Implementable Research and Practical Design Guidance

Texas ITE 2026 Annual Meeting

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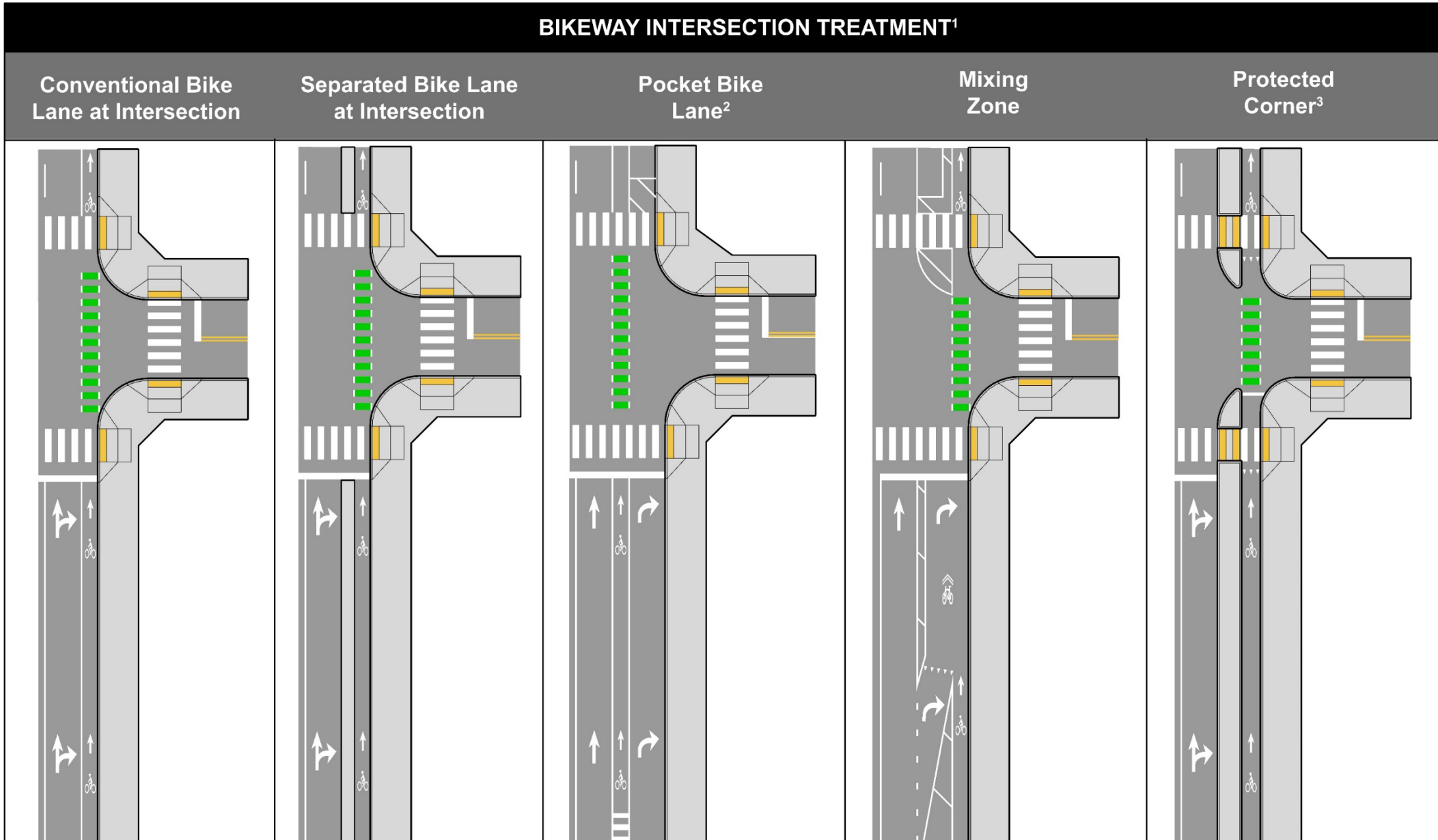
April 10, 2026

NCHRP 1125

Reducing Conflicts Between Turning Motor Vehicles and Bicycles

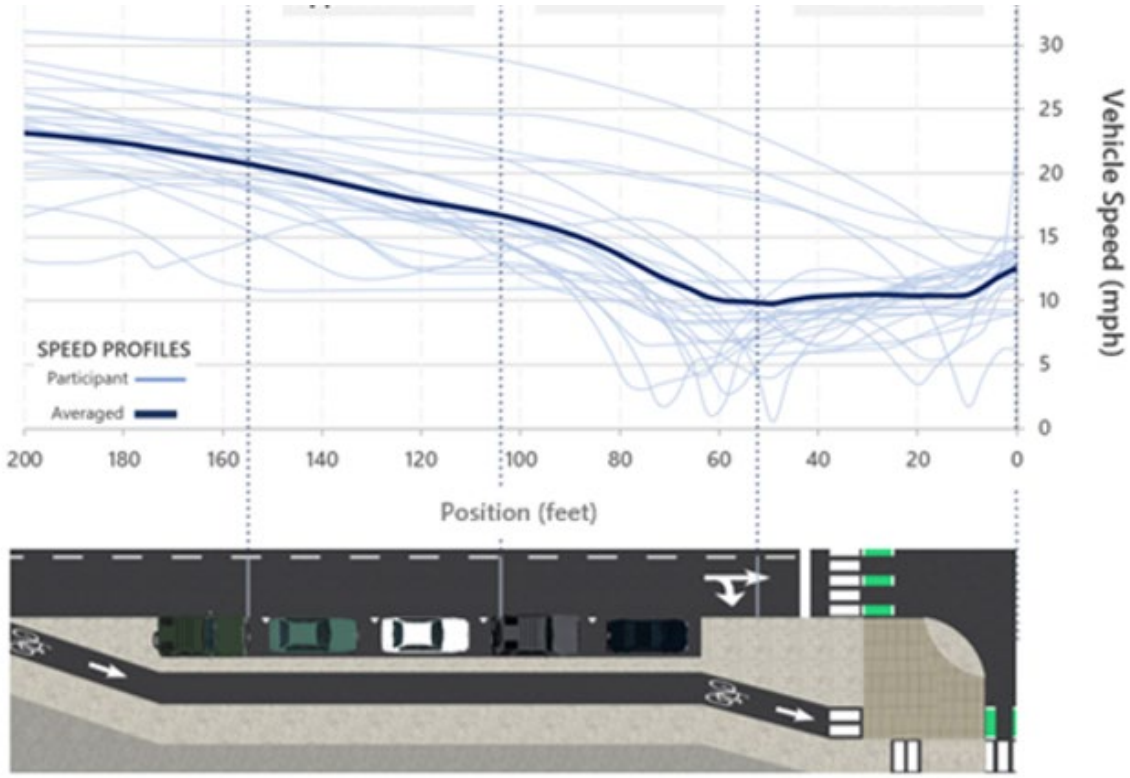
Bikeway Intersection Treatments Studied



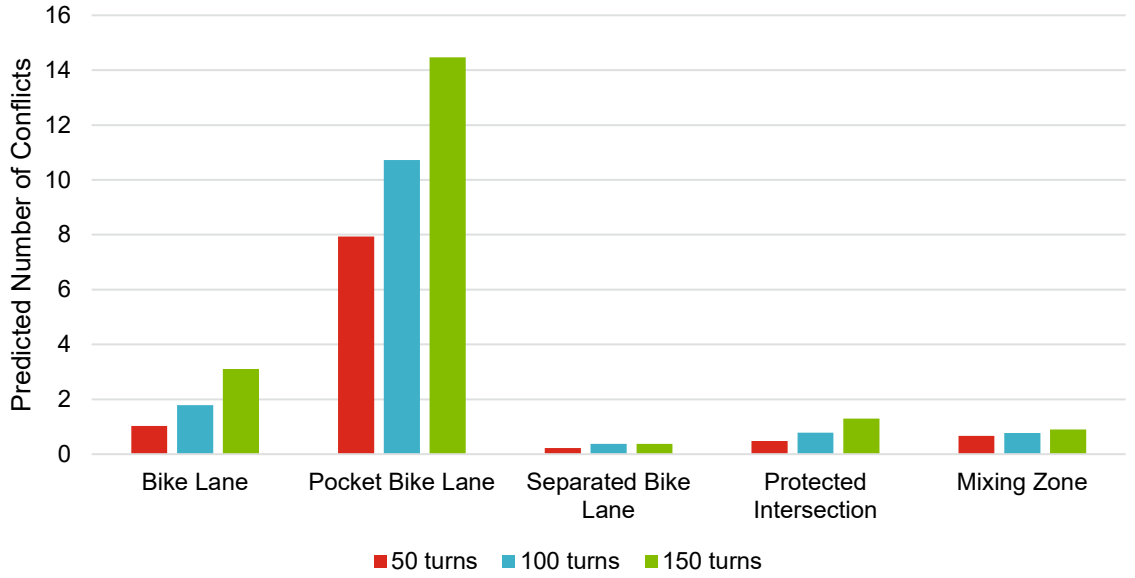
TOOLE DESIGN

Protected Corner

The decision tool recommends protected corners for any location where space can be reallocated to provide it.



50 bicycles per hour



TOOLE DESIGN

Separated Bike Lanes at Intersection

- Similar crash rates to bike lanes.
- Proportion of conflicts that were categorized as severe (5.5%) is much less than for the conventional bicycle lane (10.9%).

The decision tool recommends separated bike lane treatments where there is not space to provide a protected corner.

TOOLE DESIGN

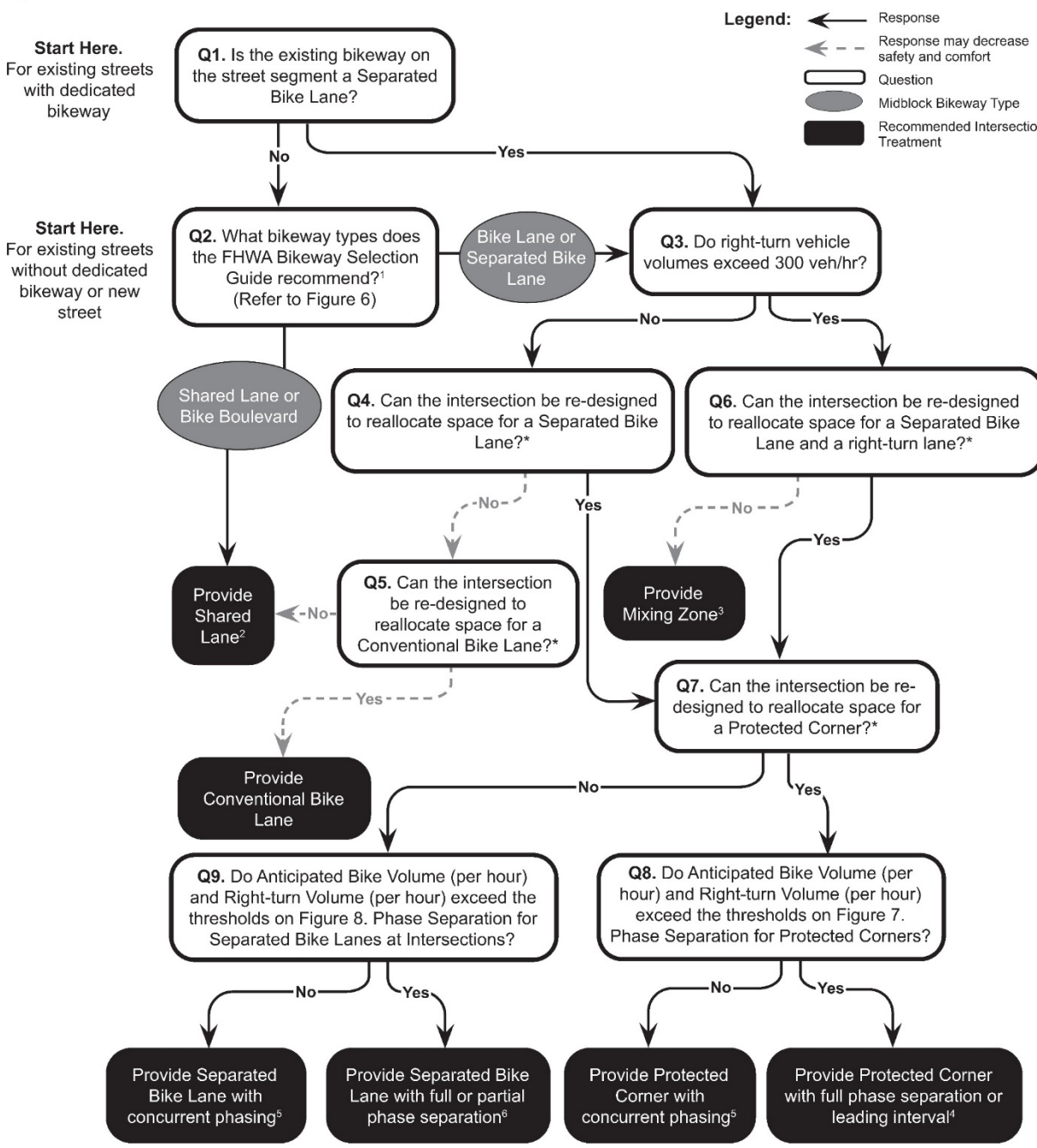
TOOLE DESIGN

Decision Tool

Data Needs

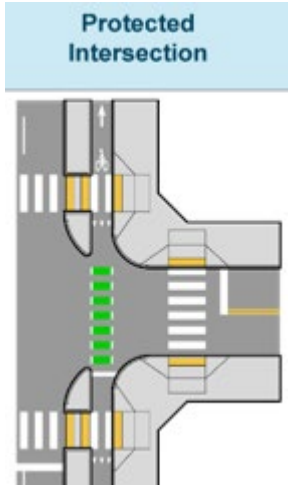
- For use in bikeway selection for the segment:
  - Motor vehicle daily volumes
  - Motor vehicle design speed/operating speed/target speed
- For use in decision tool flow chart for intersection treatment selection:
  - Motor vehicle hourly right-turning volumes
  - Existing or anticipated hourly bicycle volumes
- Additional considerations for intersection treatment selection:
  - Heavy vehicle volumes or percentages
  - Street geometry - presence of intersection skew
  - Bus stop locations

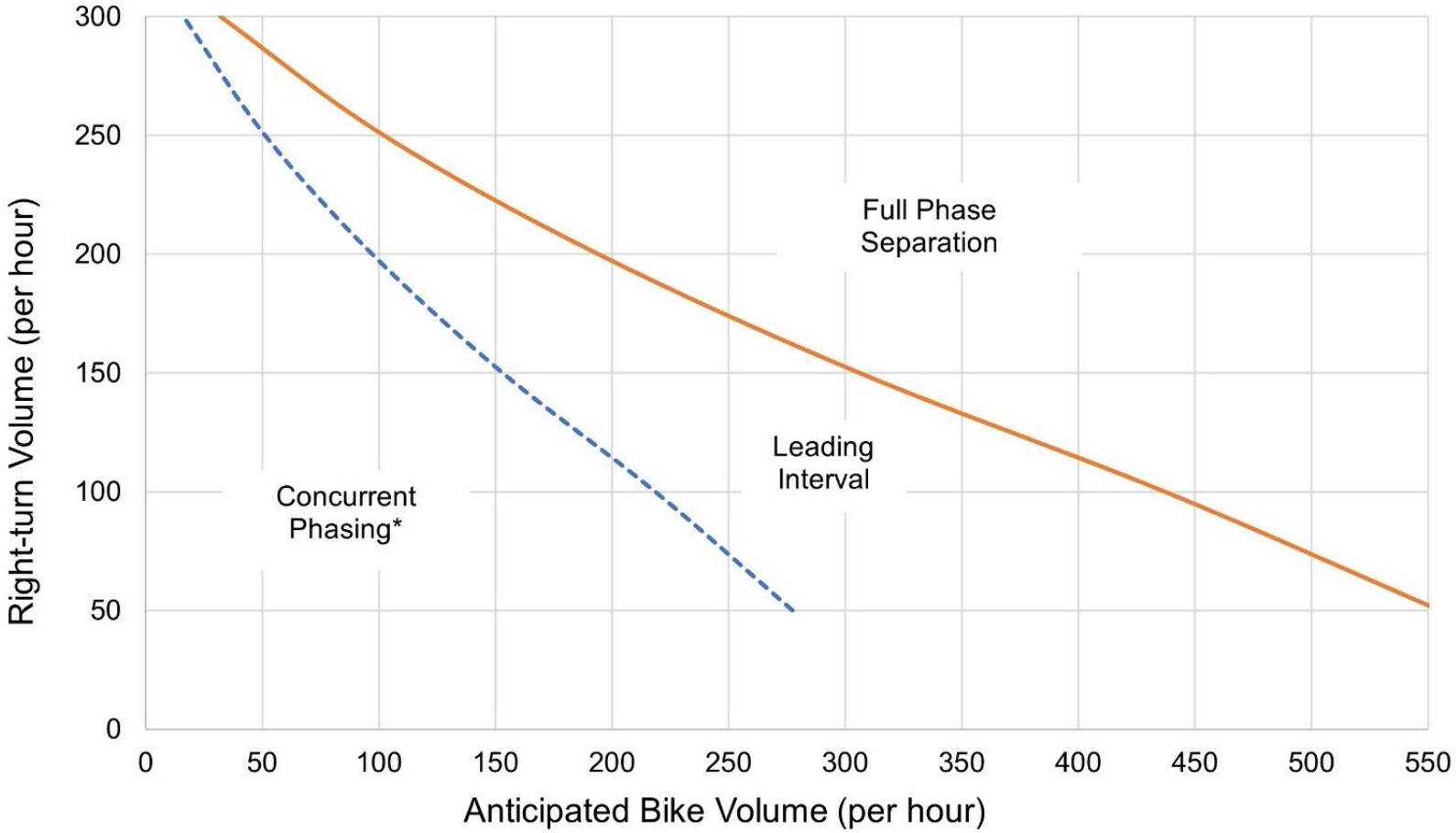
TOOLE DESIGN



* Questions 4, 5, 6, and 7 require the practitioner to consider how the space at the intersection can be adjusted to provide dedicated space for people biking. See section titled 'Strategies for Reallocating Space' for detailed strategies for narrowing travel lanes, reallocating travel lanes, and making changes to on-street parking.

