

Protected Intersection Design Training

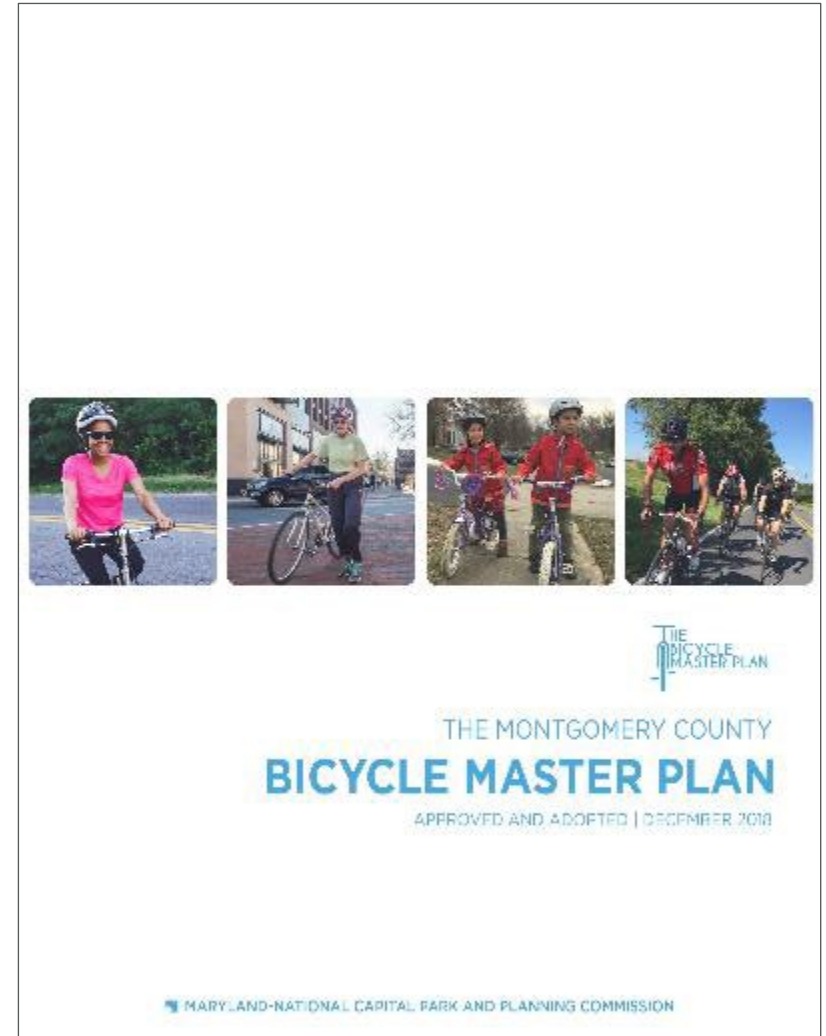


Friday, October 28th
10:00am-12:00pm

Jeremy Chrzan, PE, PTOE, LEED AP &
Megan McCarty Graham, PE

Montgomery County Bicycle Master Plan

Protected Intersections: Dedicate right-of-way and implement protected intersection improvements at all portions of the intersection on the project's right-of-way frontage where at least one street is recommended to have a sidepath, separated bike lane, buffered bike lane, or conventional bike lane. (page 142)



Introductions



Jeremy Chrzan, P.E., PTOE, LEED AP
Multimodal Design Practice Lead

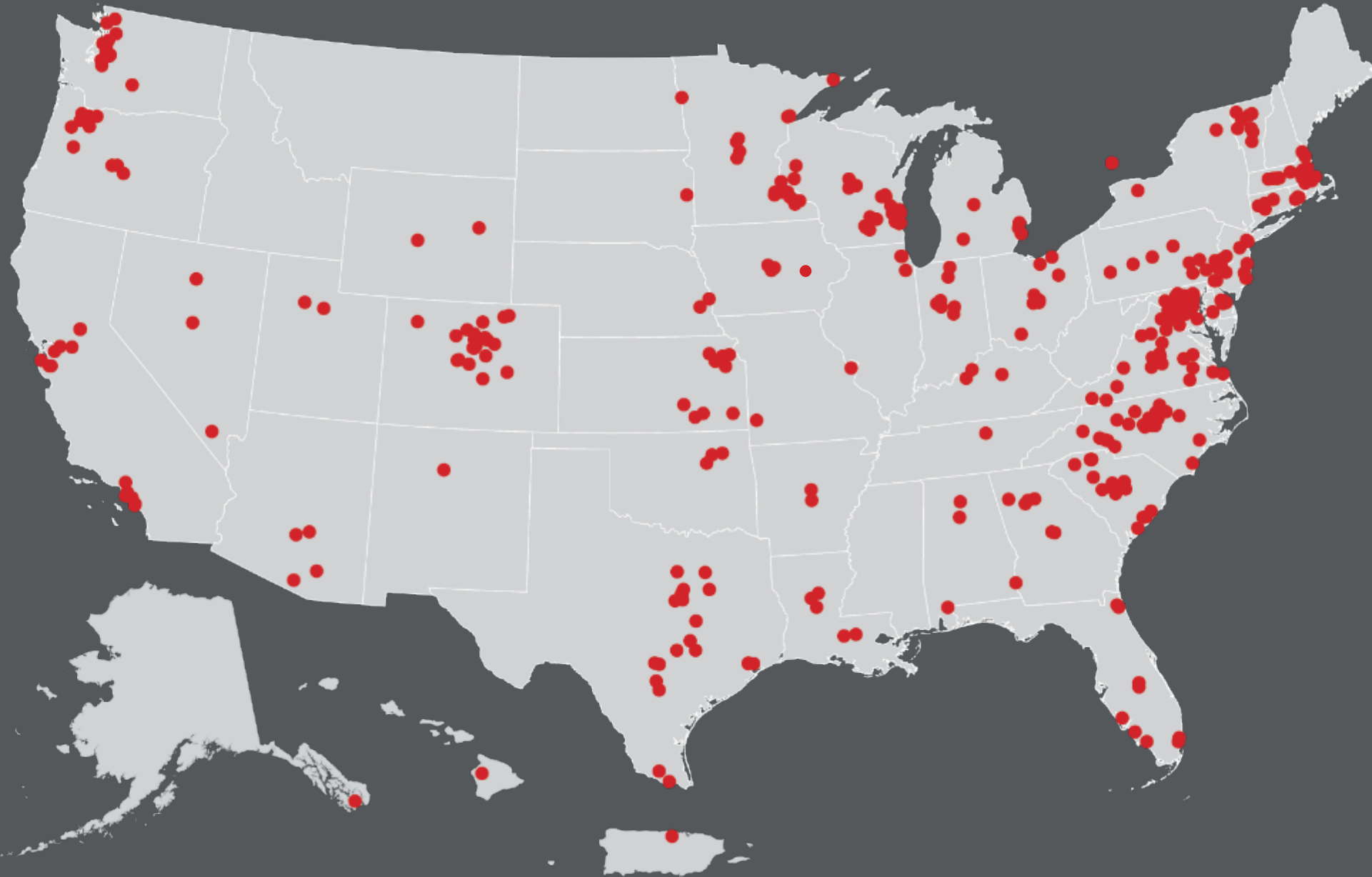


Megan McCarty Graham, P.E.
Senior Engineer

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Work Experience Across the Nation

Toole Design is the nation's leading planning, engineering, and landscape architecture firm specializing in multimodal transportation.



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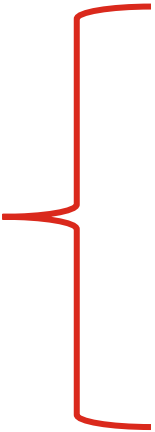
Agenda

- Introductions
- Design Basics & Principles
- How to Design Protected Intersections
- Examples from Montgomery County & Beyond
- Introducing the Protected Intersection Design Checklist
- Wrap Up/Final Q&A



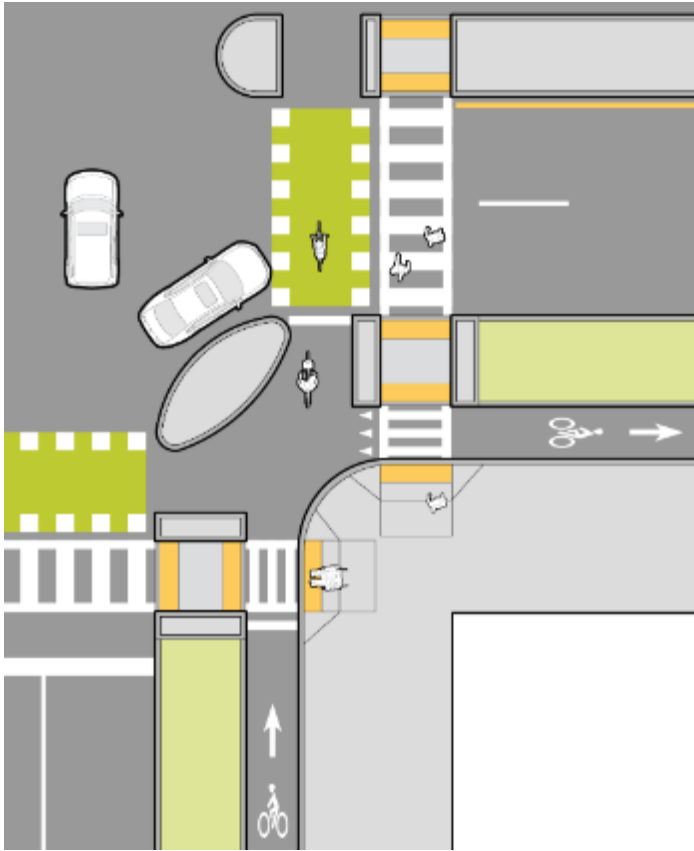
Intersection Design Principles

**Maximize
safety and
comfort**



- Minimize exposure to conflicts
- Reduce speeds at conflict points
- Communicate right-of-way priority
- Provide adequate sight distance

Why Protected Intersections?



Why?

- Intuitive and Comfortable
- Provide Clear Right-of-Way Assignment
- Promote Predictability of Movement
- Improved Visibility at Conflicts
- Reduced Number of Conflicts

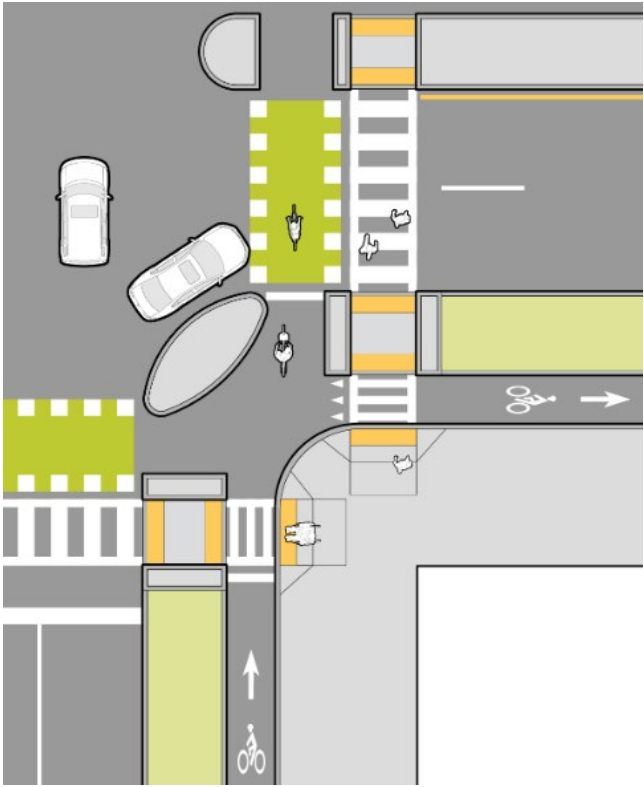
Protected Intersections

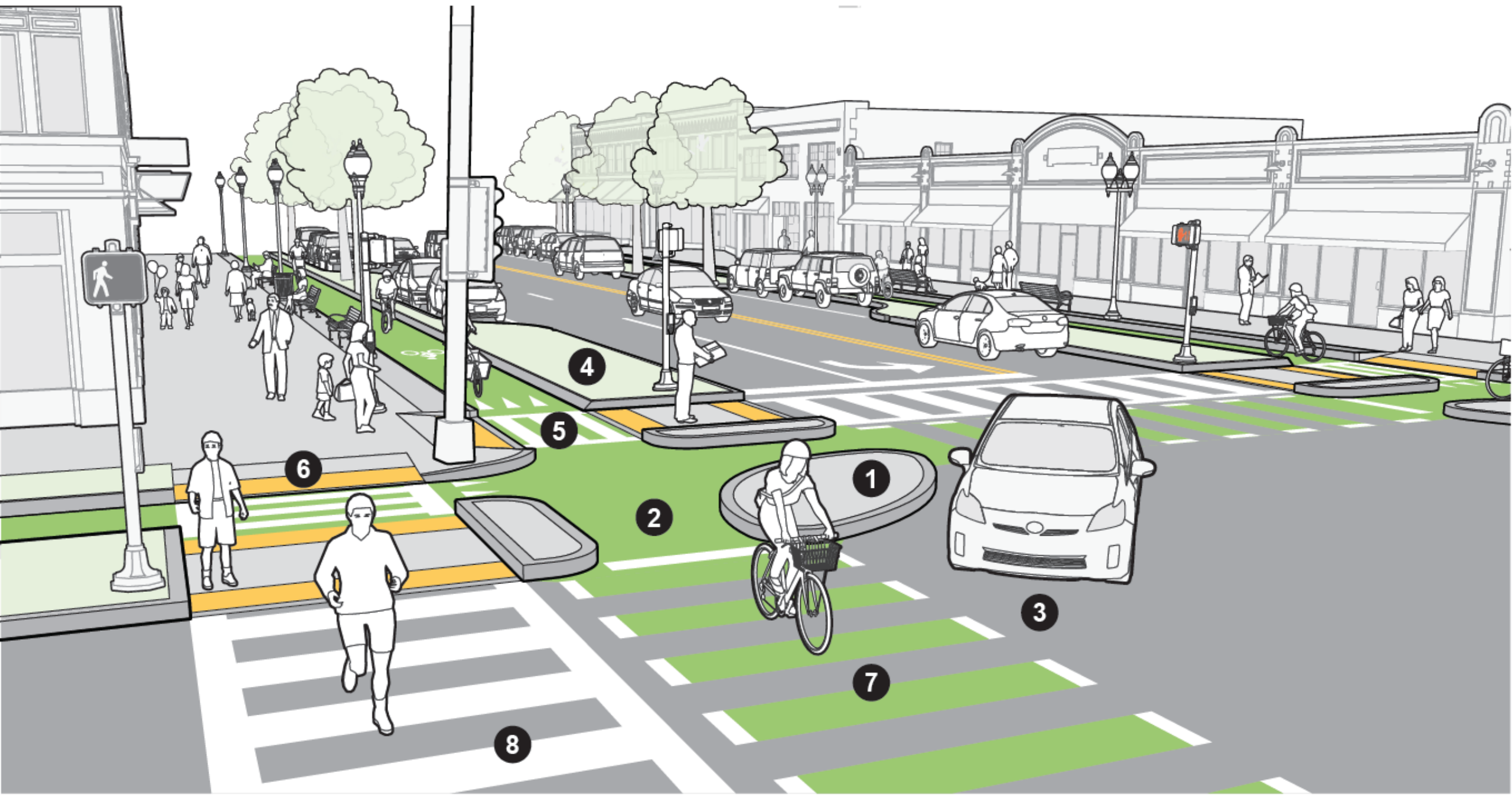
“**Protected intersections** maintain the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bike lane and shared lane designs.”

Why Protected Intersections: Controlling Speeds at Corners



Controlling Speeds at Corners





4

5

6

2

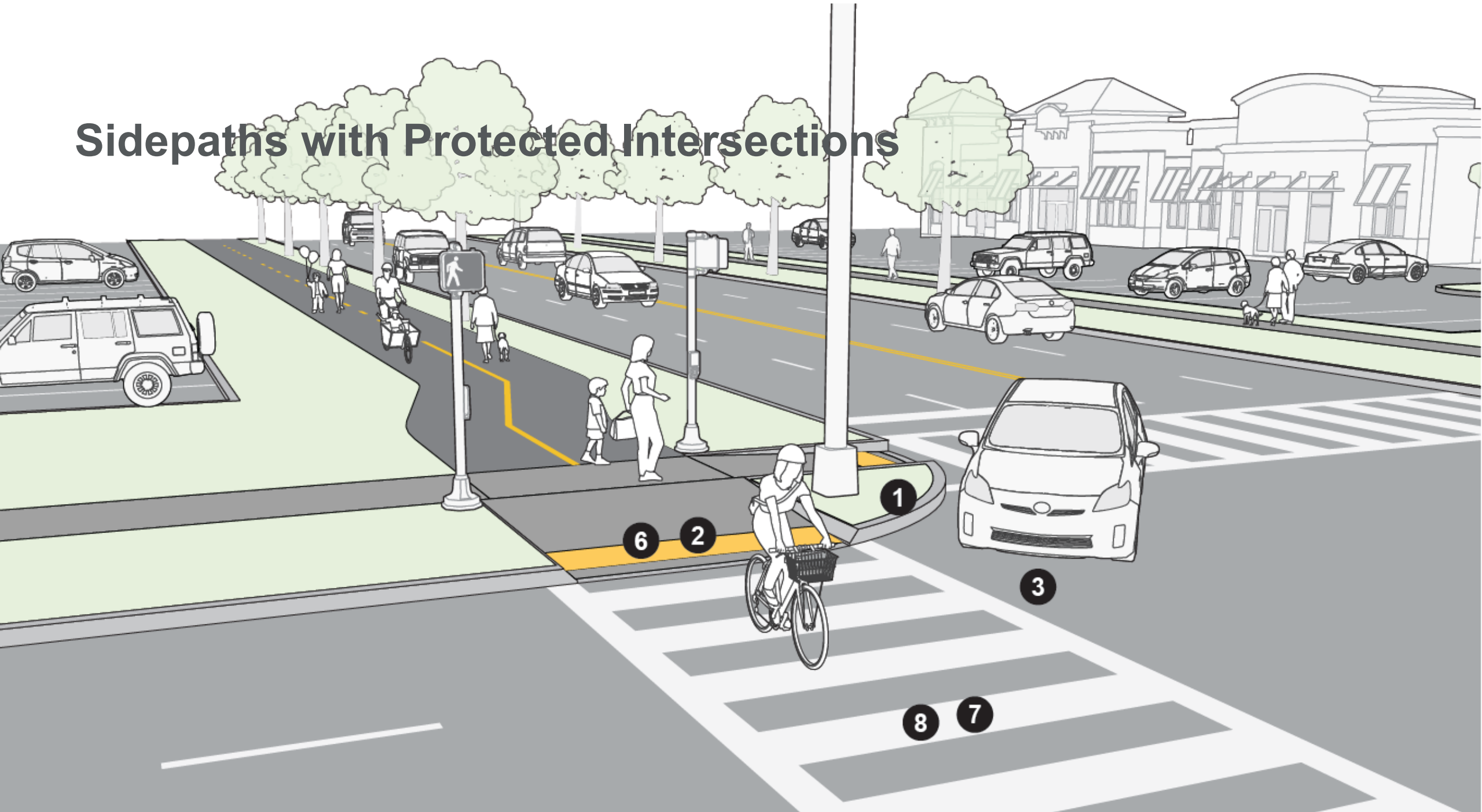
1

3

7

8

Sidepaths with Protected Intersections



Protected Intersections

Geometric Protection

Physical separation

Requires new materials, whether marking & flex posts or new curbs and pavement

Signal Protection

Dedicated signal for a specific traffic movement through intersection

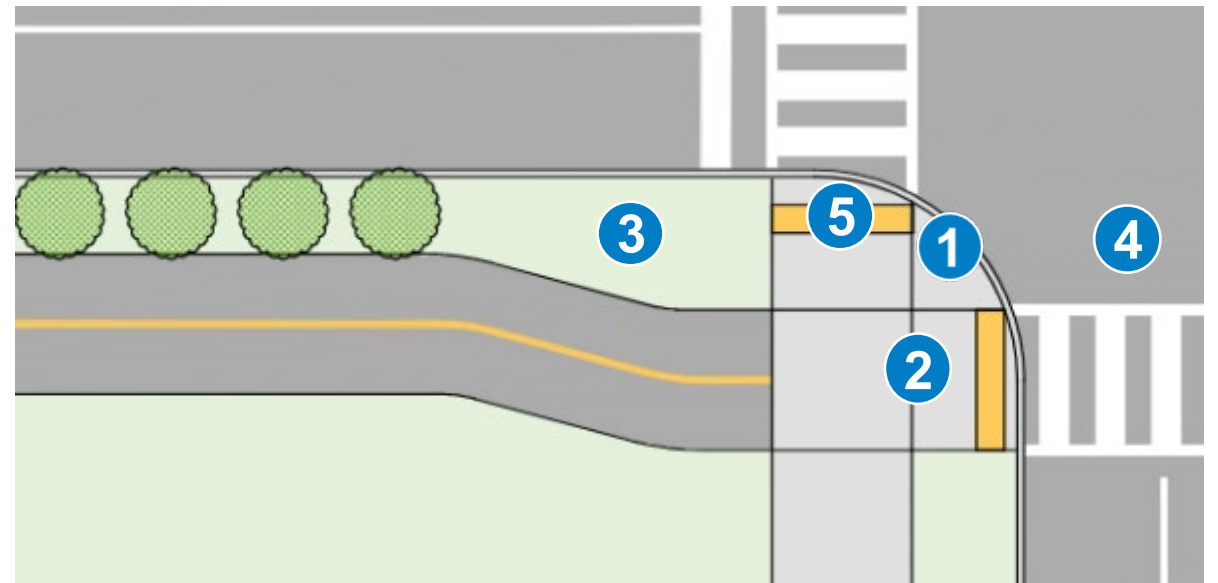
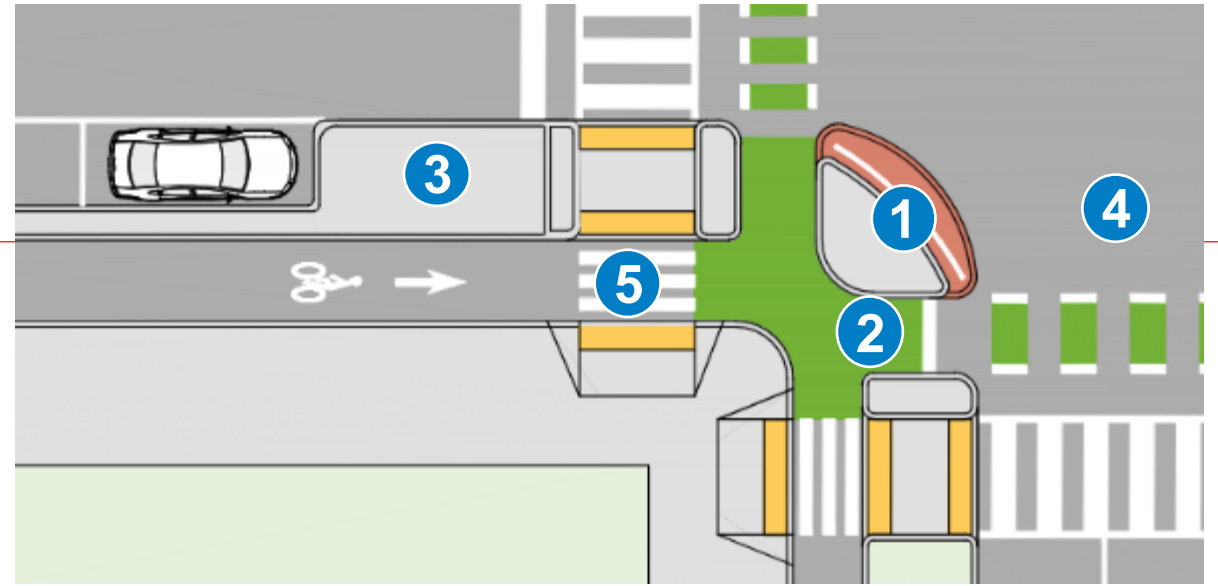
For bicycles and pedestrians, may require new traffic signals

