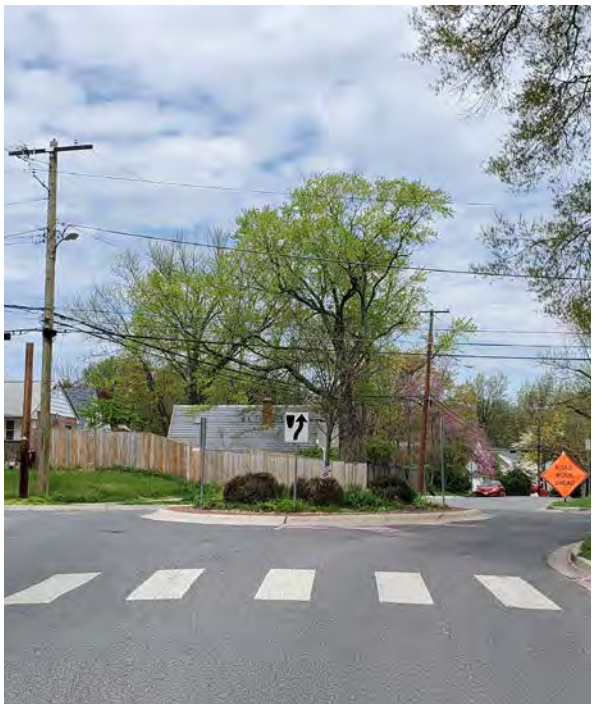
Initial research indicates mini roundabouts can reduce vehicle speeds [33] and crashes.[34]

Design Guidance

- Use yield rather than stop controls.
- Install signs to instruct vehicles to proceed to the right of the mini roundabout.
- May be used with shared lane markings, (sharrows) to indicate bicyclist usage.
- May also be used with W11-2, W11-2, S1-1, or W11-15 crossing warning sign.
- May be landscaped with low shrubs or vegetation that does not impede visibility.

Considerations

- Increasing turn radii for motor vehicles can compromise pedestrian and bicyclist safety.
- Chicanes or other traffic-calming treatments can be installed on adjacent roadways.



- Consider restricting large vehicles from these streets. Large vehicles, such as emergency response vehicles or school buses, may need to make left turns at intersections preceding the mini roundabout.
- Implement parking restrictions on the approach to the traffic circle or create mountable curbs on the outside of the mini roundabout to allow for emergency-response-vehicle access.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
- Mini-Roundabouts: Technical Summary

NEIGHBORHOOD SLOW ZONES

Purpose

Reduce speeds in residential neighborhoods.

Description

Gateways with speed limit signs on both sides of the street introduce the presence of a Slow Zone. Self-enforcing traffic calming measures such as speed humps are needed to ensure effectiveness.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

Neighborhood streets where speeds could be lowered below the current limit with:

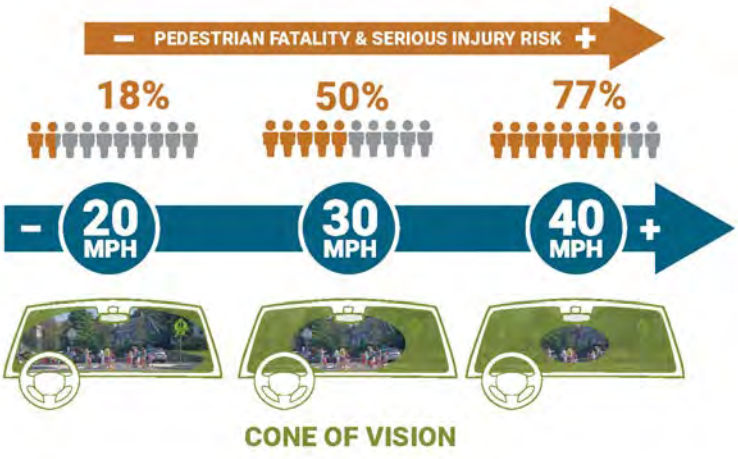
- A history of serious injury or fatal crashes.
- A high amount of vulnerable pedestrians such as children and older adults.

Applicable Street Types

- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street

Safety Benefits

- Manage speeds in residential neighborhoods.
- Create spaces where children may be safer from motor vehicle crashes.



Expected Crash Reduction

- A crash reduction estimate has not yet been developed for this treatment. Slow zones have reduced injuries by 30 percent in some jurisdictions.[35]

Design Guidance

- Place speed limit and slow zone signage on both sides of the roadway at neighborhood slow zone entrances.
- Implement traffic calming measures throughout the slow zone to self-enforce speed limits, such as:
    - Curb Extensions
    - Mini Roundabouts
    - Speed Humps
    - Raised Crossings
- Slow zones can encompass a small neighborhood, with entrances at higher-speed bordering streets.
- Lower-cost temporary materials such as pavement markings and flexible bollards can be applied quickly and broadly.

Considerations

- Neighborhood application processes can improve public engagement and support for slow zones.
- Equity variables can be assessed in the application process to prioritize locations with high crash history or historic disinvestment.

Systemic Safety Potential

Appropriate as a systemic treatment in residential neighborhoods.

Additional Information

- Philadelphia Neighborhood Slow Zone Program Application
- NACTO Urban Design Guide

NEIGHBORHOOD YIELD STREETS

Purpose

Traffic calming on residential streets.

Description

A narrow, two-way street without centerline lane markings that is designed to be used by motorists, bicyclists, and pedestrians. Parking is permitted on either side of the road and vehicles have to weave though and occasionally yield to oncoming vehicles.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

Neighborhood yield streets are primarily residential roads with low traffic volumes and speeds. Neighborhood yield streets are most effective in neighborhoods with higher density.

Applicable Street Types

- Neighborhood Yield Street

Safety Benefits

- Reduce vehicle speeds by communicating that motorists must yield to all other road users.
- Encourage cautious behavior.

Expected Crash Reduction

A crash reduction estimate has not yet been developed for this treatment.

Design Guidance

- Design must communicate that motorists must yield to other road users.
- Neighborhood yield streets do not require lane markings, signage, or striping.
- Sidewalk materials should be maintained across driveways to reduce driveway conflicts.
- Neighborhood yield streets have buffer zones between the sidewalk and road, providing opportunities for street trees, street furniture, and other landscaping.

Considerations

- Roadways should be wide enough to maintain sight distance and for motorists to use the street intuitively without risk of head-on collision.

- Pedestrians and bicyclists may walk or ride on the street.
- Neighborhood yield streets do not have designated crossing locations.
- In regards to speed, neighborhood yield streets are self-enforcing roads.

Systemic Safety Potential

Most useful as a spot treatment.

Additional Information

- Montgomery County Complete Streets Design Guidelines

NO TURN ON RED

Purpose

Reduces conflicts between turning vehicles and pedestrians and bicyclists.

Description

A sign or signal used to prohibit motor vehicles turning right when the traffic light is red.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

Signalized intersections. Especially important at:

- Intersections with crossing guards or at school crossings.
- Intersections with inadequate sight distances.
- Intersections with bike facilities.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Major Highway

Safety Benefits

Eliminates conflict between right-turning vehicles and pedestrians and bicyclists traveling through.

Expected Crash Reduction

No turn on red is expected to significantly reduce crashes. One study found a 69 percent crash increase for non-motorized users where the right-turn prohibition was removed.[36]

Design Guidance

- Install "No Turn on Red" signs (MUTCD R10-11) on each applicable approach.[37]
- Dynamic electronic signs can be used to restrict right turns to certain times of day or during certain signal phases.
- Signs restricting right turns on red should be visible to motorists stopped in the curb lane at the crosswalk.
- May increase the number of right turn on green conflicts. May be used with a leading pedestrian interval (LPI) to address the increased numbers of vehicles turning right on green.