Protected Intersection & Signal Phasing





*Consider Leading Interval

- Decision Tool uses a **threshold of two conflicts per hour** to determine a minimum threshold for full phase separation (orange line)

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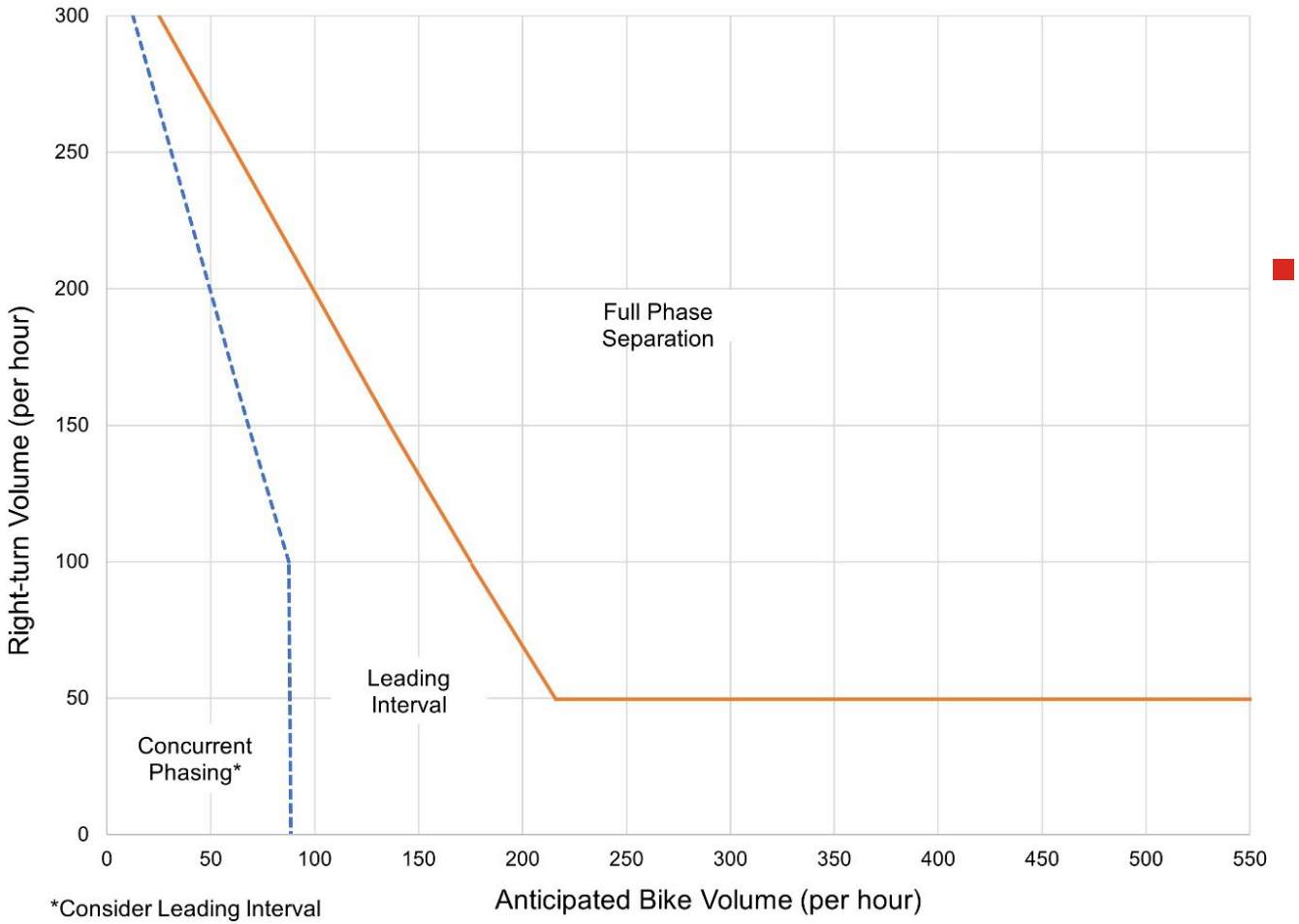
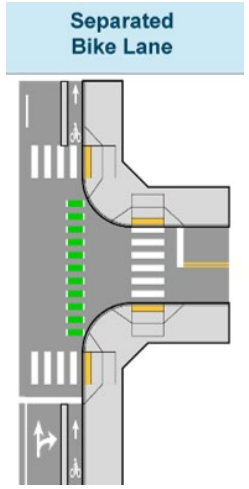
Separated Bike Lanes & Signal Phasing





- Decision Tool uses a **threshold of two conflicts per hour** to determine a minimum threshold for full phase separation (orange line)

TOOLE DESIGN

Limitations of Decision Tool

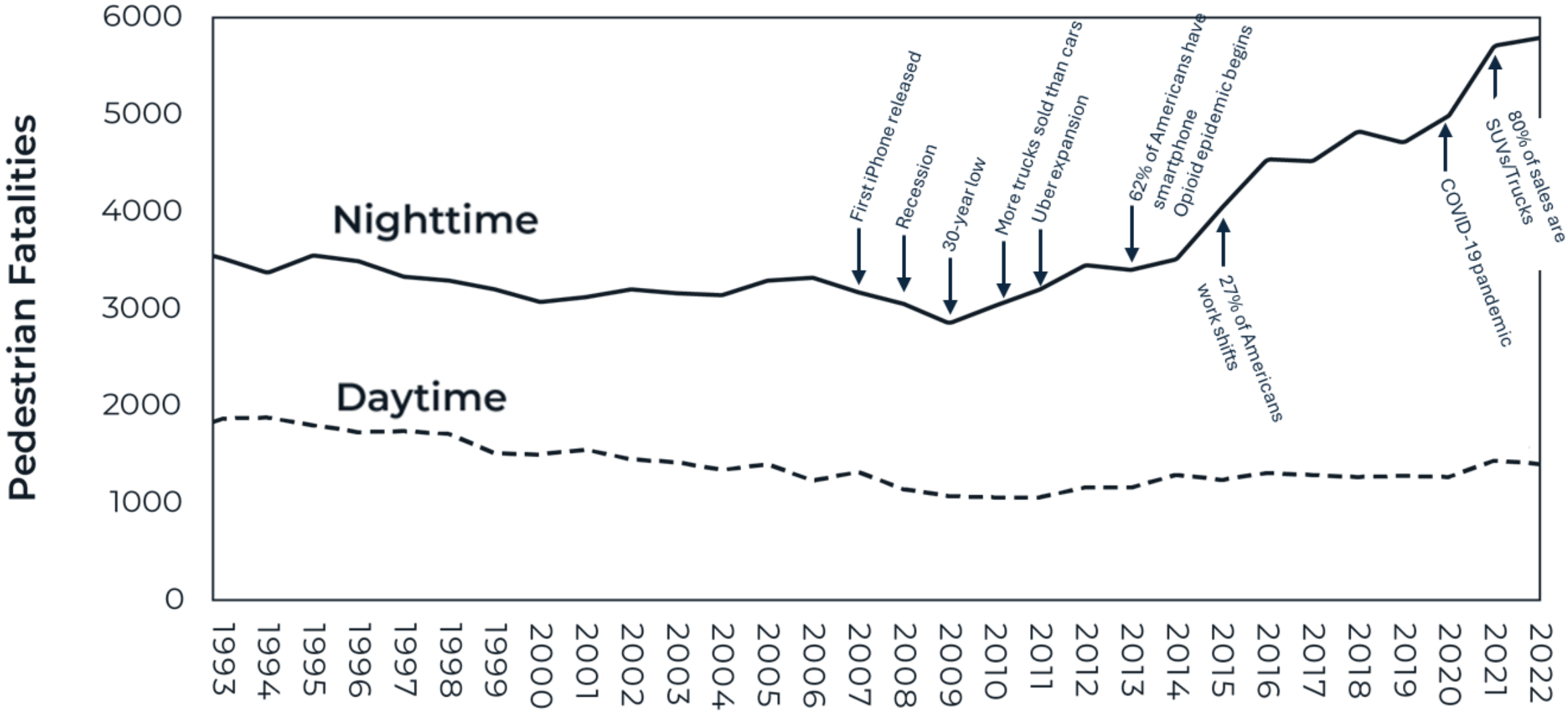
- It did not:
  - Investigate left-turn motorist conflict maneuvers
  - Investigate other intersection treatments such as roundabouts or raised crossings
  - Investigate two-way bike facilities or shared use paths

TOOLE DESIGN

NCHRP 1157

Strategies to Improve Pedestrian Safety at Night

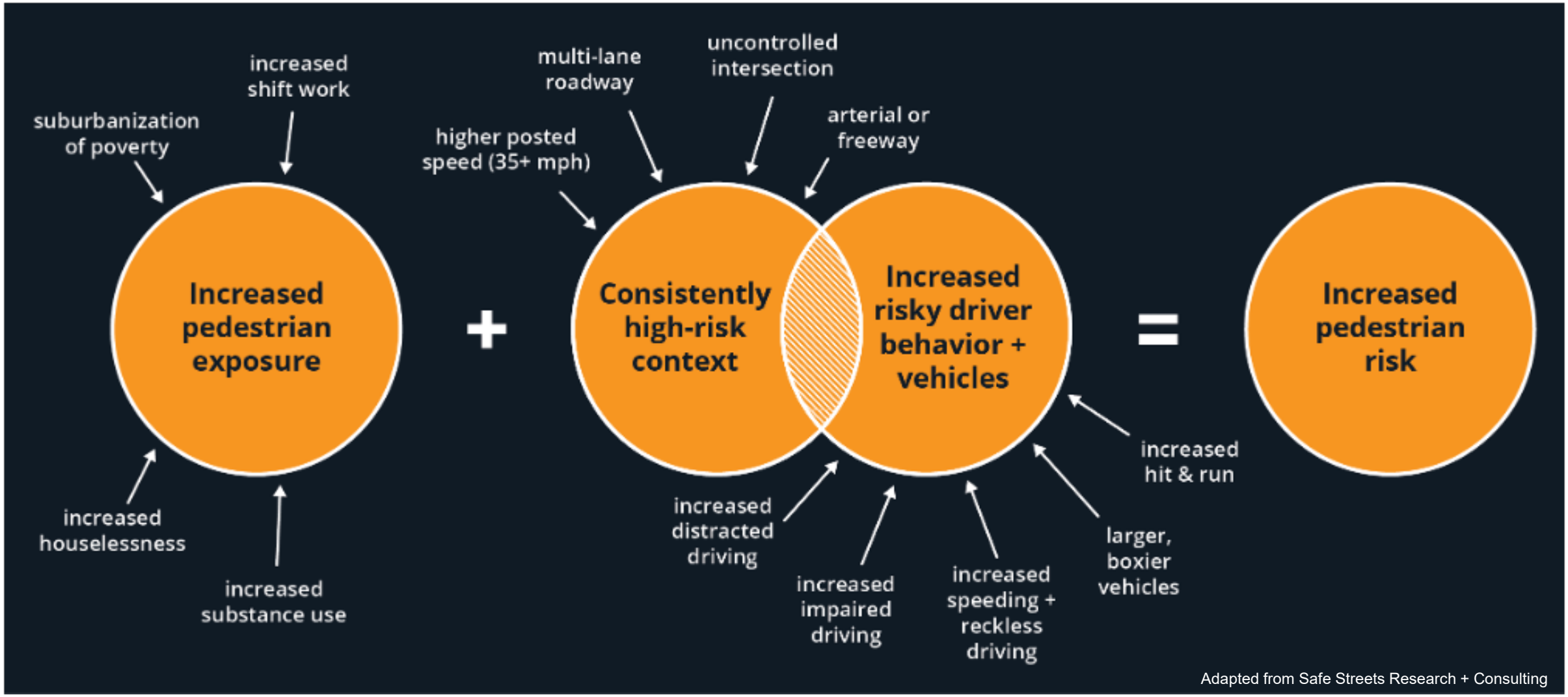
30 Years of Pedestrian Fatalities (1993-2022), by Daytime vs Nighttime



(Source: Analysis Reporting System (FARS)

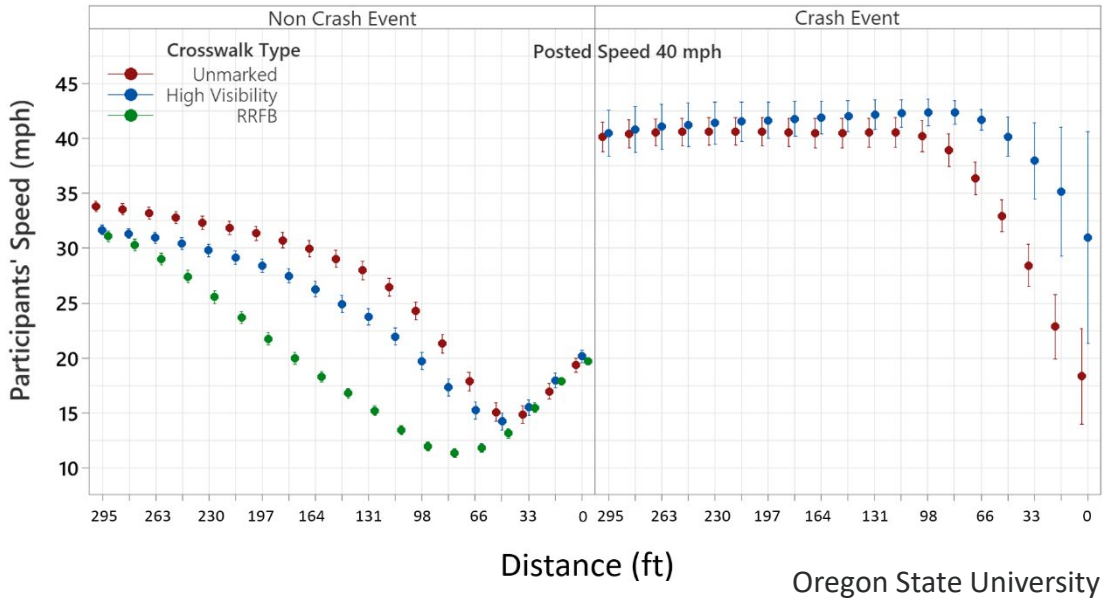
Adapted from Safe Streets Research + Consulting

Factors Associated with Increased Pedestrian Risk at Night



Higher Vehicle Speeds Create Pedestrian Risk

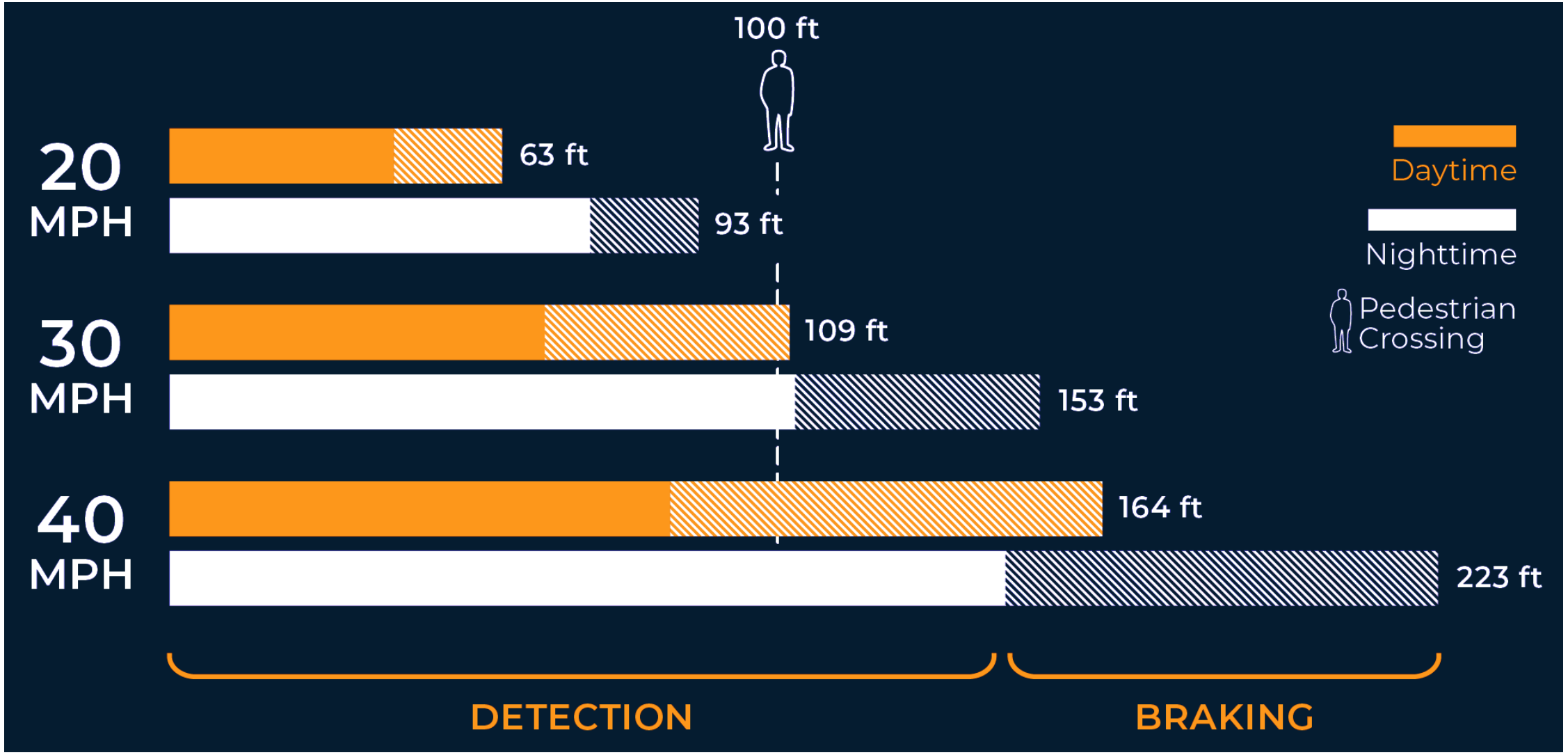
- Result in more kinetic energy transfer
- Higher risk on multilane roadways



Oregon State University

TOOLE DESIGN

Higher Vehicle Speeds Create Pedestrian Risk



Lighting alone will not substantially increase pedestrian safety in high-risk environments.

Additional nighttime pedestrian countermeasures – especially to slow driver speeds – are needed to substantially mitigate pedestrian risk at night.