Questions

Protected Intersection Design

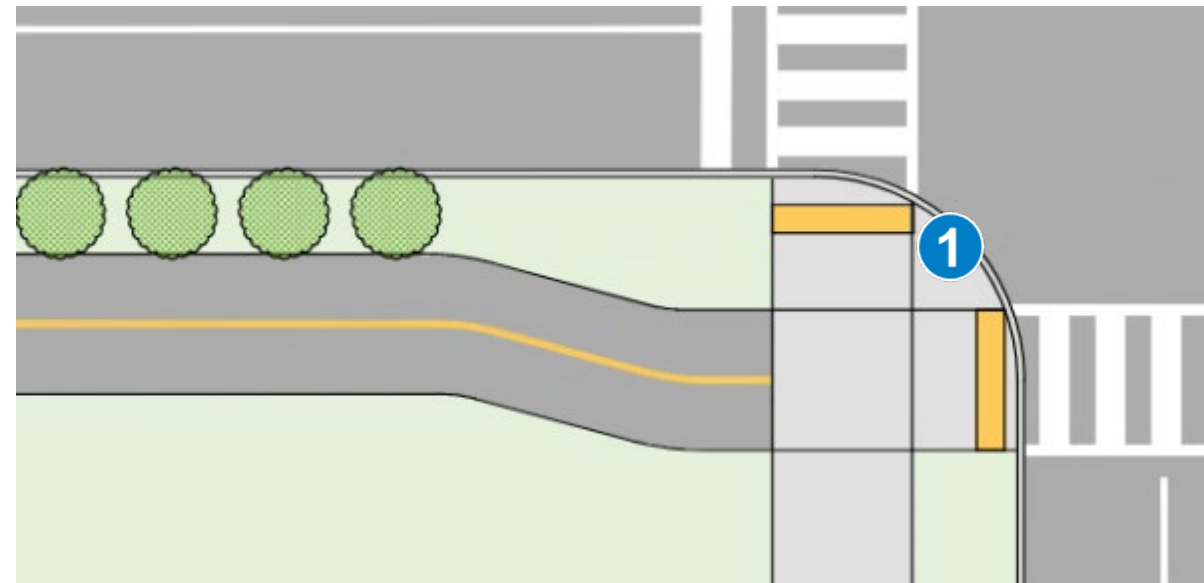
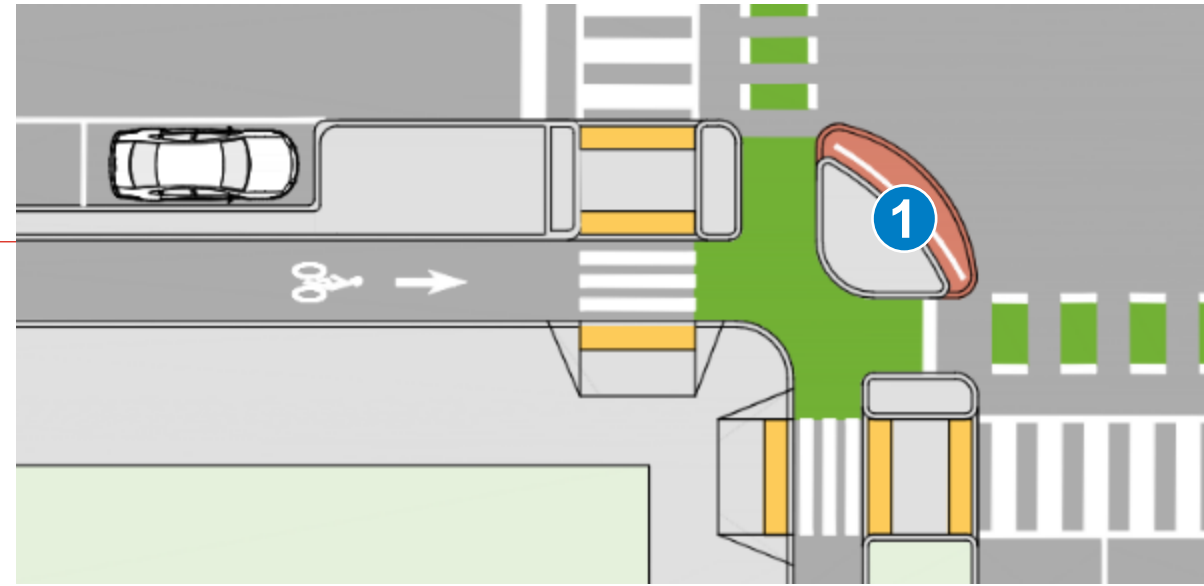
Geometric Elements of Protected Intersections

- 1 Corner Island
- 2 Bicycle Queuing Space
- 3 Clear Distance
- 4 Motorist Yield Zone
- 5 Pedestrian Crossing & Curb Ramps



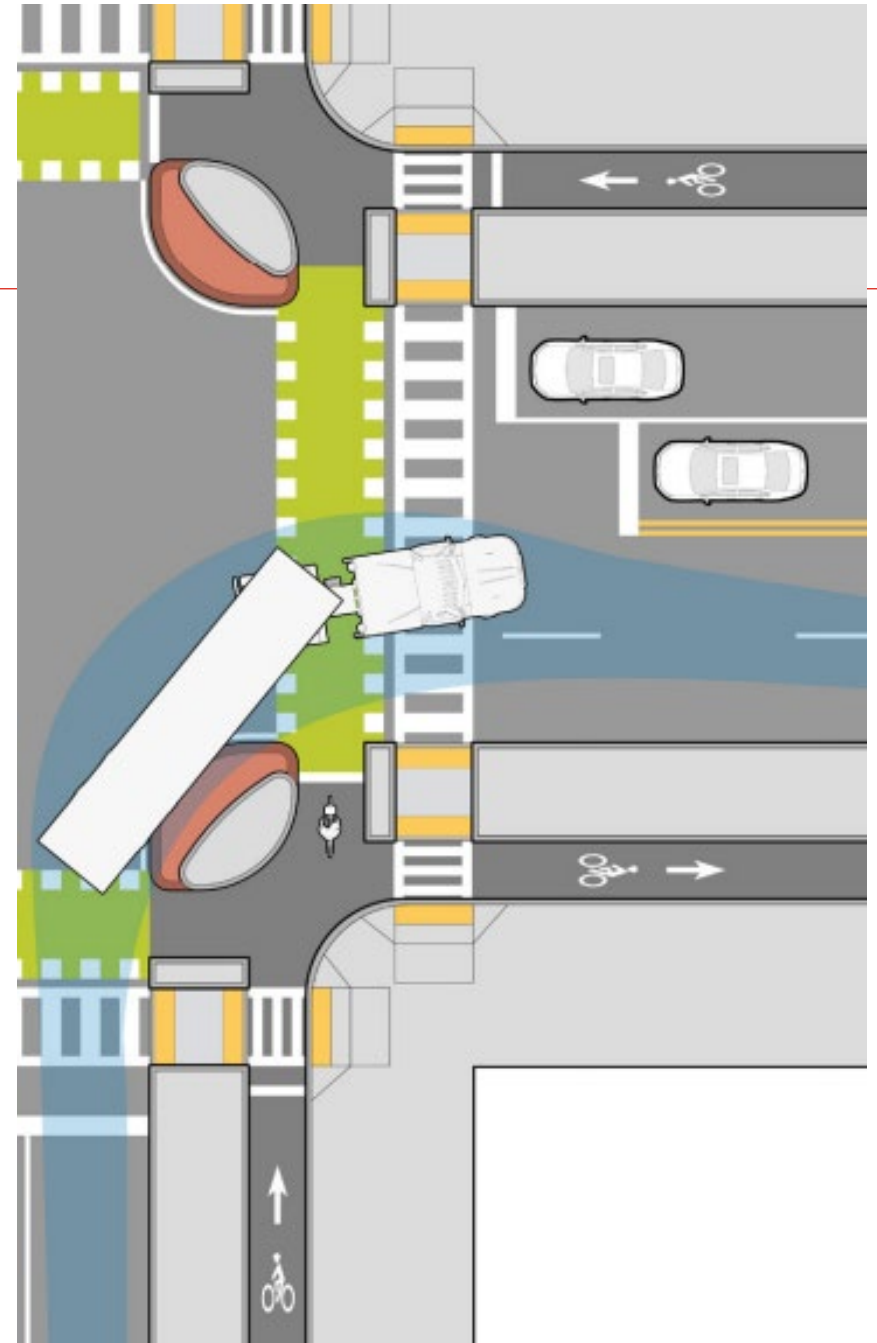
Corner Island

- Foundational element of the protected intersection
- Provides physical separation for bikeway
- Physically protects bicyclist from right-turning motor vehicles
- Creates space for a forward queuing area for bicyclists and yield space for vehicles
- Reduces total crossing distances
- Controls motorists turning speeds
- Option to include mountable truck apron

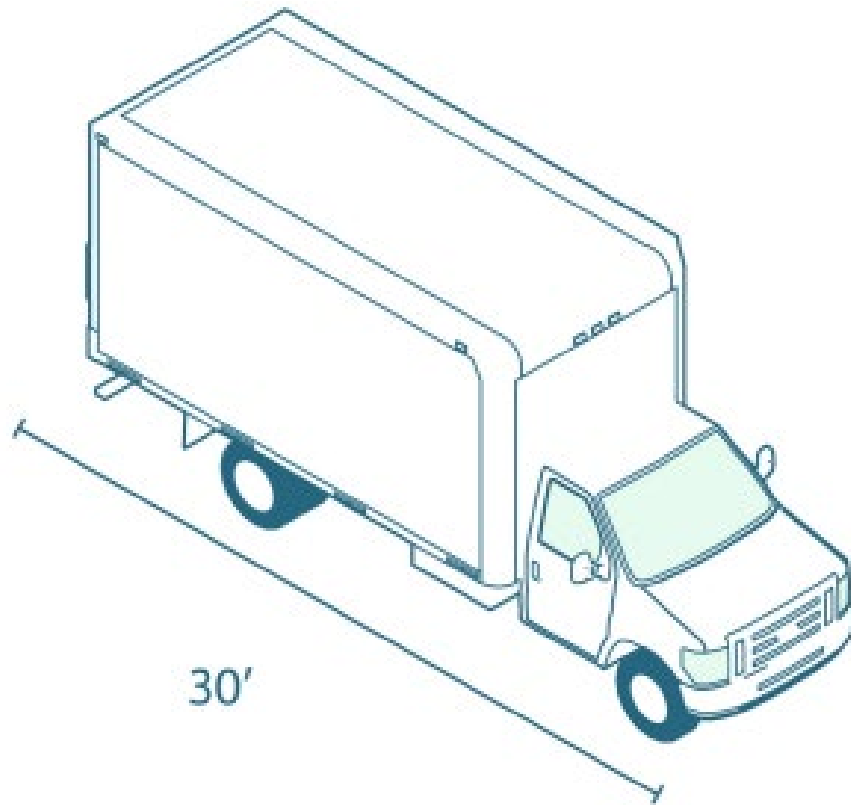


Minimize Curb Radius

- Design for ≤ 10 mph vehicle turns
- Select smallest feasible curb radius
- Factors Influencing Decision:
 - Number of travel lanes
 - Configuration of travel lanes
 - Characteristics of design & control vehicles



Design & Control Vehicles



Design Vehicle

- Least maneuverable vehicle that routinely uses the street
- Used to set radius of corner island
- Montgomery County's Standard:
 - SU-30 Single Unit Truck with 42-ft turning radius

Design & Control Vehicles

Control Vehicle

- Infrequent but necessary users of the street
- Used to set radius of mountable truck apron
- Montgomery County's Standard:
 - Fire & Rescue Services Standard Fire Truck

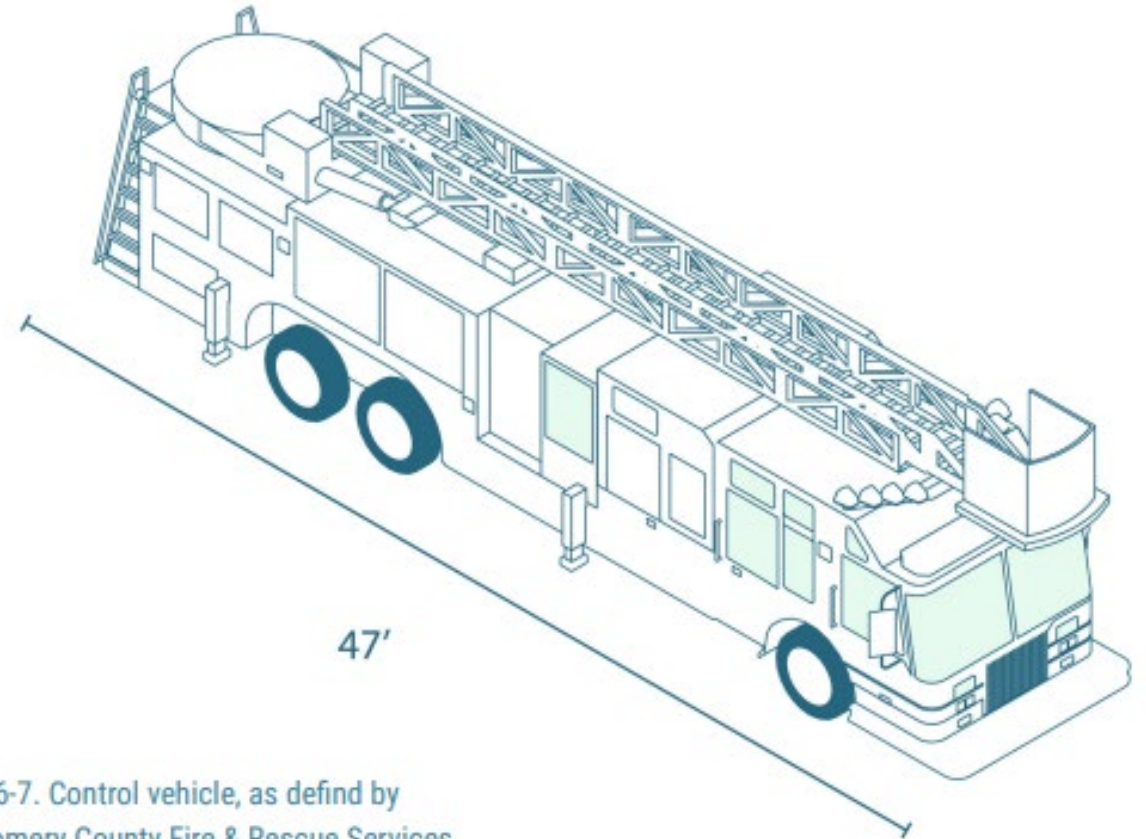
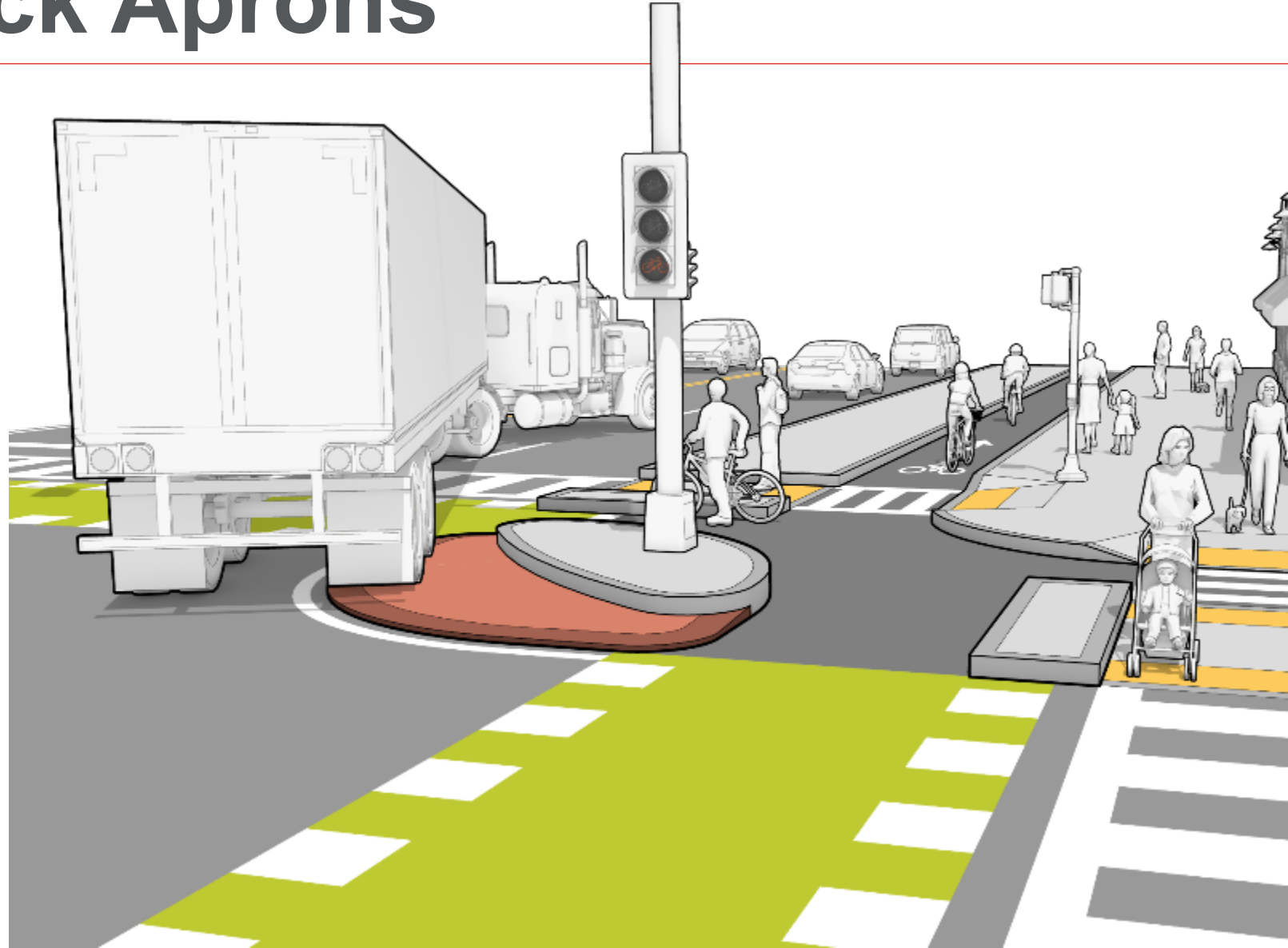


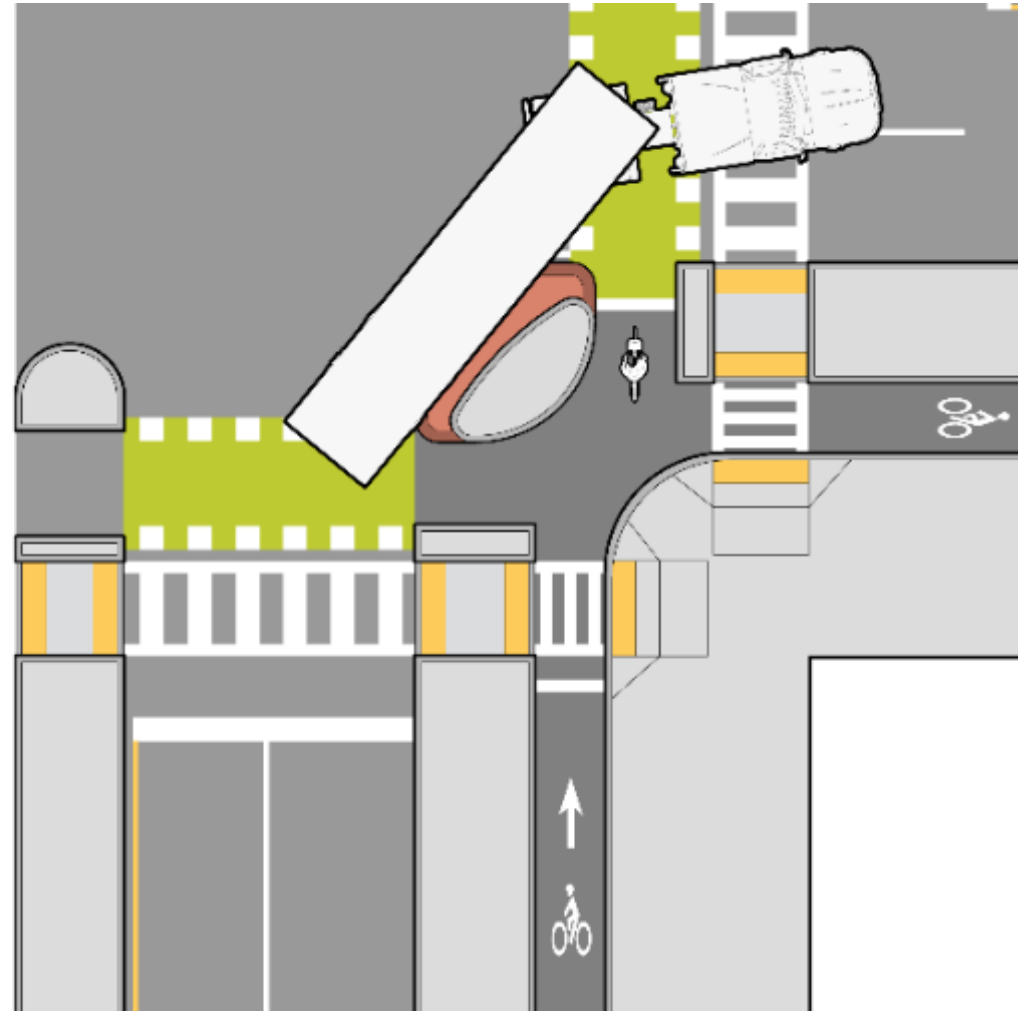
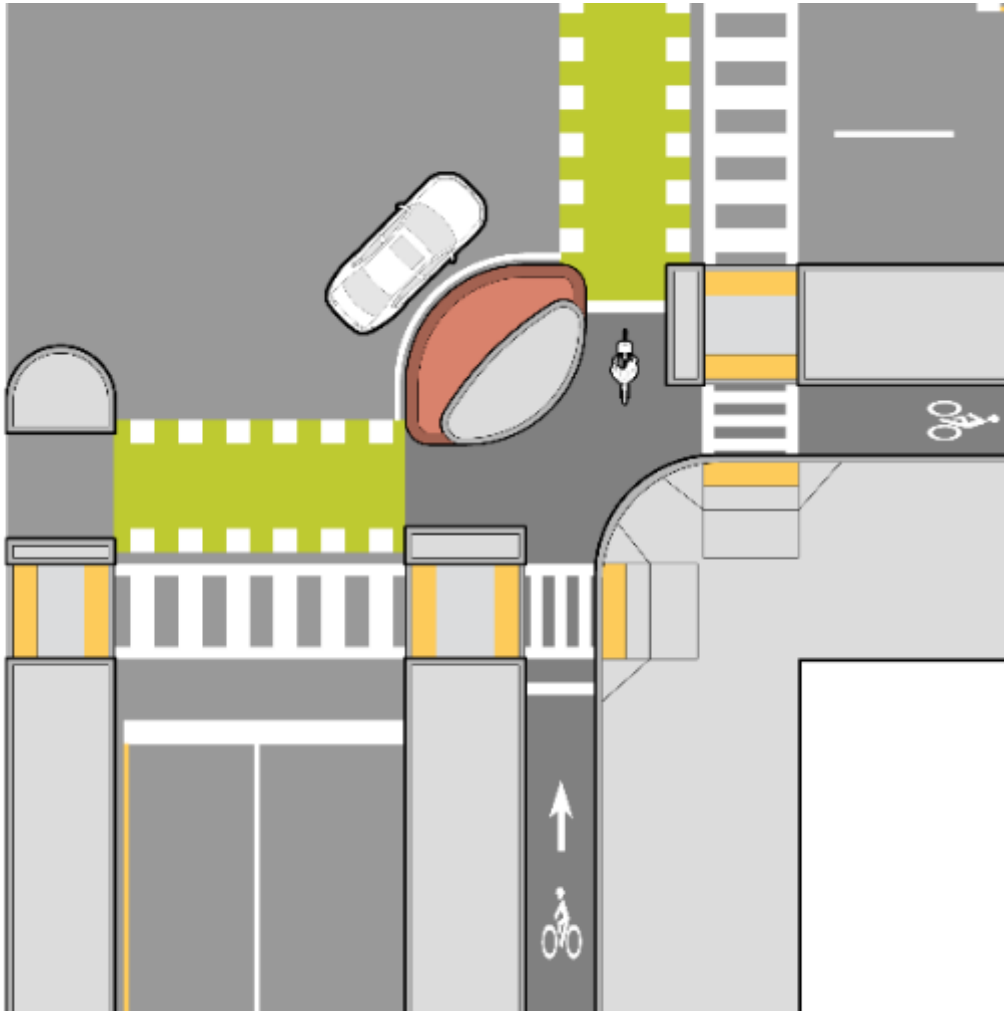
Figure 6-7. Control vehicle, as defined by Montgomery County Fire & Rescue Services

Mountable Truck Aprons

- 3" maximum
- Visually distinct
- Large radii reduces bicycle, pedestrian queuing areas
- Reduced speed for passenger vehicles
- Accommodates larger trucks



Design & Control Vehicles



Curb Radius

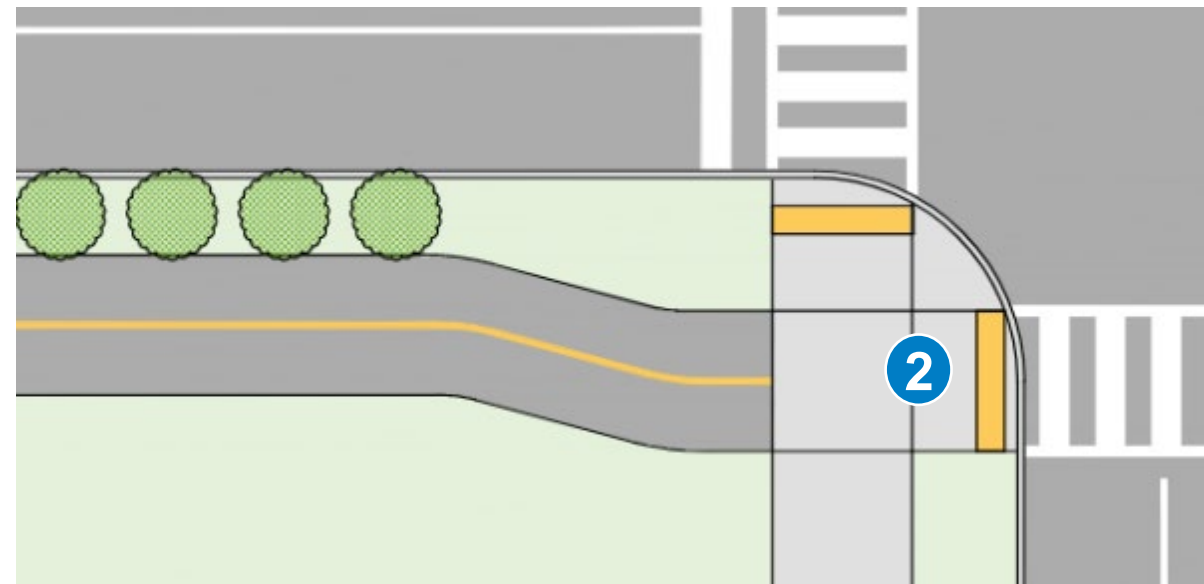
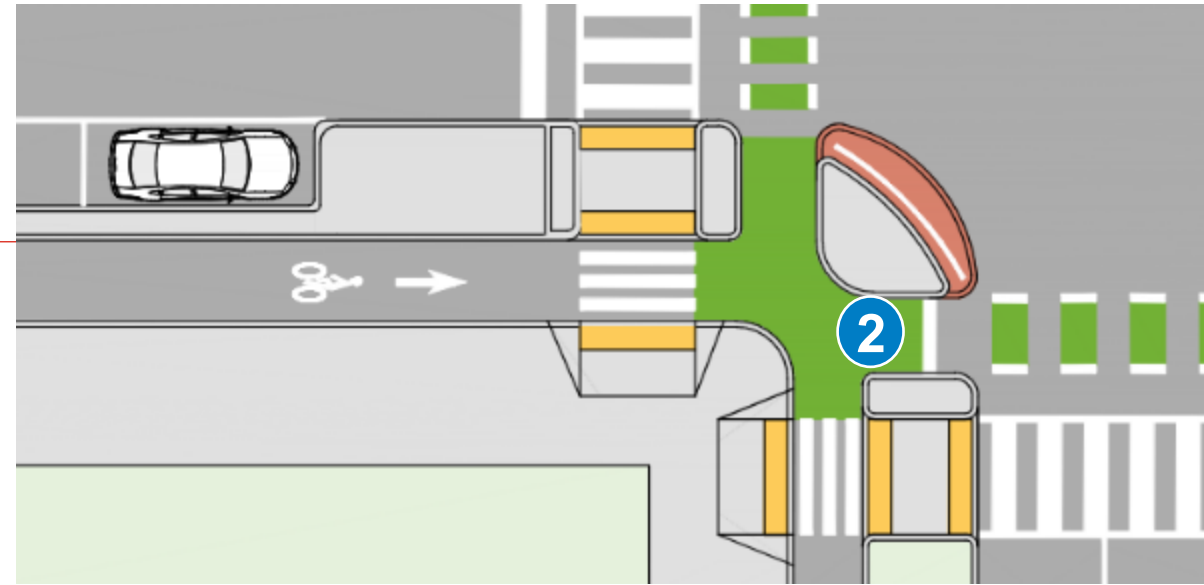