Considerations

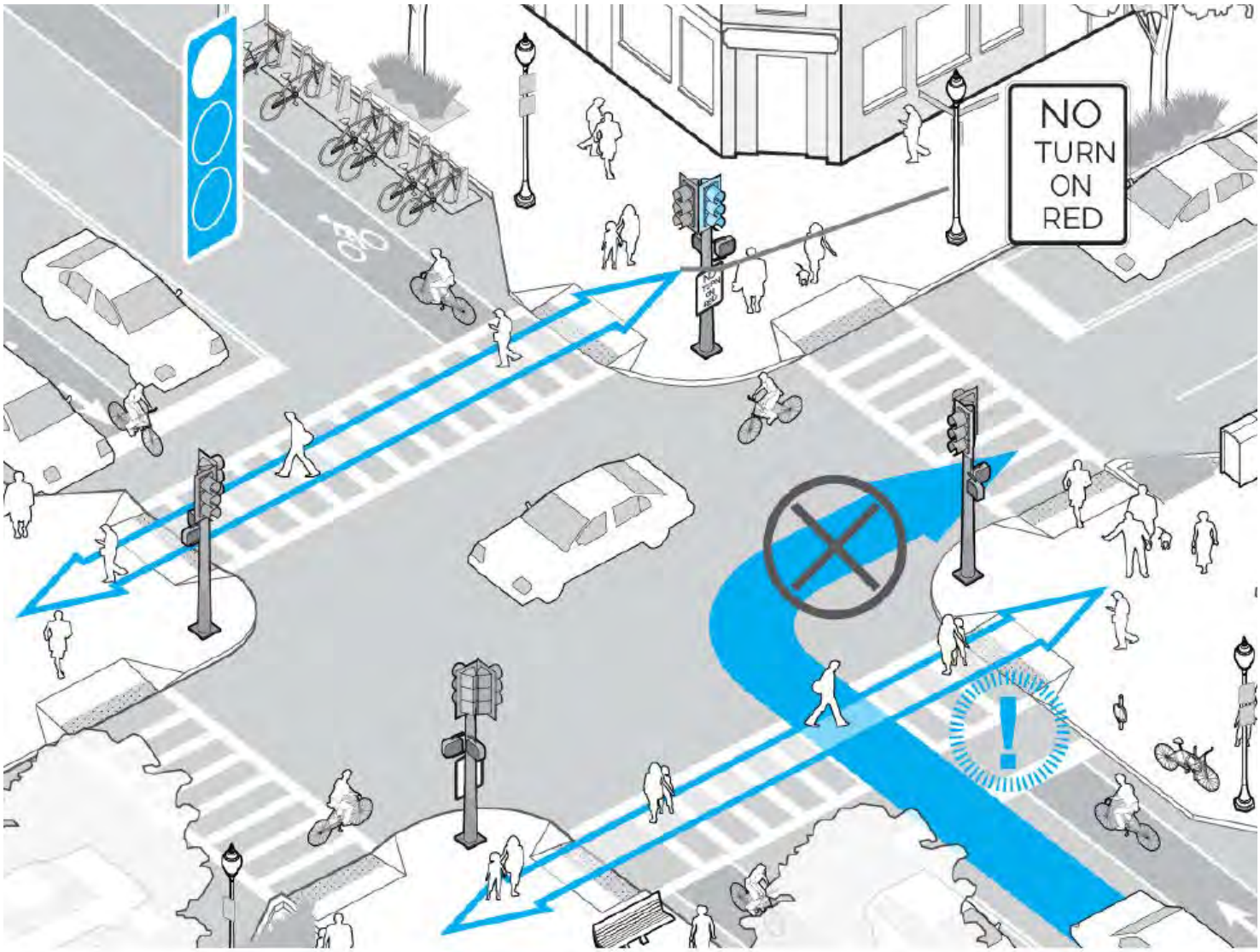
- Research indicates that dynamic signs may be more effective at reducing motorists turning right on red.
- Restricting right turns on red during times of high pedestrian volumes may be sufficient.

Systemic Safety Potential

Restricting right turns on red can be used as a systemic safety improvement in areas with frequent conflicts between turning motor vehicle and bicyclists or pedestrians.

Additional Information

- Manual on Uniform Traffic Control Devices
- PEDSAFE and BIKESAFE
- Highway Safety Manual



OFF-STREET TRAILS

Purpose

Paths outside of the curb designated for bicyclists and pedestrians.

Description

Shared-use paths that accommodate two-way traffic for bicyclists and pedestrians outside of the road right-of-way.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

Off-street trails can be located along railway or utility corridors, land dedicated for planned but unbuilt "paper" streets and through public land.

Applicable Street Types

- Not applicable, off-street trails are not within the right-of-way.

Safety Benefits

- Fewer conflicts with motor vehicles than on-road bike lanes.

Expected Crash Reduction

An 86 percent crash reduction was found for bicyclists, compared to riding in the roadway.[38]

Design Guidance

- The minimum paved width for a trail is 10 feet. Anticipated future traffic volumes should be used to guide design decisions. The minimum width to enable side-by-side travel and passing is 11 feet.
- Maximum grade should not exceed 5 percent. Grades less than 0.5 percent should be avoided.
- Ideally, provide a graded shoulder area of 3-5 feet.
- Lighting should be provided at path/roadway intersections at a minimum and at other locations where personal security may be an issue or where nighttime use is likely to be high.
- Sight distances are based on site conditions and user-based factors. Ensure sight distances are designed per the AASHTO Bike Guide.
- Provide protective railings/fences at 42 inches high if the trail is adjacent to a steep slope.

Considerations

- Trails expected to serve a high percentage of pedestrians (30 percent or more) or be used by large maintenance vehicles should be wider than 10 feet.

- Trails with high use may require pedestrian and bicycle separation. This separation can take the form of pavement markings or separate parallel paths for each user group. If separation is achieved by pavement markings, the bicycle side of the pathway should be no less than 10 feet wide and the pedestrian side should be no less than 5 feet wide.
- Trails on steep grades (3-5 percent) should be wider to account for higher bicycle speed in the downhill direction and additional space for faster bicyclists to pass slower bicyclists and pedestrians in the uphill direction.
- On sections with long steep grades, provide periodic sections with a flat grade to permit users to stop and rest.
- Lighting should be pedestrian-scale, with fixtures located about 15 feet above the trail and with 0.5 to 2.0 foot candles.
- Where lighting is not provided, reflective edge lines should be marked on the pavement.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- FHWA Bikeway Selection Guide

PARKING RESTRICTIONS AT CROSSING LOCATIONS/ DAYLIGHTING

Purpose

Improve sightlines between motorists and pedestrians or bicyclists crossing the street.

Description

Signs, pavement markings, curb extensions, or vertical delineators that restrict on-street parking near a crossing.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- Approaches to crossings where parked vehicles block sightlines.
- Approaches to crossings with high pedestrian volumes.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street
- Industrial Street
- Country Connector
- Country Road

Safety Benefits

- Prevent motorists from parking in a crosswalk, giving sufficient space for pedestrians to wait to cross the street.
- Increase sightlines for all road users.
- Encourage safer turning speeds when used on crosswalks at intersections.
- Restrict illegal parking near crosswalks.

Expected Crash Reduction

30 percent for vehicle-pedestrian crashes.[39]

Design Guidance

- Parking shall be restricted at least 20 feet from the

back of the crosswalk on all sides. Parking may be restricted up to 40 feet on all sides.

- In locations with sight distance obstructions, the parking restriction should be extended as necessary.
- Area with parking restriction can be defined using curb extensions, planters, painted curb, or flexible delineators.
- Install a “No Parking” sign (MUTCD R7 series).
- Install with a high-visibility crosswalk and curb ramps.

Considerations

- Parking removal should be discussed with community stakeholders, such as businesses and property owners.
- Converted parking spaces can be reallocated for green infrastructure or bicycle parking.
- Parking restrictions without physical barriers are less effective and may require enforcement.
- Parking restrictions may be tailored to certain times of day.
- May require removal of existing parking space markings and possibly meters.

Systemic Safety Potential

Potential for systemic implementation at all intersections with high pedestrian crossing volumes.

Additional Information

- Unsignalized Intersection Improvement Guide

PEDESTRIAN HYBRID BEACON (PHB)

Purpose

Signalized crossing for pedestrians allowing motor vehicles to proceed unless pedestrians are present.

Description

Signals at major street crossing locations that remain dark until pedestrian activates via a pushbutton. Also called High Intensity Activated Crosswalks, or HAWKs.

Estimated Cost

$ $$ **$$$** $$$$

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street
- Industrial Street
- Country Connector
- Country Road

Applicable Locations

Can be used at the midblock or at corners, but not placed in the functional area of signalized intersections. PHBs can also be used:

- Where traffic signals do not meet MUTCD warrants.
- Outside of turn lanes.
- Along bicycle routes where bicyclists must cross a major road.
- On roads with three or more lanes and where the number of daily vehicles is greater than 9,000.

Safety Benefits

- Reduce pedestrian delay.
- May reduce multiple threat crashes.
- May reduce pedestrian crossing at undesignated crossings.

Expected Crash Reduction

55 percent for vehicle-pedestrian crashes.[40]

Design Guidance

- Install pedestrian signal heads and pedestrian pushbuttons on either side of the crossing.
- Mark crosswalk with high-visibility markings.
- May be installed with pedestrian warning sign (MUTCD W11-2 or MUTCD R1-5 series).
- See Maryland MUTCD Chapter 4f and the Montgomery County Complete Streets Design Guidelines for additional information.

Considerations

- Beacons are preferably placed above the crosswalk, rather than the side of the road.
- Most effective when motor vehicle speeds are too high or gaps in traffic are too infrequent or for pedestrians to cross safely.
- PHBs are not common; consider outreach efforts when implementing a PHB to educate drivers and pedestrians.

Systemic Safety Potential

- Pedestrian Hybrid Beacons have the potential for systemic implementation at crossings on multi-lane roadways with higher traffic volumes, speed limits at 30 mph or more, and longer intervals between crossings.
- Can be a systemic treatment for all midblock crossings where roadway speed limits are 40 mph or higher.