TOOLE DESIGN

Pedestrian Risk Categories

Reduce the potential for a severe outcome through managing vehicle speeds

Decrease the likelihood of a crash through increasing driver awareness of pedestrians (visibility)

Reduce pedestrian exposure (i.e., the time pedestrians spend in the roadway)

TOOLE DESIGN

Nighttime Countermeasures

Countermeasure	Pedestrian Risk Category		
	Manage Vehicular Speeds	Enhance Visibility	Reduce Pedestrian Exposure
Road Reallocations	X		O
Speed Feedback Signs	X		
Automatic Speed Enforcement	X		
Lower Speed Limits	X		
Lighting		X	
Marked Crosswalks		X	
Traffic Signals		X	
Pedestrian Hybrid Beacons		X	
Rectangular Rapid Flashing Beacons		X	
Daylighting/Curb Extensions	O	O	X
Crossing Islands	O		X
Sidewalks/Walkways/Shared Use Paths	O	O	X

Note: X indicates the primary pedestrian risk category for that countermeasure
O indicates a secondary pedestrian risk category or categories.

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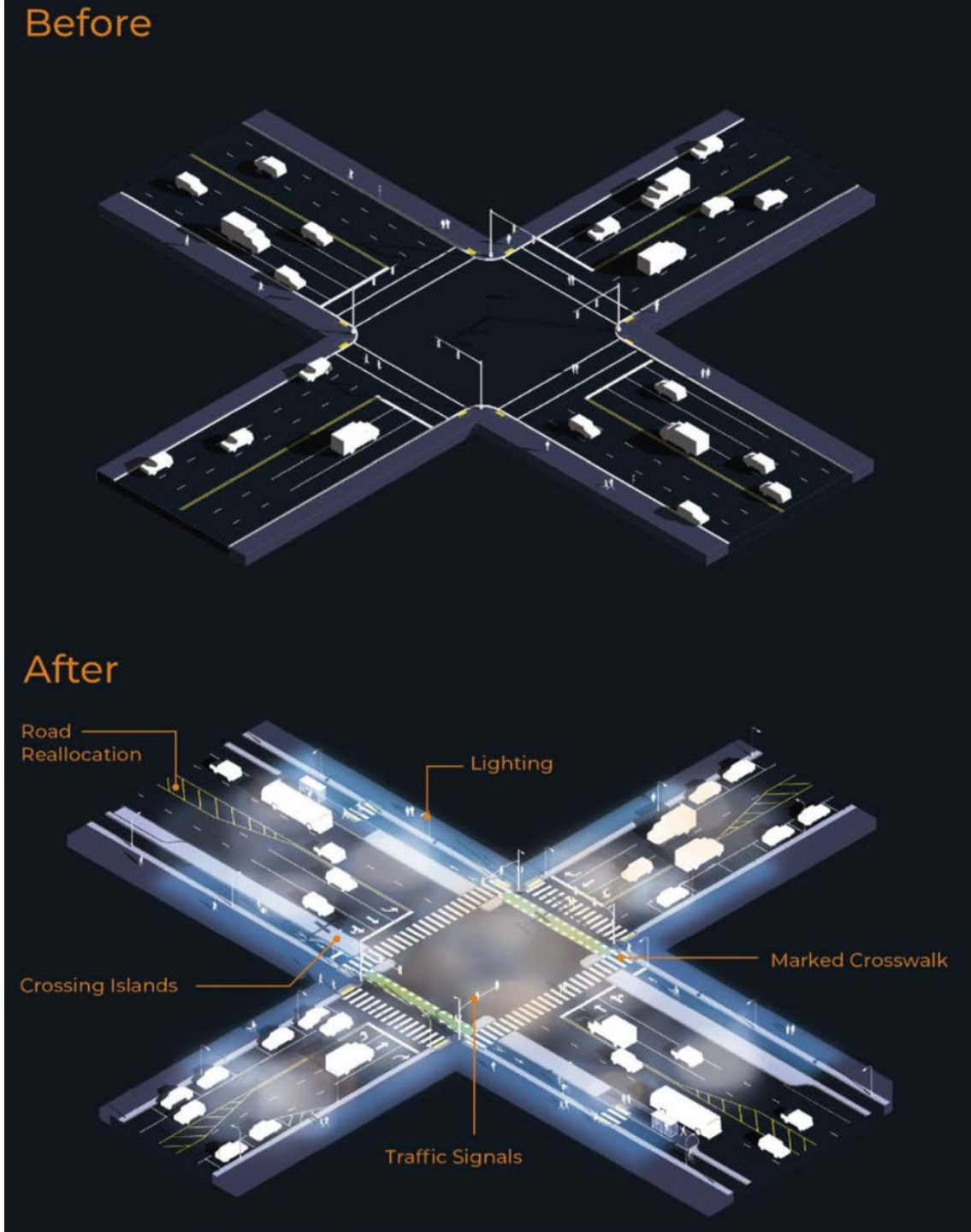
In Summary

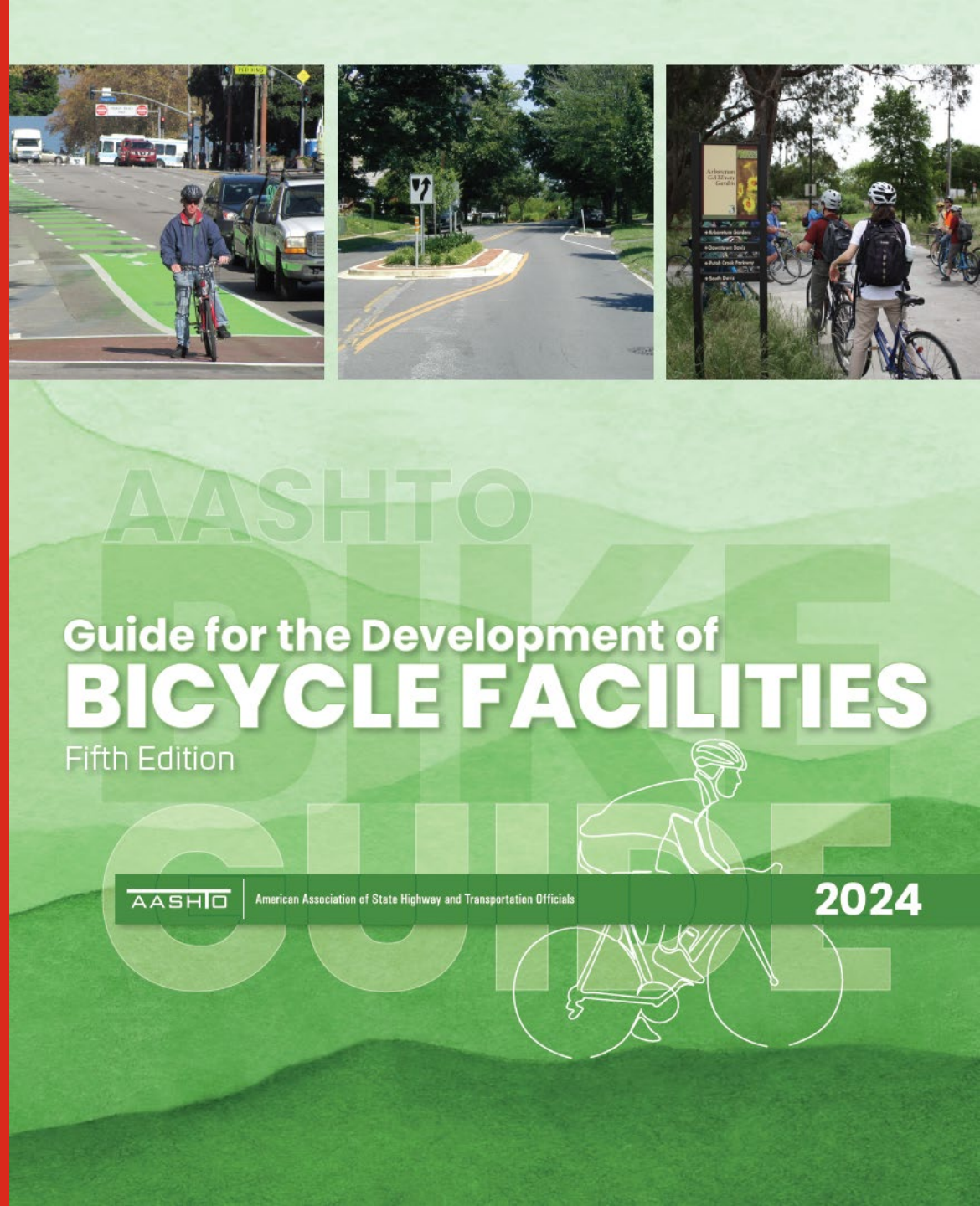
- Corridors where pedestrians have a greater risk at night should be prioritized
- Implement countermeasures that address each pedestrian risk category – manage vehicular speeds, enhance visibility, and reduce exposure
- Consider land use and context
- Consider nighttime generators such as transit stops and stations, colleges, schools, entertainment centers, and grocery stores.
- Consider high-speed, multilane roads that lack pedestrian infrastructure



TOOLE DESIGN

AASHTO

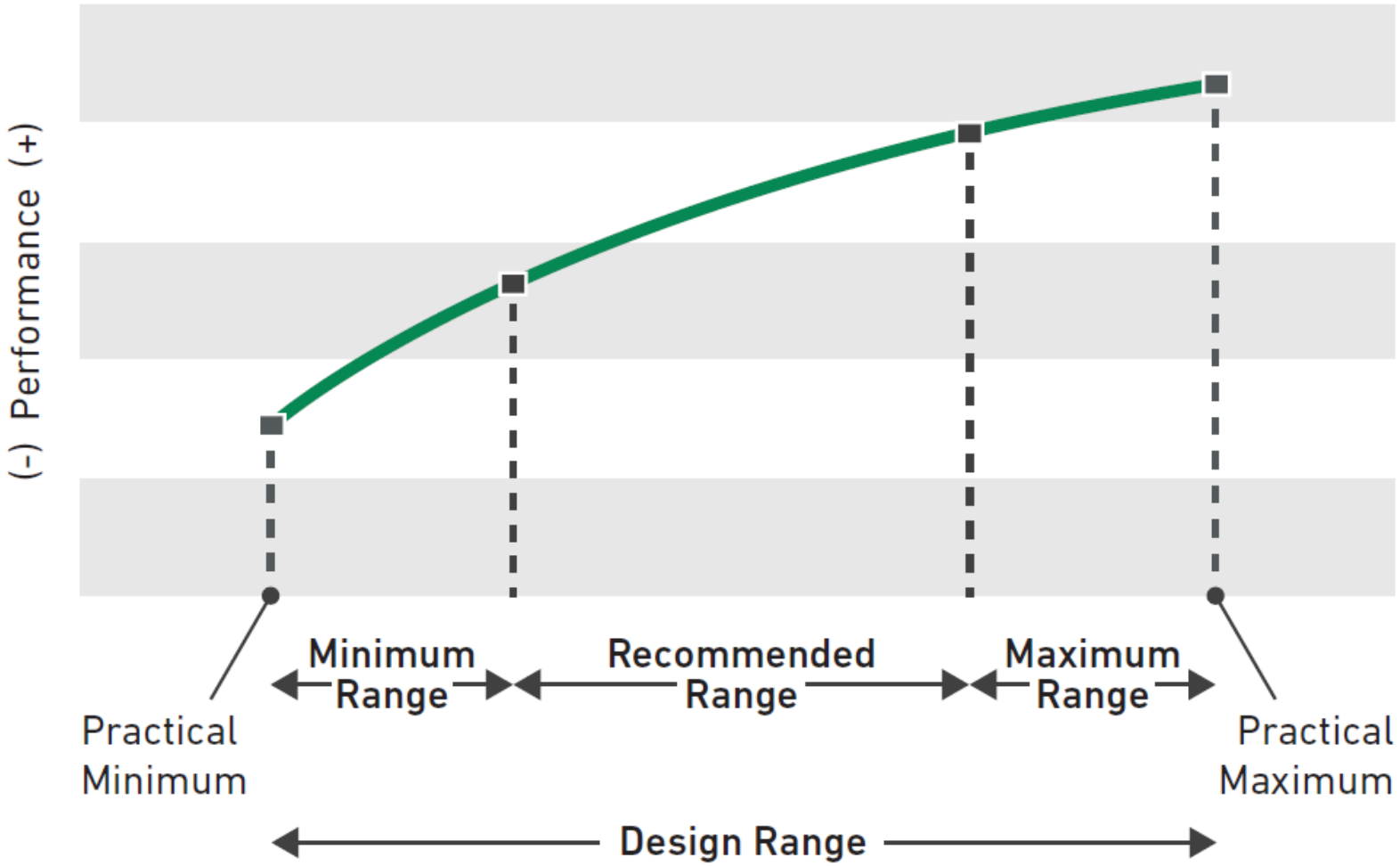
Guide for the Development of Bicycle Facilities, 5th Edition

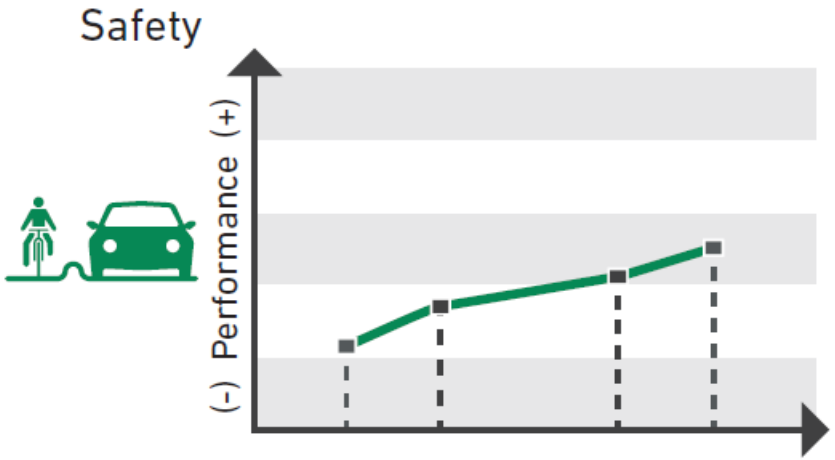


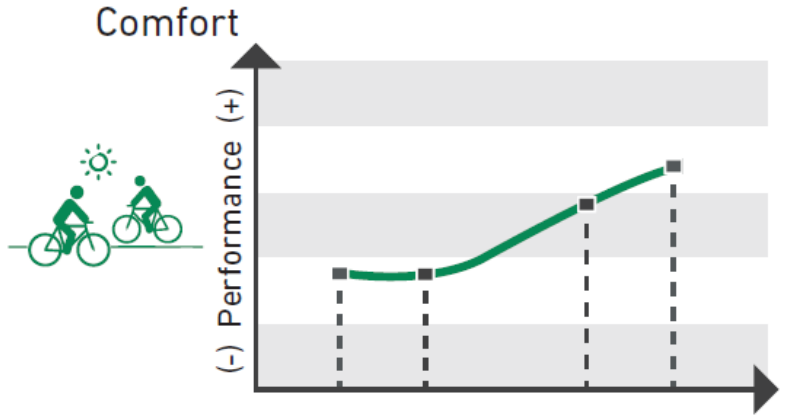
2012 Guide compared to 2024 Guide

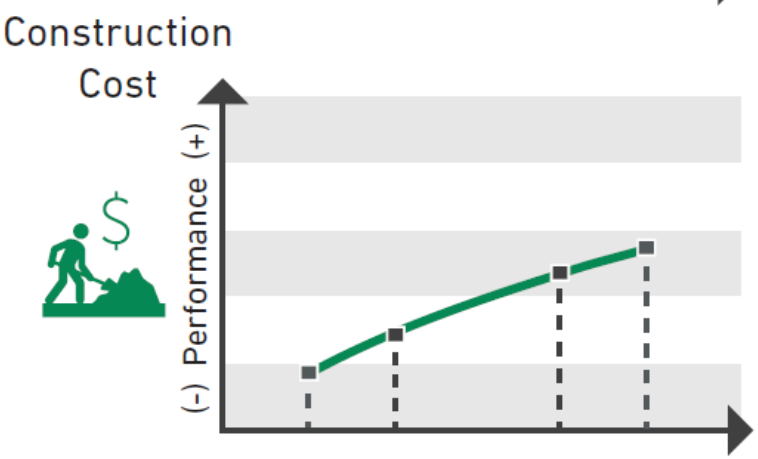
2012 Guide	2024 Guide	Notable Changes of 2024 compared to 2012
Chapter 1. Introduction	1. Introduction	REWRITE with new discussion of design range concept
Chapter 3. Bicycle Operation and Safety	2. Bicycle Operation & Safety	REWRITE of former Chapter 3
Chapter 2. Bicycle Planning	3. Bicycle Planning	REWRITE and NEW CONTENT added to former Chapter 2
	4. Facility Selection	NEW CHAPTER with a few items carried from Chapter 2
	5. Elements of Design	NEW CHAPTER with some content pulled from Chapters 4 and 5
Chapter 5. Design of Shared Use Paths	6. Shared Use Paths	REVISION of Chapter 5
	7. Separated Bike Lanes	NEW CHAPTER with new content
	8. Bicycle Boulevards	NEW CHAPTER with new content
Chapter 4. Design of On-Road Facilities	9. Bike Lanes & Shared Lanes	REVISION of Chapter 4
	10. Traffic Signals and Active Warning Devices	NEW CHAPTER with new content
	11. Roundabouts, Interchanges, and Alternative Intersections	NEW CHAPTER with new content
	12. Rural Area Bikeways	NEW CHAPTER with some content pulled from Chapter 4
	13. Structures	NEW CHAPTER with some content pulled from Chapter 5
	14. Wayfinding	NEW CHAPTER with some content pulled from Chapter 4
Chapter 7. Maintenance and Operations	15. Maintenance & Operations	REVISION of chapter 7
Chapter 6. Bicycle Parking Facilities	16. Parking, Bike Share, & End of Trip Facilities	REVISION of chapter 6