Curb Radius



Bicycle Queuing Area

- Provides space for stopping bicyclists to wait
- Fully within the view of motorists at stop line, improving bicyclist visibility
- Enables bicyclists to enter intersection prior to turning motorists, establishing a right-of-way
- Where feasible, provide more space for larger bicycles or in locations with heavier bicycle volumes



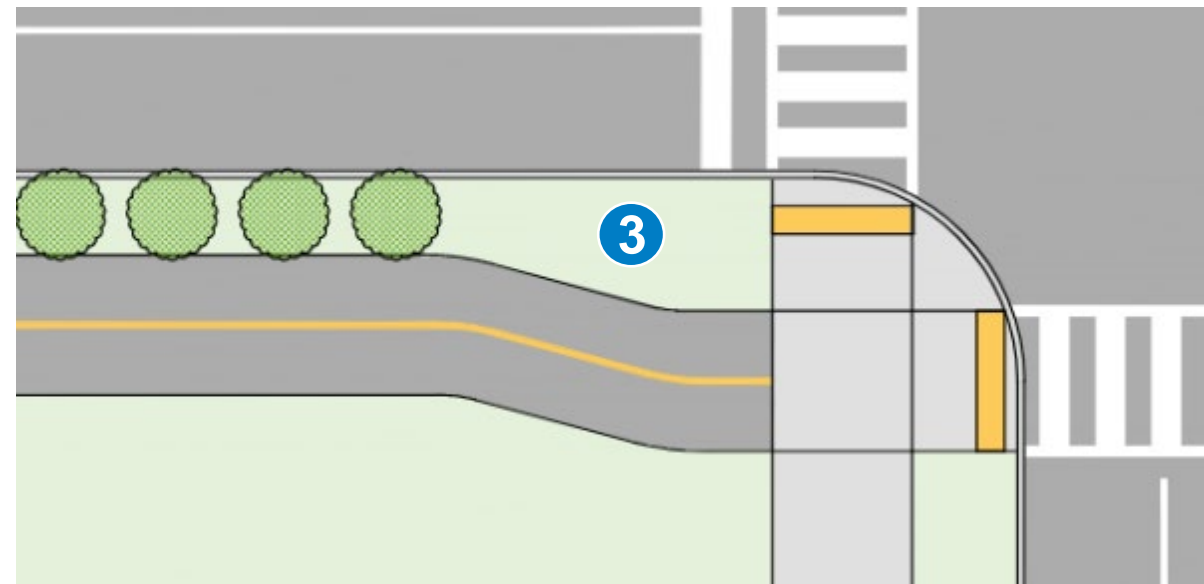
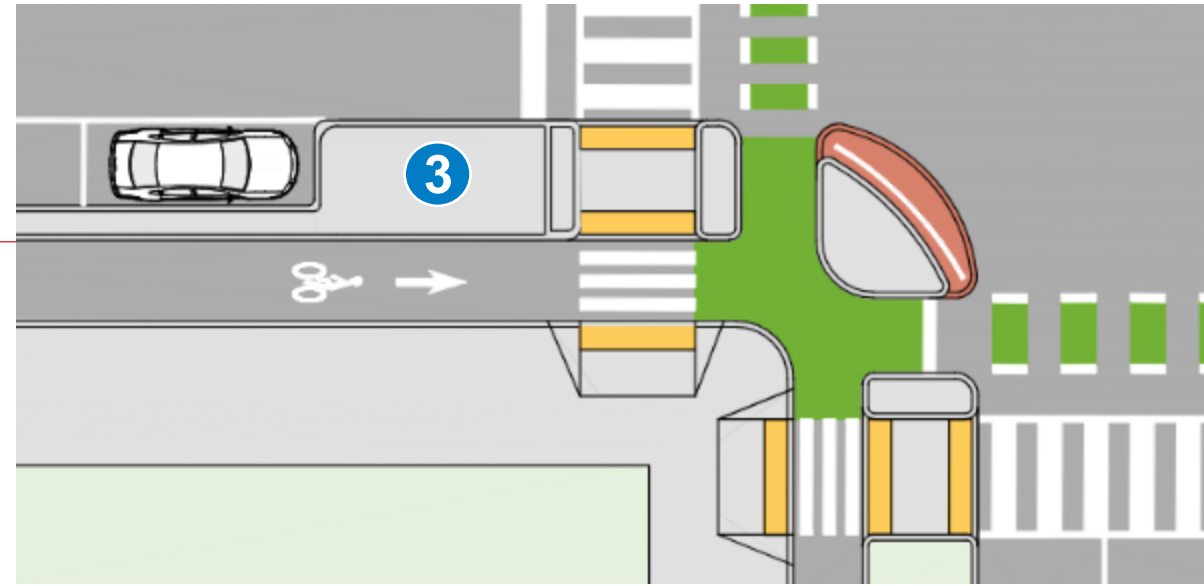
Bicycle Queuing Area

- Needs to be located outside of the design & control vehicle envelope
- Recommended minimum dimensions: **6.5' by 6.5' (wider if two-way)**
- Optional: green-colored pavement to visually delineate

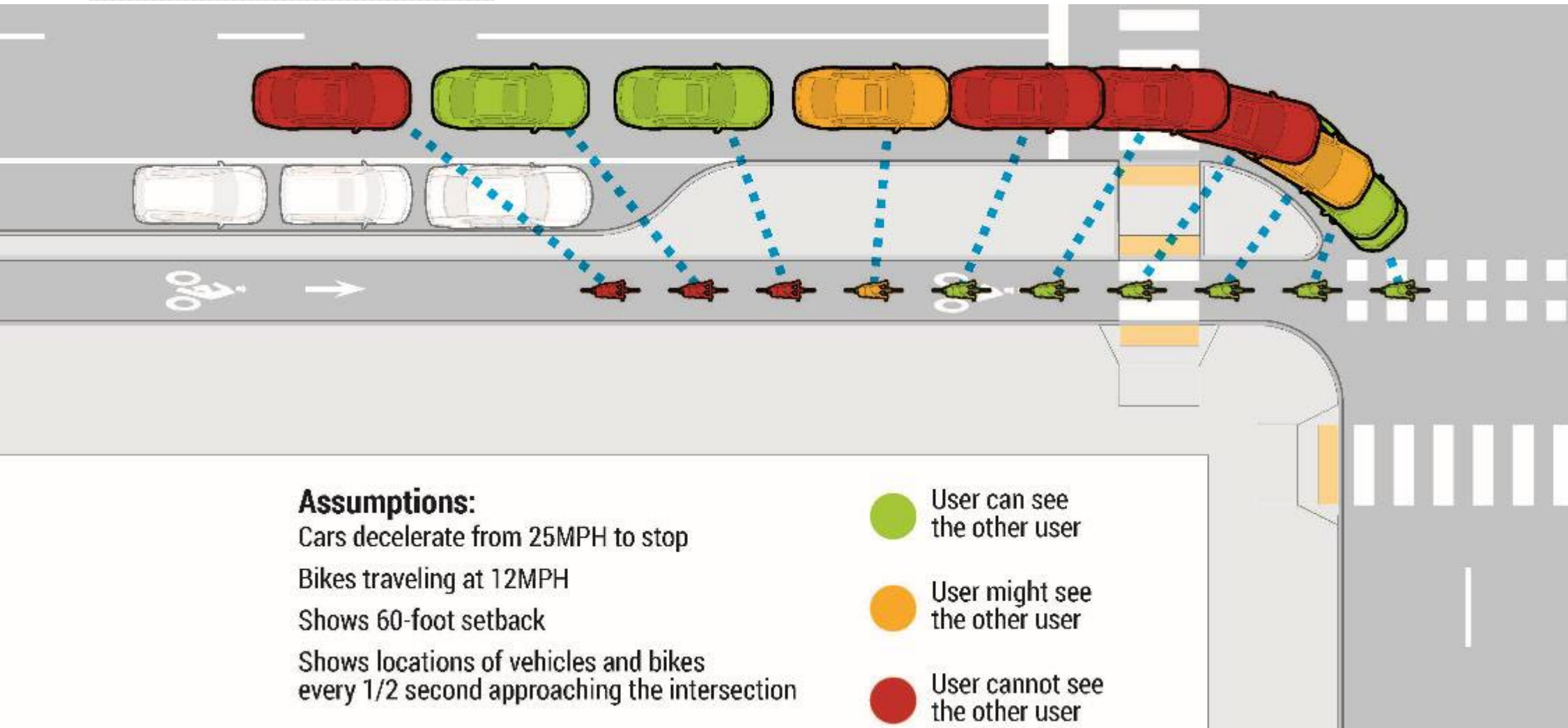


Clear Distance

- Provides necessary sight lines between motorists and bicyclists
- Provides length for motorists and bicyclists to decelerate and recognize other users in parallel or counterflow direction

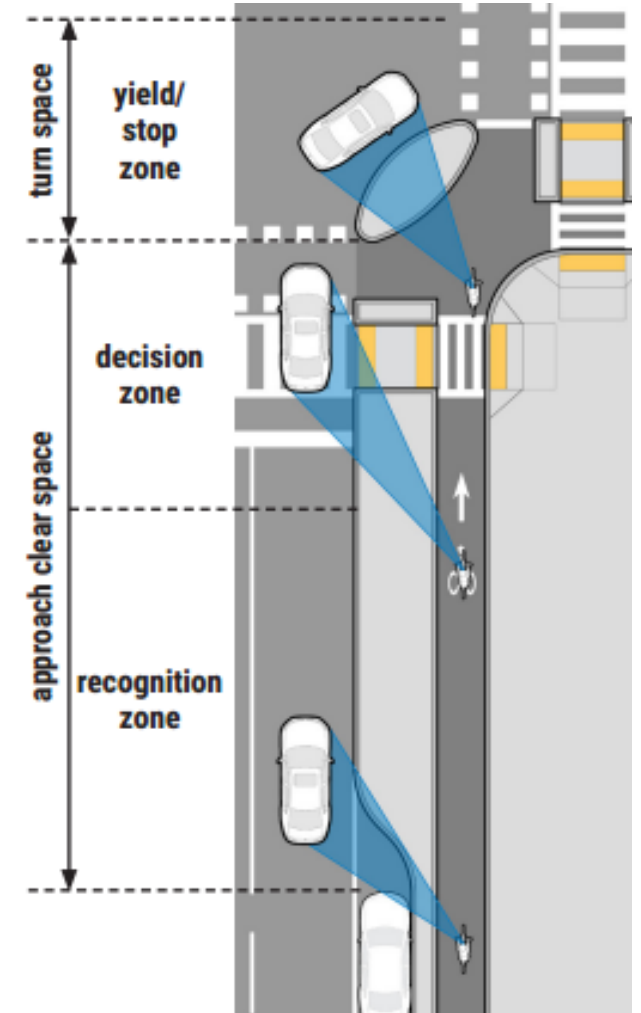
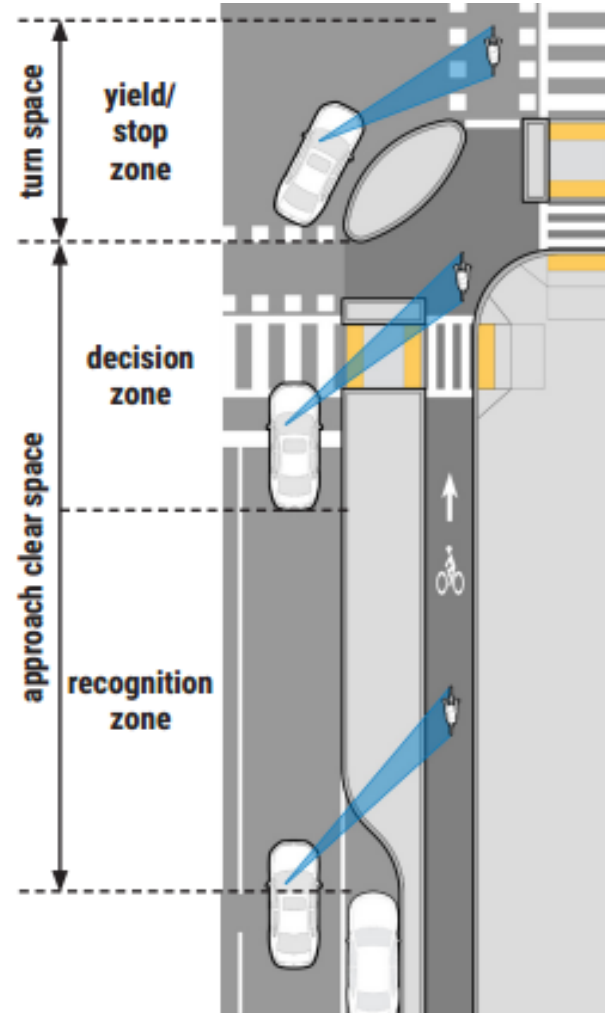


Approach Clear Space



Approach Clear Space

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



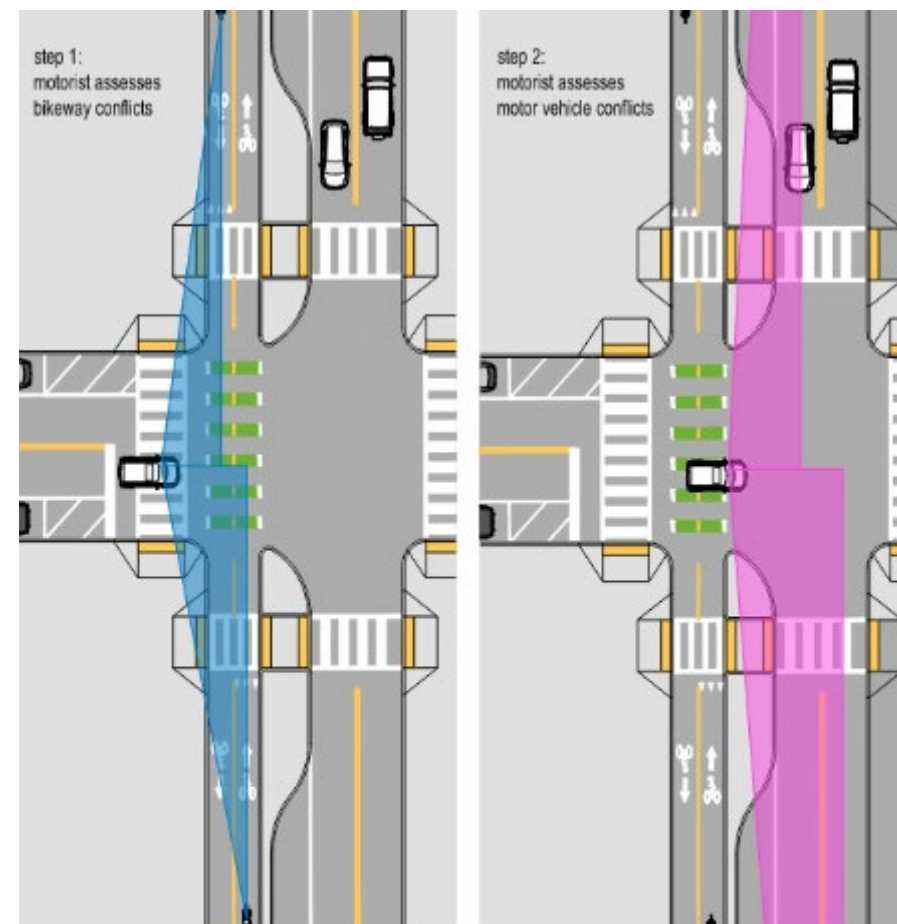
Check Intersection Sight Distances

Step 1: motorist assesses bikeway and pedestrian conflicts

(Stopping Sight Distance for Bike Design Speed)

Step 2: motorist assesses motor vehicle conflicts to complete movement

(AASHTO *Green Book* Case B Sight Triangles)



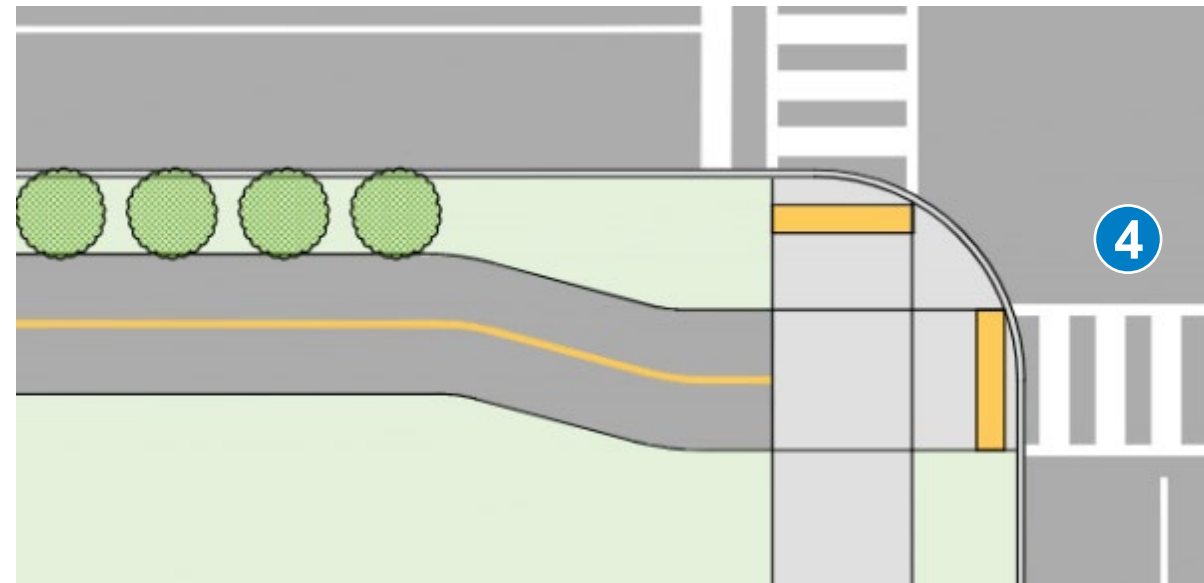
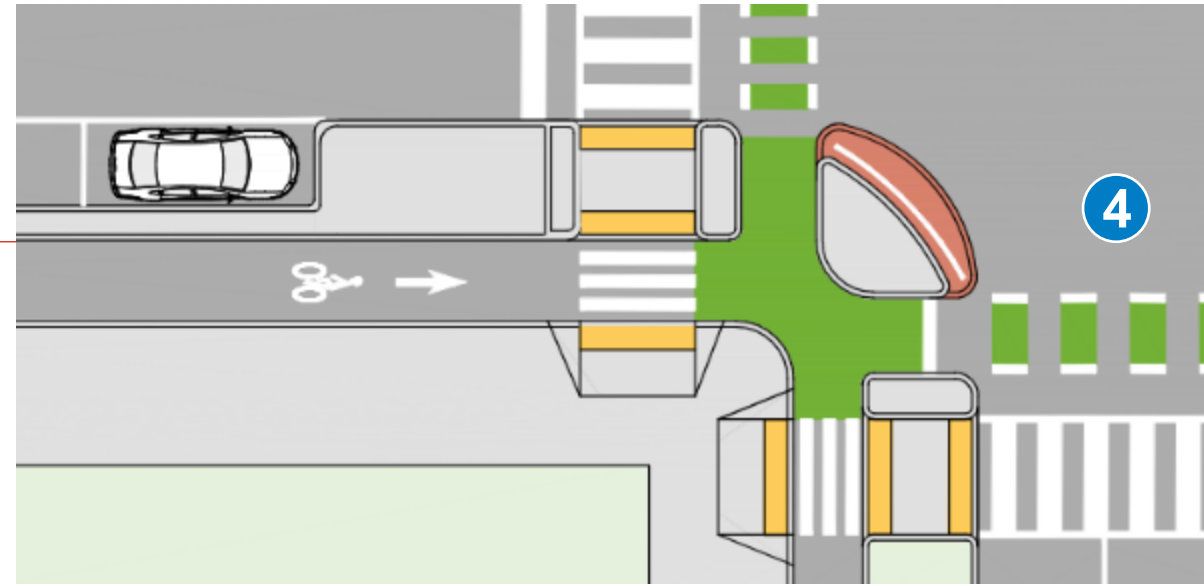
legend

▲ bike case C1 sight triangles

▲ AASHTO Green Book Case B sight triangles

Motorist Yield Zone

- Creates space for turning motorists to yield to bicyclists and pedestrians
- Improves motorist view of approaching bicyclists by reducing the need for motorists to turn their heads
- Reduces need to rely on mirrors to see bicyclists
- Bicycle and pedestrian crossings should be separate but parallel to consolidate conflict locations (unless the crossing is a shared-use path)



Motorist Yield Zone

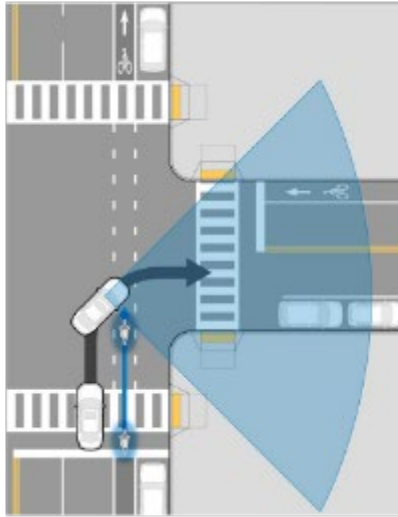
- Provide a **6-to-16.5-foot** offset for vehicle yielding
- Improves visibility at conflict points



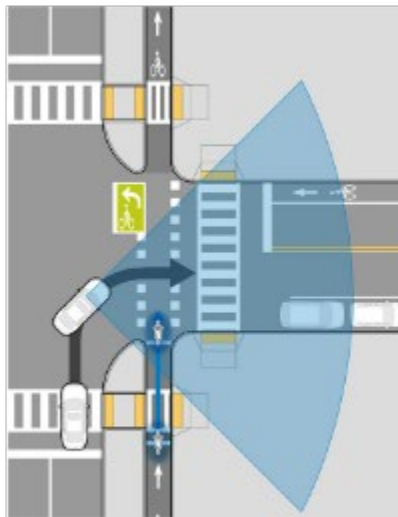
Photo by Dylan Passmore, Toole Design – Vancouver, BC, Canada