Additional Information

- NCHRP 562 & TCRP 112: Improving Pedestrian Safety at Unsignalized Intersections
- Pedestrian Hybrid Beacon Guide, Recommendations and Case Study
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- Safety Effectiveness of the HAWK Pedestrian Crossing Treatment

POSTED SPEED LIMIT (TARGET SPEEDS AND SCHOOL SPEED ZONES)

Purpose

Reduce motor vehicle speeds to prevent severe and fatal crashes.

Description

Using speed limit signs, pavement markings, and other speed reduction measures to achieve target speeds on roadways that are appropriate for the context and support the County's Vision Zero goal.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

Posted and target speeds should be considered for all roadways. Lower posted and target speeds are especially effective at reducing pedestrian crash risk in areas of high expected activity, such as:

- Near schools
- Downtown commercial areas
- Near senior living centers
- Residential neighborhoods

Applicable Street Types

All street types.

Safety Benefits

- School speed zones increase motorist awareness of vulnerable road users.
- Lower target speeds and posted speed limits may reduce motor vehicle speeds.
- Pedestrian fatalities and serious injuries are much less likely at lower speeds.

Expected Crash Reduction

An estimate has not yet been determined for this treatment; however research indicates a significant reduction in fatal and injury crashes in certain cases.[41]

Design Guidance

- Define the priority user when identifying appropriate speed limit. Within school zones, pedestrians and bicyclists should always be given priority.
- Indicate school speed zones with signs (including MUTCD S4-5 series, S5-1, S5-3, R2-1).
- Pavement markings indicating the speed limit can supplement signs.
- Most effective when used in conjunction with other traffic calming treatments.

Considerations

- School speed zones can be implemented for certain hours throughout the day, such as around arrival and dismissal times.
- Signs should be used carefully. Overuse can lead to drivers ignoring them.

Systemic Safety Potential

Areawide reductions to a 20-mph default residential speed and 25 mph default speed on non-residential streets are a systemic approach to speed reduction.

School speed zones should be a systemic safety improvement to all elementary, middle, and high school locations.

Additional Information

- Manual on Uniform Traffic Control Devices 2009, Sec. 7B.08–7B.10.
- National Center for Safe Routes to School, The School Zone: School Zone Signs and Pavement Markings.

PROTECTED CROSSING SPACING FOR MANAGING CONFLICTS

Purpose

Create gaps in motor vehicle traffic flow for pedestrians and bicyclists to cross safely without unnecessary delay or detour.

Description

Protected crossings located along streets according to the Montgomery County Complete Streets Design Guidelines.

Estimated Cost

$ $$ **$$$** $$$$

Applicable Locations

Any road with pedestrian detour between protected crossings that exceeds the Montgomery County Complete Streets Design Guidelines

Applicable Street Types

All street types.

Safety Benefits

- Reduce crash risk between crossing pedestrians or bicyclists and motor vehicles through conflict elimination.
- Encourage crossing at safer locations, especially on higher speed or volume roads.
- Increase predictability of pedestrian or bicyclist and motor vehicle interactions.

Expected Crash Reduction

Varies by specific treatment selection for each protected crossing. See each treatment for crash reduction estimates.

Design Guidance

- See Complete Streets Design Guidelines figure 6.25 for maximum protected crossing spacing and minimum signalized intersection spacing by complete street type.
- Specific design guidance for protected crossings varies based on crossing configuration and treatment selection.
- See other treatments in this toolkit for design guidance on constituent elements of a protected crossing.

Considerations

- There are instances when more frequent crossing distances are appropriate based on land use patterns or pedestrian uses along a given corridor.
- The protected crossing spacing in the Complete Street Guide should be considered a "rule of thumb" and flexibility is necessary in implementation.

Systemic Safety Potential

Consider for systemic application based on Montgomery County Complete Streets Design Guidelines spacing requirements.

Additional Information

- Montgomery County Complete Streets Design Guidelines
- FHWA Pedestrian Safety Guide and Countermeasure Selection System
- Manual on Uniform Traffic Control Devices

PROTECTED INTERSECTIONS

Purpose

Improve the safety of pedestrians and bicyclists crossing intersections.

Description

Protected intersections are a type of intersection design that improves safety by reducing the speed of turning traffic, improving sightlines, and designating space for all road users. Protected intersections reduce conflict points between motorists and bicyclists.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

Any intersection with existing or planned sidepaths, separated bike lanes, buffered bike lanes, or conventional bike lanes.

Applicable Street Types

- Downtown Boulevard
- Downtown Street
- Boulevard
- Town Center Boulevard
- Town Center Street
- Neighborhood Connector
- Industrial Street
- Country Connector
- Country Road

Safety Benefits

- Reduces the speed of turning motor vehicles.
- Improves sightlines and designates space for all road users.
- Reduces conflict points between motor vehicles, pedestrians and bicyclists.

Expected Crash Reduction

A crash reduction rate has not yet been determined. However, studies of "bend out" intersection approaches find that separation distance of 6.5 – 16.5 feet offers the greatest safety benefit, with a better safety record than conventional bike lane designs.[42]

Design Guidance (see graphic below)

1. Corner refuge island size may vary. The curb radius along the path of motor vehicle travel should minimize turning motorist speeds to 15 mph or less.
2. The forward bicycle queuing area should allow at least one bicyclist to wait without obstructing crossing bicyclists or pedestrians.
3. The motorist yield zone should be 6 feet in length minimum, up to a typical car length (16.5 feet), to create space for a turning motorist to yield to a through moving bicyclist.
4. A pedestrian crossing island should be a minimum of 6 feet in width to minimize pedestrian crossing distances of the street.
5. Marked pedestrian crosswalks should be provided across all bike lane crossings.
6. Bicycle crossings should be separate from pedestrian crossings. They can be supplemented with green pavement to improve contrast.

Considerations

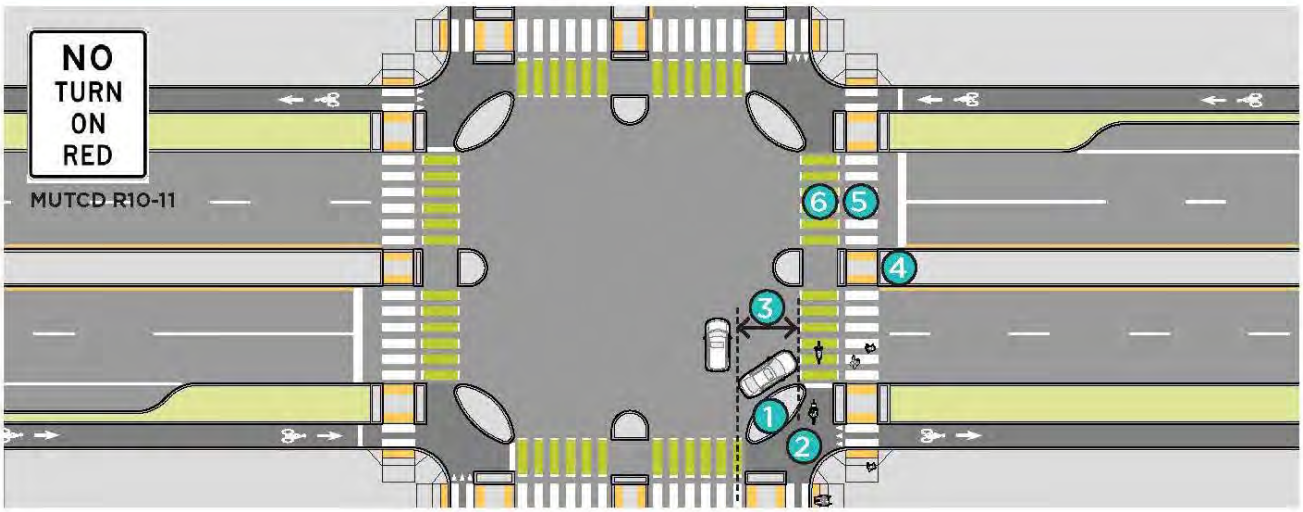
Creating space for a motorist to yield to bicyclists and pedestrians. Research has found crashes are reduced at locations where bicycle crossings are set back from the motorist travel way by a distance of 6 to 20 feet, creating space for turning motorists to yield. At locations where the street buffer is less than 6 feet midblock, additional dedication from developments may be necessary.

Systemic Safety Potential

Potential for systemic safety application at all intersections at least one street has a sidepath, separated bike lanes, buffered bike lanes, or a conventional bike lane, except at intersections where the street without a bikeway (if applicable) is a Neighborhood Street or Neighborhood Yield Street.

Additional Information

- Montgomery County Complete Streets Design Guidelines
- Montgomery County Bicycle Facility Design Toolkit



PROTECTED SIGNAL PHASES

Purpose

Separate vehicular turns from pedestrian and bicyclist movement to eliminate conflicts.

Description

Green- or red-arrow signals to restrict left or right motorist turning, allowing pedestrians and bicyclists to use crossings without interactions from turning vehicles.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- Intersections with high turning volumes.
- Intersections in urban areas.
- Intersections with a high volume of pedestrians or bicyclists.

Applicable Street Types

All street types.