Figure 1-1: Design Range









Bicyclist Design User Profiles

Comfort Typology of Bicyclists

Design User Profile	Non-Bicyclist	Interested but Concerned	Somewhat Confident	Highly Confident
Bicycling Preferences	Uncomfortable bicycling in any condition, have no interest in bicycling, or are physically unable to bicycle.	Often not comfortable with bike lanes; may bike on sidewalks even if bike lanes are provided. Prefer off-street or separate bicycle facilities or quiet or traffic-calmed residential roads. May not bike at all if bicycle facilities do not meet needs for perceived comfort.	Generally prefer more separated facilities, but comfortable riding in bicycle lanes or on paved shoulders if need be.	Comfortable riding with traffic; will use roads without bike lanes.
Percent of Population	31–37%	51–56%	5–9%	4–7%

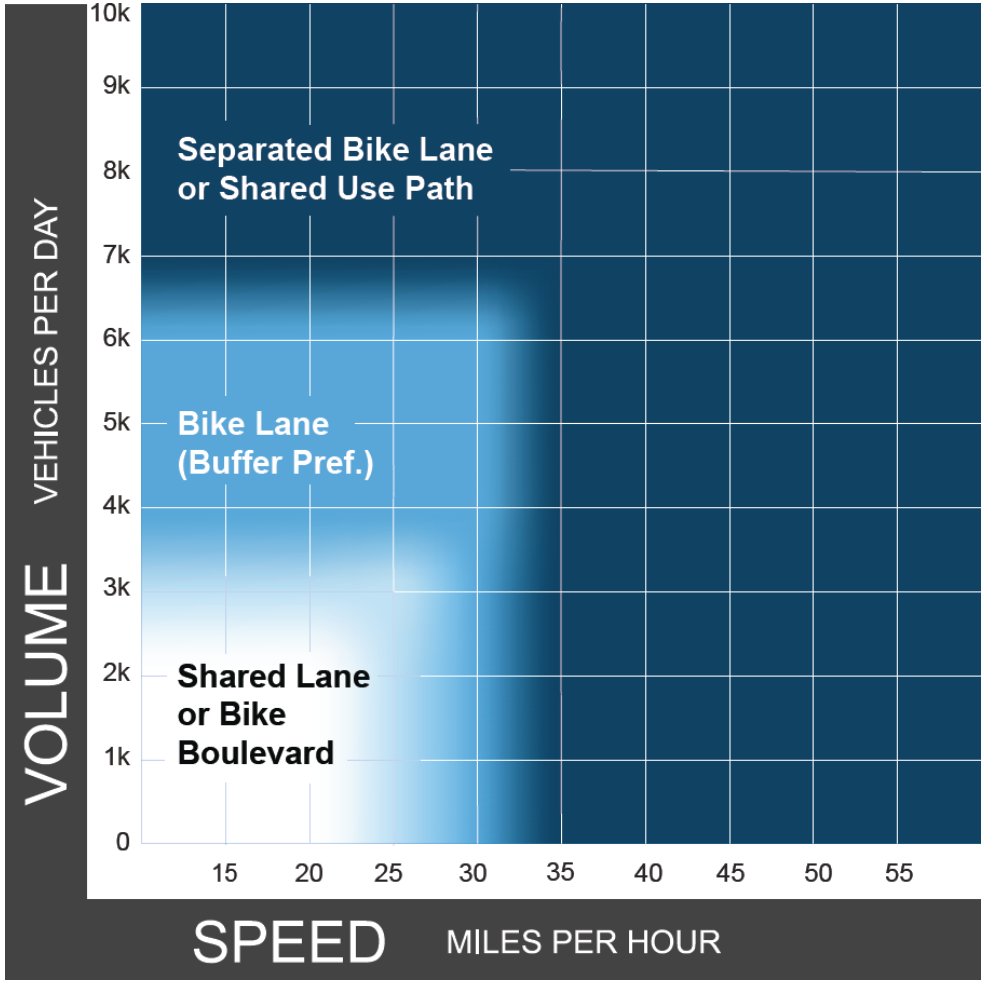
Figure 2-2: Comfort Typology of Bicyclists (See Chapter 2 References: Dill and McNeill, 2016)

Urban, Suburban and Rural Town Contexts

- Identifies the **preferred** bikeway type assuming:

- **<u>Design User</u> =** Interested but Concerned bicyclist

- **<u>Analysis</u> =** Level of Traffic Stress



TOOLE DESIGN

Bicyclist Spaces

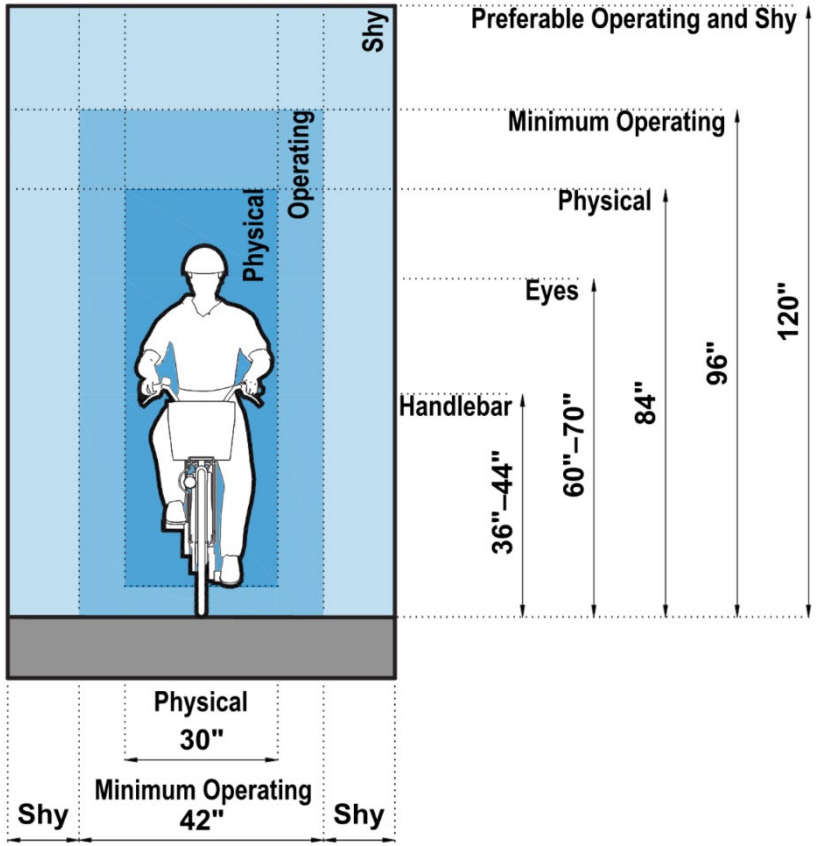


Figure 2-5: Typical Adult Bicyclist Operating Space

Table 2-5: Bicyclist Lateral Shy Distance to Physical Elements

Physical Element	Shy Distance (in.)	
	Practical Minimum	Recommended Range
Intermittent Elements (such as tree, flex post, pole)*	0	24–36
Traffic Signs and Supportive Posts on Curbed Roadways	12	24–36
Traffic Signs and Supportive Posts adjacent to Shared Use Paths	24	36–48
Continuous Elements (such as fence, railing, planter)	12	24–36
Vertical Curbs	6	12–24
Mountable or Sloping Curbs	0	6–12

** To reduce crash risks, eliminating the shy distance is not preferable as any additional shy distance will be beneficial.*

TOOLE DESIGN

Separated Bike Lanes

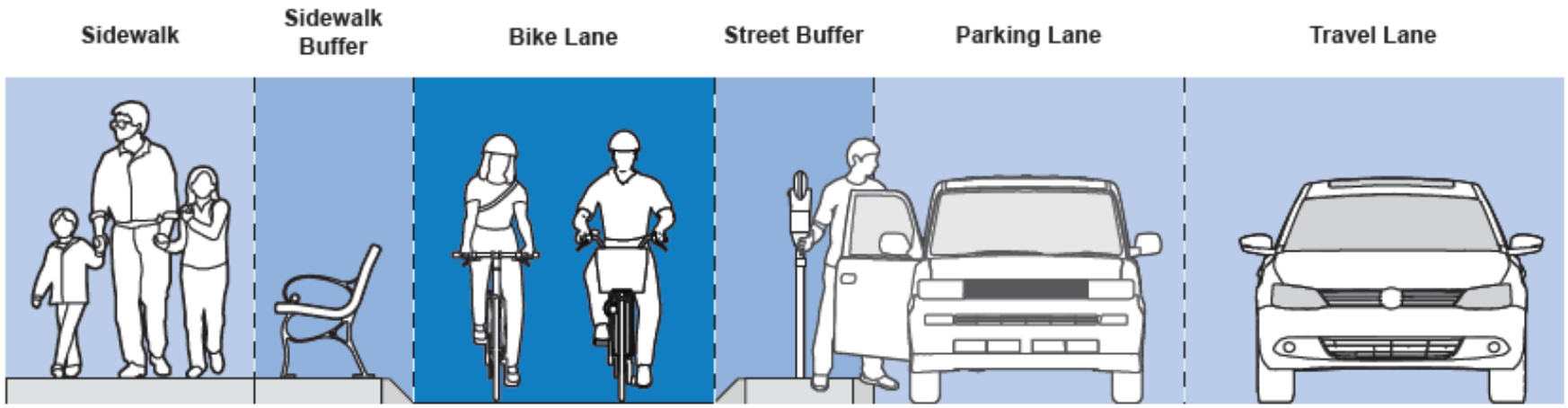
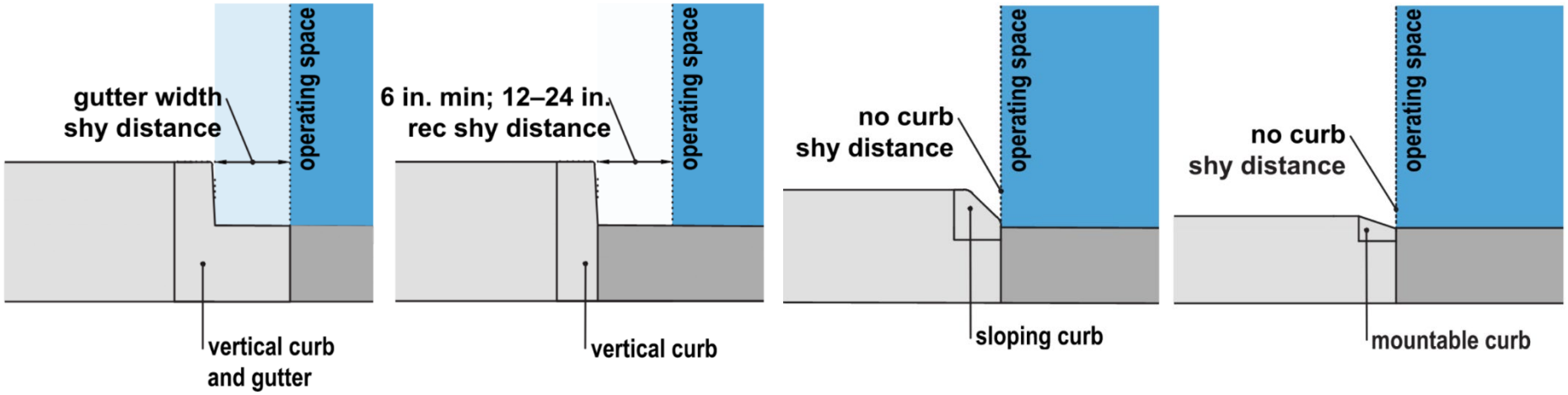


Figure 7-1: Separated Bike Lane Zones



TOOLE DESIGN

Protected Intersections

- Minimizing Exposure to Conflicts
- Reducing Speeds at Conflict Points
- Transitions between Elevations
- Right-of-Way Priority
- Sight Distance

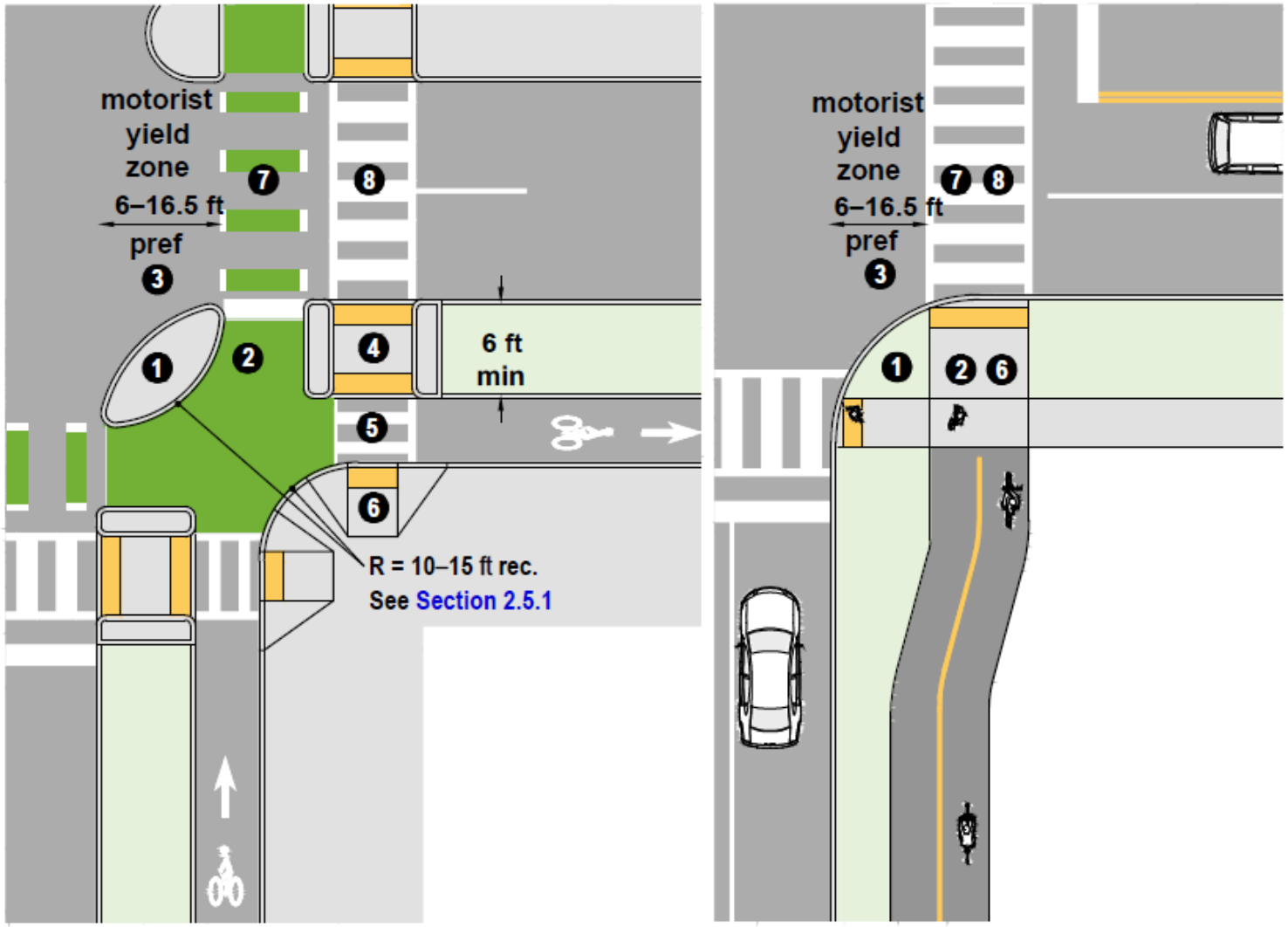


Figure 7-13: Protected Intersection Design for Separated Bike Lanes and Side Paths

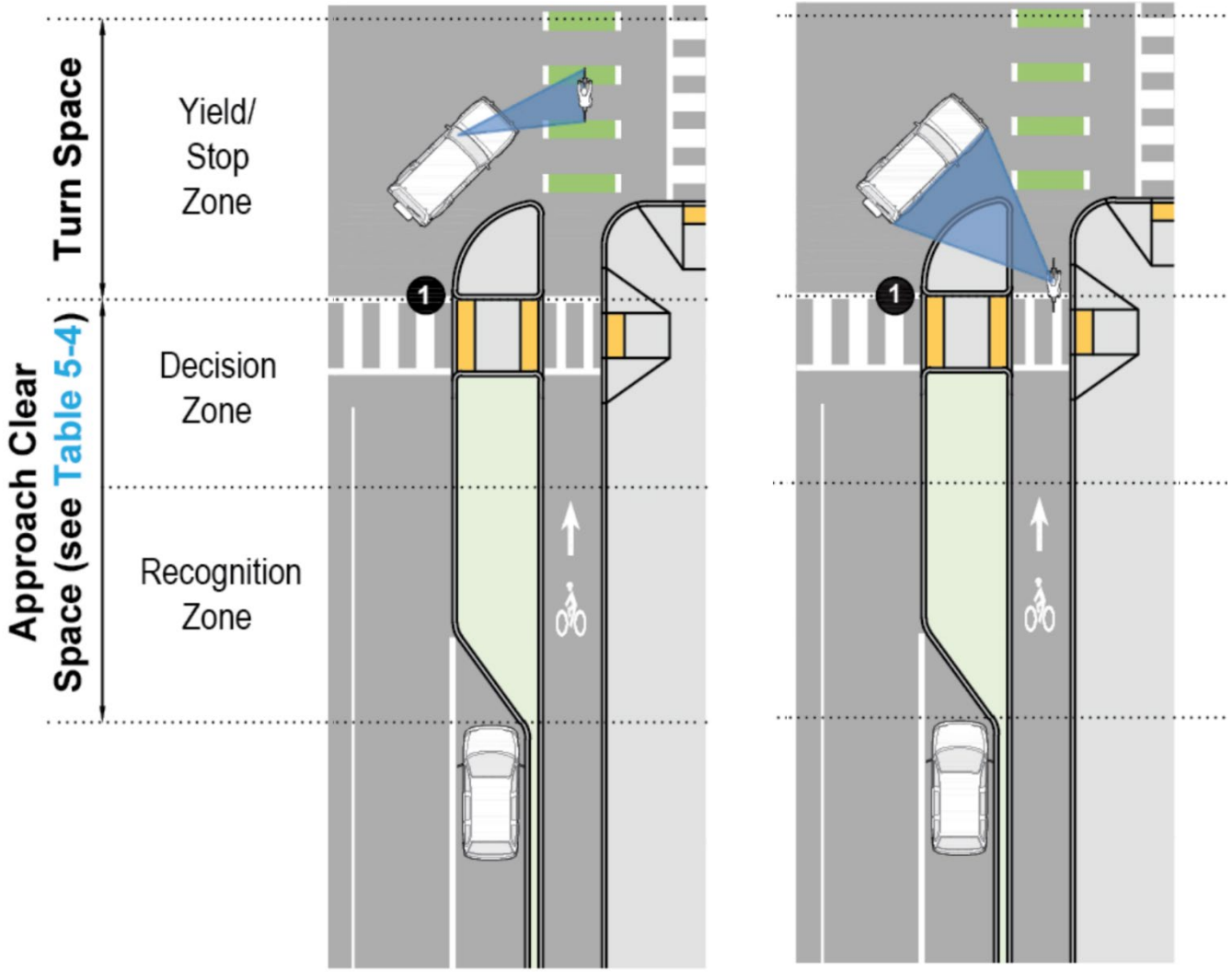
TOOLE DESIGN

Right Turn Sight Distances Across Separated Bike Lanes and Side Paths

Table 5-4: Recommended Intersection Approach Clear Space by Vehicular Turning Design Speed