Visibility at Conflict Points

Motorist's view at
conventional bike lane



Motorist's view at
separated bike lane



Visibility at Conflict Points



conventional bike lane



protected intersection

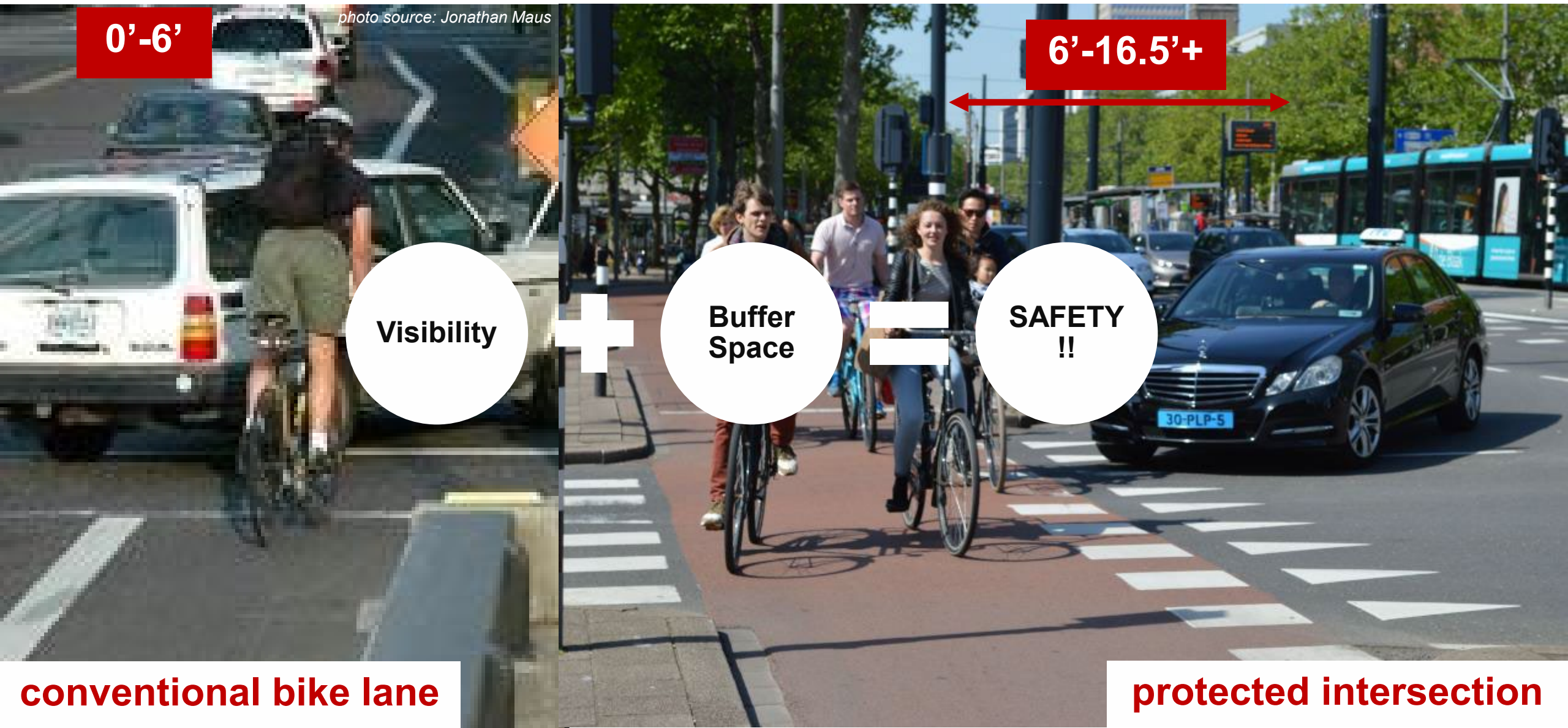
Visibility at Conflict Points



conventional bike lane

protected intersection

Visibility at Conflict Points



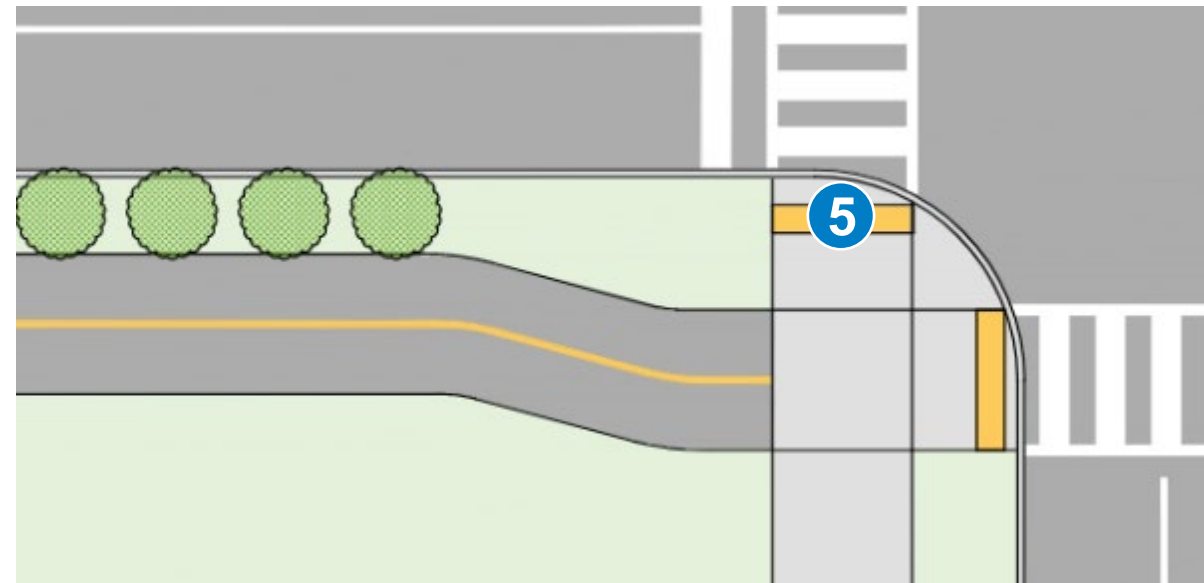
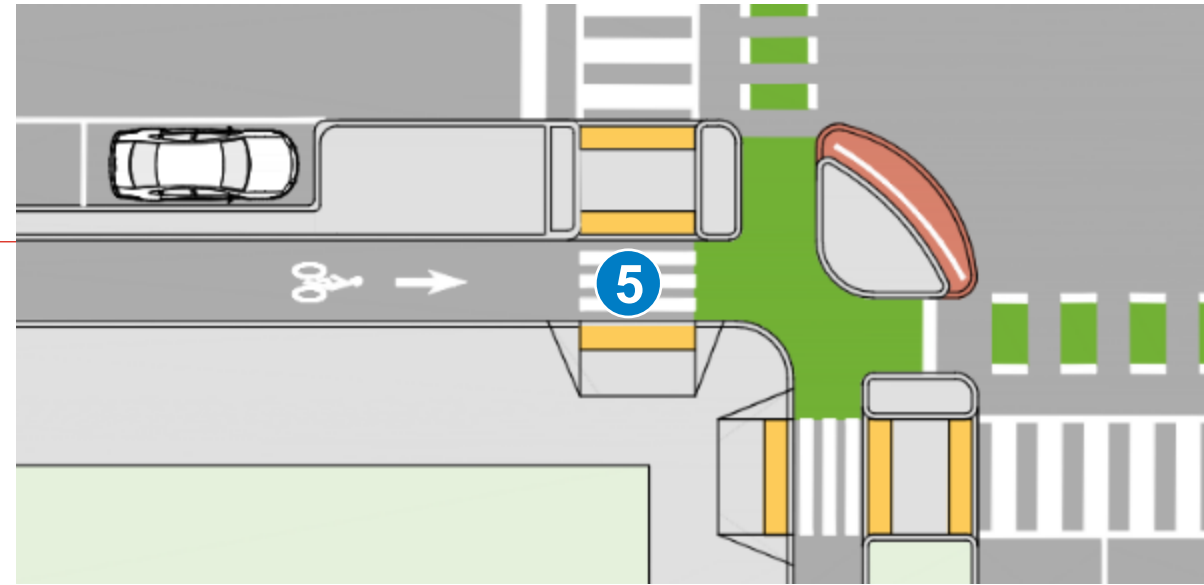
Pedestrian Elements

Pedestrian Refuge

- A 6' or wider pedestrian refuge median should be provided between the motor vehicle lane & bikeway
- Must include detectable warning surfaces

Pedestrian Curb Ramps

- Required when bikeway is at street or intermediate level
- Provides ADA-compliant connection from sidewalk to cross bikeway
- Must include detectable warning surfaces



Pedestrian Elements

Detectable Warning Surfaces

- Required at locations where curb ramps transition pedestrians to bike lane and motorist lanes of the street

Pedestrian Crossing of Bikeway

- Indicates the preferred crossing of the bike lane
- Communicates that bikes are to stop/yield to pedestrians in the crossing
- Provides clear pedestrian path, reducing likelihood that pedestrians will enter the bike lane except when crossing



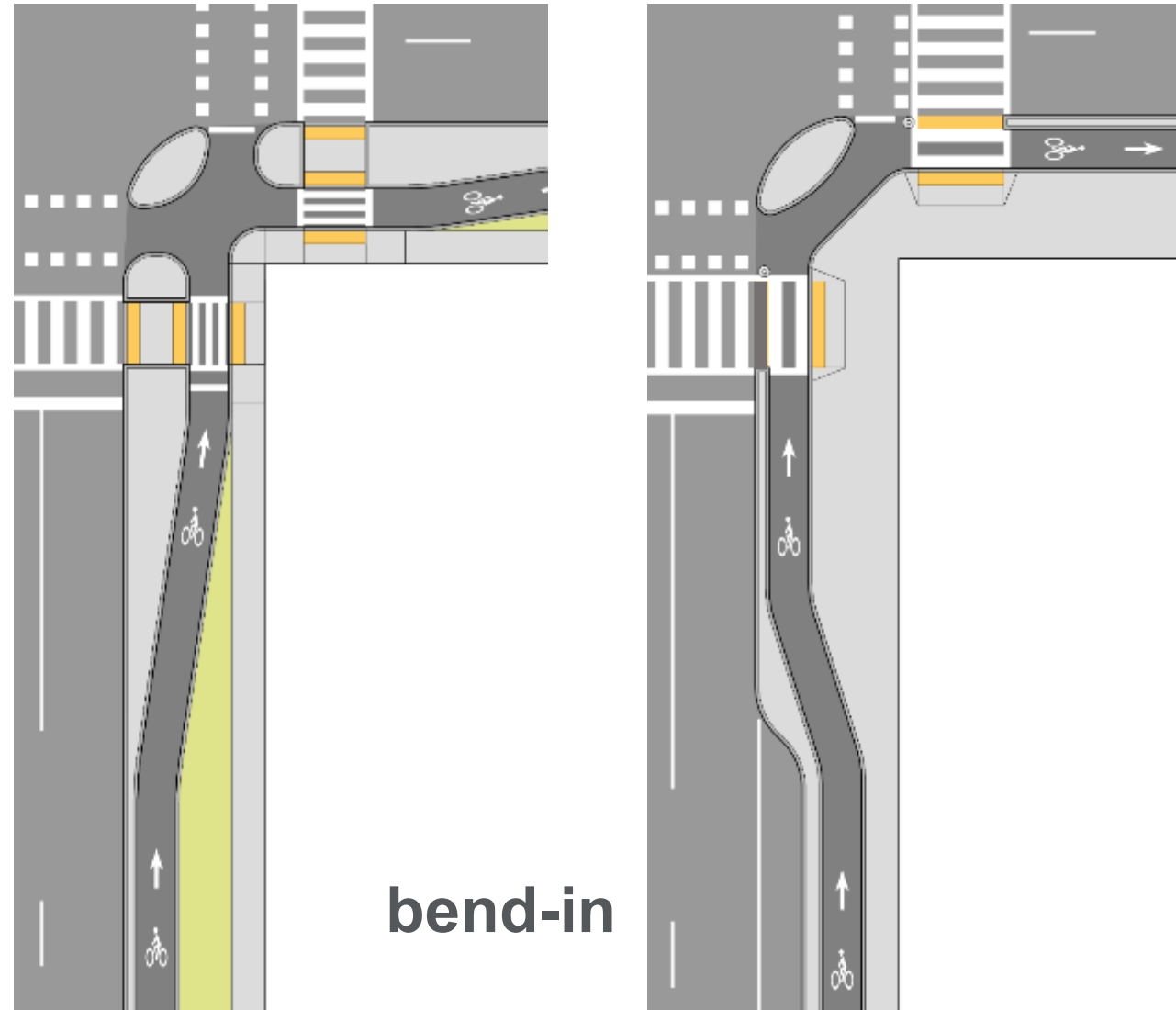
Improved Safety for All Users

- Clearly defined pathways increase likelihood of predictable behavior from all road users
- Increased visibility improves motor vehicle yielding rates at bike and pedestrian crossings
- Well identified crossing locations provide shorter crossings for pedestrians and bicyclists along with refuge areas
- Slower motor vehicle turning speeds due to tighter intersection geometry

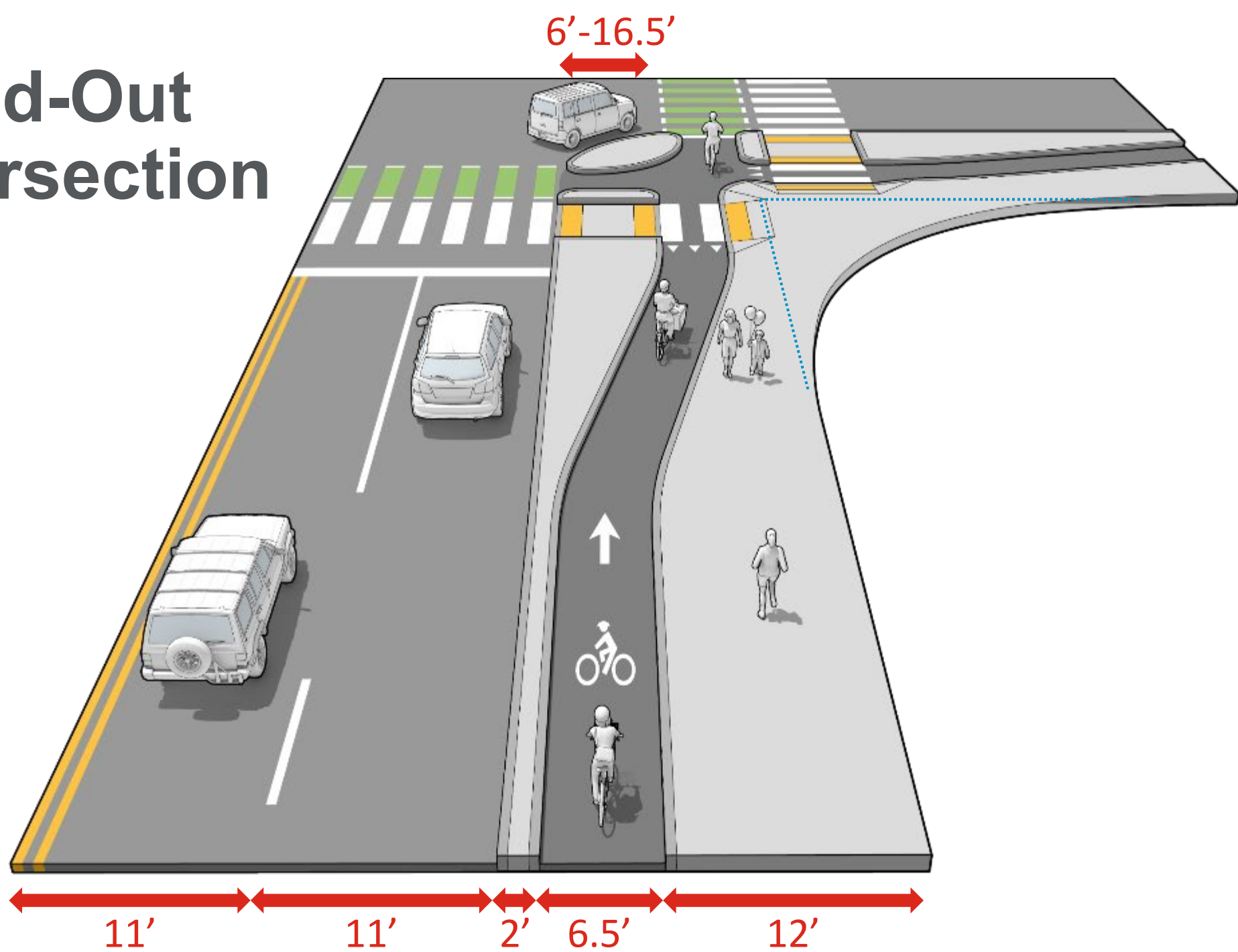


Design for Constrained Locations

- Maximum taper 3:1
- Bend-out preferred (motorist yield zone, bus stops, pedestrian refuge area, loading and parking)
- Separation increases sight distance
- Corner island affects motorist yield zone
- Bend-in generally used to increase sidewalk widths at corners

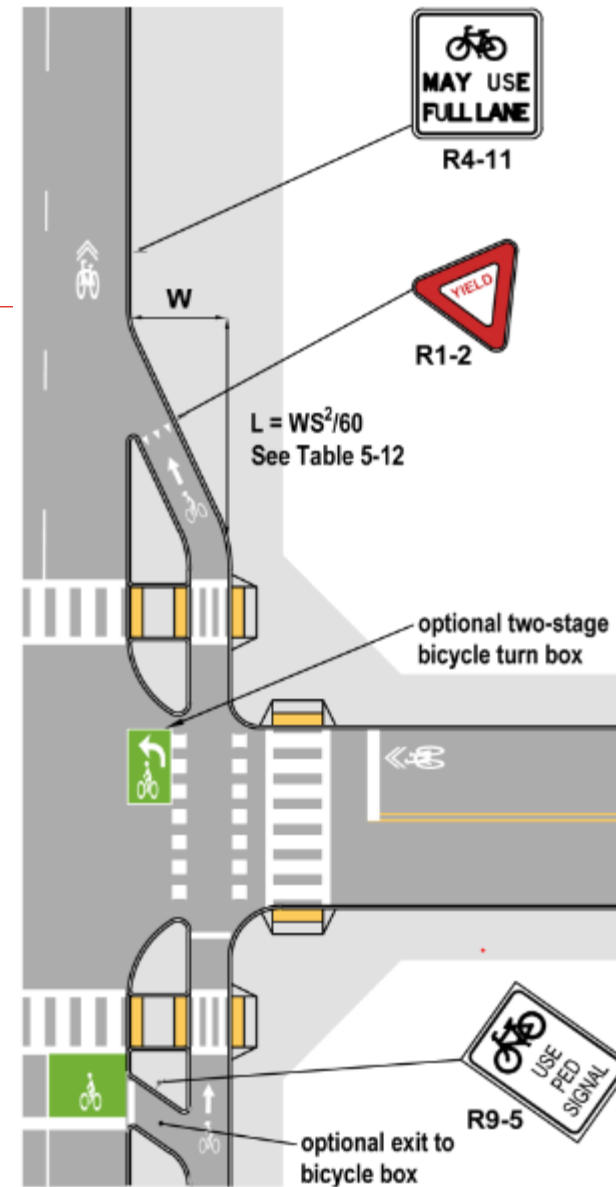


Bend-Out Intersection

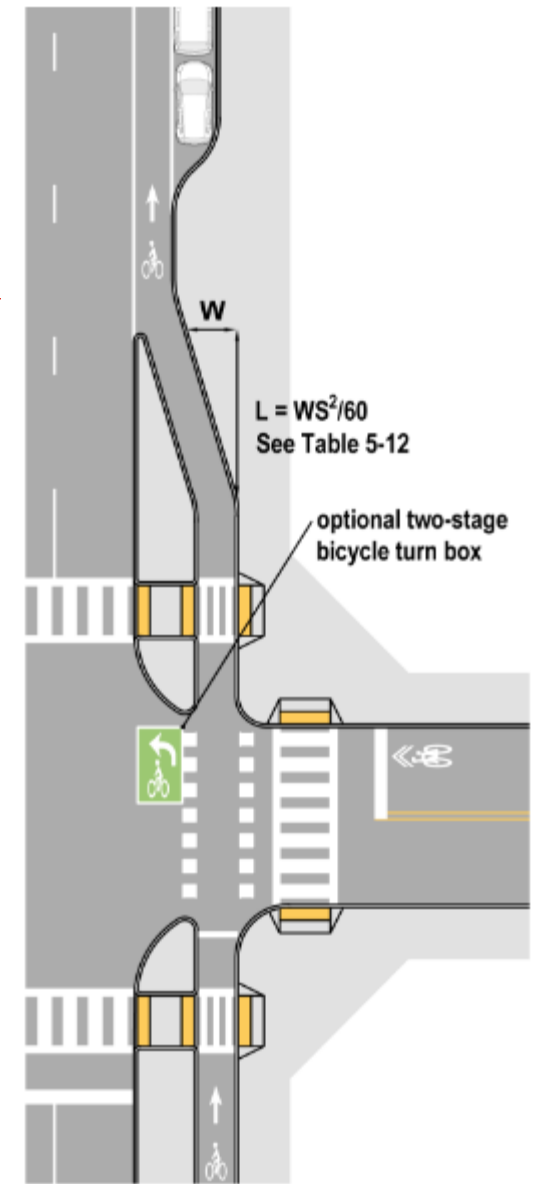


Bikeway Transitions

- Transition will vary depending on context
- Transition design should clearly communicate how bicyclists should enter and exit the intersection and minimize conflicts with other users
- Preferable to transition from a SBL to a standard bike lane (or other) on the far side of the intersection to maximize comfort & safety of bicyclists



Transition to
Shared Lane



Transition to
Bike Lane

Signal Phase Separation

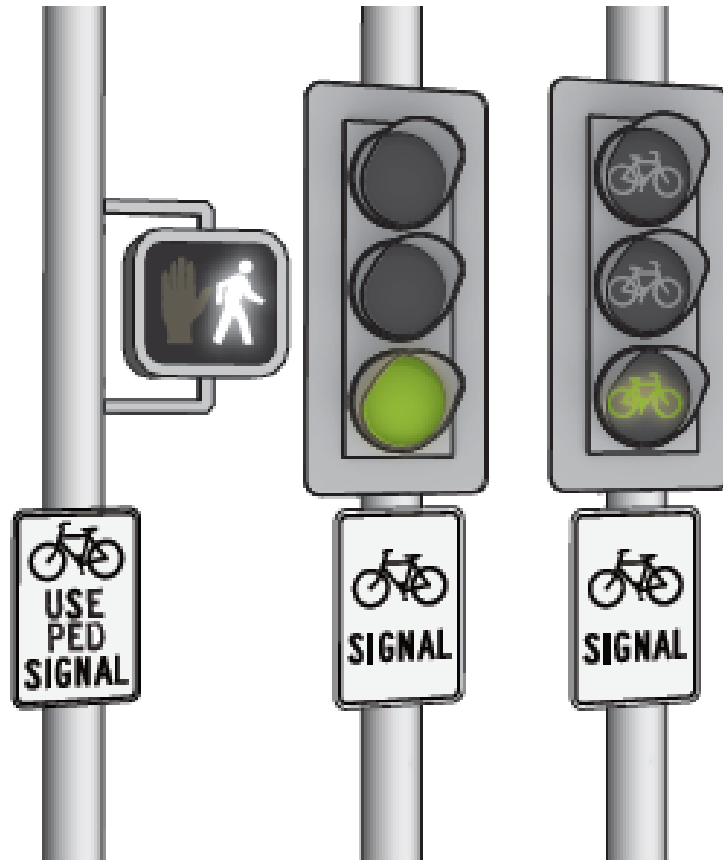
- Eliminates or reduces turning vehicle and bicycle conflicts
- Improves bicyclist safety at intersections

Three Factors:

1. Type of bikeway (one-way or two-way)
2. Motorist turn direction (left- or right-turn)
3. Number of motor vehicle travel lanes left-turning vehicle crosses

Hourly Volume Thresholds for Separate Turn Phases		
	Left Turn Crossing One Oncoming Lane	Left Turn Crossing Two Oncoming Lanes
One-Way Separated Bike Lane	<p>≥ 100</p> <p>≥ 150*</p>	<p>≥ 50</p> <p>≥ 150*</p>
Two-Way Separated Bike Lane or Sidepath	<p>≥ 50</p> <p>≥ 100*</p>	<p>ANY</p> <p>≥ 100*</p>

Traffic Signal Options for Bicyclists

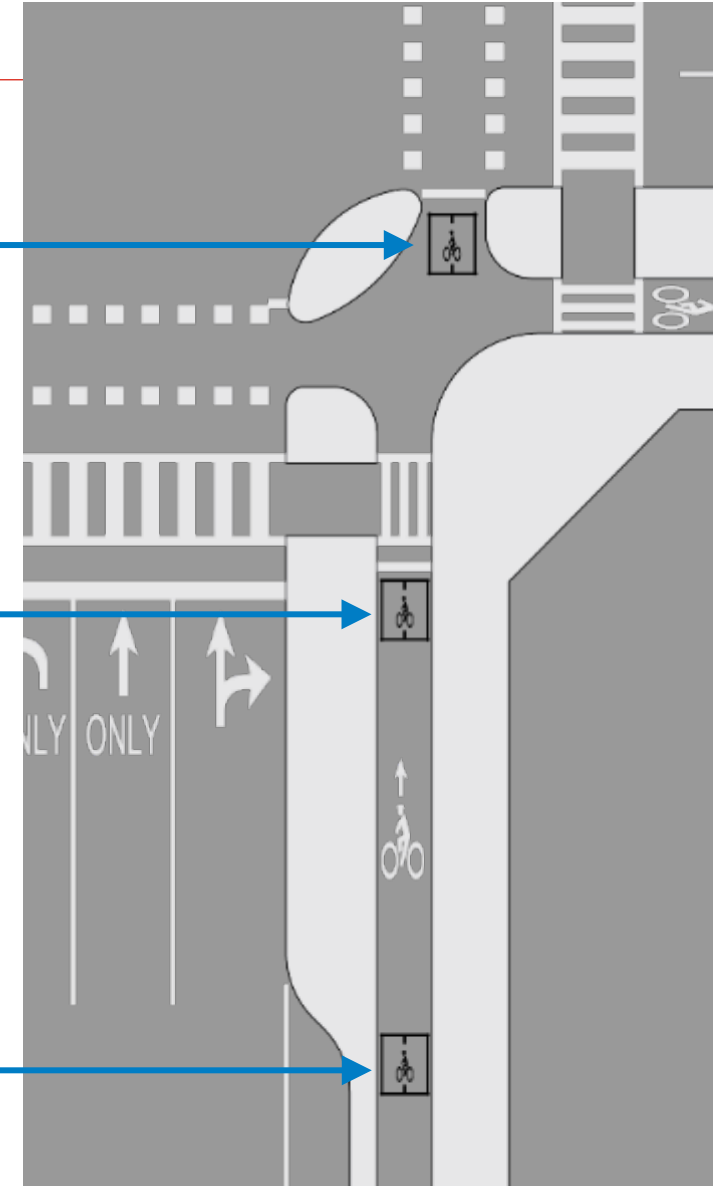


Bicycle Detection

- Used at actuated signals
- Stop bar detection for most locations
- Advanced detection to extend green and minimize delay for bicyclists
- Also provide detection for bike boxes and turn queue boxes