Safety Benefits

- Eliminate conflicts between turning vehicles and road users crossing parallel to traffic.
- Reduce instances of motorists turning at higher speeds and "sneaking" through intersections during yellow or red signal phases.

Expected Crash Reduction

36 percent for exclusive pedestrian phase for vehicle-pedestrian crashes.[43]

Design Guidance

- Install green- or red-arrow capabilities in traffic signals.
- Can be used for both right turning and left turning vehicles.

- When restricting right turns, install a “No Right Turn on Red” sign (MUTCD R10-11 series).
- Exclusive left turn lanes support protected left turn phasing.

Considerations

- Needs of pedestrians, bicyclists, trucks, buses, and motor vehicles should be considered.
- Consider volume of motorists turning left and right.
- May reduce intersection vehicle capacity and increase vehicle queuing and blocking.

Systemic Safety Potential

Useful as a systemic safety improvement at locations with a history of serious injury or fatal right- or left-turn crashes, or at high-risk locations with the same roadway and land use characteristics.

Additional Information

- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
- FHWA Traffic Signal Timing Manual, Chapter 4

RAISED CROSSING

Purpose

Reduce vehicle speeds, increase motorist yielding, and improve bicyclist and pedestrian crossing safety.

Description

Crossings elevated at least three inches above the roadway, up to the sidewalk level.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Raised crossings are a treatment option often used at the midblock. However, intersections can also have raised crosswalks or the entire intersection can be raised.
- Roadways with a posted speed of 30 mph or lower.
- Common on school campuses, at shopping centers, and in pick up/drop off zones.

Applicable Street Types

- Downtown Street
- Town Center Street
- Neighborhood Connector
- Neighborhood Street
- Neighborhood Yield Street

Safety Benefits

- Increases pedestrian prominence in motorist field of vision.
- May reduce vehicle speeds and improve motorist yielding.
- Provides flatter surface for pedestrians with disabilities.

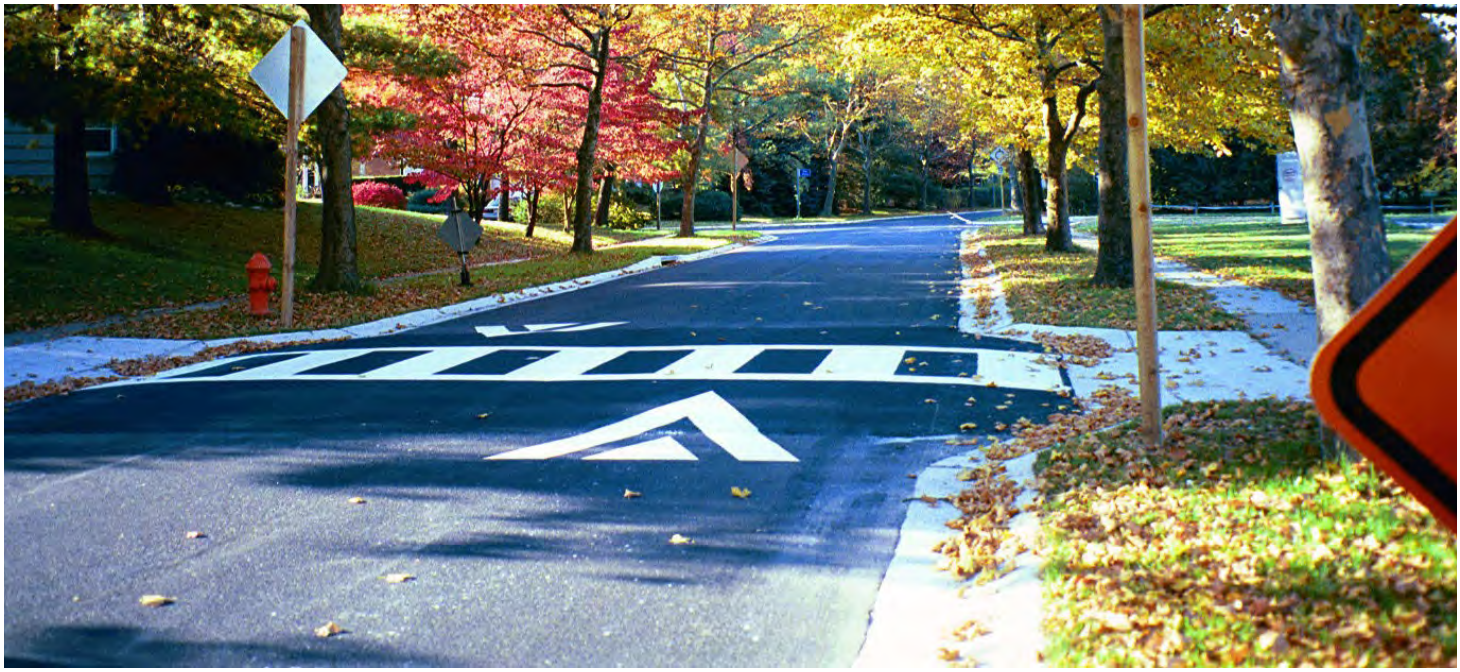
Expected Crash Reduction

45 percent for pedestrian crashes.[44]

51 percent for bicycle-motor vehicle crashes on entrances or exits to streets and driveways.[45]

Design Guidance

- Place ramps on each vehicle approach.
- Raised crossings are often demarcated with different paving materials and additional paint markings.



- Mark the crossing with high-visibility crosswalk markings.
- Install with applicable warning sign (MUTCD W11-1, W11-2, W11-15, or S1-1).
- Raised crossings do not require curb ramps, though truncated domes should be included at each crossing entrance.

Considerations

- Raised crossings at sidewalk level are preferred for pedestrian accessibility and comfort, and safety.
- Raised crossings should not be used on steep curves or roadways with steep grades.
- May be used for bicyclists along crossings for shared use paths.
- Consider drainage needs.
- Further consideration is needed for roadways heavily used by trucks, buses, and emergency vehicles.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- Field Guide for Selecting Countermeasures at Uncontrolled Pedestrian Crossing Locations
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations

RAISED MEDIANS

Purpose

Restrict motor vehicle turn movements, reduce head-on collisions, and provide refuge for crossing pedestrians.

Description

Continuous raised medians are curbed sections in the center of a roadway that separate opposing directions of motor vehicle travel.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- At intersections.
- Along the entire block.
- At midblock crossings.
- Across intersections where it is desirable to restrict motor vehicles turning left due to insufficient yielding or excessive speeds.

Applicable Street Types

All street types.

Safety Benefits

- Reduce potential conflict points by minimizing motor vehicle left turns.
- If six feet or greater, allow pedestrians to cross one direction of vehicle travel at a time.
- Reduce pedestrian crossing distance.
- Reduce vehicular turning speeds.
- Provide space for additional lighting at the crossing.
- Can improve motorist safety where a continuous raised median replaces continuous two-way center turn lanes.

Expected Crash Reduction

46 percent all crashes at raised medians.[46]

Design Guidance

- Medians may be landscaped or paved with a material different to that of the roadway.
- Continuous raised medians require 6 feet width to provide pedestrian refuge or 8 feet width to provide bicyclist refuge.
- Crossings must have ramps or cut-throughs to be fully accessible.

Considerations

- Landscaping can be added along the median, but vegetation at any crossings should not obstruct visibility for the pedestrian or motorist.
- May increase vehicle through speeds.
- Emergency vehicles may need to travel in lanes of opposing direction of travel.
- Continuous raised medians use space that can be used for bike lanes or wider sidewalks.
- Wide medians increase the pedestrian crossing distance.
- Can be installed with an active warning beacon at midblock crossings.

Systemic Safety Potential

May be applied as a systemic safety improvement on corridors where motor vehicles do not sufficiently yield to pedestrians or bicyclists.

Pedestrian refuge is needed where motor vehicle speeds are above 30 mph and average motor vehicle volumes are above 9,000 vehicles per day.

Additional Information

- Chapter 8 of Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide
- American Disabilities Act Accessibility Guidelines for Buildings and Facilities
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- FHWA Proven Safety Countermeasures

RECTANGULAR RAPID FLASHING BEACON (RRFB)

Purpose

Increase driver yielding to pedestrians at mid-block crossings.

Description

Bright, irregularly flashing LEDs, mounted with pedestrian crossing signs, which increase pedestrian visibility to drivers at uncontrolled crossings.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

RRFBs are a treatment option at many types of unsignalized pedestrian crossings, including at standard pedestrian, school, or trail crossings.

- RRFBs are particularly effective at multilane crossings with speed limits under 40 mph.[47]
- Consider a Pedestrian Hybrid Beacon (PHB) for roadways with multiple lanes and higher speeds.

Applicable Street Types

See Complete Street Guidelines for detailed list of acceptable speeds, volumes and lanes that Montgomery County would consider the use of an RRFB.

Safety Benefits

- Increases driver yielding.
- May increase effectiveness of other safety treatments, such as advance yield markings with "YIELD HERE FOR PEDESTRIAN" signs.
- More effective than traditional overhead beacons.[48]
- At multilane crossings, multiple threat crashes still exist.