Effective Vehicle Turning Radius	Vehicular Turning Speed	Recommended Approach Clear Space
<18 ft	<10 mph[a]	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

[a] Most low-volume driveways and alleys



Geometric Design Treatments to Improve Intersection Safety

- Medians and Pedestrian Refuge Islands; Hardened Centerlines
- Curb Extensions
- **Curb Radius**
- **Mountable Truck Aprons**
- Raised Crossings
- Multiple Threat Crossing Treatments
- Bike Ramps
- Directional Indicators

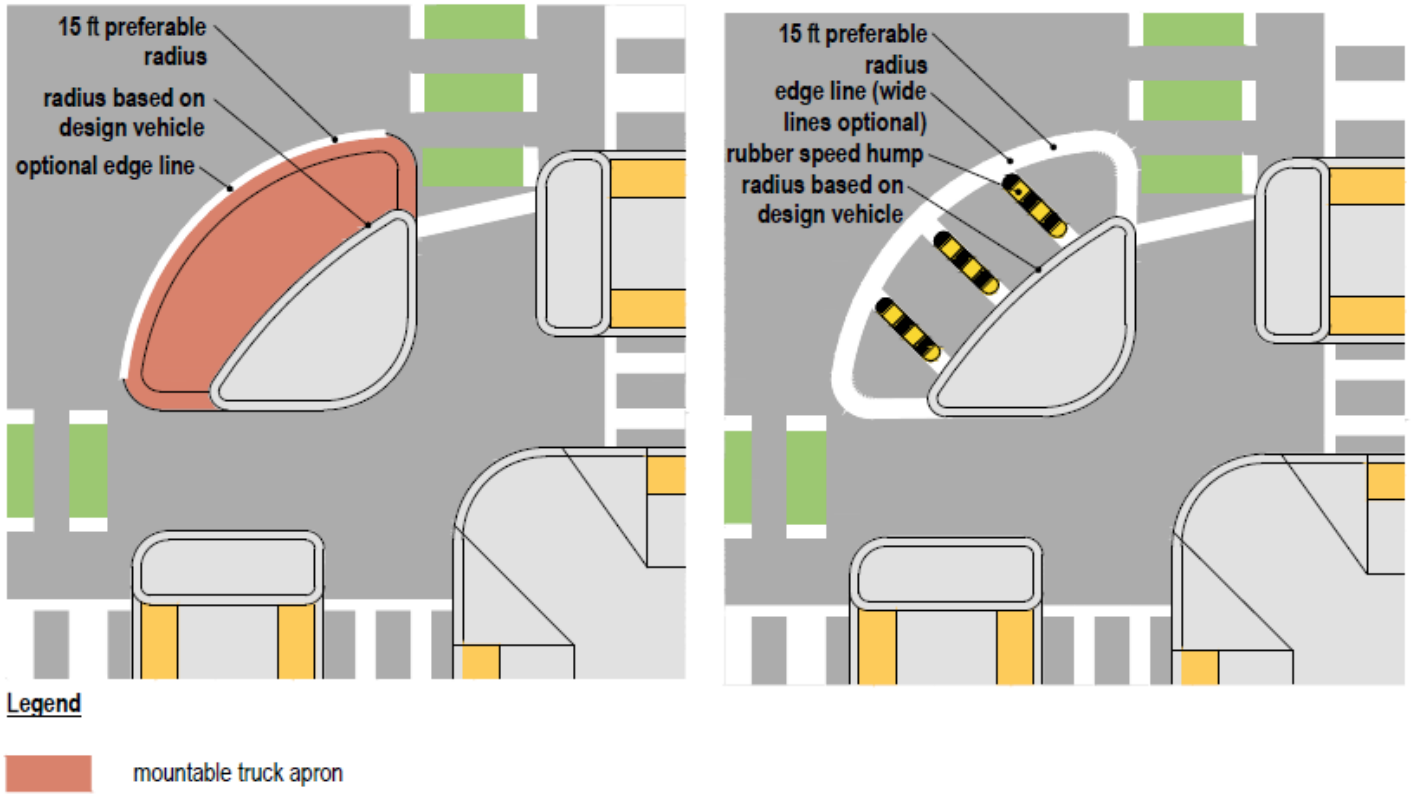


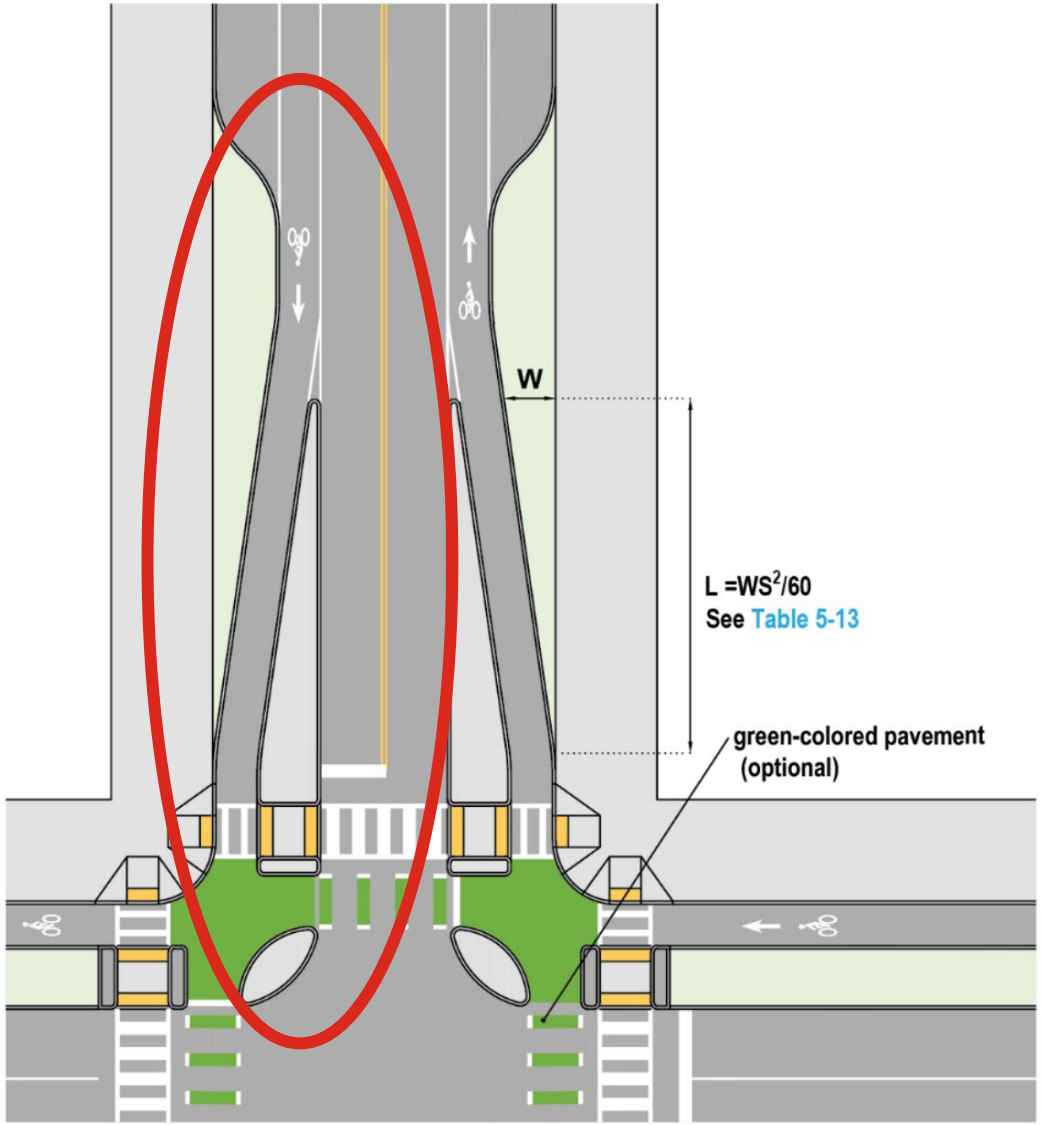
Figure 5-18: Mountable Truck Apron

TOOLE DESIGN

Bike Lanes at Intersections and Driveways

- You can transition bike lanes to separated bike lanes at intersections

- NCHRP 1125 recommends this above all other options for safety and comfort