**typical
locations**

100' for
advanced
detection

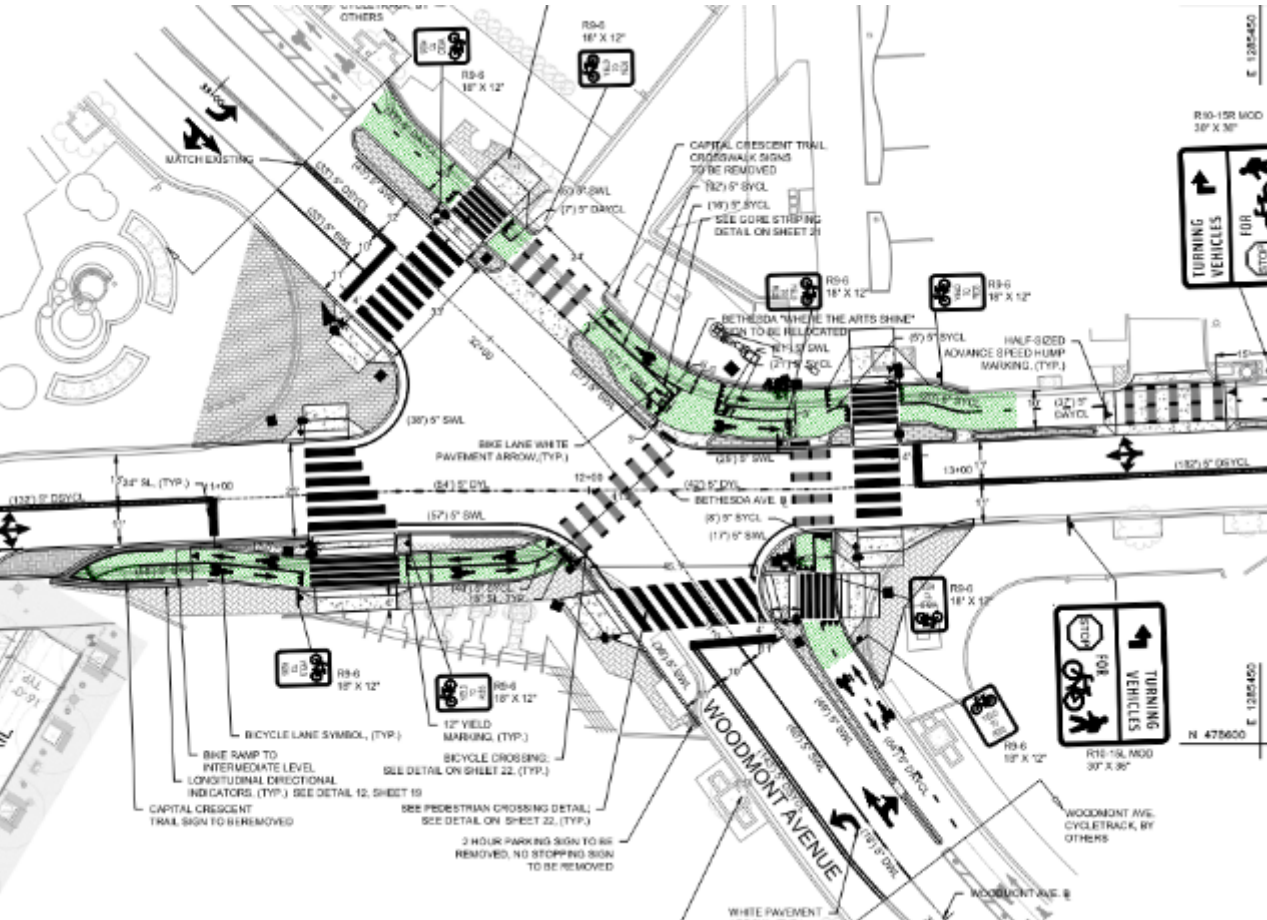


Questions

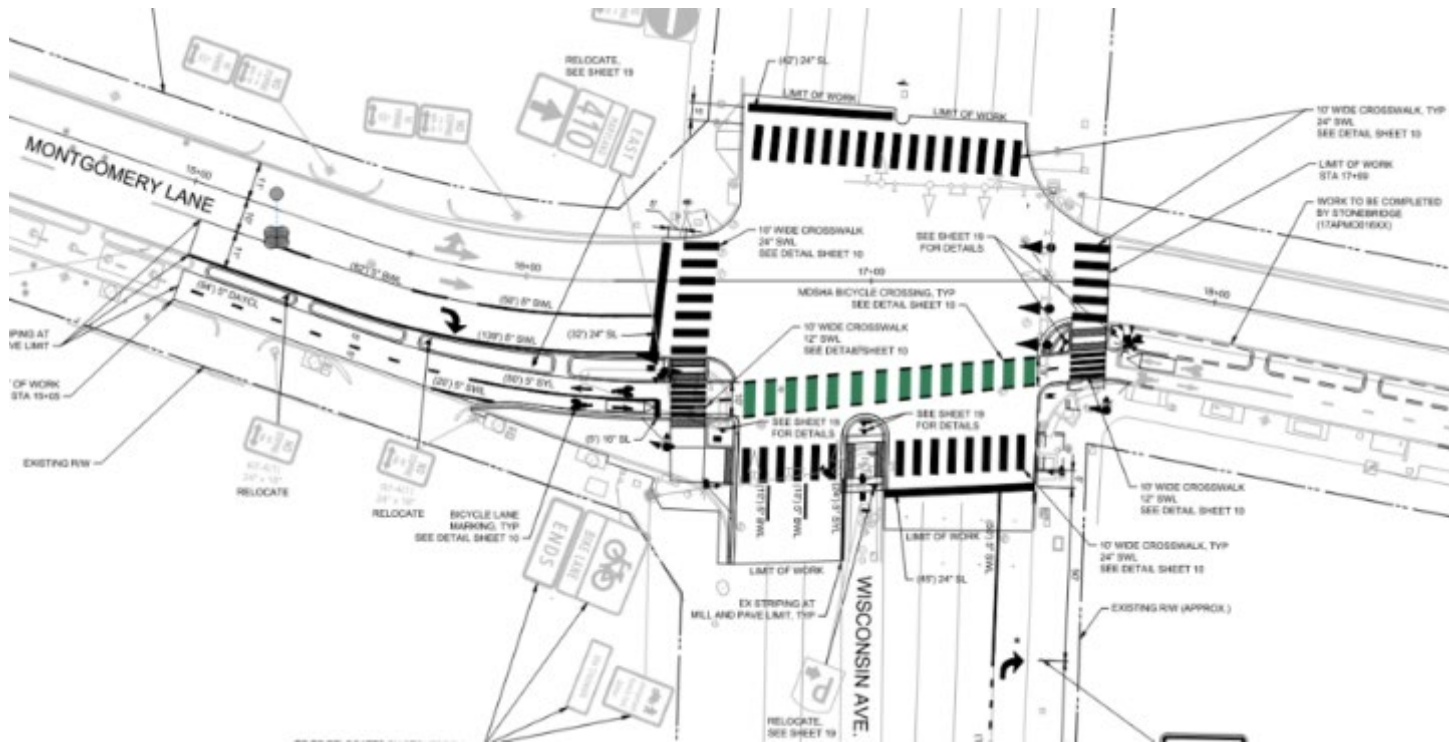
Protected Intersection Examples

Montgomery County & Beyond

Capital Crescent Surface Trail, Bethesda



Montgomery Ave & Wisconsin Ave, Bethesda



Spring Street & 2nd Avenue, Silver Spring



2nd Avenue & Fenwick, Silver Spring



Protected Intersections in the US



Protected Intersections in the US

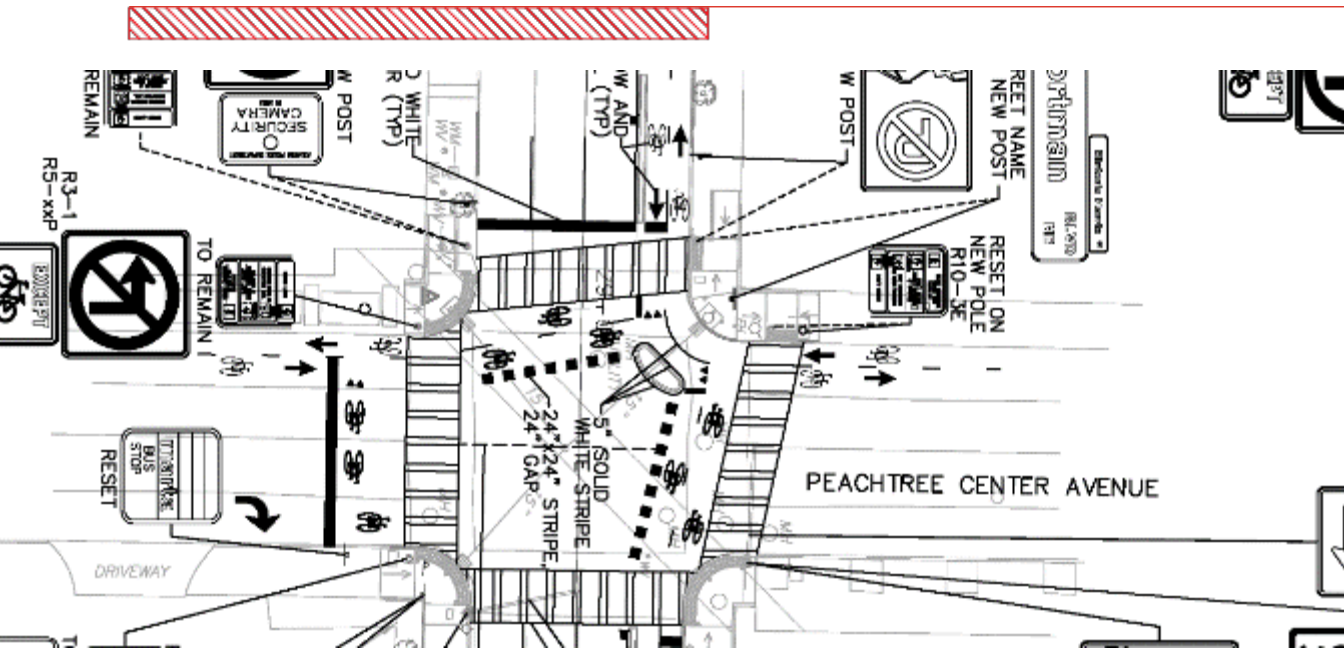


Design Challenge: Middlebrooke Pike (Knoxville, TN)

- Small bike lane buffer required bend-out at intersection
- Large truck movements required truck aprons for corner island



Design Challenge: John Portman Cycle Track (Atlanta, GA)



- Transition from buffered bike lane to separated bike lane
- Small buffer doesn't leave much space for corner island

QUICK Break!



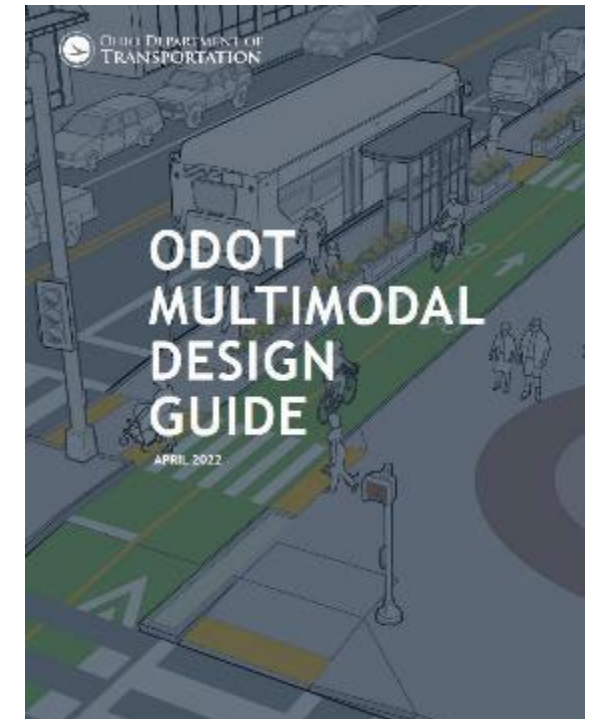
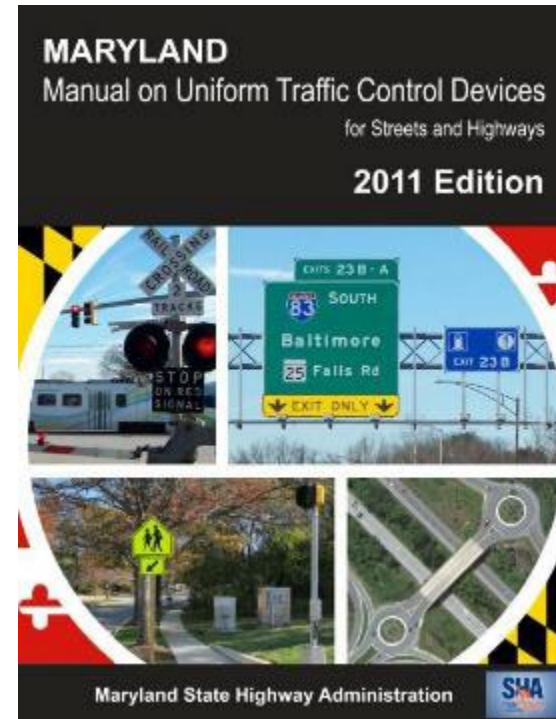
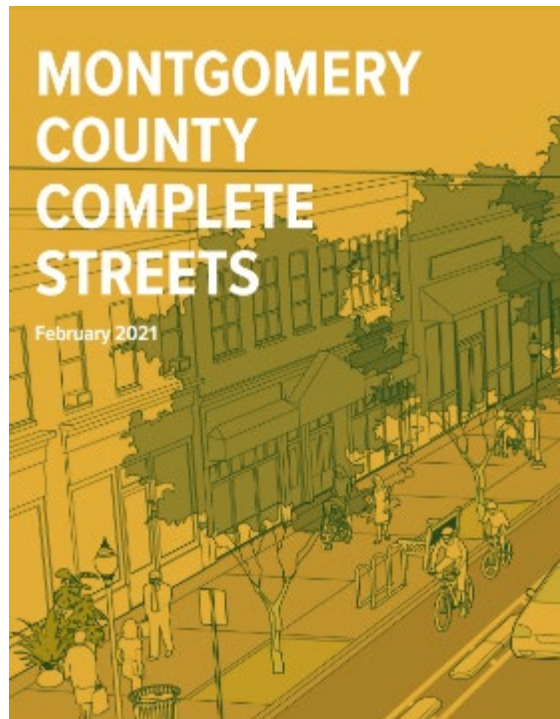
5 minutes = back at 11:20 AM

Protected Intersection Review Checklist

Developed by Toole Design for Montgomery County



Checklist Resources



Information Needed to Complete Checklist

Street Names

Ownership of Street

Street Type

Proposed Bikeway Type(s)

Intersection Control Type

Turning Movement Counts (if Signalized)

Bikeway Types Review



No Bikeway



Conventional Bike Lane



Buffered Bike Lane

Bikeway Types Review



One-Way Separated
Bike Lane



Two-Way Separated
Bike Lane



Sidepath
(Shared Use Path)

How To Use The Checklist

Complete this section once for the entire intersection:

Street Names

Ownership

Street Types

Proposed Bikeway Types

Design & Control Vehicles

Control Type (Signal vs. Stop)

PROTECTED INTERSECTION REVIEW CHECKLIST

Project Name: Name of Applicant:
Project Number: Name of Reviewer:

LOCATION INFORMATION

Complete this section for each intersection.

INTERSECTION INFORMATION

Complete this section for the entire intersection.

Street Name: <input type="text"/>	Street Name: <input type="text"/>
Ownership: (select one) <input type="checkbox"/> Montgomery County <input type="checkbox"/> Maryland SHA	Ownership: (select one) <input type="checkbox"/> Montgomery County <input type="checkbox"/> Maryland SHA
Street Type: (select one) <input type="checkbox"/> Downtown <input type="checkbox"/> Town Center <input type="checkbox"/> Neighborhood <input type="checkbox"/> Industrial <input type="checkbox"/> Country <input type="checkbox"/> Other	Street Type: (select one) <input type="checkbox"/> Downtown <input type="checkbox"/> Town Center <input type="checkbox"/> Neighborhood <input type="checkbox"/> Industrial <input type="checkbox"/> Country <input type="checkbox"/> Other
Proposed Bikeway Type: (select one or two) <input type="checkbox"/> One-Way Separated Bike Lane <input type="checkbox"/> Two-Way Separated Bike Lane <input type="checkbox"/> Conventional Bike Lane <input type="checkbox"/> Buffered Bike Lane <input type="checkbox"/> Sidewalk <input type="checkbox"/> No Bikeway	Proposed Bikeway Type: (select one or two) <input type="checkbox"/> One-Way Separated Bike Lane <input type="checkbox"/> Two-Way Separated Bike Lane <input type="checkbox"/> Conventional Bike Lane <input type="checkbox"/> Buffered Bike Lane <input type="checkbox"/> Sidewalk <input type="checkbox"/> No Bikeway

DESIGN & CONTROL VEHICLES

Complete this section for the entire intersection.
See Complete Streets Design Guide, Section 6.1 Design Vehicle Versus Control Vehicle, for additional information.


Design Vehicle:
Control Vehicle:

INTERSECTION CONTROL TYPE

Complete this section for the entire intersection.

Control Type: (select one)
 Signalized
 All-Way Stop
 Two-Way Stop

Please note: Turning movement counts are needed to complete checklist.

Date:  Page of

Design & Control Vehicles

DESIGN & CONTROL VEHICLES

Complete this section for the entire intersection.

See Complete Streets Design Guide, Section 6.4 Design Vehicle Versus Control Vehicle for additional information.

Design Vehicle:

SU-30

Control Vehicle:

Montgomery Co. Fire Truck

*standard for most intersections in Montgomery County

(see Complete Streets Design Guide, Section 6.4 for additional information)

Design Elements Checklist



Complete the Design Elements for each corner of the intersection:

- Geometric Design
- Signing & Marking
- Signalization (if applicable)

Project Name: Name of Applicant: Intersection Corner:
 Project Number: Intersection Name: Intersection Crossing:

DESIGN ELEMENTS CHECKLIST

Complete this section for each intersection corner and crossing. For any elements that do not meet the requirements, provide an explanation in the comments. Definitions and design guidance, reference graphics, tables, and figures are provided in the Appendix.

GEOMETRIC DESIGN

	Met (Y or N, or N/A)	Value	Requirements	Comments	
Corner Island					
A	Corner Island*	-	N/A	Corner Island is included in design plans.	
B	Corner Radius	+		Radius of corner Island set to 15'. If not, provide explanation in the comments and complete Section C, Mountable Truck Apron, below.	
C	Mountable Truck Apron	-		Mountable truck apron is included, radius is set to 15'. If not included/appropriate, mark N/A.	
Bicycle Queuing Space					
D	Bicycle Queuing Space	-		Bicycle queuing space has been provided and is outside of the design vehicle envelope. Recommended minimum depth is 6.5'.	
F	Bikeway Type	-	N/A	Select based on street type and available width and volumes. Recommendations for bikeway widths are provided in Table 2 in the appendix. Street types and facility selection are provided in Table 3 in the appendix.	
F	Bikeway Width	-		Bikeway meets minimum width requirements in Table 2 in the appendix. Sidepath minimum width is typically 10'. If width does not meet requirements, provide explanation in comments.	
G	Separated Bike Lane Curb Type	-	N/A	Separated bike lane is beveled. For sidepaths, enter N/A.	
H	Stop Bar	-	N/A	22" bicycle stop line is present and outside of the vehicle travel path. Consider if a second stop bar is necessary across the bikeway at pedestrian crossings. This may be appropriate in areas with high volumes of pedestrian activity but may require additional bicyclist detection (see bikeway detection section).	
Clear Distance					
J	Clear Distance*	+		Confirm adequate clear distance for sight lines between parallel traveling motorists and bicyclists. Clear distance meets minimum requirements in Table 1 in the appendix. (Default is 20' clear distance where corner radius is 15').	
K	No Parking/Restricted Use Signs	-	N/A	No Parking or No Stopping signs have been included to restrict vehicles from parking or stopping within the clear distance zone.	

*Items with an asterisk are considered an absolute requirement and must be achieved in order to proceed.

How To Use The Checklist

Refer to appendices, figures, reference graphics and tables at the end of the checklist for definitions and illustrations of concepts

APPENDIX A DEFINITIONS & RESOURCES

These definitions provide supplemental explanations of elements referenced in the checklist.

GEOMETRIC DESIGN

Definition & Specifications

Resources & Additional Information

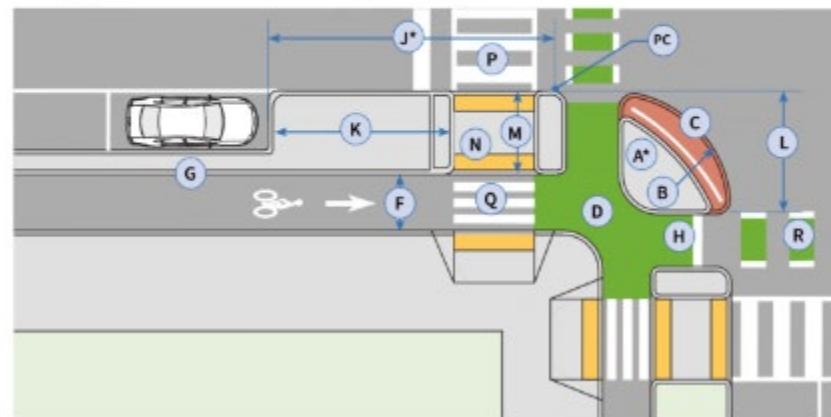
Corner Island			
A	Corner Island	The corner island allows the bikeway to be physically separated up to the intersection crossing point where potential conflicts with turning motor vehicles can be controlled more easily. It serves an important purpose and must be present in order to be considered a protected intersection. Design, geometry, and materials may vary from project to project, constructed with a vertical curb, or other materials, and may include a mountable truck apron.	NAACTO Don't Give Up at the Intersection
B	Corner Radius	The default corner radius on most street types in Montgomery County is 15'. Exceptions include a default 25' corner radius when at least one street is industrial and a default 10' corner radius when all intersecting streets are Neighborhood Connectors, Neighborhood Streets, or Neighborhood Yield Streets. Designers should assume a maximum 30 mph turning speed for passenger cars and a 5 mph turning speed for all other vehicles.	Complete Streets Design Guide, February 2021 (PAGE 196)
C	Mountable Truck Apron	Where a design or control vehicle requires a wider turning radius than the default corner radius requirement allows, a mountable truck apron is required. Mountable truck aprons are part of the traveled way and must be designed to discourage bicyclists and pedestrians from using them as a queuing area. The outer mountable truck radius should be set to 15' (or the recommended radius for the design vehicle). Radius closer to bikeway should be defined by the control vehicle. Mountable curb must be no taller than 3".	Complete Streets Design Guide, February 2021 (PAGE 196 & 203) Montgomery County Planning Department Bicycle Facility Design Toolkit

REFERENCE GRAPHICS

Use these example graphics to identify elements in the checklist.

EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



TABLES & FIGURES

These tables & figures are referenced in the checklist.

TABLE C - INTERSECTION APPROACH CLEAR DISTANCE BASED ON EFFECTIVE VEHICLE TURNING RADIUS

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

Definitions, Specifications, & Resources

GEOMETRIC DESIGN

		<u>Met</u> (Y or N, or N/A)	<u>Value</u>	<u>Requirements</u>
Corner Island				
A	Corner Island*		N/A	Corner Island is included in design plans.
B	Corner Radius			Radius of corner island set to 15'. If not, provide explanation in the comments and complete Section C Mountable Truck Apron below.
C	Mountable Truck Apron			Mountable truck apron is included, radius is set to 15'. If not included/appropriate, mark N/A.

GEOMETRIC DESIGN

		<u>Definition & Specifications</u>	<u>Resources & Additional Information</u>
Corner Island			
A	Corner Island	The corner island allows the bikeway to be physically separated up to the intersection crossing point where potential conflicts with turning motor vehicles can be controlled more easily. It serves an important purpose and must be present in order to be considered a protected intersection. Design, geometry, and materials may vary from project to project, constructed with a vertical curb, or other materials, and may include a mountable truck apron.	NACTO Don't Give Up at the Intersection
B	Corner Radius	The default corner radius on most street types in Montgomery County is 15'. Exceptions include a default 25' corner radius when at least one street is Industrial and a default 10' corner radius when all intersecting streets are Neighborhood Connectors, Neighborhood Streets, or Neighborhood Yield Streets. Designers should assume a maximum 10 mph turning speed for passenger cars and a 5 mph turning speed for all other vehicles.	Complete Streets Design Guide, February 2021 (PAGE 196)
C	Mountable Truck Apron	Where a design or control vehicle requires a wider turning radius than the default corner radius requirement allows, a mountable truck apron is required. Mountable truck aprons are part of the traveled way and must be designed to discourage bicyclists and pedestrians from using them as a queuing area.	Complete Streets Design Guide, February 2021 (PAGE 196 & 203)
		The outer mountable truck radius should be set to 15' (or the recommended radius for the design vehicle). Radius closer to bikeway should be defined by the control vehicle. Mountable curb must be no taller than 3".	Montgomery County Planning Department Bicycle Facility Design Toolkit

Geometric Design

GEOMETRIC DESIGN

		<u>Met</u> (Y or N, or N/A)	<u>Value</u>	<u>Requirements</u>	<u>Comments</u>
Corner Island					
A	Corner Island*		N/A	Corner Island is included in design plans.	
B	Corner Radius			Radius of corner island set to 15'. If not, provide explanation in the comments and complete Section C Mountable Truck Apron below.	
C	Mountable Truck Apron			Mountable truck apron is included, radius is set to 15'. If not included/appropriate, mark N/A.	