Expected Crash Reduction

47 percent for vehicle-pedestrian crashes.[49]

Design Guidance

- Place on both sides of an uncontrolled crosswalk.
- If pole-mounted, place below a W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign and above a diagonal downward arrow (W16-7P) plaque.
- May also be used with an overhead-mounted W11-2, S1-1, or W11-15 crossing warning sign, located at or immediately adjacent to an uncontrolled marked crosswalk.
- If sight distance approaching the crosswalk is limited, an additional RRFB may be installed on the approach with a post-mounted W11-2, S1-1, or W11-15 sign with an AHEAD (W16-9P) or distance (W16-2P or W16-2aP) plaque. Consider other treatments in these locations.

Considerations

- RFBs should not be used in conjunction with "Yield," "Stop," or traffic signal control (except at roundabouts).
- If multiple RRFBs are needed in close proximity, consider redesigning the roadway to address systemic safety challenges.
- Other treatments may be more appropriate in locations with sight distance constraints.

Systemic Safety Potential

Spot treatment or targeted systemic locations, such as trail or school crossings are appropriate. Broad application suggests other treatments such as speed reduction or roadway redesign may be necessary.

Additional Information

- Montgomery County Complete Streets Design Guidelines
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- Maryland Manual on Uniform Traffic Control Devices

ROAD DIETS AND LANE WIDTH REDUCTIONS

Purpose

Reduce the speed of traffic, reduce crossing distances and/or provide additional space for other elements of the roadway.

Description

Reduce the number of lanes (road diets), the width of lanes (lane width reductions), or both.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

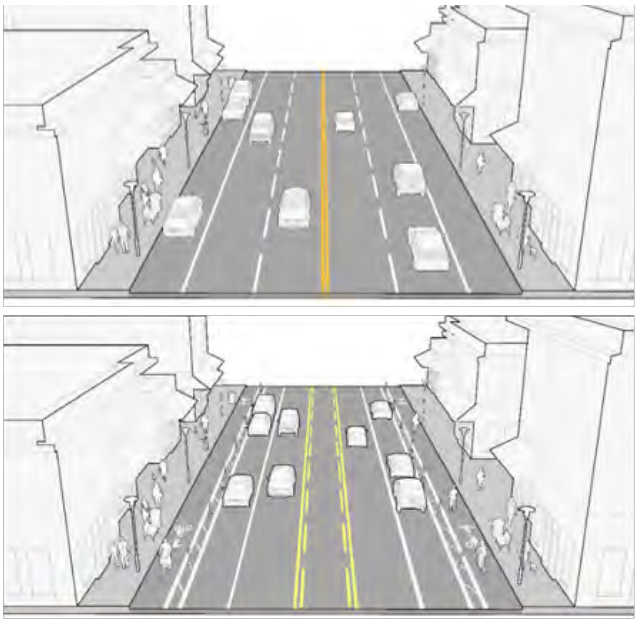
- Multi-lane roads are eligible for lane reconfiguration.
- Emphasis should be placed on roads with priority pedestrian and bicyclist routes.
- Lane reconfiguration can be done in urban, suburban, and rural areas.

Applicable Street Types

All street types.

Safety Benefits

- Increase available space for additional safety infrastructure for pedestrians or bicyclists.
- May reduce the number of potential conflict points.
- May slow motor vehicle operating speeds.
- May reduce crossing distances by eliminating a lane or through provision of a pedestrian median island.



Example of a four to three lane conversion with separated bike lanes.

Expected Crash Reduction

47 percent for all crashes in suburban areas.[50]

29 percent for all crashes in urban areas.[51]

Design Guidance

- Eliminating a travel through lane can make room for a bicycle lane, turn lanes, wider sidewalks, median island, curb extensions, on-street parking, transit lane, landscaping, or other uses.
- Road diets are often considered on roadways with up to 24,000 daily vehicles.
- In urban areas, certain lane widths are mandated by Montgomery County Bill 33-13. For all other lane widths, see the Complete Streets Design Guidelines.
- Lane width of outside travel lanes may be slightly wider to accommodate curbside uses. See Complete Street Design Guidelines for outside travel lane widths per street type.

Considerations

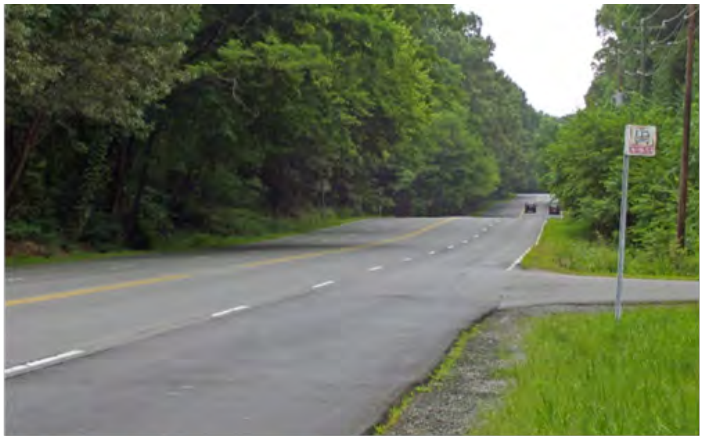
- Eliminating a travel through lane may increase congestion and vehicle queuing and blocking during peak travel hours.
- Evaluate impact of a road diet on all road users, not just vehicles.
- Consider implementing a road diet in conjunction with pavement overlay.
- The FHWA recommends considering factors including:
    - Volume thresholds, such as average daily traffic
    - Vehicle speed
    - Trip generation estimates
    - Level of Service
    - Quality of Service
    - Pedestrian and bicyclist volumes
    - Transit and freight operations
    - Peak hour and peak direction traffic flow

Systemic Safety Potential

Spot treatment. Context is important to analyze need.

Additional Information

- Evaluation of Lane Reduction "Road Diet" Measures on Crashes
- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
- Road Diet Informational Guide
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- FHWA Achieving Multimodal Networks



Road before four to three lane conversion

Road after four to three lane conversion

ROAD IMPROVEMENTS AT CURVES

Purpose

Prevent or provide motor vehicles the opportunity to recover from lane departure at curves.

Description

Enhanced delineation and friction; creating or widening shoulders; improving clear zones; flattening slopes; or adding barriers such as cable barriers, guardrails, or concrete barriers at curves.

Estimated Cost

$ $$ **$$$** $$$$

Applicable Locations

At horizontal curves on rural roadways where data indicate a higher risk of roadway departure serious injuries or fatalities, such as:

- Sharp or blind curves
- Curves without shoulders
- Curves with steep side slopes

Applicable Street Types

- Country Connector
- Country Road
- Major Highways

Safety Benefits

- Allows drivers to recover from lane departure.
- Reduces crash severity of roadway departures.
- Prevents roadway departure with physical barriers such as guardrails if roadside recovery design is not possible.

Expected Crash Reduction

Varies by improvement type. According to national statistics, 27 percent of all fatal crashes occur at curves, and 80 percent of all fatal crashes at curves are roadway departures.[52]

Design Guidance

- Low-cost countermeasures include:
    - Chevron and curve warning signs (MUTCD W1-x).[53]
    - Retroreflective pavement markings
    - Raised retroreflective lane markers
- Pavement friction improvements may reduce lane or roadway departures.

- Wider clear zones and flatter slopes allow for recovery from roadway departure.
- Where both rumble strips and guardrails are provided, locate guardrails at least 5 feet from the rumble strips.
- Longitudinal barriers should be between pedestrian or bicyclist facilities and the motor vehicle travelway. Also provide a fence between pedestrian and bicyclist facilities and steep side slopes.
- The MUTCD requires that sign supports within the clear zone must be made breakaway or shielded by a barrier.
- On roads posted at speeds 45 mph or lower, the MUTCD breakaway requirement may be met when upgrading sign retroreflectivity.
- For new or resurfacing projects, use pavement edge treatments that allow drivers to return to the travelway.