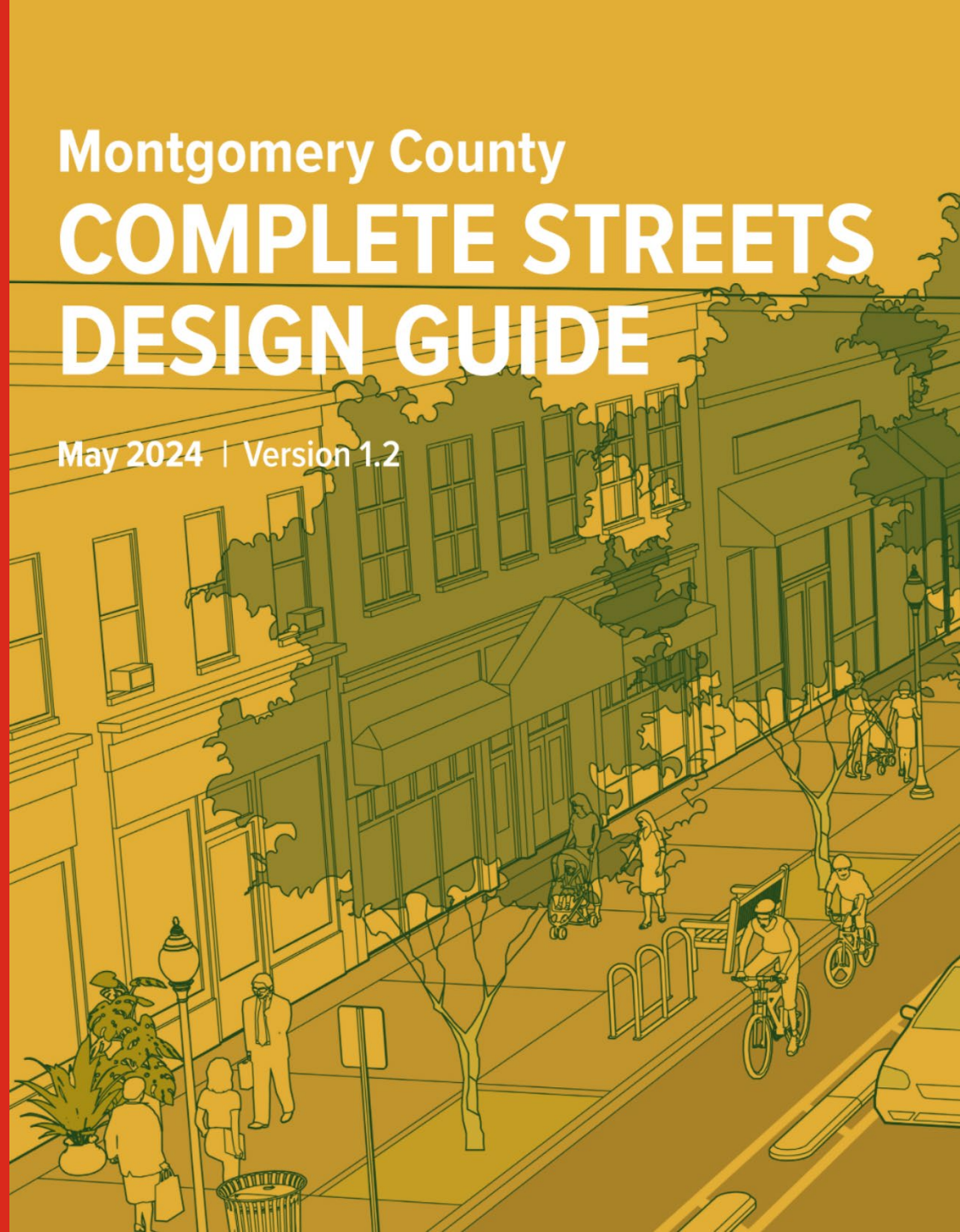


TOOLE DESIGN

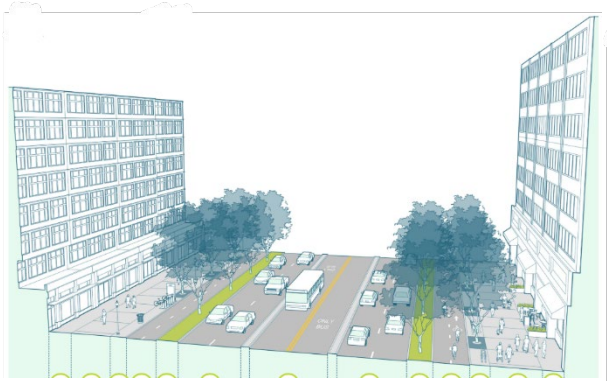
Montgomery County, Maryland

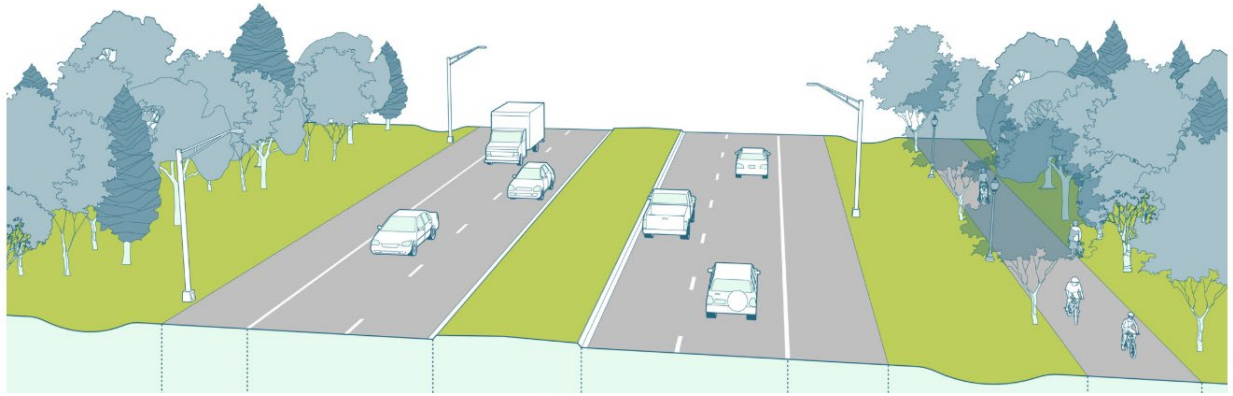
Complete Streets Design Guide

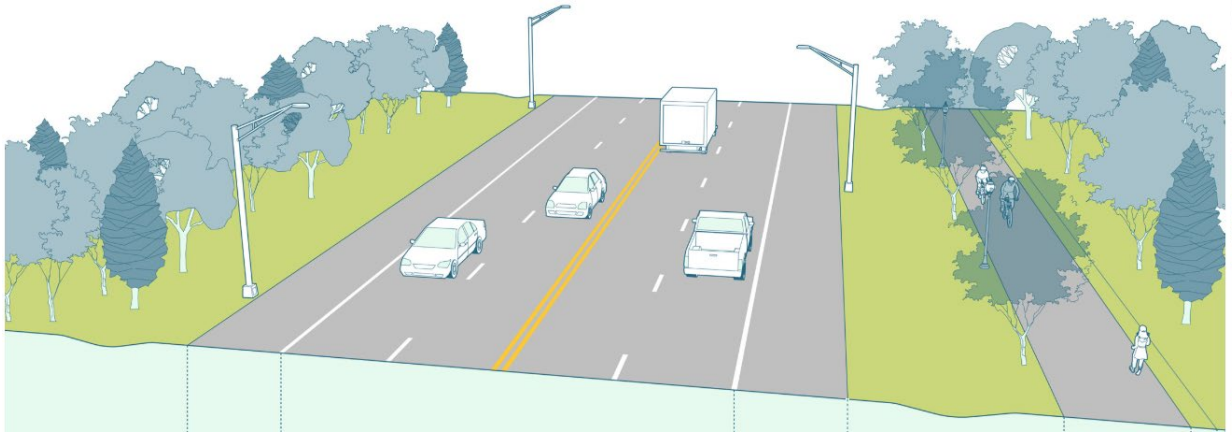
Suite of Design Guidance

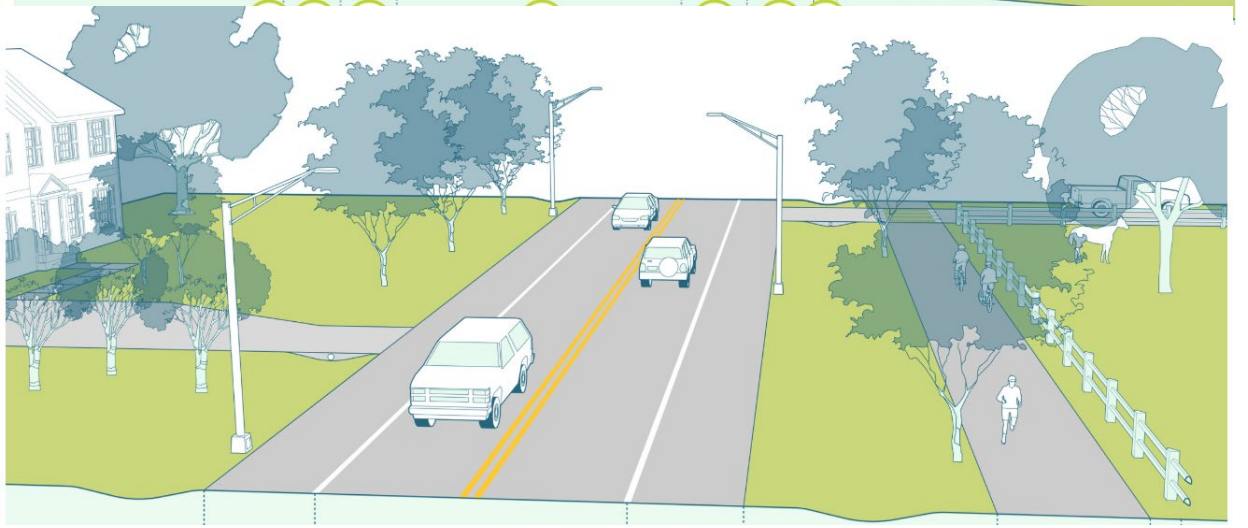


Complete Streets Guide

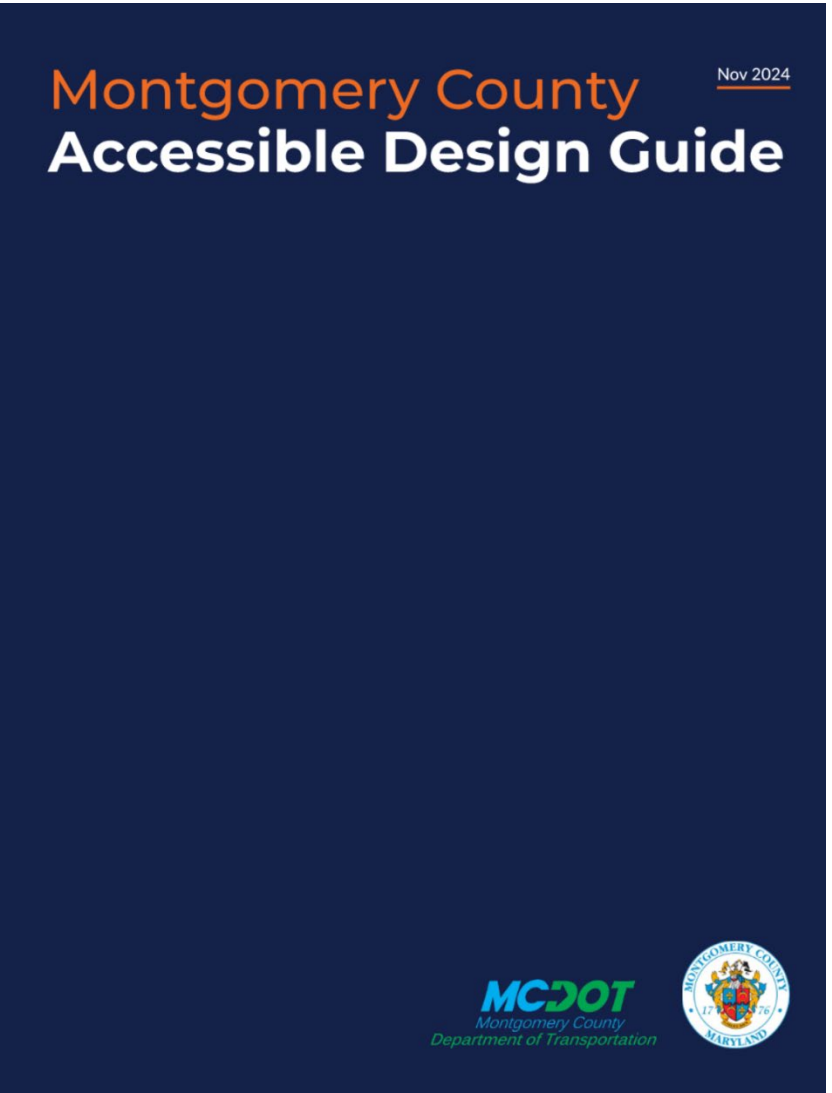








The Suite!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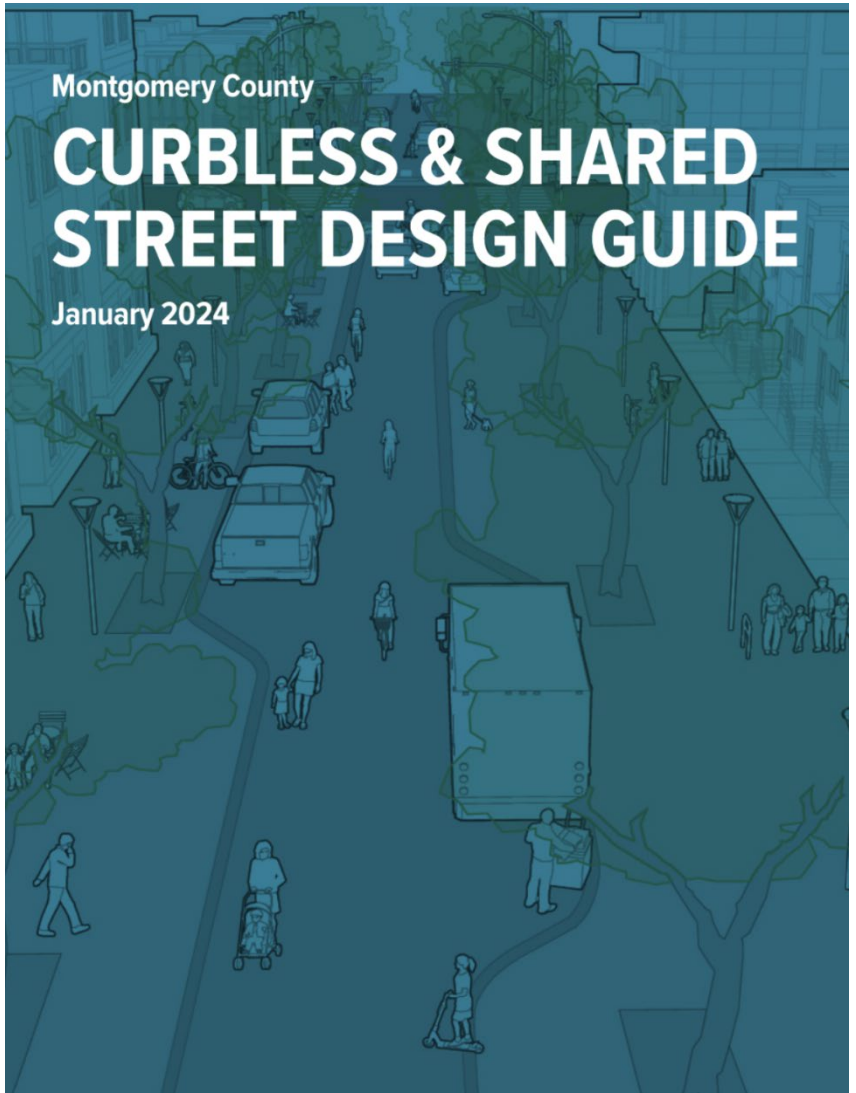
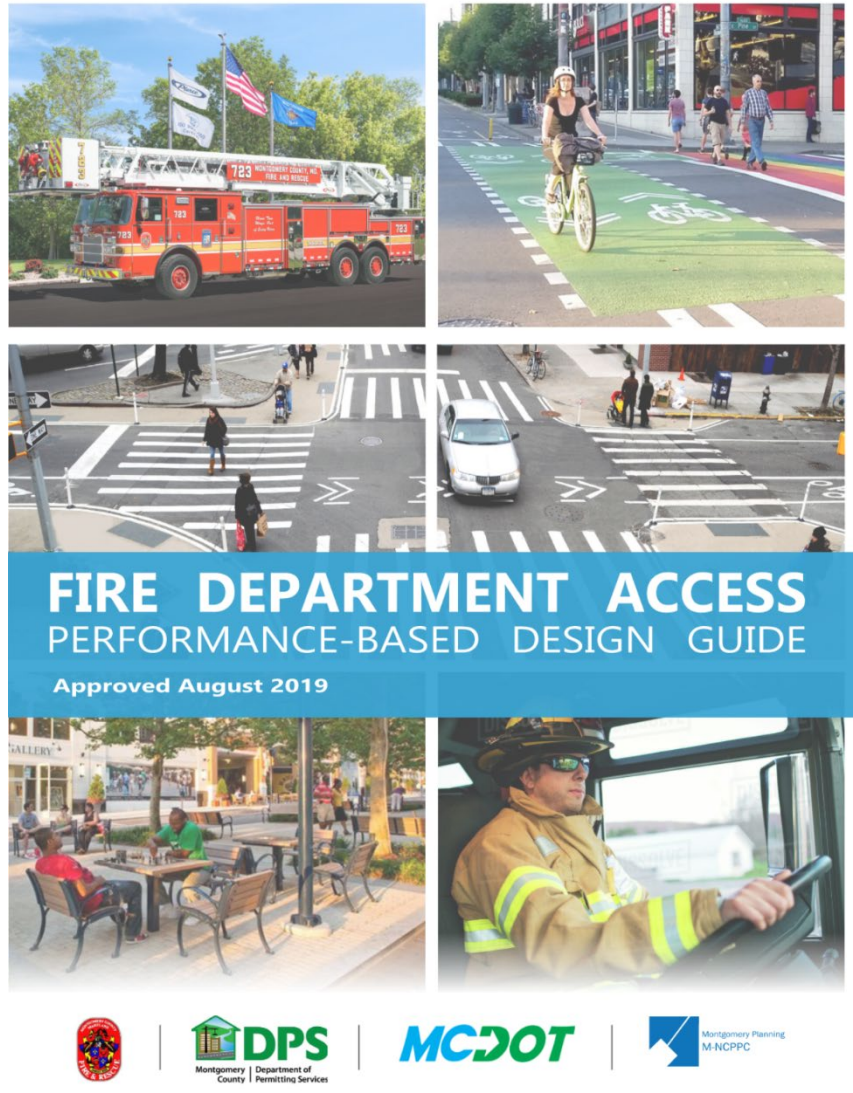

Montgomery County
CURBLESS & SHARED STREET DESIGN GUIDE
January 2024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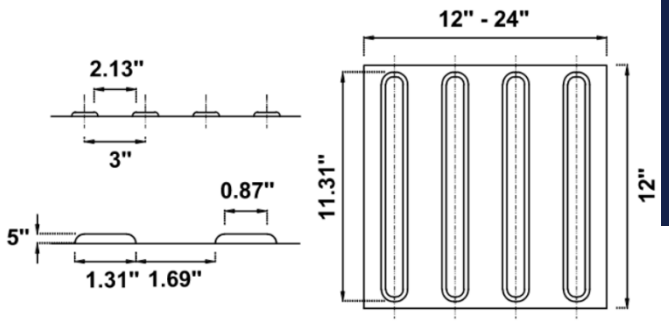
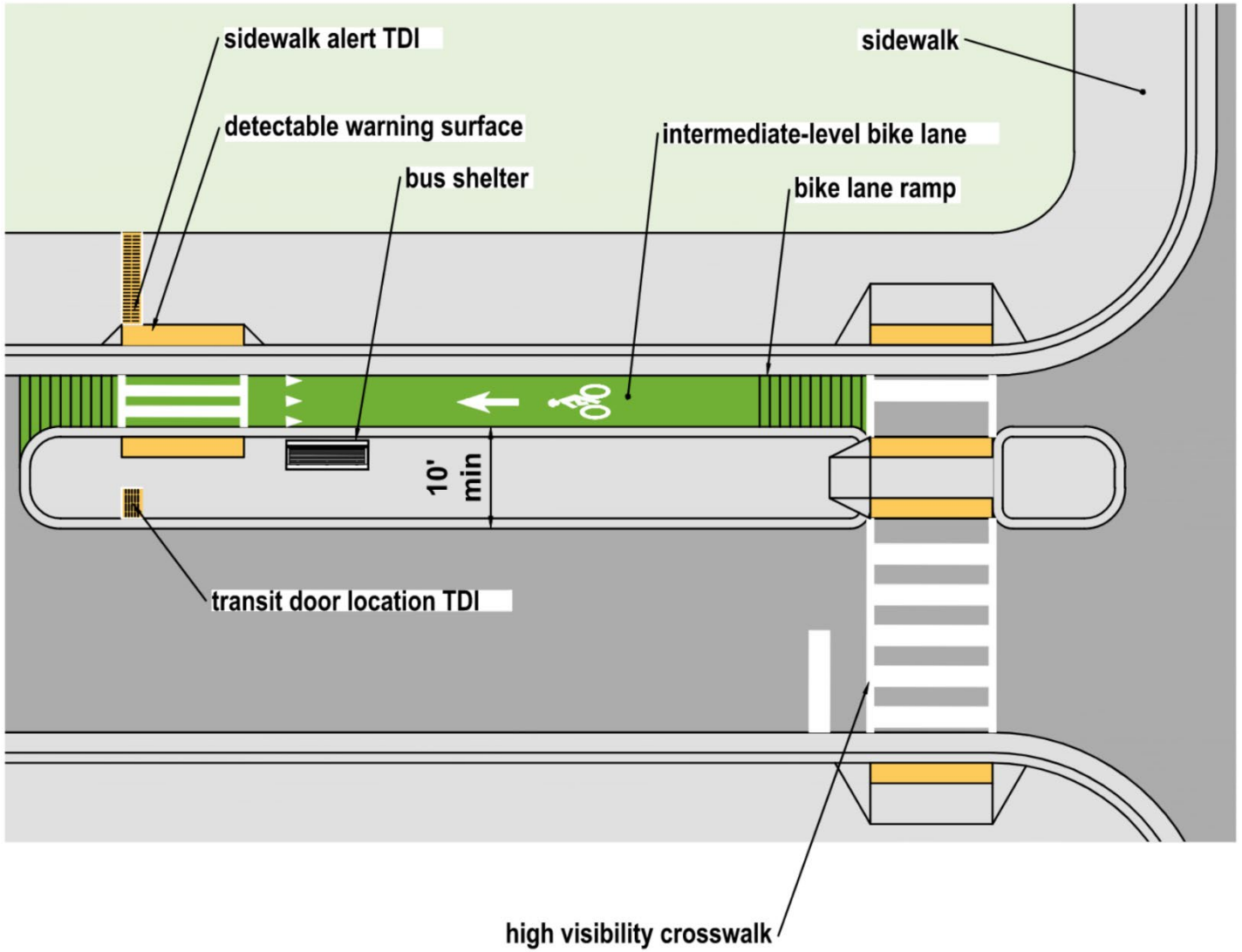
MCDOT
Montgomery Planning
M-NCPPC