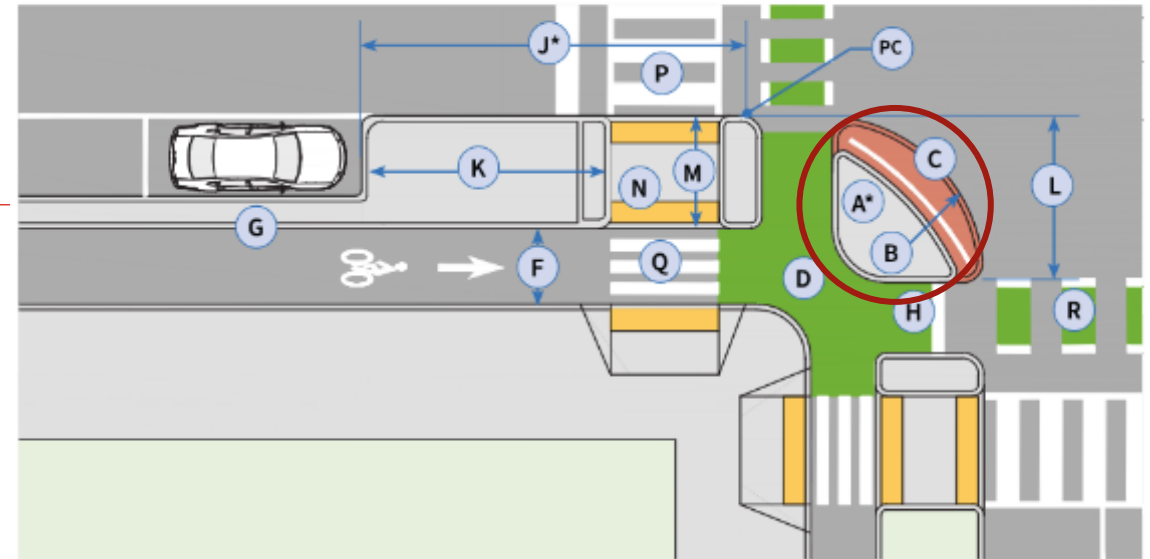
Geometric Design

GEOMETRIC DESIGN

		Met. (Y or N, or N/A)	Value	Requirements
Corner Island				
A	Corner Island*		N/A	Corner Island is included in design plans.
B	Corner Radius			Radius of corner island set to 15'. If not, provide explanation in the comments and complete Section C. Mountable Truck Apron below.
C	Mountable Truck Apron			Mountable truck apron is included, radius is set to 15'. If not included/appropriate, mark N/A.

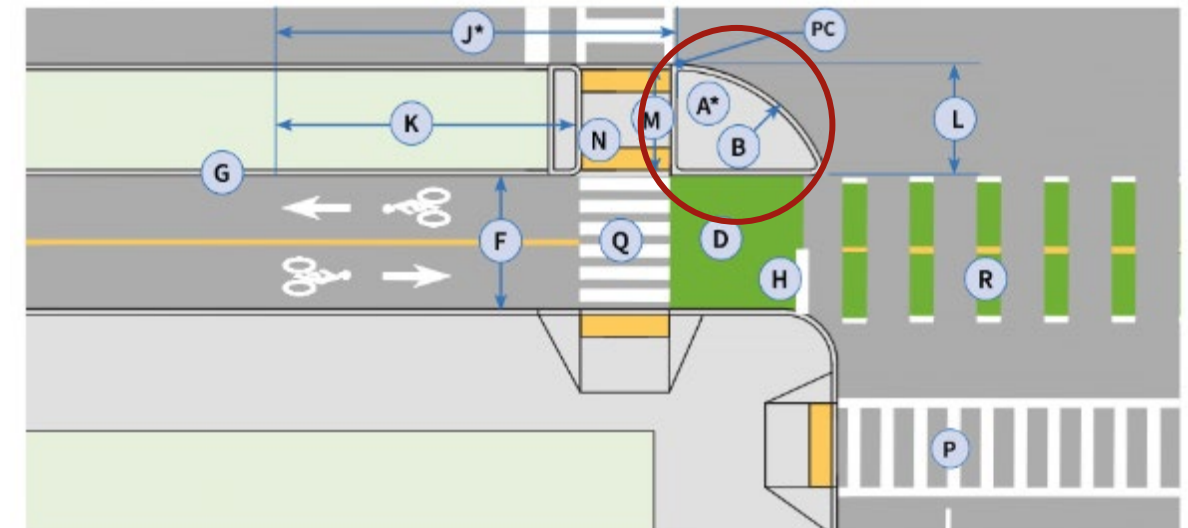
EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



EXAMPLE 2:

Two-Way Separated Bike Lane Intersection with No Intersecting Bikeway



A – Corner Island



B – Corner Radius

- Default corner radius in Montgomery County is 15'
- Exceptions:
 - 25' corner when at least one street is industrial
 - 10' when all are neighborhood connectors, or yield streets
 - See Complete Streets for more details



C – Mountable Truck Apron

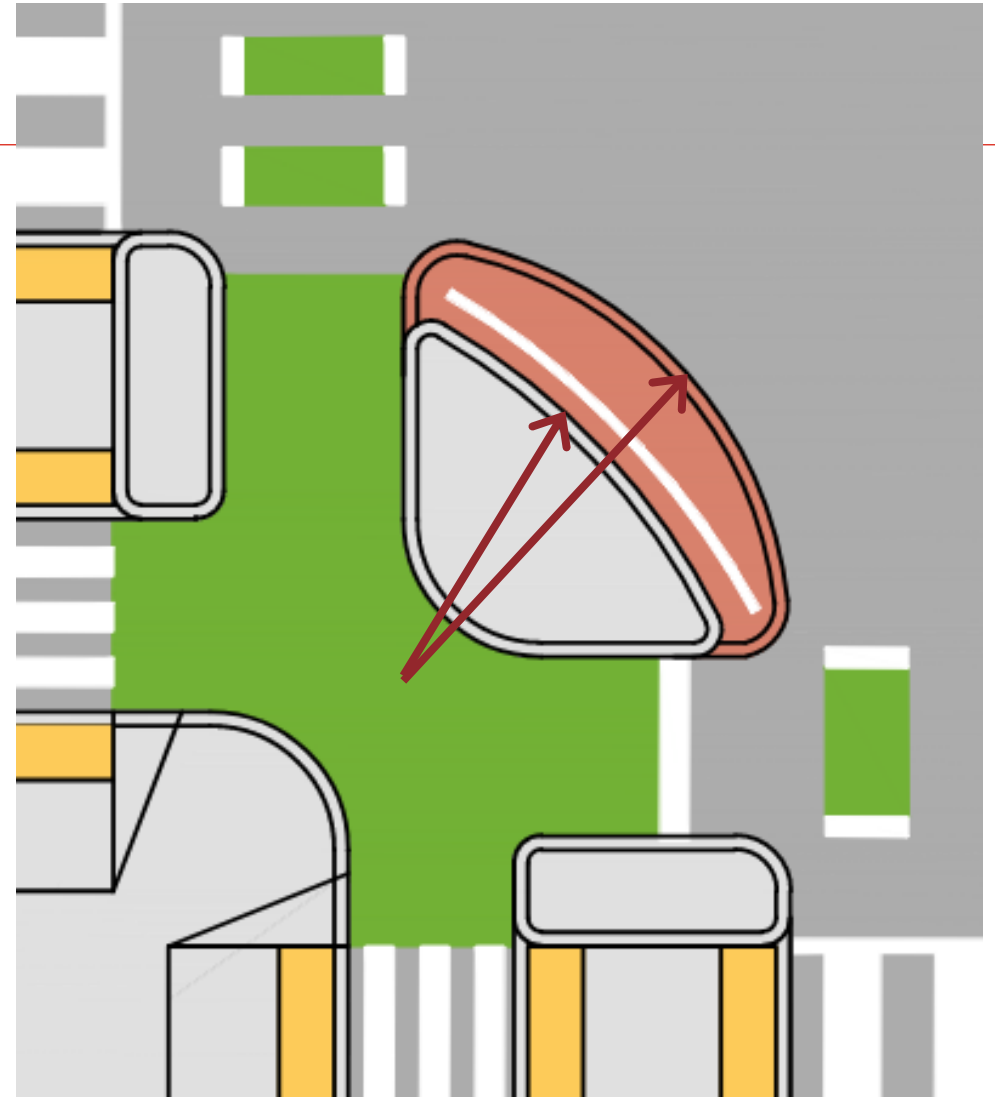
- Where design or control vehicle requires a wider turning radius, mountable truck apron is **required**
- Mountable Truck Apron radius should be 15'
- Concrete curb radius set to accommodate control vehicle



Geometric Design

GEOMETRIC DESIGN

		Met. (Y or N, or N/A)	Value	Requirements
Corner Island				
A	Corner Island*	Y	N/A	Corner island is included in design plans.
B	Corner Radius	N	25'	Corner radius of protected island set to 15'. If not, provide explanation in the comments and complete Section C - Mountable Truck Apron below.
C	Mountable Truck Apron	Y	15'	Mountable truck apron is included, radius is set to 15'. If not included/ appropriate, mark N/A.



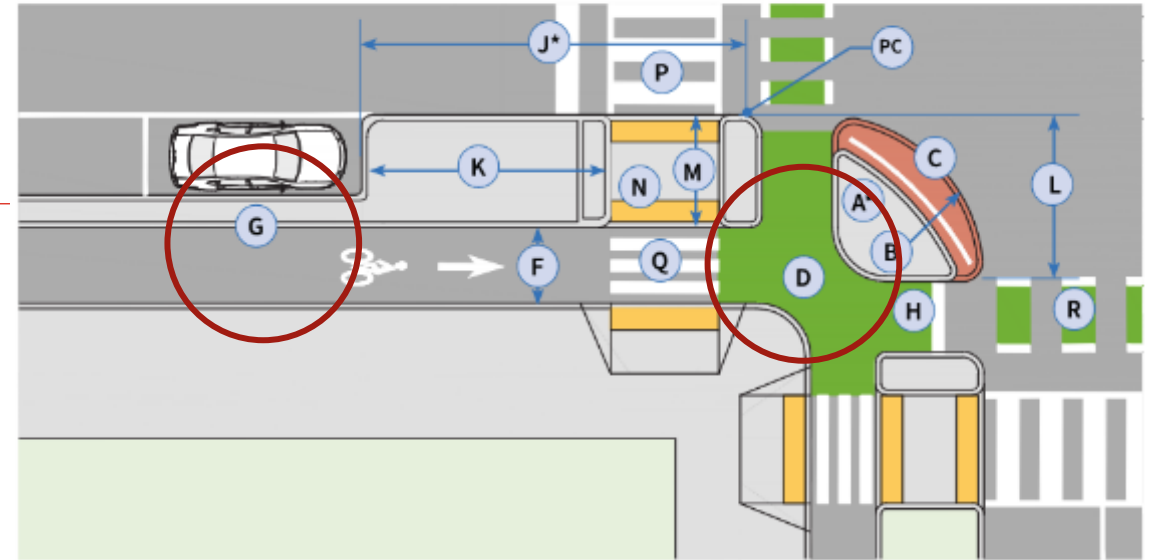
Geometric Design

Bicycle Queuing Space

D	Bicycle Queuing Space			Bicycle queuing space has been provided and is outside of the design vehicle envelope. Recommended minimum depth is 6.5'.
E	Bikeway Type		N/A	Select based on street type and available width and volumes. Recommendations for bikeway widths are provided in Table 2 in the appendix. Street types and facility selection are provided in Table 3 in the appendix.
F	Bikeway Width			Bikeway meets minimum width requirements in Table 2 in the appendix. Sidepath minimum width is typically 10'. If width does not meet requirements, provide explanation in comments.
G	Separated Bike Lane Curb Type		N/A	Separated bike lane is beveled. For sidepaths, enter N/A.
H	Stop Bar		N/A	12" bicycle stop line is present and outside of the vehicle travel path. Consider if a second stop bar is necessary across the bikeway at pedestrian crossings. This may be appropriate in areas with high volumes of pedestrian activity but may require additional bicyclist detection (see bikeway detection section).

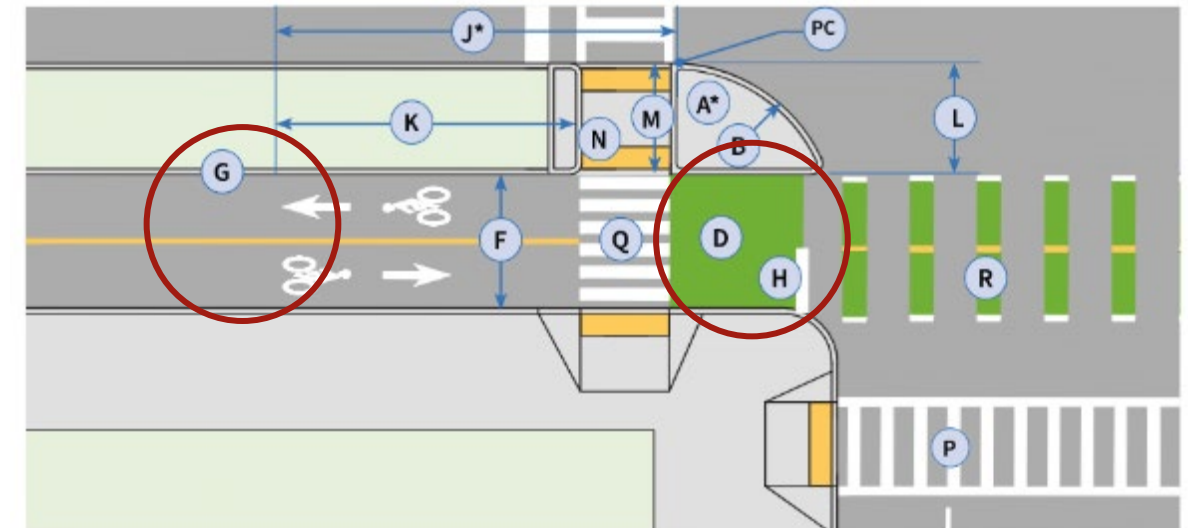
EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



EXAMPLE 2:

Two-Way Separated Bike Lane Intersection with No Intersecting Bikeway



D - Bicycle Queuing Space

- Minimum depth of **6.5'**
- Width of opening should match bikeway width or wider
- More recommended if high volume bicycle traffic anticipated



E – Bikeway Type

List Bikeway Type used on the leg of the street being evaluated

Used to inform F – Bikeway Width

Proposed Bikeway Type:
(select one or two)

- One-Way Separated Bike Lane
- Two-Way Separated Bike Lane
- Conventional Bike Lane
- Buffered Bike Lane
- Sidepath
- No Bikeway

F - Bikeway Width

Provide a consistent bikeway width through:

- Bicycle Queuing Area
- Bikeway Crossing
- Bikeway

Width based on bikeway type



F - Bikeway Width

- Use Table 2 to determine recommended bikeway widths
- Sidepath widths are typically 10' wide or greater

Same Direction Bicyclists per Peak Hour	One-Way Separated Bike Lane Width (feet)		Bidirectional Bicyclists per Peak Hour	Two-Way Separated Bike Lane Width (feet)	
	Default	Minimum		Default	Minimum
< 150	6.5	5.0	<150	10.0	8.0
150 – 750	8.0	6.5	150-400	11.0	10.0
>750	10.0	8.0	>400	14.0	11.0

G - Separated Bikeway Curb Type

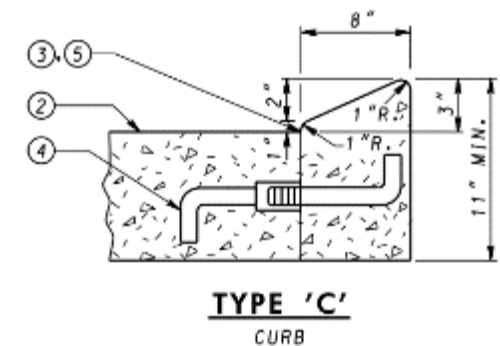
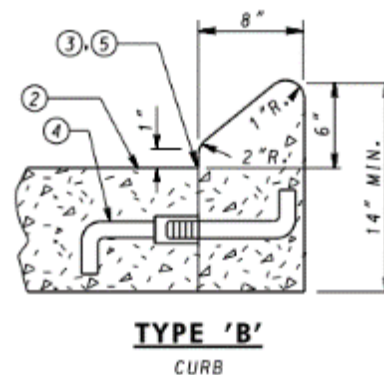


Requirements:

- Beveled curb (Type B) preferred;
- Mountable (Type C) allowed

Standard 620.02 Type B & C

MD SHA Type B & C Curb



H - Bicycle Stop Bar



Requirements:

- 12" Stop Bar
- Only across correct direction
- Outside of vehicle travel path
- Not in conflict with the mountable truck apron



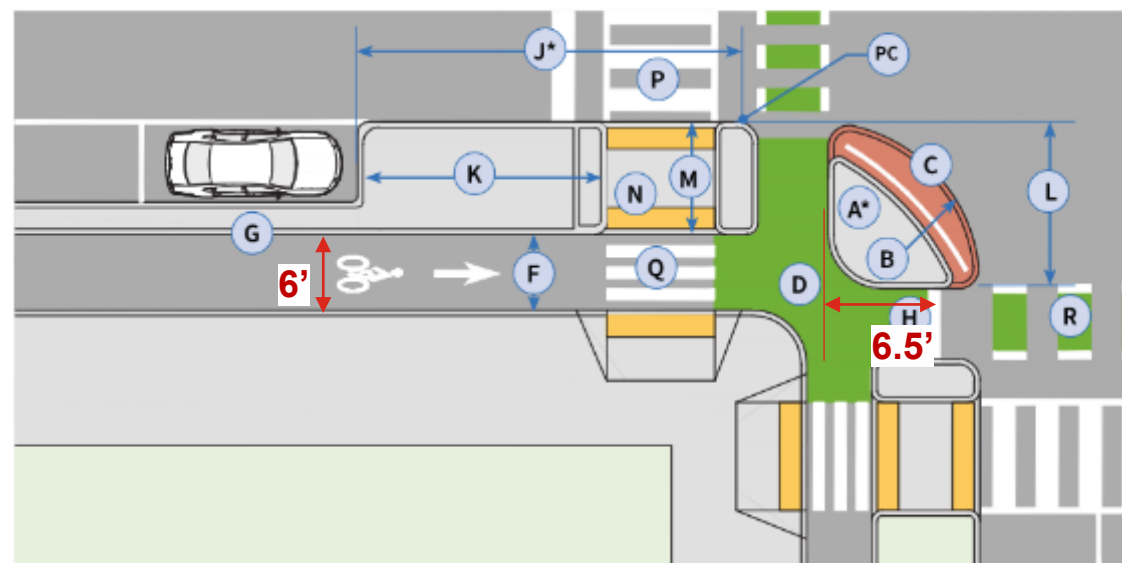
Geometric Design



		<u>Met</u> (Y or N, or N/A)	<u>Value</u>	<u>Requirements</u>
Bicycle Queuing Space				
D	Bicycle Queuing Space	Y	6.5'	Bicycle queuing space has been provided and is outside of the design vehicle envelope. Recommended minimum depth is 6.5'.
E	Bike Lane Type	Y	N/A	Select based on street type and available width and volumes. Recommendations for width and volumes are provided in Table L. Street types and facility selection are provided in Table Y.
F	Bikeway Width	Y	6'	Bikeway meets minimum width requirements in Table Table F in Appendix A. Sidepath minimum width is typically 10'. Enter width of bikeway in "value". If width does not meet requirements, provide explanation in comments.
G	Separated Bike Lane Curb Type	Y	N/A	Adjacent to separated bikeways, proposed curb is beveled. For shared use paths, enter N/A.
H	Stop Line	Y	N/A	12" bicycle stop line is present and outside of the vehicle travel path. Consider if a second stop bar is necessary across the bikeway at pedestrian crossings. This may be appropriate in areas with high volumes of pedestrian activity, but may require additional bicyclist detection (see bikeway detection below).

EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



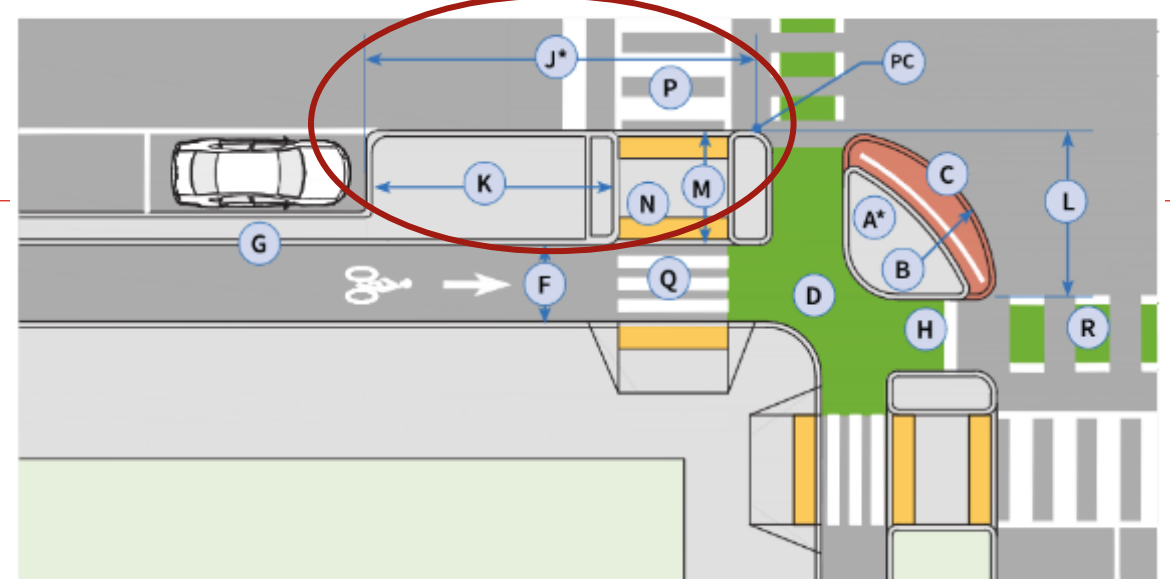
Geometric Design

Clear Distance			
J	Clear Distance*		Confirm adequate clear distance for sight lines between parallel traveling motorists and bicyclists. Clear distance meets minimum requirements in Table 1 in the appendix. (Default is 20' clear distance where corner radius is 15')
K	No Parking/Restricted Use Signs	N/A	No Parking or No Stopping signs have been included to restrict vehicles from parking or stopping within the clear distance zone.

Motorist Yield Zone			
L	Motorist Yield Zone		Motorist yield zone provides a 6' to 16.5' offset for vehicle yielding. If not, provide explanation of other treatments used to reduce motor vehicle turning speeds and reduce conflicts (i.e., through signalization) in comments (see signalization below.)

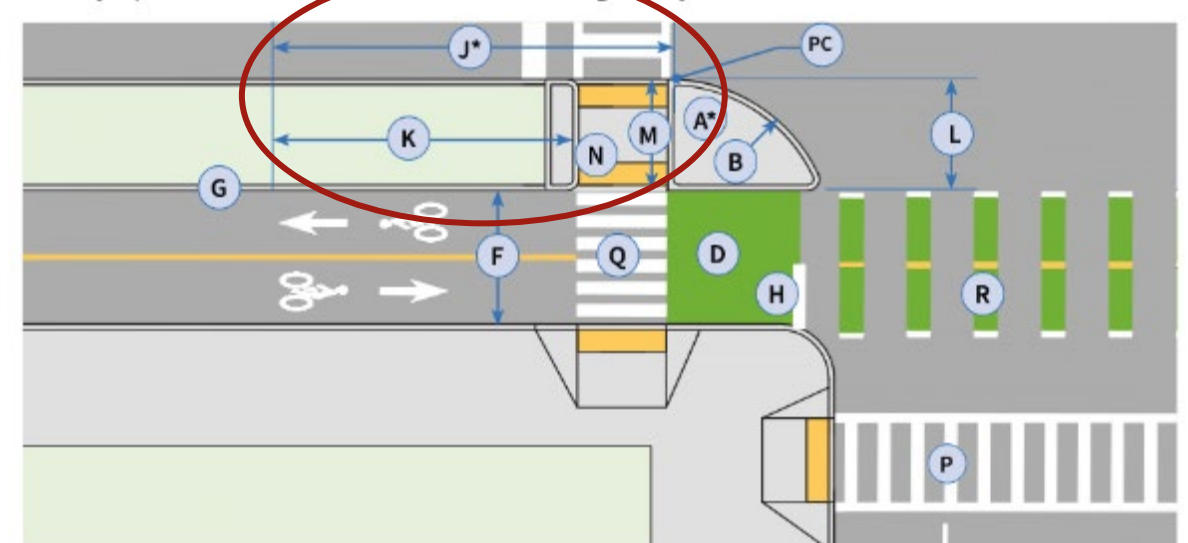
EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



EXAMPLE 2:

Two-Way Separated Bike Lane Intersection with No Intersecting Bikeway

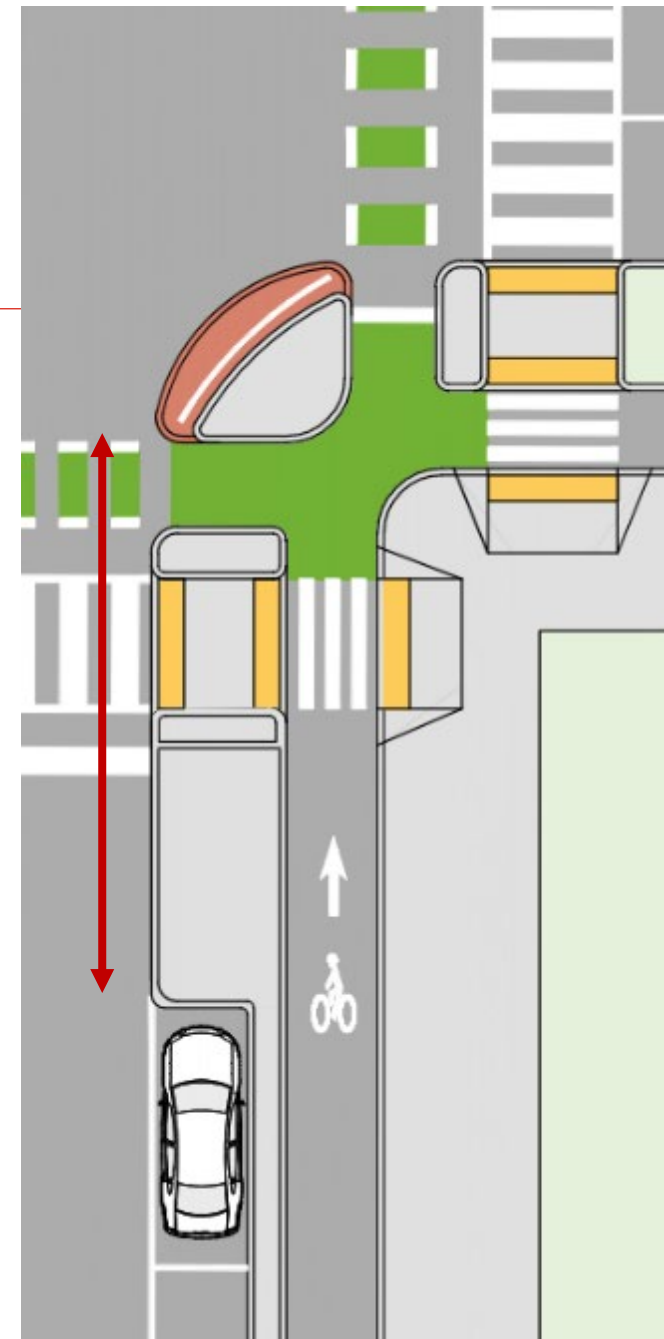


J - Clear Distance

- Measure from Point of Curvature (PC) of motorists effective turning radius (i.e. fastest path) to nearest permitted sight obstruction

Table 1: Intersection Approach Clear Distance Based on Effective Vehicle Turning Radius

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



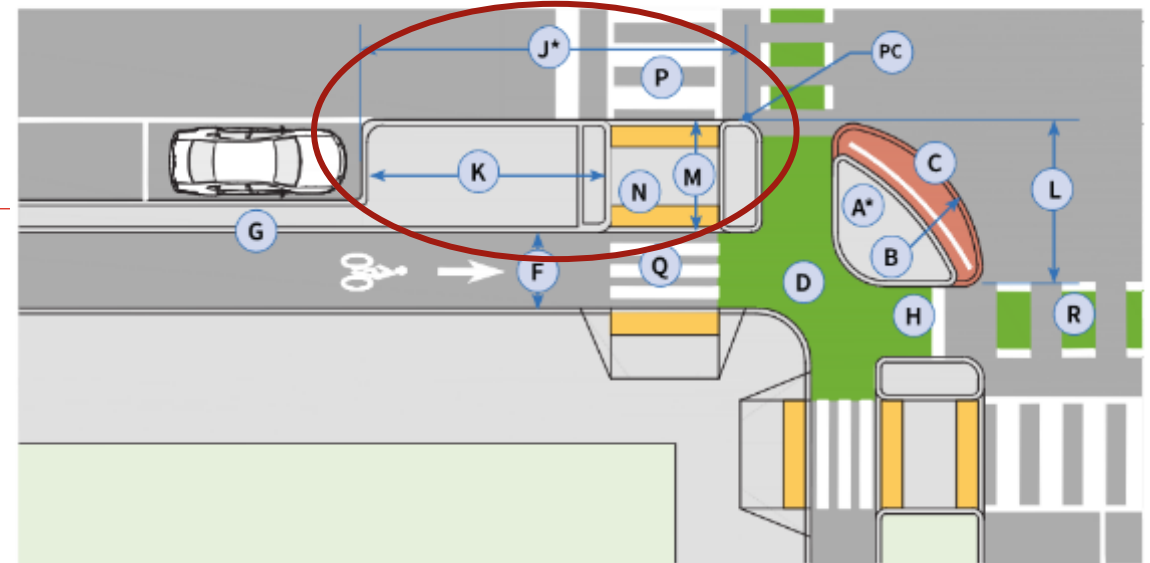
K – No Parking

Clear Distance			
J	Clear Distance*		Confirm adequate clear distance for sight lines between parallel traveling motorists and bicyclists. Clear distance meets minimum requirements in Table 1 in the appendix. (Default is 20' clear distance where corner radius is 15')
K	No Parking/Restricted Use Signs	N/A	No Parking or No Stopping signs have been included to restrict vehicles from parking or stopping within the clear distance zone.