Considerations

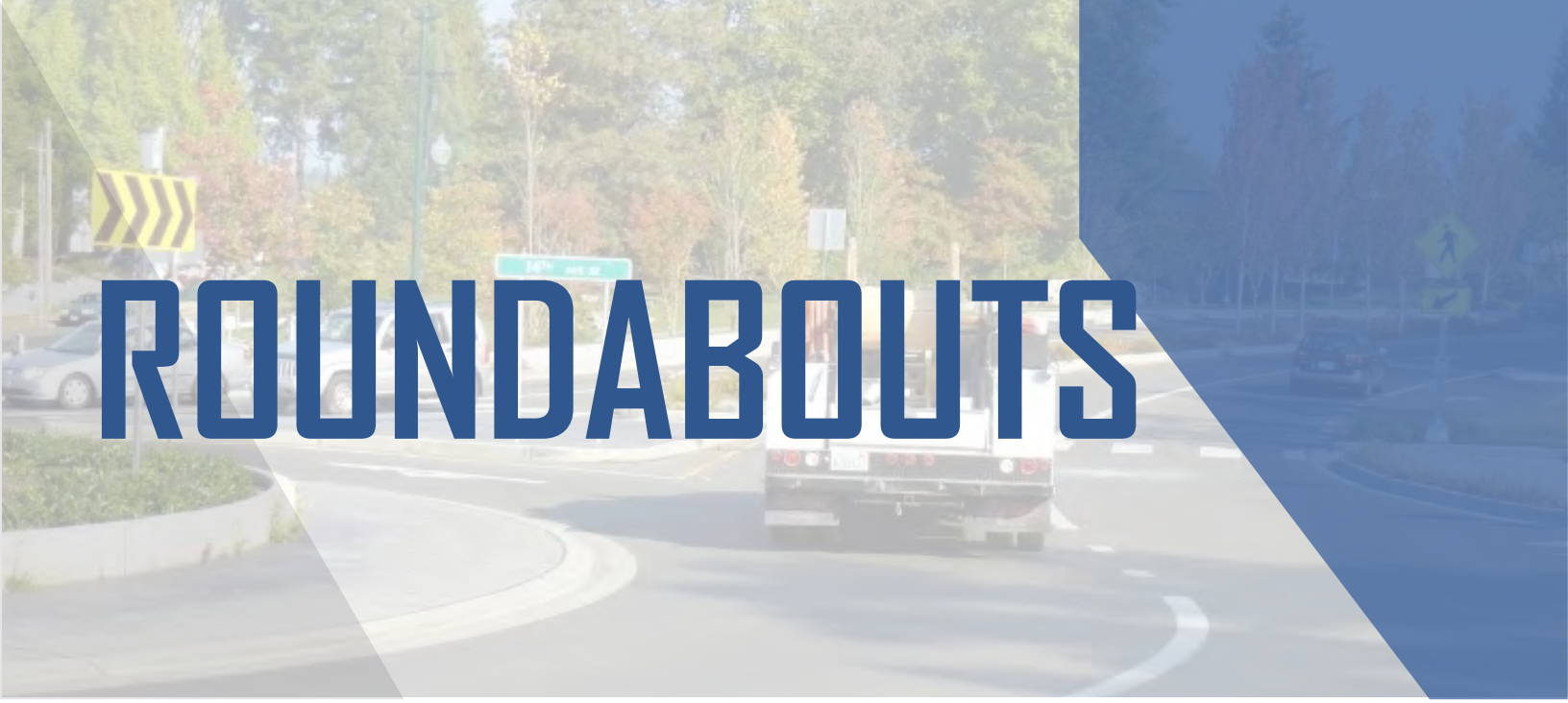
- If roadside hazards cannot be mitigated, reducing crash severity through protective barriers, such as guardrails or cable barriers, is an alternative.
- May encourage higher vehicular speeds.

Systemic Safety Potential

Systemic treatment possible on rural roads at sharp curves or locations with steep side slopes. Especially important on higher-speed rural roads.

Additional Information

- FHWA Low-Cost Treatments for Horizontal Curve Safety 2016
- FHWA Proven Safety Countermeasures:
    - Enhanced Delineation and Friction for Horizontal Curves
    - Roadside Design Improvements
- AASHTO Roadside Design Guide



ROUNDABOUTS

Purpose

Reduce vehicle speeds, reduce high-speed collisions, and eliminate all left turns.

Description

Circular intersections controlled by yield-control rather than a signal or stop.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

Roundabouts can replace signalized intersections, or be installed at intersections where signals are unwarranted. They can also be installed at:

- Intersections of local, collector, or arterial roadways
- Intersections with high left-turning vehicle volumes
- Intersections with more than four legs
- An entrance to an area signifying a change in land use.

Applicable Street Types

- Downtown Boulevards
- Downtown Streets
- Boulevards
- Town Center Boulevards
- Town Center Streets
- Neighborhood Connectors
- Neighborhood Streets
- Industrial Streets
- Country Connectors
- Country Roads
- Major Highways

Safety Benefits

- Reduces vehicle speeds.
- Eliminates angle collisions.
- Places emphasis on motorists yielding to all road users.

Expected Crash Reduction

82 percent in severe crashes for two-way stop-controlled intersection to roundabout conversion.[54]

78 percent in severe crashes for signalized intersection to roundabout conversion.[55]

Design Guidance

- Curbed island in the middle of the intersection, often with landscaping.
- Inscribed diameter is typically less than 200 feet.
- Speeds and geometry should facilitate motor vehicle yielding. Entry speeds should be about 15 to 18 mph. Motorists can be slowed at exit and entry points with horizontal or vertical deflection.
- Channelization islands at all approaches can direct vehicles and slow traffic.
- Mark yield lines at all entries.
- Install crossing treatments for both pedestrian and bicyclists at least 20 feet from roundabout entry.
- Install with warning signs (MUTCD W11-1, W11-2, W11-15, or S1-1).[56]
- May be installed with pedestrian-activated signals or beacons at crosswalks.
- See Montgomery County Complete Streets Design Guidelines for maximum diameter.

Considerations

- Mini roundabouts may be more effective at intersections with low speeds and volumes.
- Take into account pedestrian and bicycle volumes, the design vehicle, number of lanes, and available rights of way.
- Wayfinding should be provided for motorists, pedestrians, and bicyclists.
- Multi-lane or higher-speed roundabouts may not be suitable for intersections with high pedestrian and bicyclist volumes.
- Mini roundabouts may be more effective at intersections with low speeds and volumes.

Systemic Safety Potential

Spot treatment or targeted systemic locations for a corridor management program, such as gateways between areas with different target speeds.

Additional Information

- NCHRP Report 672, Roundabouts: An Informational Guide, Second Edition
- NCHRP Report 834, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook

SEPARATED BIKE LANES

Purpose

To provide physical separation between bicyclists and motorists.

Description

Separated bike lanes provide exclusive space for bicycling, combining 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.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Applicable on streets with three or more lanes or speeds of 30 mph or greater.
- Suited for truck or bus routes, or streets where bike lane obstruction is likely to be frequent.
- 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.

Applicable Street Types

- Downtown Boulevards
- Downtown Streets
- Town Center Boulevards
- Town Center Streets
- Industrial Streets
- Other streets as determined by the Bicycle Master Plan

Safety Benefits

Physical separation of motorists, bicyclists and pedestrians reduces chance of collisions.

Expected Crash Reduction

74 percent reduction in crashes reported in Montreal, but reduction varies overall from 8 to 94 percent.[57]

Design Guidance

On roads with two to four through lanes, one-way directional separated bike lanes are preferred to a two-way separated bike lane on one side of the street as they:

- Follow normal traffic flows, whereas two-way separated bike lanes can create unexpected movements.
- Result in simpler transitions to other facilities.

- Are less likely to need signal modifications.
- Separated bike lanes can provide different levels of separation:
    - Flexible delineator posts ("flex posts") offer the least separation and are appropriate as an interim solution.
    - Raised buffers provide the greatest level of separation from traffic but will often require road reconstruction.
    - On-street parking offers a high-degree of separation but may require raised buffer treatments at intersections.