Tactile Surfaces





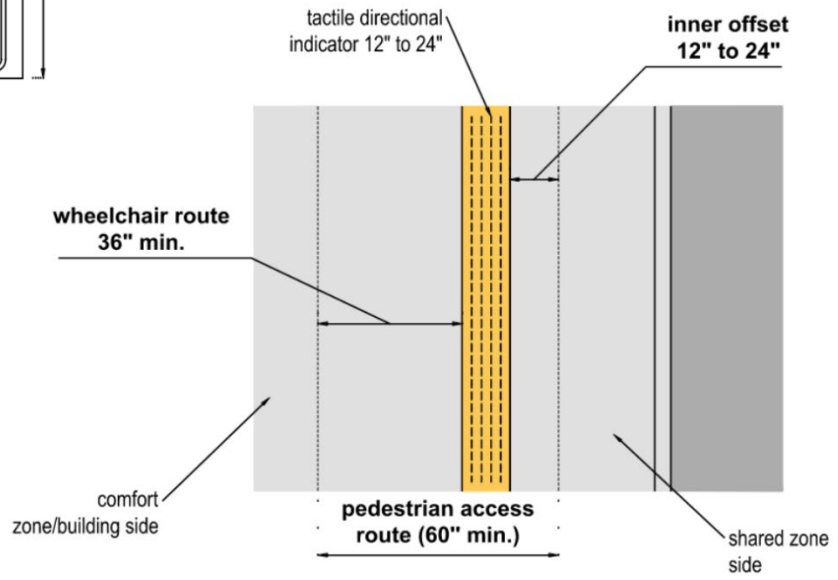
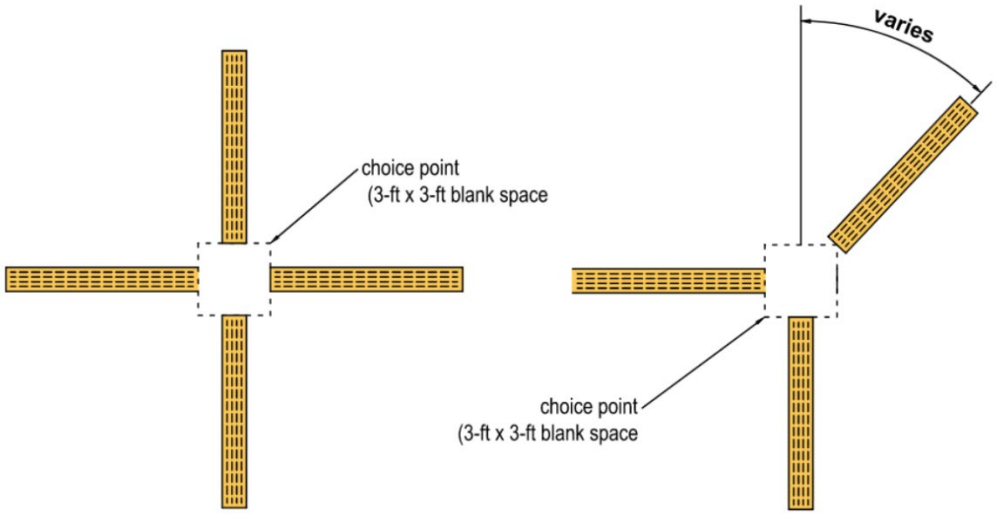
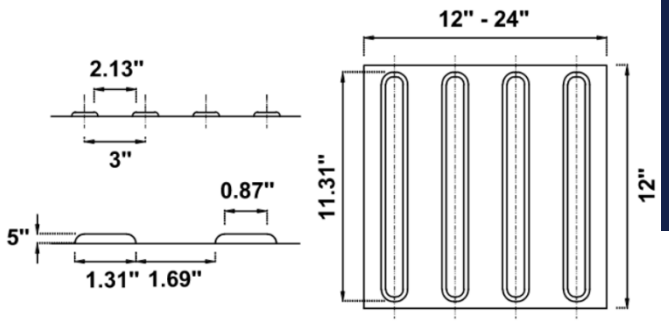
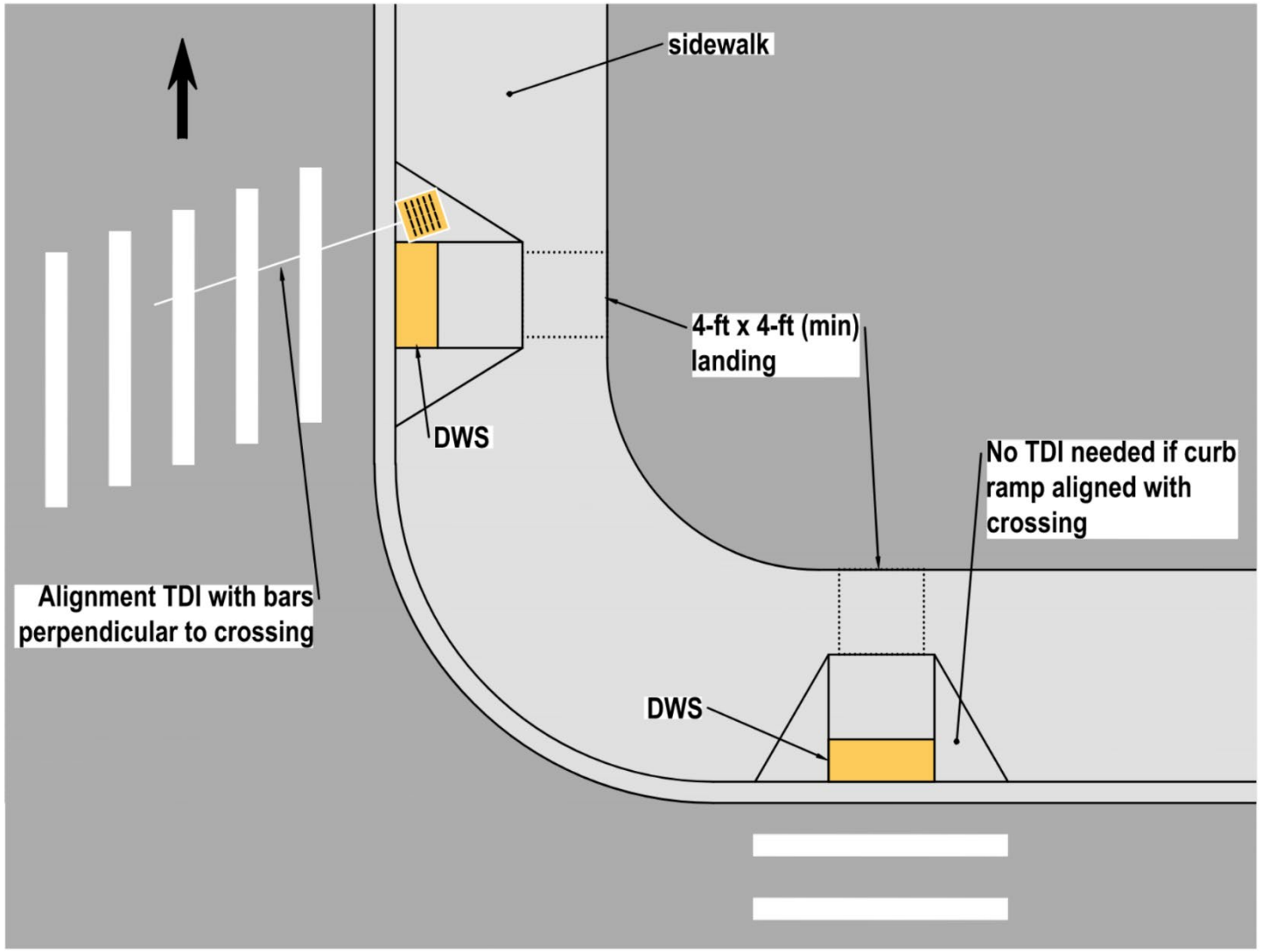


Figure 12: Illustration of choice point indicator at guidance TDI intersection



Tactile Surfaces



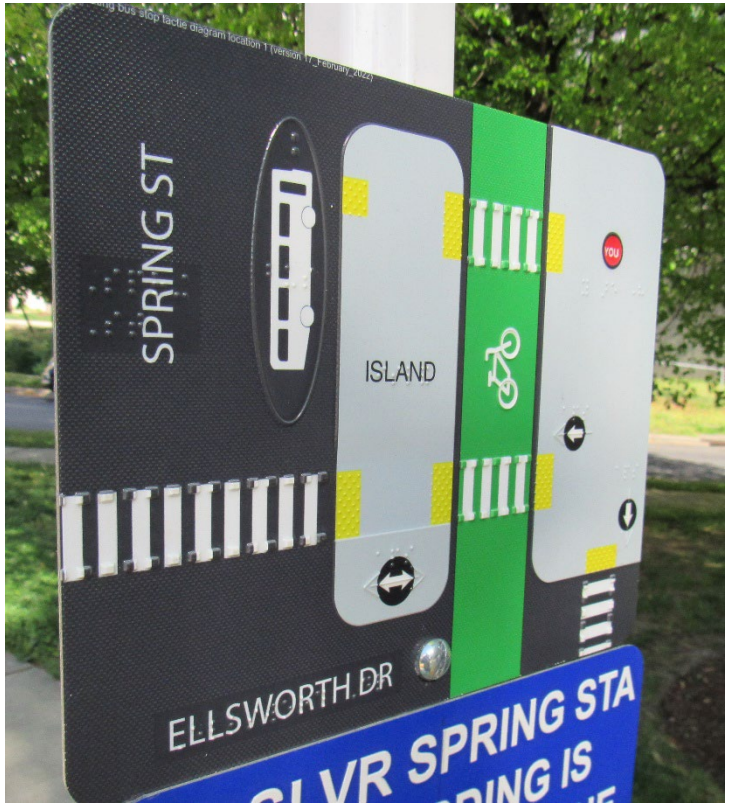


Audible Messages

100%
Found this helpful

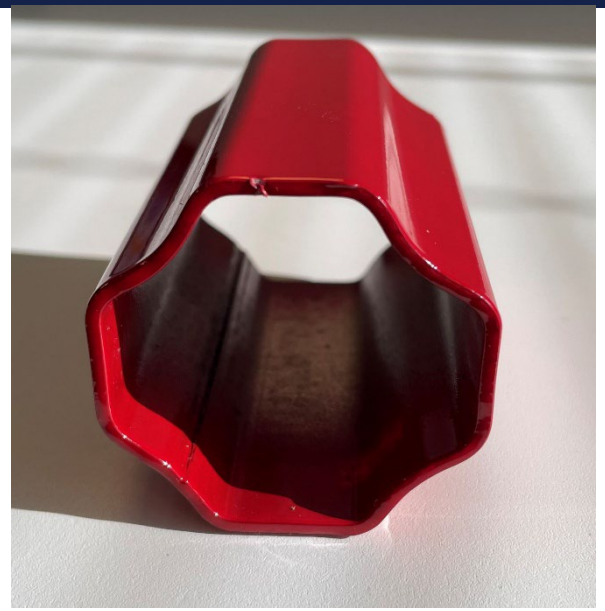
Tactile Signs

Using braille and tactile maps
80% - 88%
Could locate the crosswalks



Bus Stop Poles

94%
Found pole shape helpful in bus stop ID

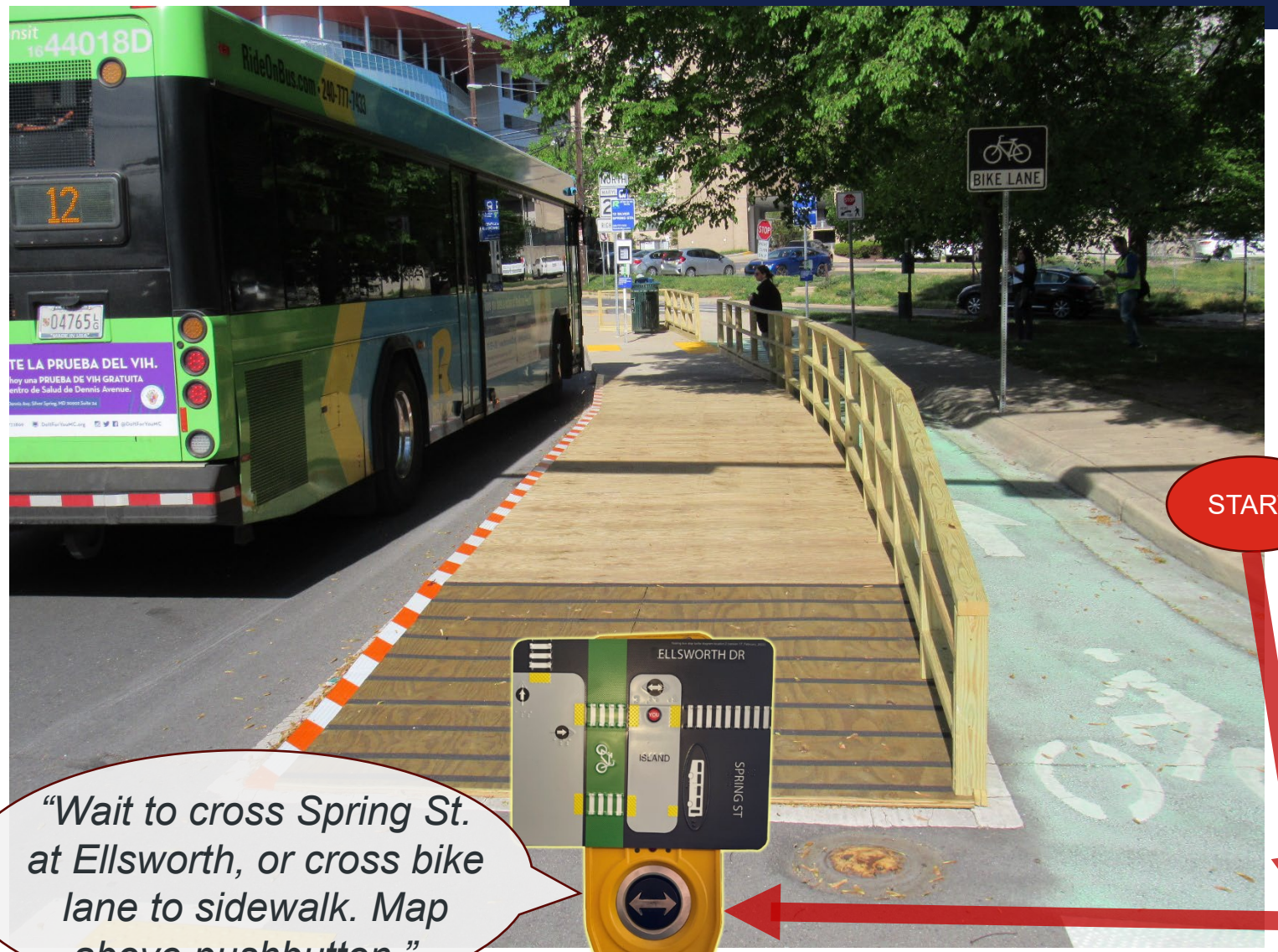


Octagonal shaped sign post for primary bus ID pole

TOOLE DESIGN

Bike Lane Xings

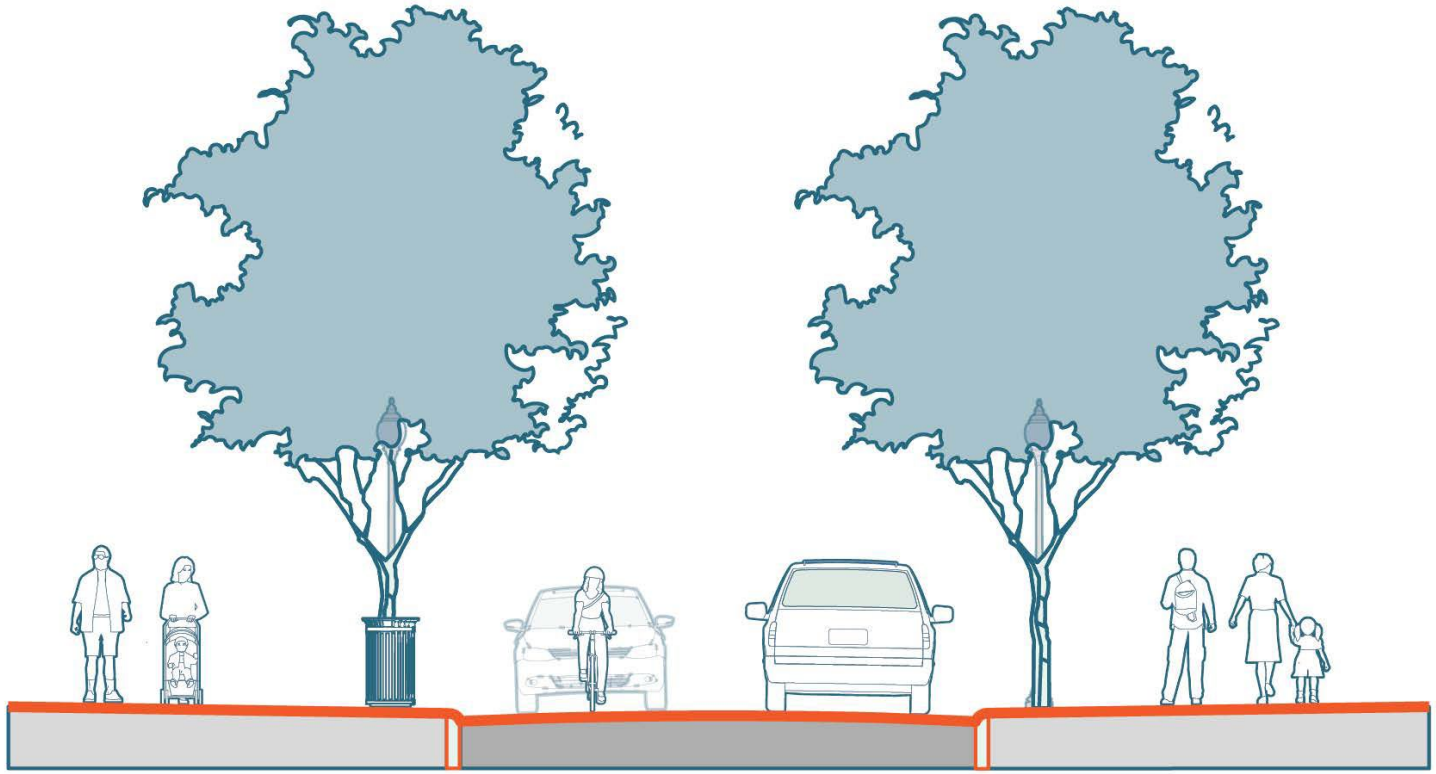
100% found crosswalk
87% found APS
93% bike lane crossing



TOOLE DESIGN

Curbless Streets

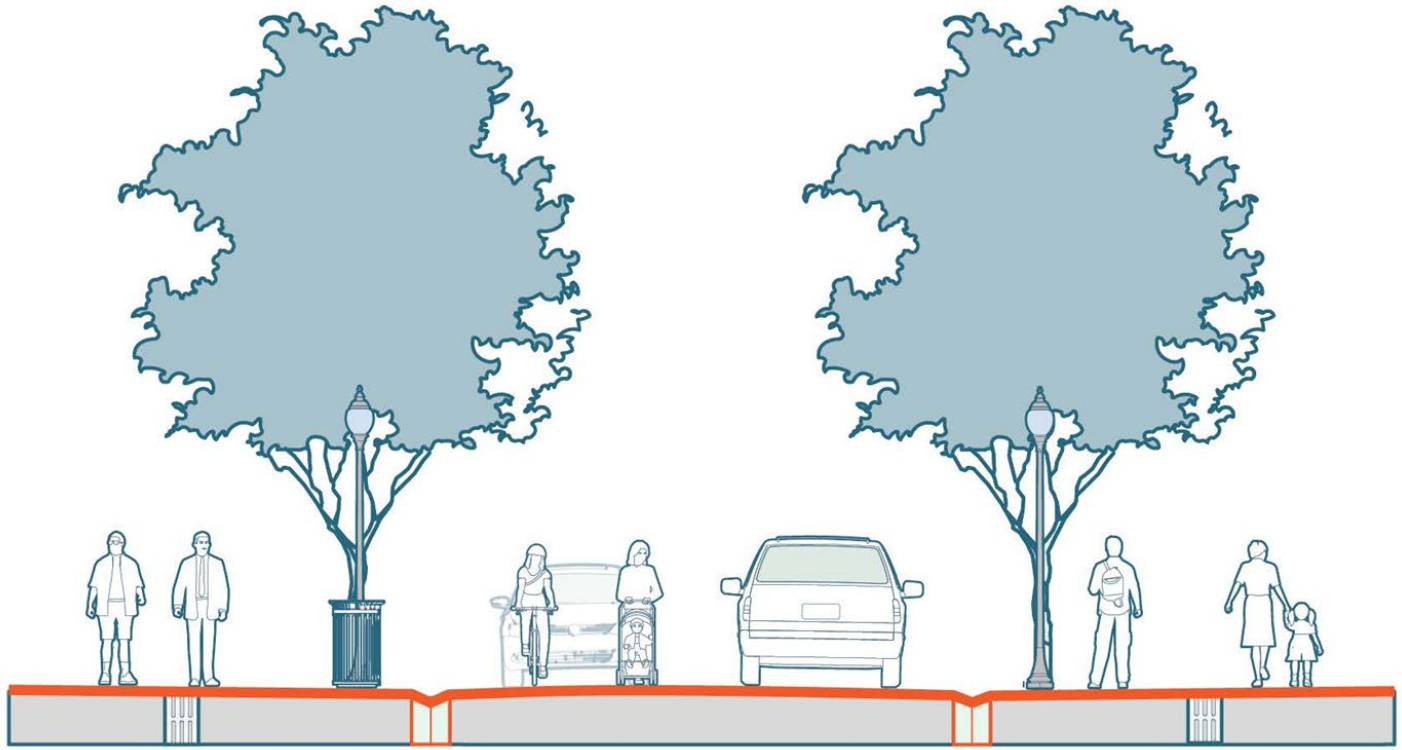
- A **Curbless Street** functions like a Conventional Street but lacks a vertical curb and gutter.
- Curbless Streets are designed to encourage slow speeds; the overall design and use will lead people walking and traveling in a wheelchair to use the area reserved for non-motor vehicle use —the "Comfort Zone"—to travel along the street and detectable, designated crossings to cross the street.