No Parking or No Stopping signs must be included where applicable to restrict vehicles from parking or stopping in clear zone

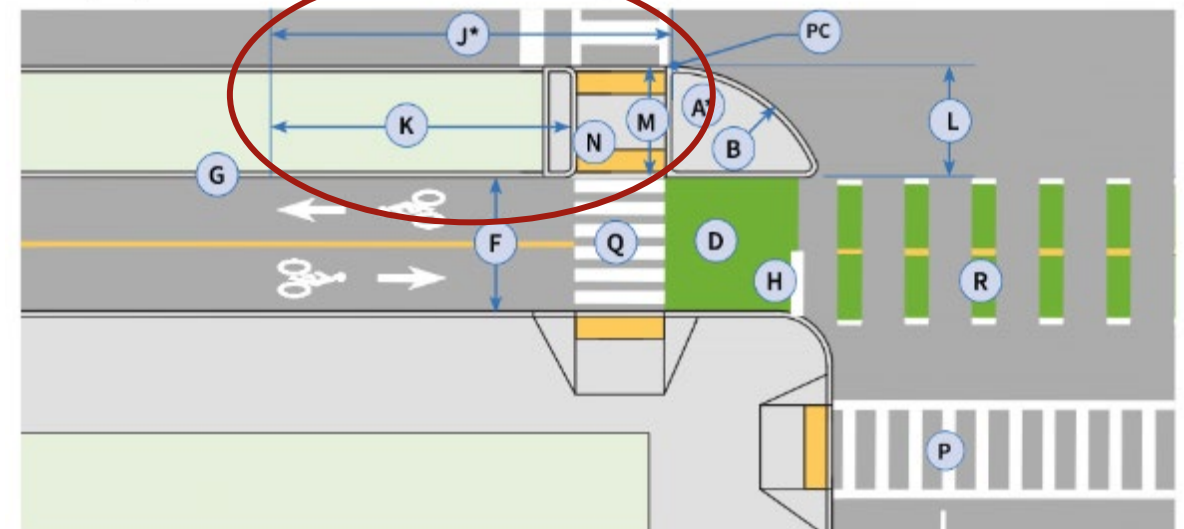
EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



EXAMPLE 2:

Two-Way Separated Bike Lane Intersection with No Intersecting Bikeway



L – Motorist Yield Zone

Requirements:

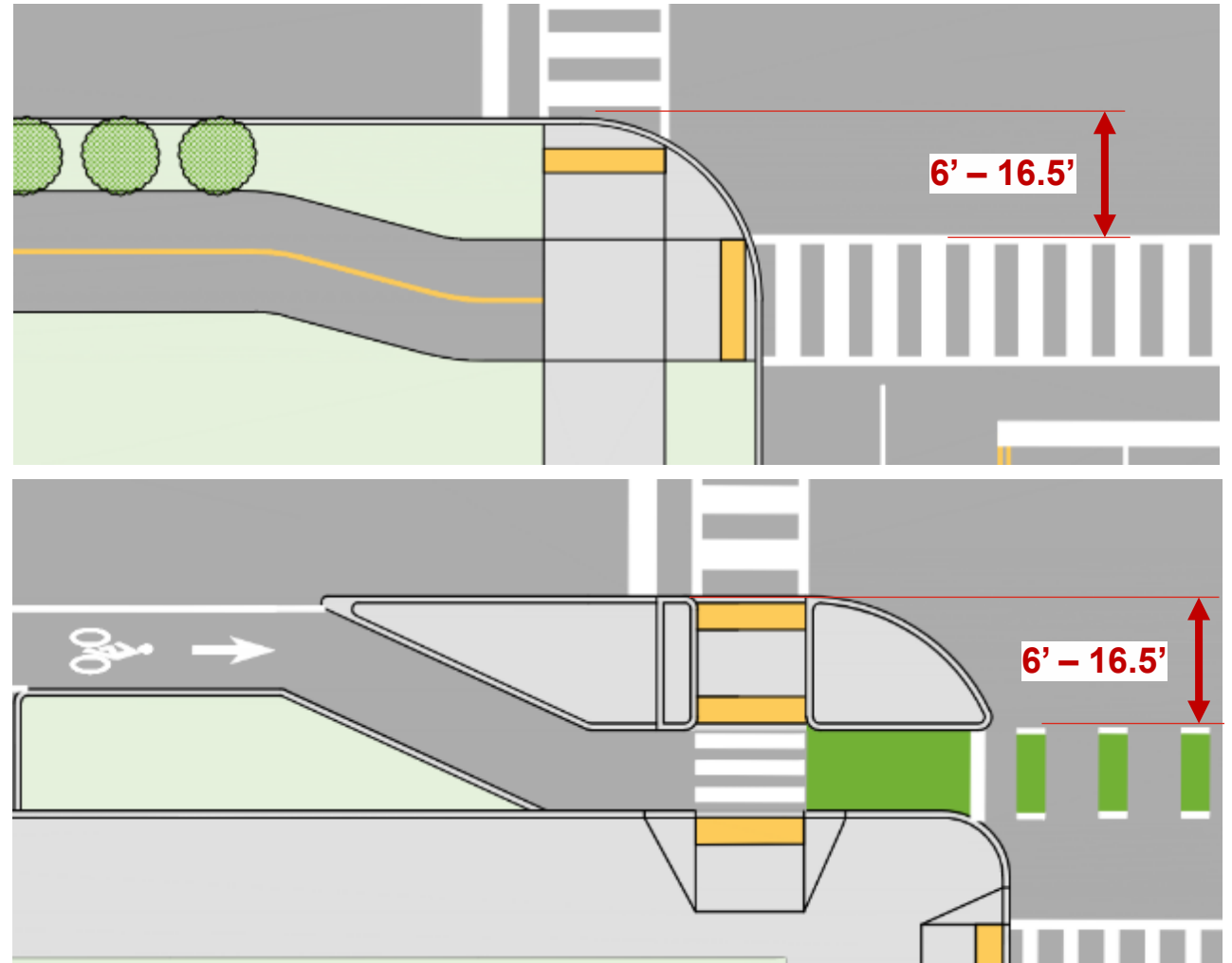
- 6' to 16.5' of yielding space
- measured from edge of traveled way to bikeway crossing



L – Motorist Yield Zone

Requirements:

- 6' to 16.5' of yielding space
- measured from edge of traveled way to bikeway crossing



Geometric Design

Pedestrian Refuge

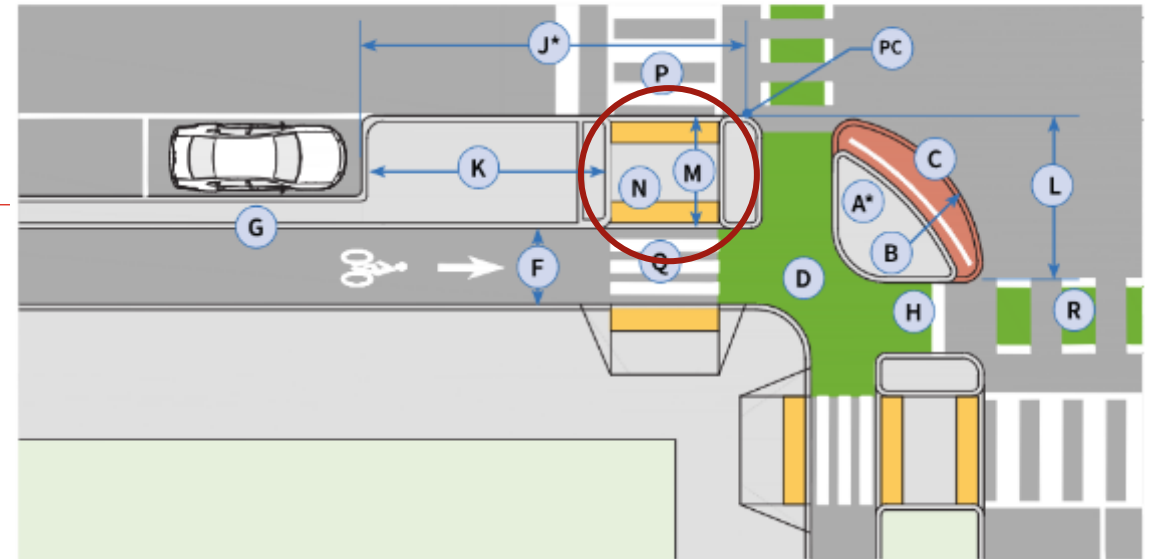
M	Pedestrian Refuge			A 6' or wider pedestrian refuge median is provided between the motor vehicle travel lane and the bikeway, and is located outside of the design vehicle turning envelope.
N	Detectable Warning Surfaces		N/A	Appropriate Detectable Warning Surfaces (DWS) are provided in the curb ramp and pedestrian refuge median (as applicable).

Other Elements

O	Fire Hydrant		N/A	If fire hydrant is present, it has been relocated outside of the corner?
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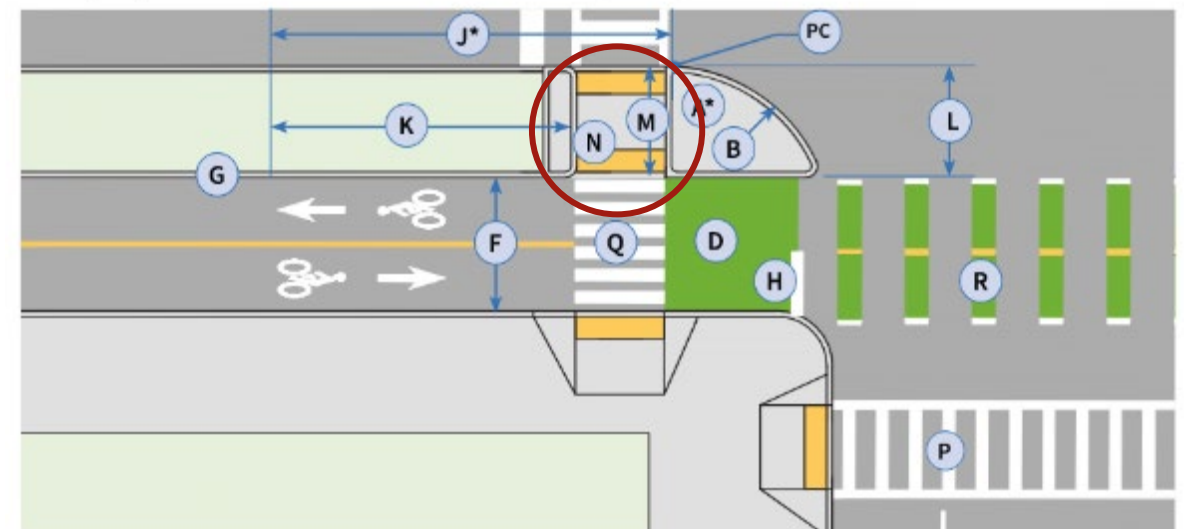
EXAMPLE 1:

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



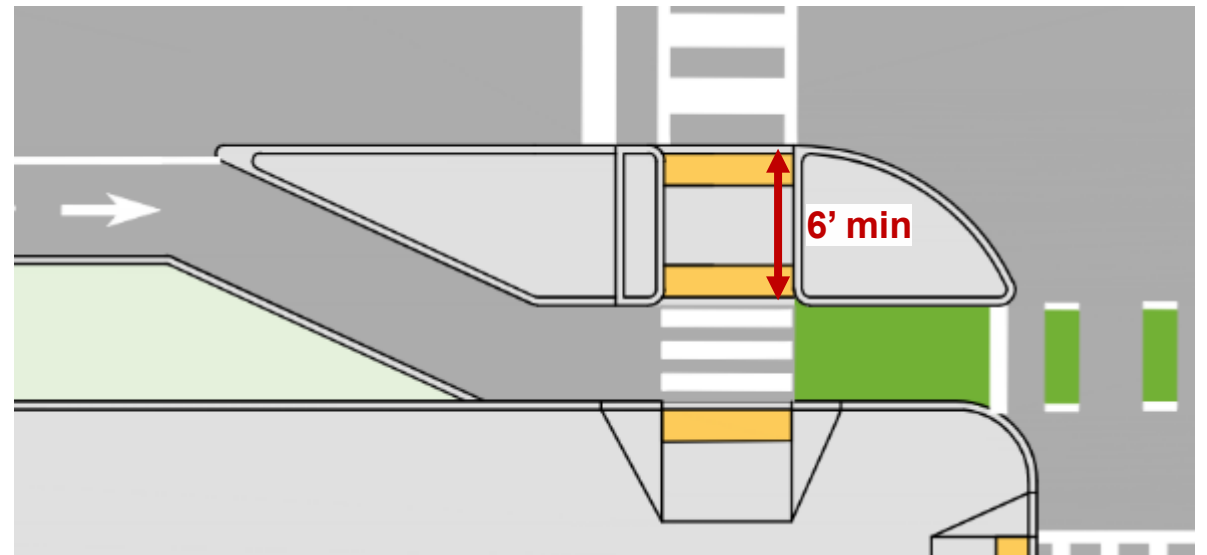
EXAMPLE 2:

Two-Way Separated Bike Lane Intersection with No Intersecting Bikeway



M – Pedestrian Refuge

- Minimum 6' width required to create pedestrian refuge
- Outside of turning vehicle envelope
- Recommended where possible



N – Detectable Warning Surfaces

Requirements:

- provided in 6' or wider pedestrian refuge
- equal to the width of the crossing

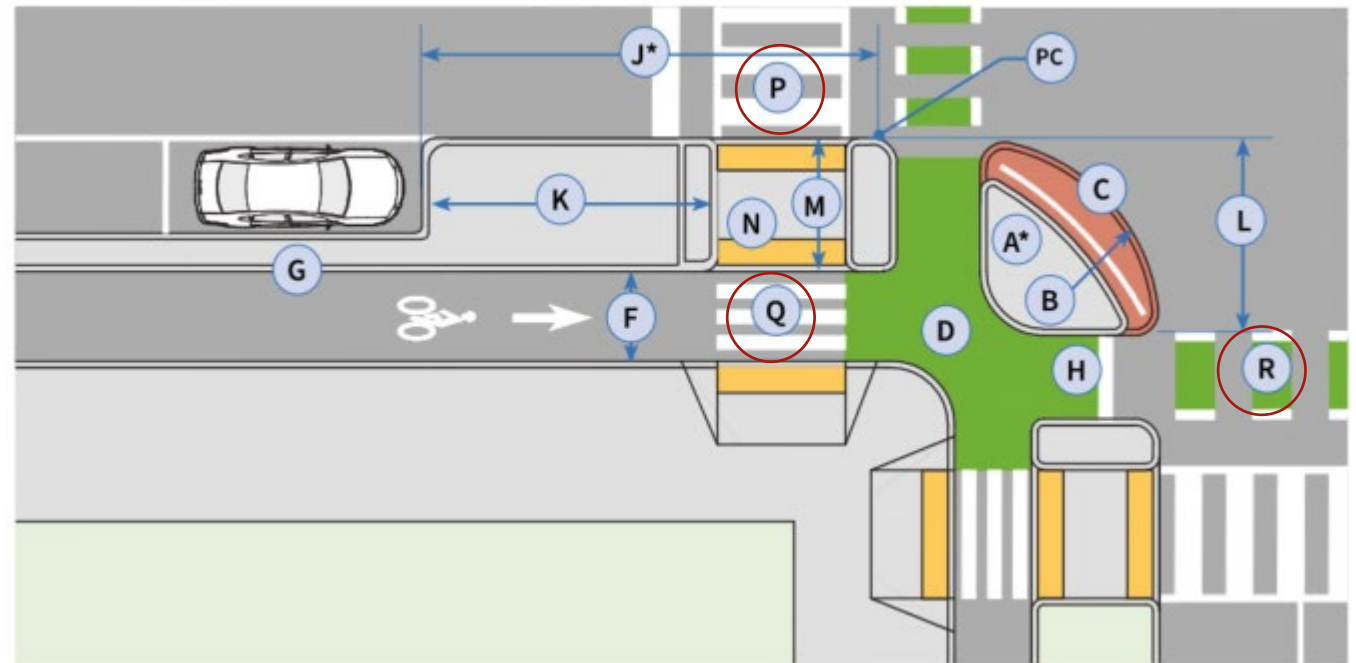


Signing & Marking

SIGNING & MARKING

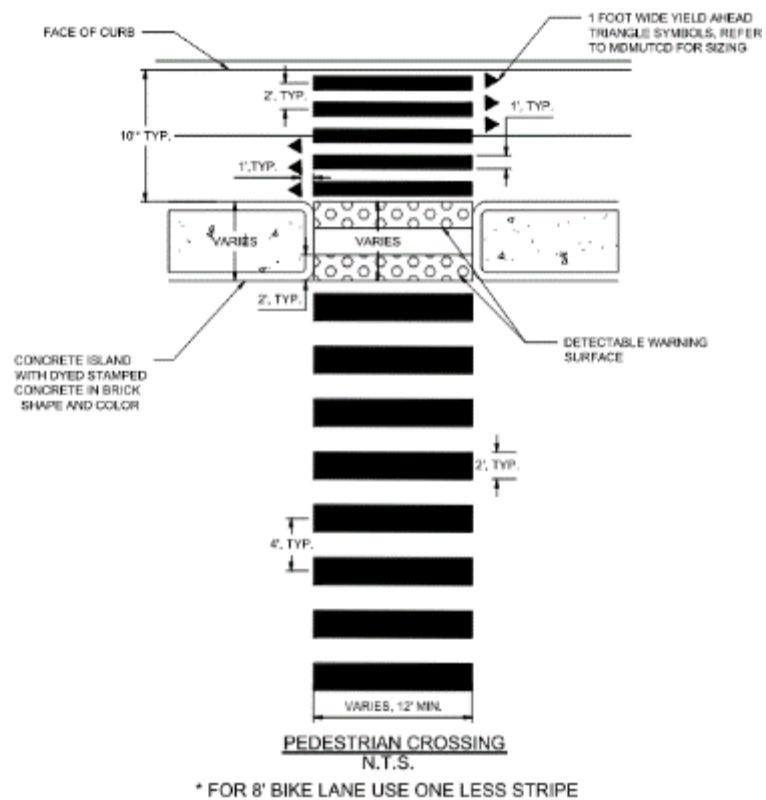
		Met (Y or N, or N/A)	Value	Requirements
Crossing Markings				
P	Pedestrian Crossing of Travel Lanes Markings			High-visibility crosswalk markings are provided that cover the full width of the sidewalk or sidepath and are at least 10' wide. Crosswalk markings are aligned with the Bikeway Crossing Markings (if applicable) to the maximum extent possible.
Q	Pedestrian Crossing of Separated Bike Lane Markings			A Pedestrian crossing of the bikeway is provided.
R	Bikeway Crossing Markings and Signing			Bikeway crossing markings are provided (if applicable) and align with roadway ownership. Specify which standard is used. Bikeway crossing markings are aligned with the crosswalks (if applicable) to the maximum extent possible. If crossing of the bikeway is uncontrolled, a MD MUTCD R9-6 Bikes Yield To Peds sign is provided.
S	Green-Colored Pavement			Where provided, green-colored pavement markings follow Montgomery County Standards.