Considerations

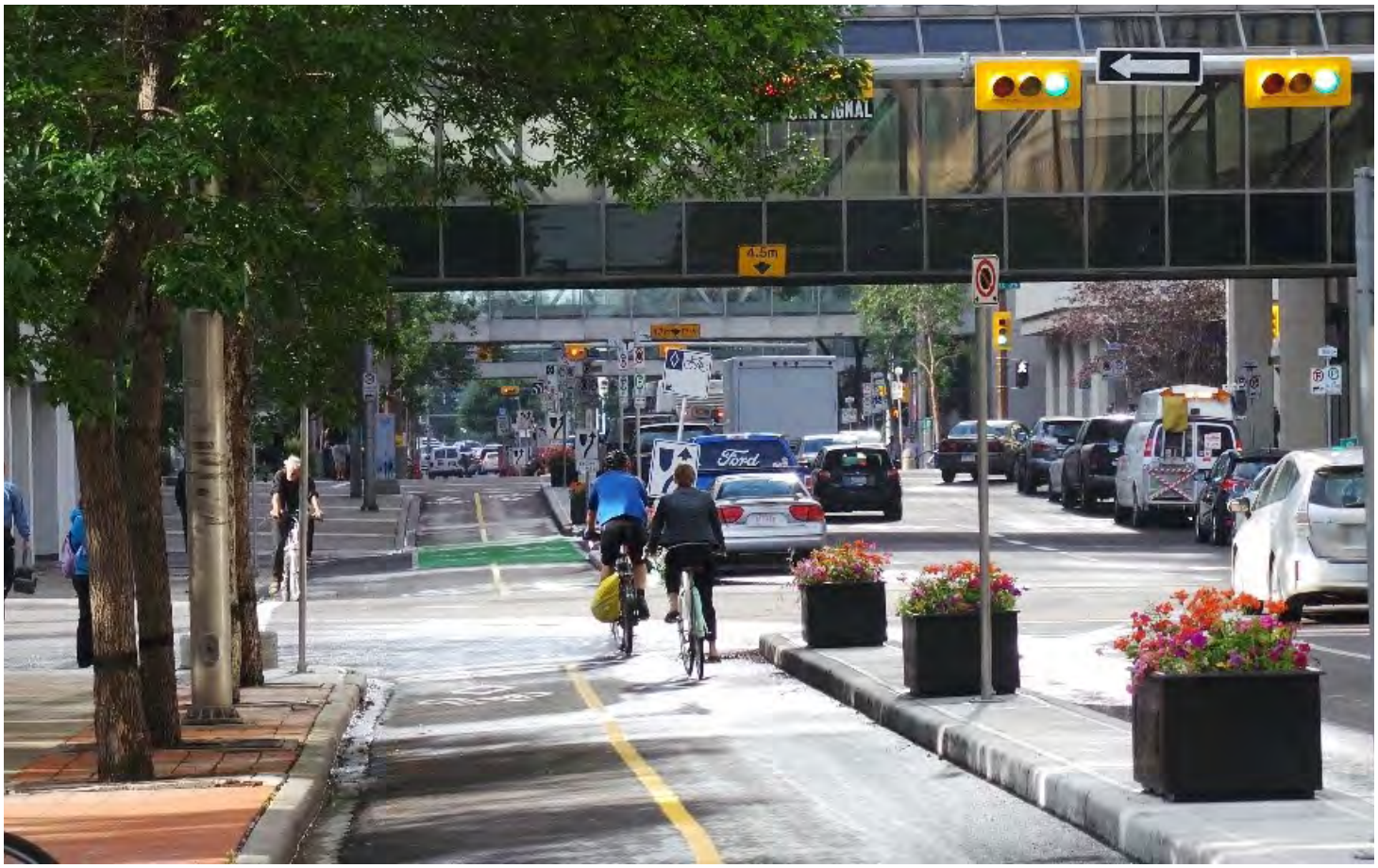
- More attractive to a wider range of bicyclists than striped bikeways on higher volume and faster speed roads.
- Prevent motor vehicles from driving, stopping, or waiting in the bikeway.
- Provide greater comfort to pedestrians by separating them from bicyclists.

Systemic Safety Potential

Best suited as a spot treatment. Should be implemented along corridors identified in the Bicycle Master Plan and where identified as the default bikeway treatment in the Complete Streets Design Guide.

Additional Information

- AASHTO Guide for the Development of Bicycle Facilities
- FHWA Bikeway Selection Guide
- NACTO Urban Bikeway Design Guide



Source: City of Calgary Bike Program

SHARED STREETS

Purpose

Prioritize pedestrian and bicycle movement by slowing vehicular speeds and communicating clearly through design features that motorists must yield to all other users.

Description

Streets designed such that pedestrians and bicyclists can walk or ride on the street and cross at any location, rather than at designated locations.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

Urban streets where it is desirable to prioritize walkability and slow traffic speeds to enhance livability and economic development goals.

Applicable Street Types

Downtown Streets

Safety Benefits

- Slower traffic speeds reduce severity of collisions.
- Slower speeds plus pedestrian/bicycle-centric design disincentivize vehicular traffic.
- Lack of curbs encourage cautious behavior on the part of all users.

Expected Crash Reduction

40 percent reduction in crashes on Dutch streets that had been converted to shared streets.[58]

Design Guidance

- Shared streets should not have vertical curbs, so that pedestrians can use the entire right-of-way. A lack of curbs encourages cautious behavior on the part of all users, which in turn reinforces slower speeds and comfortable walking and bicycling conditions.
- Motor vehicle speeds should not exceed 15 mph at any time.
- Shared street gateway treatments should inform drivers they are entering a shared space. Common ways to do so include:
    - Narrowing entrances to one lane.
    - Elevating the street to the pedestrian level.
    - Using a colored or textured pavement.
- Traffic volumes should not exceed 100 vehicles in the peak hour.

Considerations

- The curbless nature of shared streets enhances universal access.
- Street zones may be delineated with pavement materials, color, bollards or street furniture.
- Sidewalk space in front of buildings should be paved with a surface that is smooth and vibration-free.
- Stormwater on shared streets can be captured using valley gutters, additional inlets and/or bioswales or other green infrastructure.
- A shared street may be closed to motor vehicles to host public events. Care should be taken to maintain access for bicyclists when it is closed to vehicles.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- Minneapolis Shared Street Study

SHOULDERS

Purpose

Provide space for pedestrian and bicycle travel and provide space for errant motor vehicles.

Description

Paved shoulders extend the roadway on the outside of travel lanes. Rumble strips are textured asphalt on edgelines to alert motorists of the edge of the road.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Shoulders and rumble strips can be applied to all roadway projects.
- Shoulders are most effective in rural settings where dedicated bikeways would not fit or be appropriate.

Applicable Street Types

- Country Connector
- Country Road
- Major Highways

Safety Benefits

- Reduce risk of crashes.
- Shoulders provide recovery area for motor vehicles that stray from the travel lane.
- Rumble strips alert motor vehicles that are traveling outside their lane.
- Improve sightlines for motorists at intersecting streets.
- In rural areas, where dedicated sidewalks and bicyclist infrastructure may be not appropriate for the surrounding context, shoulders provide valuable space for pedestrian and bicycle travel.
- Reduce pedestrian and bicyclist travel in motor vehicle travel lanes on high-speed rural roadways.

Expected Crash Reduction

13-51 percent in single vehicle, run-off-road fatal and injury crashes for shoulder rumble strips.[59]

Design Guidance

- Shoulders that accommodate bicyclists should measure at least 5 feet wide. Shoulders should be 8 feet wide on Country Roads and 10 feet wide on Country Connectors.
- Shoulders should be wider if guard rails or vertical barriers are present. Consider vehicle speeds and traffic volumes.
- Shoulders and rumble strips are used on open-section roads.
- Rumble strips should be designed for bicyclist safety. Rumble strips should be installed at least 4 feet from the outside edge of the paved shoulder.
- Rumble strips should have gaps to allow bicyclists to exit the shoulder.
- Rumble strips may be installed on the shoulder, on edgelines, or at the center line of an undivided roadway.

Considerations

- Wide shoulders encourage higher vehicular speeds.
- If shoulders in both directions are unfeasible, prioritize the uphill direction, the inside of a horizontal curve, and the downgrade of a vertical curve.
- On roads where posted speed exceeds 30 mph and volumes exceed 6,000 motorists per day, bikeable shoulders do not create low-stress environments.
- A rumble strip does not create a protected bike facility. Refer to the Montgomery County Bike Plan for facility recommendations and selection guidance.

Systemic Safety Potential

Consider as a systemic safety application on any road without a curb.

Additional Information

- FHWA Achieving Multimodal Networks
- FHWA Proven Safety Countermeasures: Shoulder Rumble Strips
- AASHTO Roadside Design Guide 2011
- Montgomery County Bicycle Facility Design Toolkit 2018

SIDEPATHS

Purpose

Paths outside of the curb designated for bicyclists and pedestrians.

Description

Shared-use paths that accommodate two-way traffic for bicyclists and pedestrians. While separated from traffic, they are located inside and parallel to the road right-of-way.

Estimated Cost

$ $$ $$$ **$$$$**

Applicable Locations

- Applicable on streets with three or more lanes, speeds of 30 mph or greater, or 6,000 vehicles or more.
- Suited for truck or bus routes, or streets where bike lane obstruction is likely to be frequent.
- Sidepaths may be preferable to separated bike lanes if low pedestrian volumes are anticipated in order to minimize right-of-way impacts.

Applicable Street Types

- Boulevard
- Neighborhood Connector
- Industrial Street
- Country Connector
- County Road
- Major Highway
- Other streets as determined by the Bicycle Master Plan

Safety Benefits

- Fewer conflicts with motor vehicles than on-road bike lanes.[60]

Expected Crash Reduction

An 86 percent crash reduction was found for bicyclists who used sidepaths, compared to riding in the roadway.[60]

Design Guidance

- A minimum 2-foot graded area with clearance from lateral obstructions, such as bushes, large rocks, bridge piers, abutments, and poles.
- A minimum 1-foot clearance from "smooth" features, such as bicycle railings or fences with appropriate flaring and treatments.
- Ideally, a graded shoulder area of 3 to 5 feet, with a

5-foot minimum buffer from traffic.

- Separation of modes in areas with existing or anticipated higher levels of activity, including a 10-foot (minimum width) bikeway and a 5-foot (minimum width) walkway.
- Adequate widths to enable side-by-side travel and passing, typically at least 11 feet wide.

Considerations

Sidepaths are attractive to a wider range of bicyclists compared to striped bikeways.

They require:

- High-quality construction and maintenance that avoids pavement cracking and buckling.
- Asphalt preferably as the surface material. If concrete is used, use longer sections with small joints for a smoother riding experience.
- Intuitive and safe intersection crossings.
- Straight alignments to allow direct and higher speed travel.
- Removal of poles, trees, or other obstructions that are present in many existing sidepath locations.
- Adequate lighting for nighttime use.