One-Way Separated Bike Lane Intersection with Mountable Truck Apron



P – Pedestrian Crossing of Travel Lanes

- Follow Montgomery County Standard
- High-visibility, continental style
- At least as wide as sidewalk, no less than 10' in width



Q - Pedestrian Crossing of Separated Bikeway

- 12” markings with 12” spacing
- Pedestrian crossing of bikeway to a refuge or transit stop
- Not necessary if part of a one-stage crossing (no median refuge)



R – Bikeway Crossing Markings

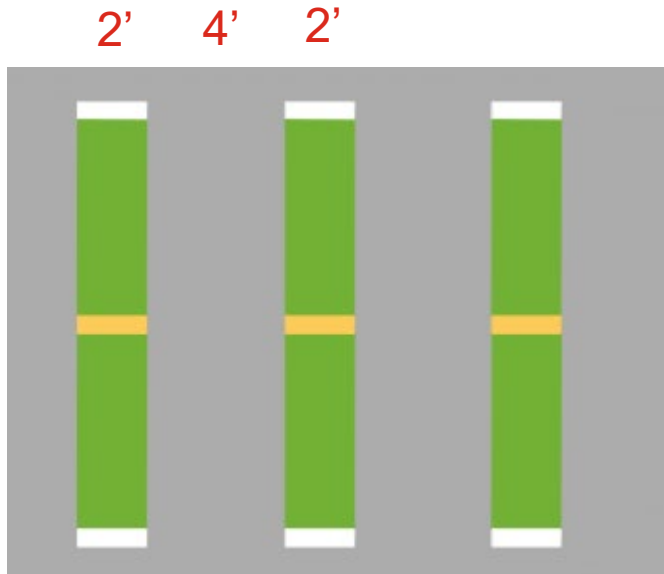
Should only be used when connecting to a facility on far side of intersection (omit if no bikeway facility on opposite side)

Align with the pedestrian crosswalk markings to the maximum extent possible

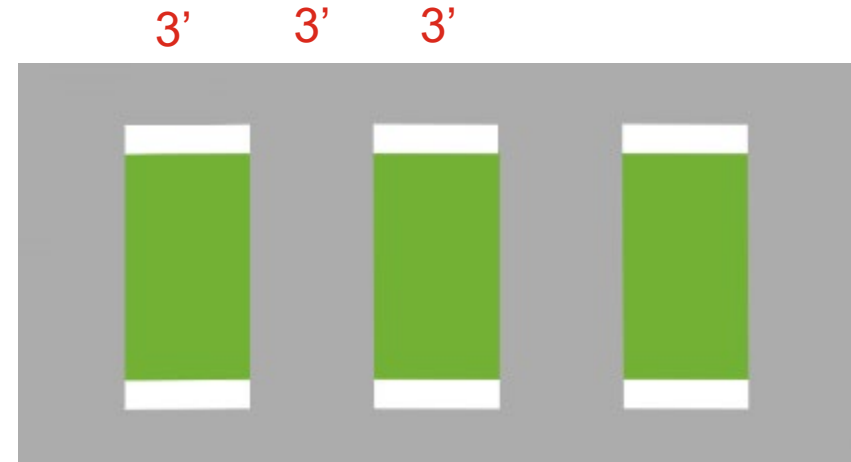
For uncontrolled crossings, MD MUTCD R9-6 Bikes Yield to Peds sign should be provided



R – Bikeway Crossing Markings (by Ownership)

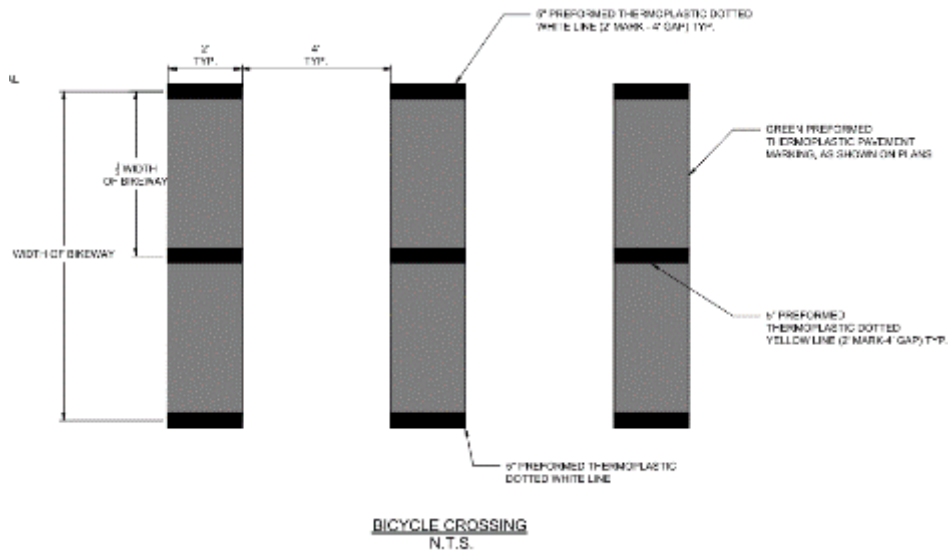


Montgomery County
2' marking, 4' gap, 2' marking

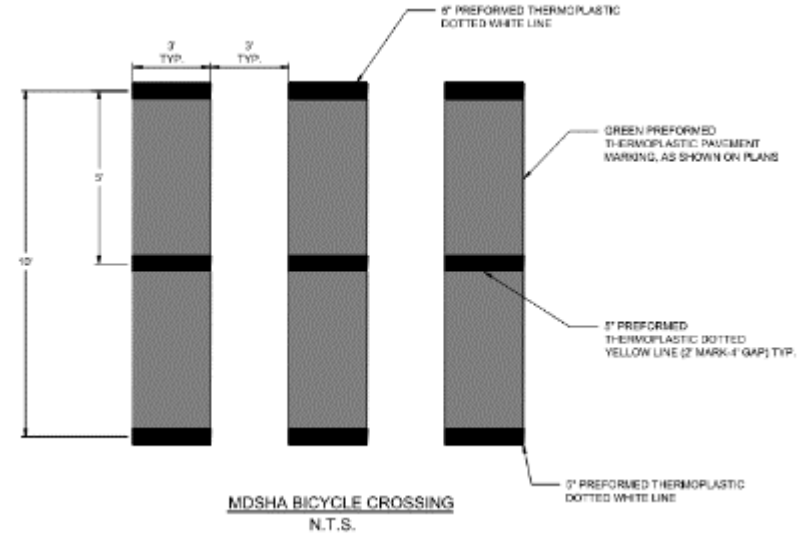


Maryland SHA
3' marking, 3' gap, 3' marking

R – Bikeway Crossing Markings (by Ownership)



Montgomery County
2' marking, 4' gap, 2' marking



Maryland SHA
3' marking, 3' gap, 3' marking

S – Green-Colored Pavement

Optional, but recommended to improve visibility and alert all roadway users to the dedicated space

Where provided, should follow Montgomery County Standards



Signal Design Considerations

- Select from one of the Bikeway Signalization Strategies:
 - Bicycle-Only Signal
 - Bikes follow Pedestrian Signal
 - Bikes follow Standard Traffic Signal

Note: For two-way bikeways, or contraflow bicycle movements, provide either a dedicated bicycle signal or sign to follow pedestrian signal

	Met (Y or N, or N/A)	Value	Requirements
Bikeway Signalization Strategy			
Which of the following signalization strategies does the through-bicycle movement follow? (Select one and selection.)			
<input type="checkbox"/> Bicycle-Only Signal			
		N/A	Bicycle Signal design follows all MD MUTCD guidance.
		N/A	NO TURN ON RED (MD MUTCD R10-11) sign is present.
<input type="checkbox"/> Bikes follow Pedestrian Signal			
		N/A	Pedestrian signal head is visible from the bikeway queuing area/stop line location.
		N/A	BIKES USE PED SIGNAL sign (MD MUTCD R9-5) is provided.
		N/A	Leading Pedestrian Interval has been added (or considered, and determined infeasible. If so, provide explanation in comments.)
<input type="checkbox"/> Bikes follow Standard Traffic Signal			
		N/A	Bikeway operates one-way only. Two-way bikeway operations must use one of the other two signalization strategies or standard signal head <u>must</u> be installed for the counterflow bicyclist.
		N/A	Standard signal head is visible from the bikeway queuing area/stop line location.

Bicycle-Only Signal

- Beneficial to provide additional bicycle crossing time vs. following pedestrian signal
- Must comply with all MD MUTCD guidance & FHWA Interim Approvals
- Must include a No Turn on Red Sign (MD MUTCD R10-11) for approaches that conflict with the bike movement



FHWA Interim Approval

Bike signal head application:

- Can only be used without conflicting vehicle turns
- Cannot be used at Pedestrian Hybrid Beacons (PHBs)



Bikes Follow Pedestrian Signal

- Pedestrian signal head is visible from the bikeway queuing area/stop line location
- Bikes Use Ped Signal Sign (MD MUTCD 9-5) should be provided
- Leading Pedestrian Interval should be considered

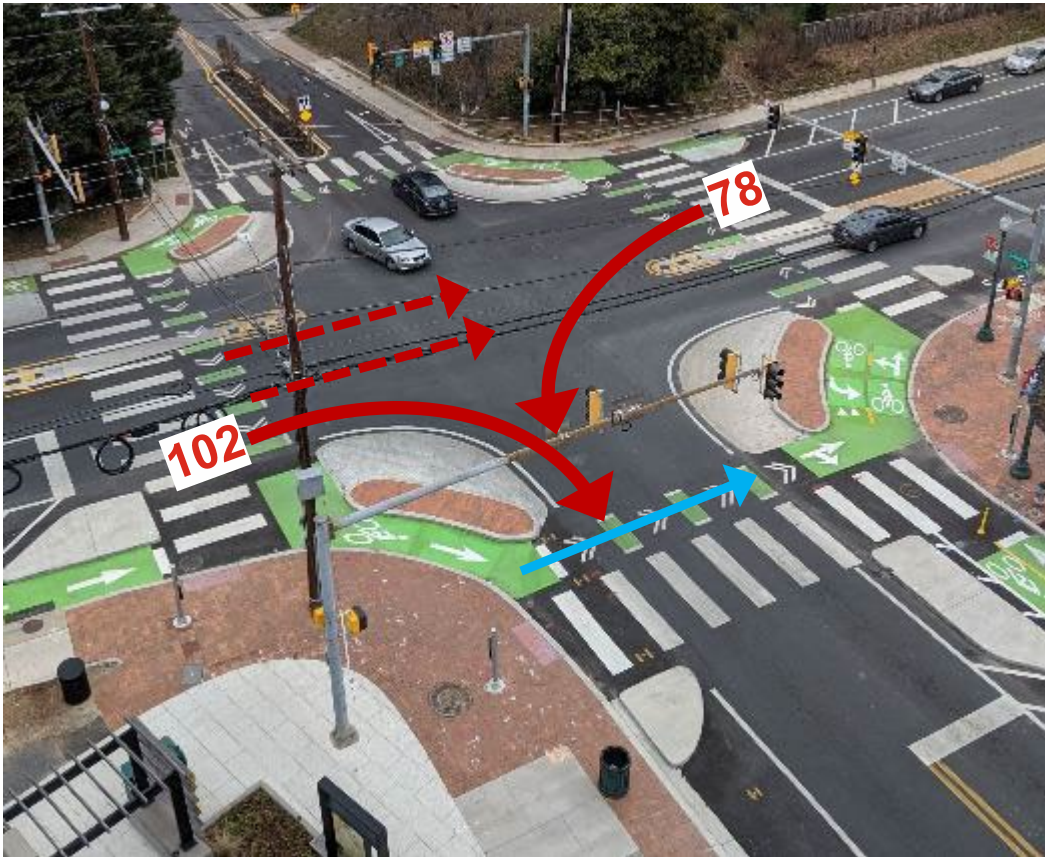


Bikes Follow Standard Traffic Signal

- No dedicated bike signal or adjacent pedestrian signal
- ONLY appropriate for one-way bikeways



Example 1: One-Way Bikeway



Signal Phasing

Fill in the vehicle volume and lane data to determine if phase separation is recommended or required. Refer

Traffic Volumes & Lane Data

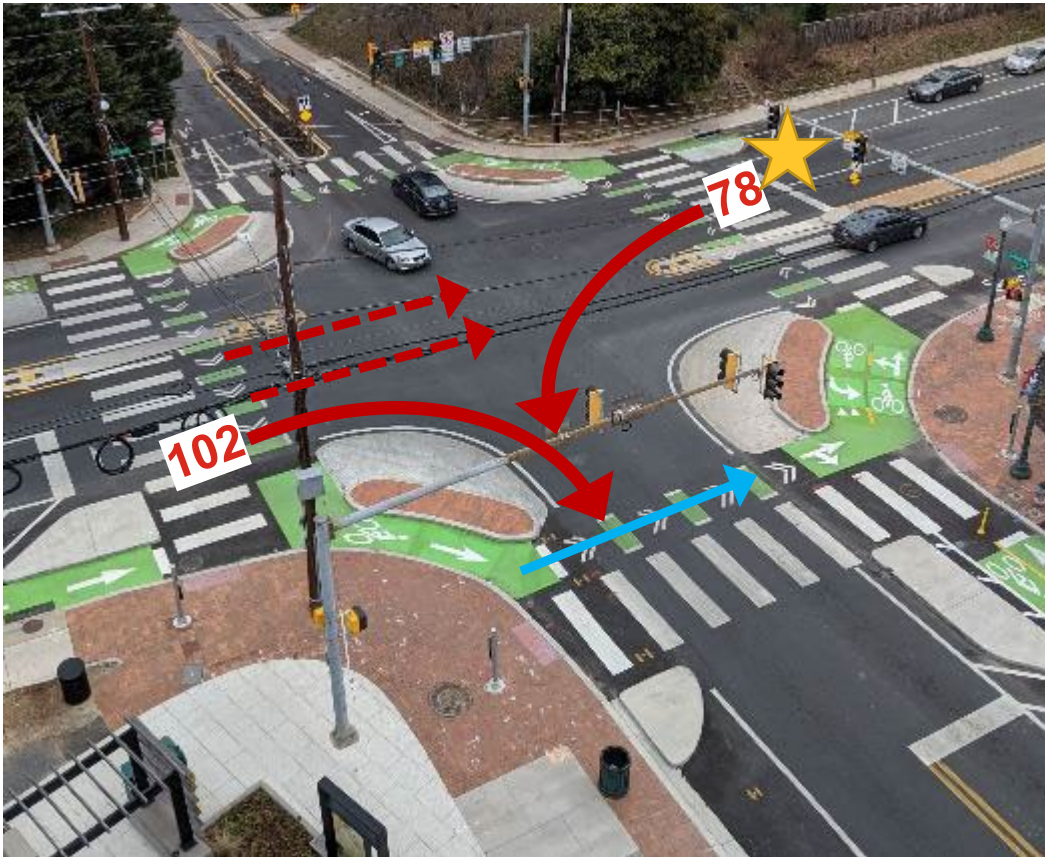
Input the number of peak hour vehicles per hour for each turn.	102	Volume of peak hour right turning vehicles (across bikeway)
	78	Volume of peak hour left turning vehicles (across bikeway)
Input the number of lanes crossed by left-turning vehicles.	2	Number of travel lanes crossed by left-turning vehicles














Bikeway Phase Separation

Is phase separation recommended based on Figure X?	N/A	
If phase separation is recommended, is phase separation provided?	N/A	

*Volumes are for illustrative purposes only

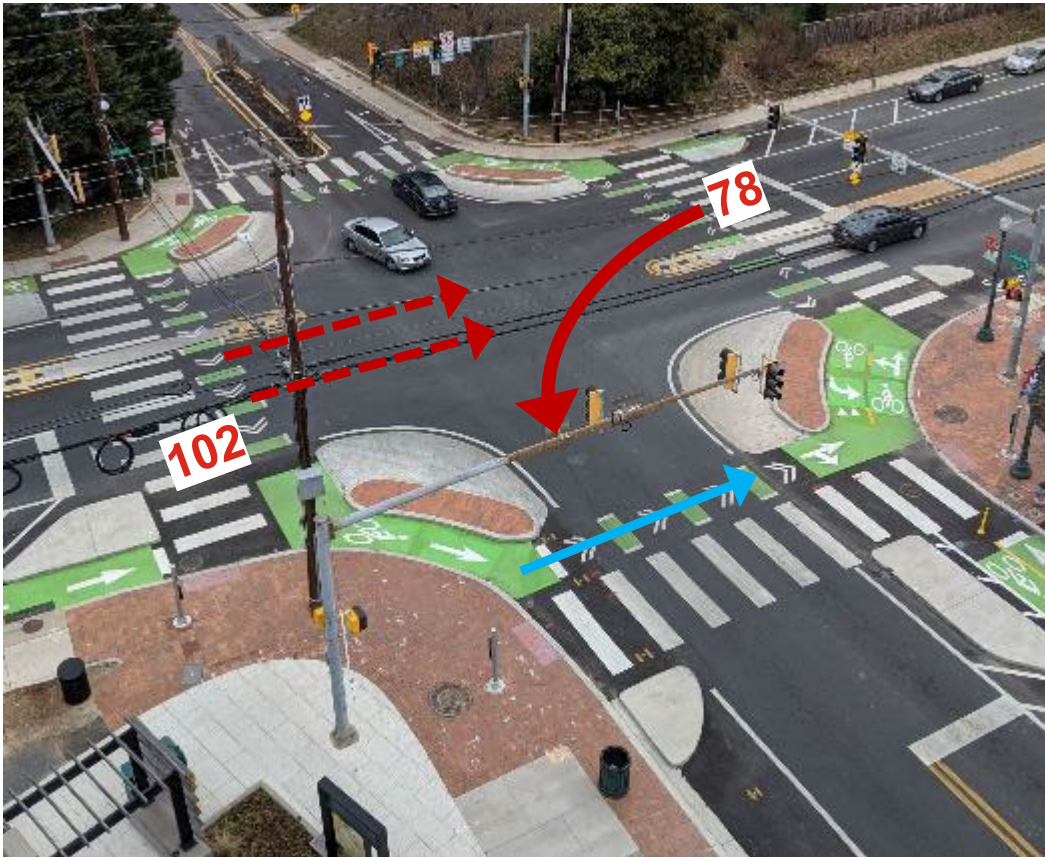
Example 1: One-Way Bikeway



Hourly Volume Thresholds for Separate Turn Phases		
	Left Turn Crossing One Oncoming Lane	Left Turn Crossing Two Oncoming Lanes
One-Way Separated Bike Lane	≥ 100  $\geq 150^*$  	≥ 50   78 $\geq 150^*$   102
Two-Way Separated Bike Lane or Sidepath	≥ 50  $\geq 100^*$  	ANY  $\geq 100^*$  

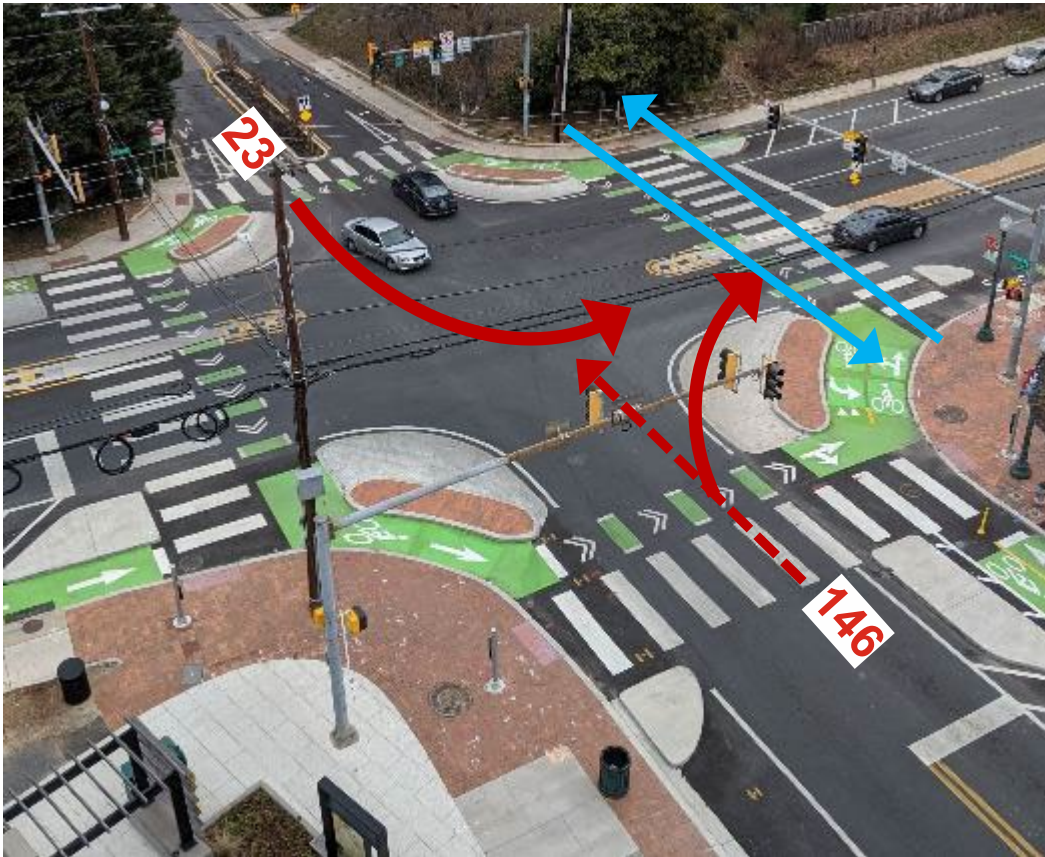
*Threshold also applies to left turns on one-way streets

Example 1: One-Way Bikeway



Signal Phasing			
Fill in the vehicle volume and lane data to determine if phase separation is recommended or required. Refer			
Traffic Volumes & Lane Data			
Input the number of peak hour vehicles per hour for each turn.	102	Volume of peak hour right turning vehicles (across bikeway)	
	78	Volume of peak hour left turning vehicles (across bikeway)	
Input the number of lanes crossed by left-turning vehicles.	2	Number of travel lanes crossed by left-turning vehicles	
Bikeway Phase Separation			
Is phase separation recommended based on Figure X?	yes	N/A	
If phase separation is recommended, is phase separation provided?		N/A	

Example 2: Two-Way Bikeway



Signal Phasing

Fill in the vehicle volume and lane data to determine if phase separation is recommended or required. Refer

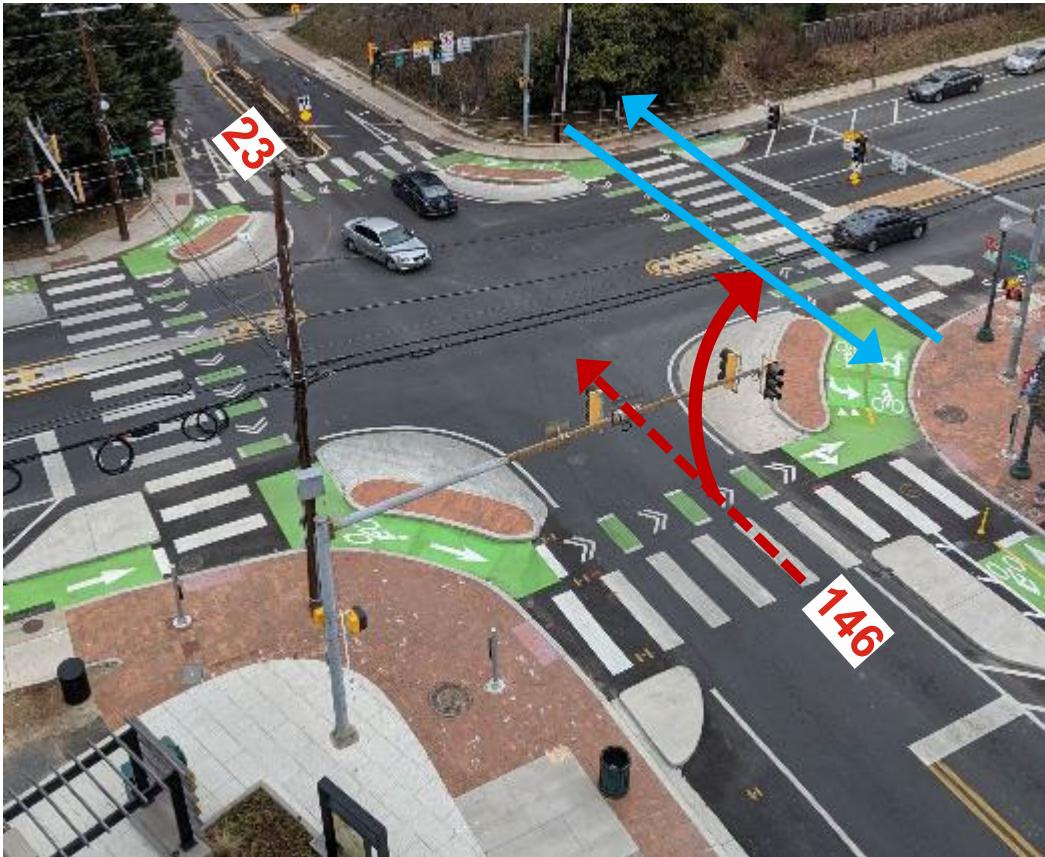
Traffic Volumes & Lane Data

Input the number of peak hour vehicles per hour for each turn.	146	Volume of peak hour right turning vehicles (across bikeway)
	23	Volume of peak hour left turning vehicles (across bikeway)
Input the number of lanes crossed by left-turning vehicles.	1	Number of travel lanes crossed by left-turning vehicles

Bikeway Phase Separation

Is phase separation recommended based on Figure X?	N/A	
If phase separation is recommended, is phase separation provided?	N/A	

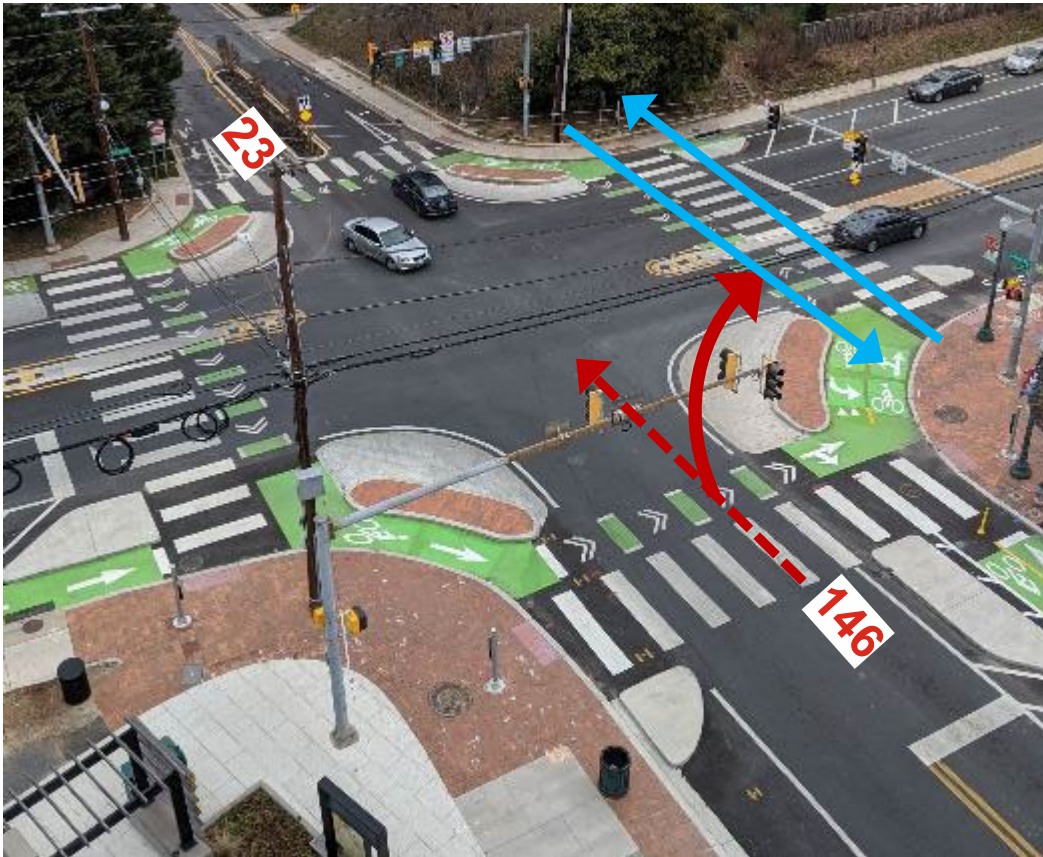
Example 2: Two-Way Bikeway



Hourly Volume Thresholds for Separate Turn Phases		
	Left Turn Crossing One Oncoming Lane	Left Turn Crossing Two Oncoming Lanes
One-Way Separated Bike Lane	≥ 100 $\geq 150^*$	≥ 50 $\geq 150^*$
Two-Way Separated Bike Lane or Sidepath	≥ 50 23 $\geq 100^*$ 146	ANY $\geq 100^*$

*Threshold also applies to left turns on one-way streets

Example 2: Two-Way Bikeway



Signal Phasing

Fill in the vehicle volume and lane data to determine if phase separation is recommended or required. Refer

Traffic Volumes & Lane Data

Input the number of peak hour vehicles per hour for each turn.	146	Volume of peak hour right turning vehicles (across bikeway)
	23	Volume of peak hour left turning vehicles (across bikeway)
Input the number of lanes crossed by left-turning vehicles.	1	Number of travel lanes crossed by left-turning vehicles

Bikeway Phase Separation

Is phase separation recommended based on Figure X?	yes	N/A	
If phase separation is recommended, is phase separation provided?		N/A	

Questions?

Thank you!

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