Systemic Safety Potential

Best suited as a spot treatment. Should be implemented along corridors identified in the Bicycle Master Plan and where identified as the default bikeway treatment in the Complete Streets Design Guide.

Additional Information

- FHWA Bikeway Selection Guide

SIGNAL TIMING AND PEDESTRIAN RECALL

Purpose

Slow motor vehicle speeds and reduce pedestrian crossing delay.

Description

Coordinated signal timing can limit motor vehicle speed when sufficient traffic congestion exists for a platoon. Pedestrian pushbuttons, available at either side of a crossing can activate the pedestrian signal.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- Signal timing can be adjusted at all signalized intersections, with a priority for locations with medium-to-high pedestrian volumes.
- Pushbuttons are not applicable at intersections with pedestrian recall, though all pedestrian signals must be accessible to and usable by people with disabilities whether or not a pushbutton is present.

Applicable Street Types

All street types.

Safety Benefits

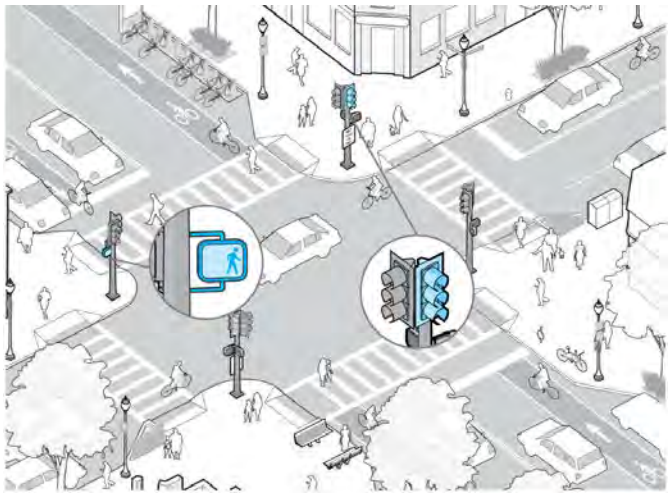
- Reduces pedestrian delay to cross.
- Improved convenience of crossing reduces unsafe crossing behavior.
- Coordinated signal timing can manage vehicle speeds in certain circumstances, leading to improved safety for all road users.

Expected Crash Reduction

50 percent for vehicle-pedestrian crashes, depending on specific signal phasing.[61]

Design Guidance

- Pedestrian pushbutton should be easy to access.
- Install pushbutton on either side of the crossing.
- Pushbutton location must comply with ADA regulations.
- Pushbuttons can be made accessible by providing audible tones or vibrations.



Considerations

- Signal timing operations must account for motor vehicle volumes and turning movement volumes.
- Longer walk intervals and shorter cycle lengths (less than 90 seconds) service pedestrians better.
- Concurrent signal phasing gives pedestrians more frequent crossing opportunities and less delay compared to exclusive signal phasing.
- Passive detection devices may be used in place of pedestrian pushbuttons.
- May impact delay to all travel modes.

Systemic Safety Potential

May be implemented systemically along corridors with:

- Infrequent crossing opportunities.
- Short pedestrian phases.
- High pedestrian or bicyclist volumes.

Additional Information

- Traffic Signal Timing Manual
- Manual on Uniform Traffic Control Devices
- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System

SPEED HUMPS, TABLES, AND CUSHIONS

Purpose

Reduce motor vehicle speeds.

Description

Speed humps are paved ramps measuring 3- to 4-inches high that extend the full width of the street. Speed tables are wider or have a flat top. Speed cushions have wheel cutouts to allow large vehicles to pass through unaffected.

Estimated Cost

$ **$$** $$$ $$$$

Applicable Locations

- Vertical traffic control measures such as speed humps, tables, and cushions are best used on streets with lower motor vehicle speeds and volumes.
- Useful in areas where traffic calming is needed, such as near schools.

Applicable Street Types

- Downtown Boulevards
- Downtown Streets
- Town Center Boulevards
- Town Center Streets
- Neighborhood Connectors
- Neighborhood Streets
- Neighborhood Yield Streets
- Industrial Streets

Safety Benefits

- Reduce motor vehicle speeds.
- May reduce the frequency and severity of crashes for all road users.

Expected Crash Reduction

A definitive crash reduction estimate has not been established. Research suggests speed humps, tables, and cushions reduce crash severity.[61]

Design Guidance

- Install speed humps perpendicular to the flow of traffic.
- Speed humps and tables can be paved or painted to warn motorists and to be visually pleasing.
- Speed humps can be placed periodically along a route to reinforce speed control.
- Well-designed speed humps, tables, and cushions allow vehicles and people riding bikes to proceed over the device at the intended speed with minimal discomfort.
- Do not install on the curve of the roadway.

Considerations

- Consider priority and delay of emergency response vehicles, truck or public transit use of the street, street type, and effectiveness of slowing vehicles versus bicyclist comfort level.
- A pedestrian crossing can be provided on the flat portion of a speed table – also referred to as a "raised crossing." See raised crossing treatment in this toolkit for more details.
- May create drainage problems.
- Many speed humps in a succession may cause problems for buses.
- Investigate feasibility of other traffic calming measures first. Speed humps are typically a last-resort treatment.

Systemic Safety Potential

Best suited as a spot treatment.

Additional Information

- PEDSAFE Countermeasures Guide
- Manual on Uniform Traffic Control Devices
- AASHTO Guide for the design of Bicycle Facilities

TREE BUFFER

Purpose

Separate sidewalk from the roadway, narrow motorists' field of vision. Add shade, comfort, and beauty to the street.

Description

Trees in raised medians or on the edge of streets.

Estimated Cost

$ $$ $$$ $$$$

Applicable Locations

- Residential neighborhoods.
- Downtown commercial areas.
- Rural roads.
- Areas near schools.

Applicable Street Types

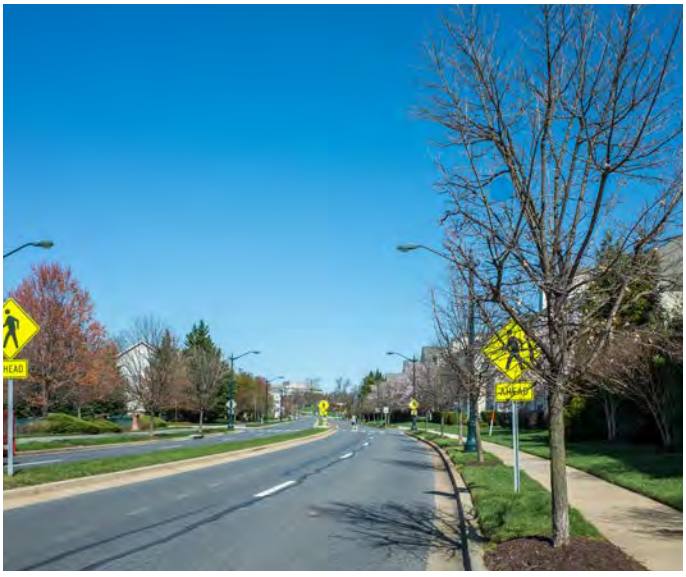
All street types.

Safety Benefits

- Large, mature trees can provide a physical barrier between the road and pedestrian pathways.
- May reduce vehicle speeds due to increased perceived friction and sense of enclosure.
- Lower vehicle speeds can result in improved safety outcomes for all road users.

Expected Crash Reduction

The overall safety impacts of street trees are complex and a definitive estimate of crash or injury impacts for all road users has not been established.



Design Guidance

- Select the right tree species for a space to provide canopy and minimize maintenance costs.
- Provide access to 800 cubic feet or more of unrestricted and unshared soil space.
- Provide soil depth of 36 inches or more.
- Street trees are healthier in areas with greater permeable surface access.
- Provide minimum 5-foot-wide tree pit in urban contexts, and continuous vegetation in the planting strip in non-urban contexts where possible.
- Coordinate placement of street trees with street lights, overhead utilities, street furniture, and traffic signals.
- Tree pits may accommodate trees when additional sidewalk is needed to accommodate pedestrian volumes.
- Make sure to minimize construction impacts including trenching and soil compaction in root areas.
- See Complete Street Design Guide's Chapter on Green Streets for more information.

Considerations

- Width of planting zone should be considered so trees do not damage the sidewalk as they grow.
- Street trees can improve vibrancy of the street scape.
- Street trees help to create a sense of enclosure.
- Consider allocation of space to optimize tree health and maintenance.
- Sight distance (and the maintenance needed to maintain a safe sight distance) must be considered for street trees near intersections or on roadway curves.

Systemic Safety Potential

Street trees can be included for traffic calming on all street types. Sight lines should be maintained on all street types and clear zones as applicable.

Additional Information

- Montgomery County Roadside Tree Protection Law Design Guidelines and Specifications

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VISIONZERO COMMUNITY TOOLKIT

Montgomery Planning