TOOLE DESIGN

Shared Streets

- A **Shared Street** is also curbless but lacks the modal separation of a Curbless Street.
- Pedestrians, people riding bicycles or scooters, and cars mix in the same space (or pedestrians can opt to travel in the Comfort Zone).

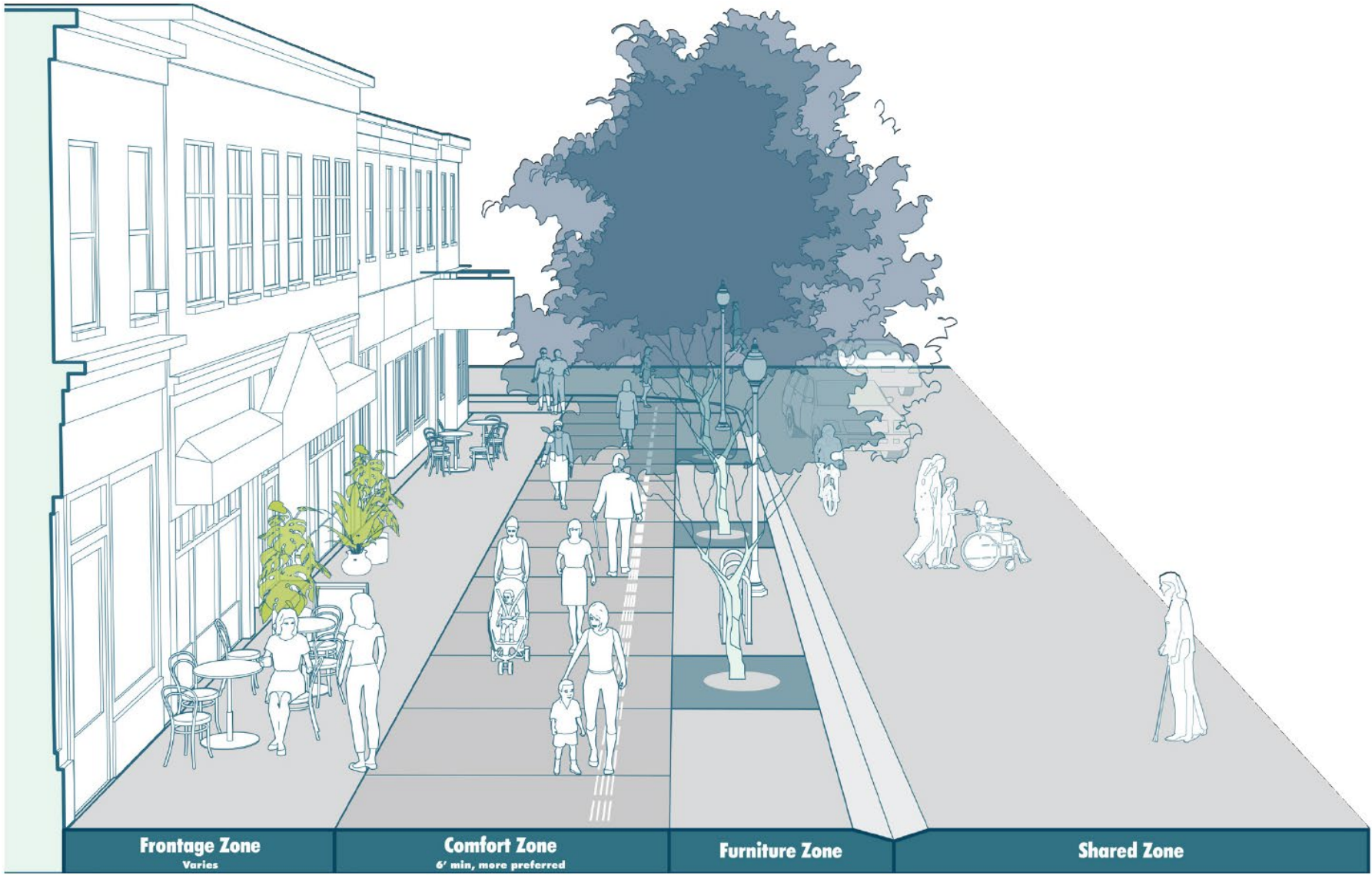


Montgomery County

CURBLESS & SHARED STREET DESIGN GUIDE

Street Zones

- Frontage Zone
- Comfort Zone
- Furniture Zone
- Shared Zone
  vs Vehicle Zone

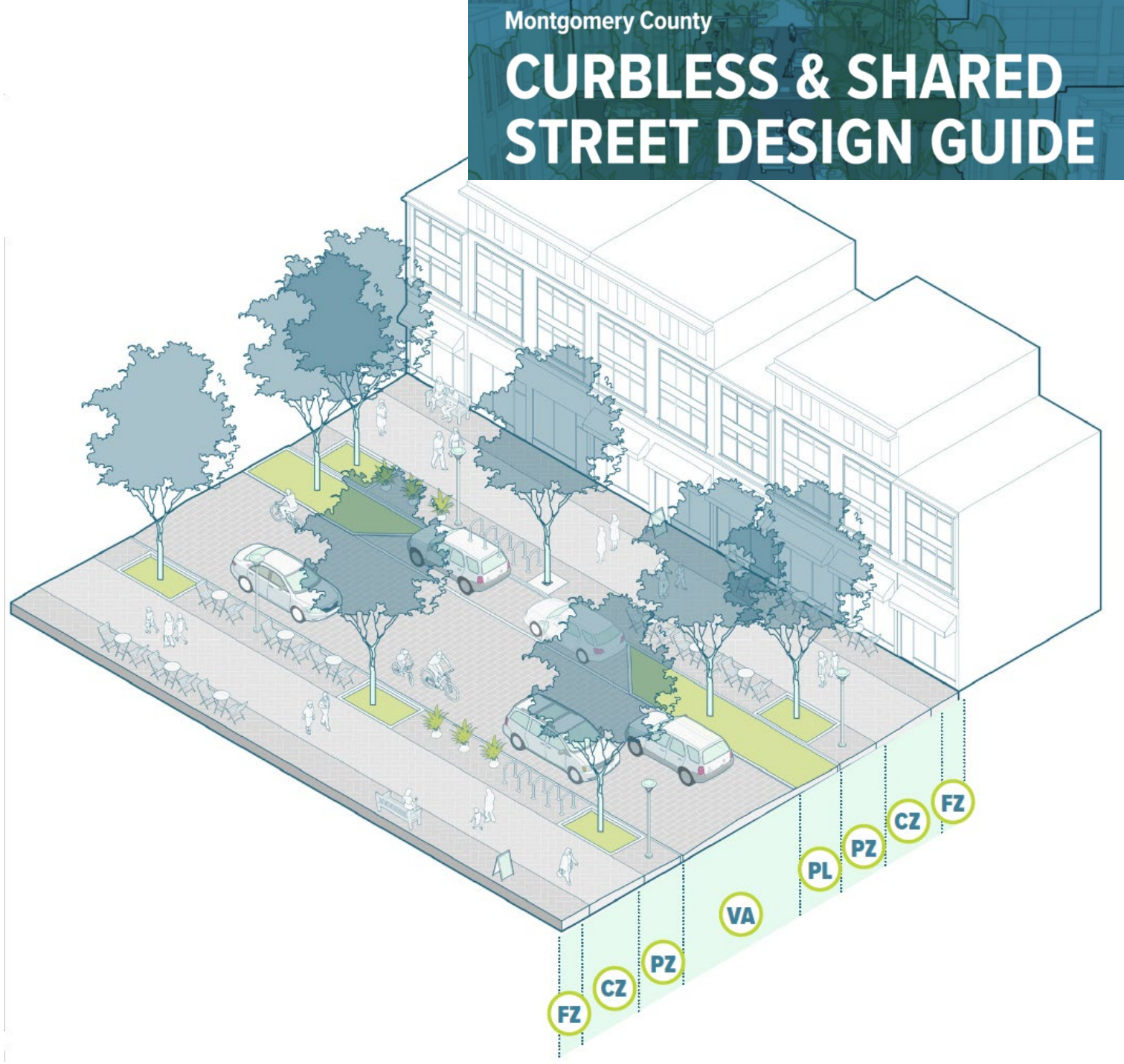


TOOLE DESIGN

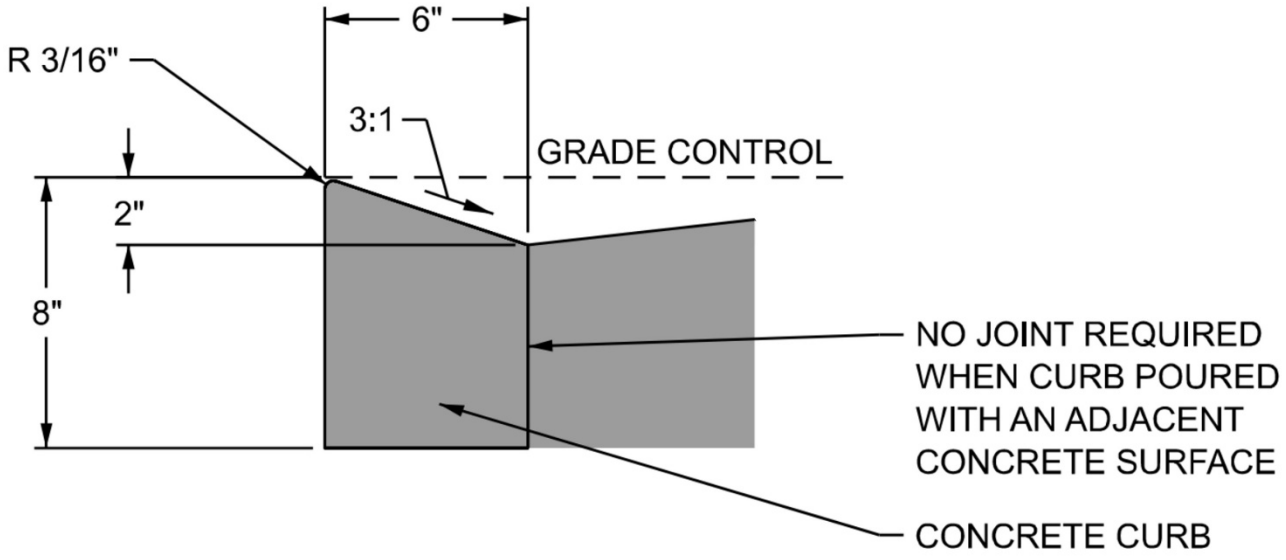
Curbless Streets

Pedestrian Space	Emphasis on Comfort Zone; Can cross anywhere
Motor Vehicles Volumes	Low
Motor Vehicle Speeds	Low
Loading	Accommodated
Garages Access	Limited # Spaces
On-Street Parking	Limited. If provided: 1-side at a time
ROW	Likely 50-70’ typically, down to 30’ min

TOOLE DESIGN



Curbless Streets



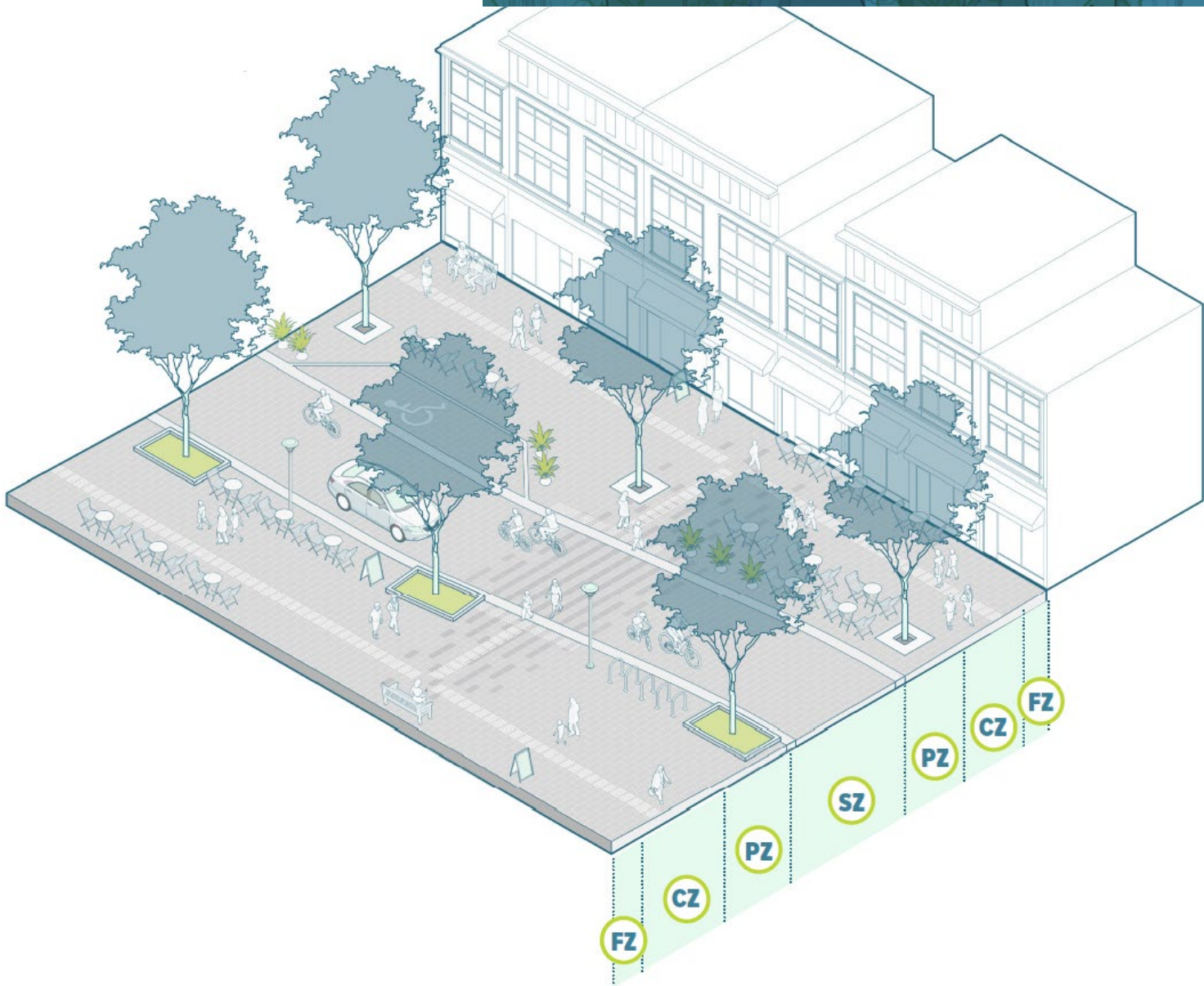
Detectable Sloping Curbs

Montgomery County

CURBLESS & SHARED STREET DESIGN GUIDE

Shared Streets

Pedestrian Space	Can walk anywhere; Comfort zone is available
Motor Vehicles Volumes	Very Low
Motor Vehicle Speeds	Very Low
Loading	Regulated to certain hours or vehicle sizes
Garages Access	Strongly discouraged
On-Street Parking	Accessible spaces only; if provided: 1-side at a time
ROW	44-50’ typ., down to 30’ min

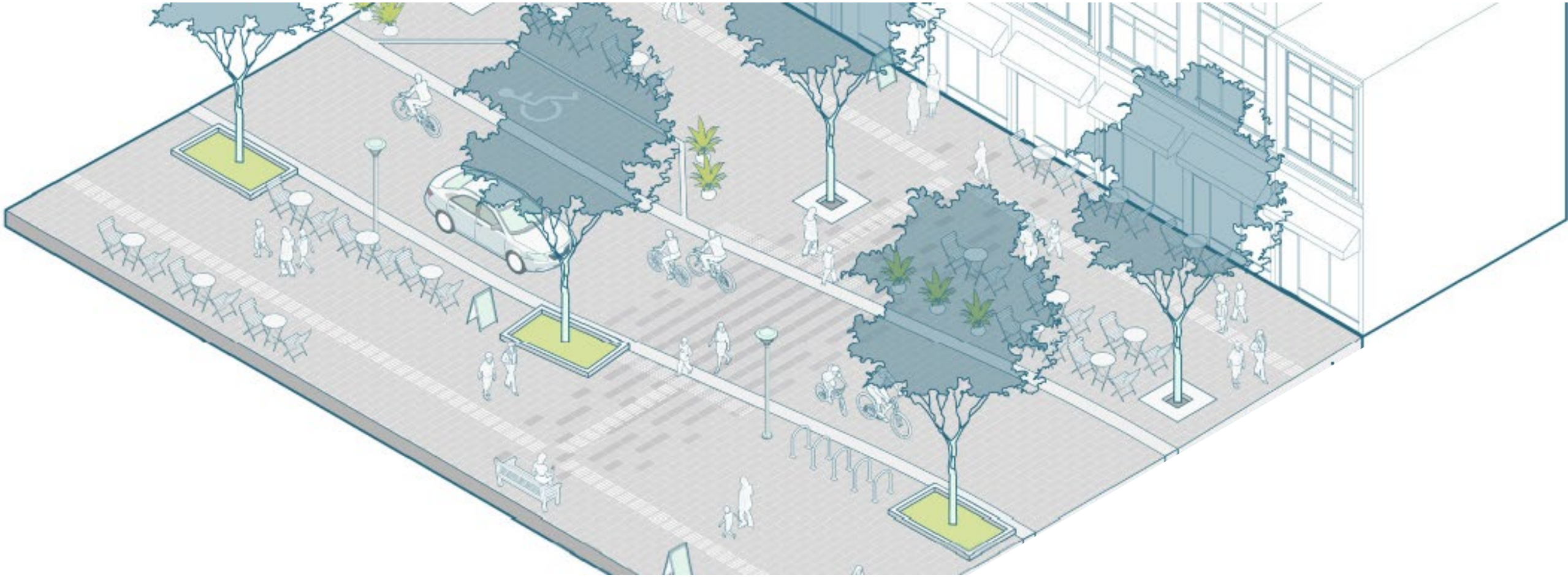


TOOLE DESIGN

Curbless Streets - Crossings

TOOLE DESIGN

Shared Streets - Crossings

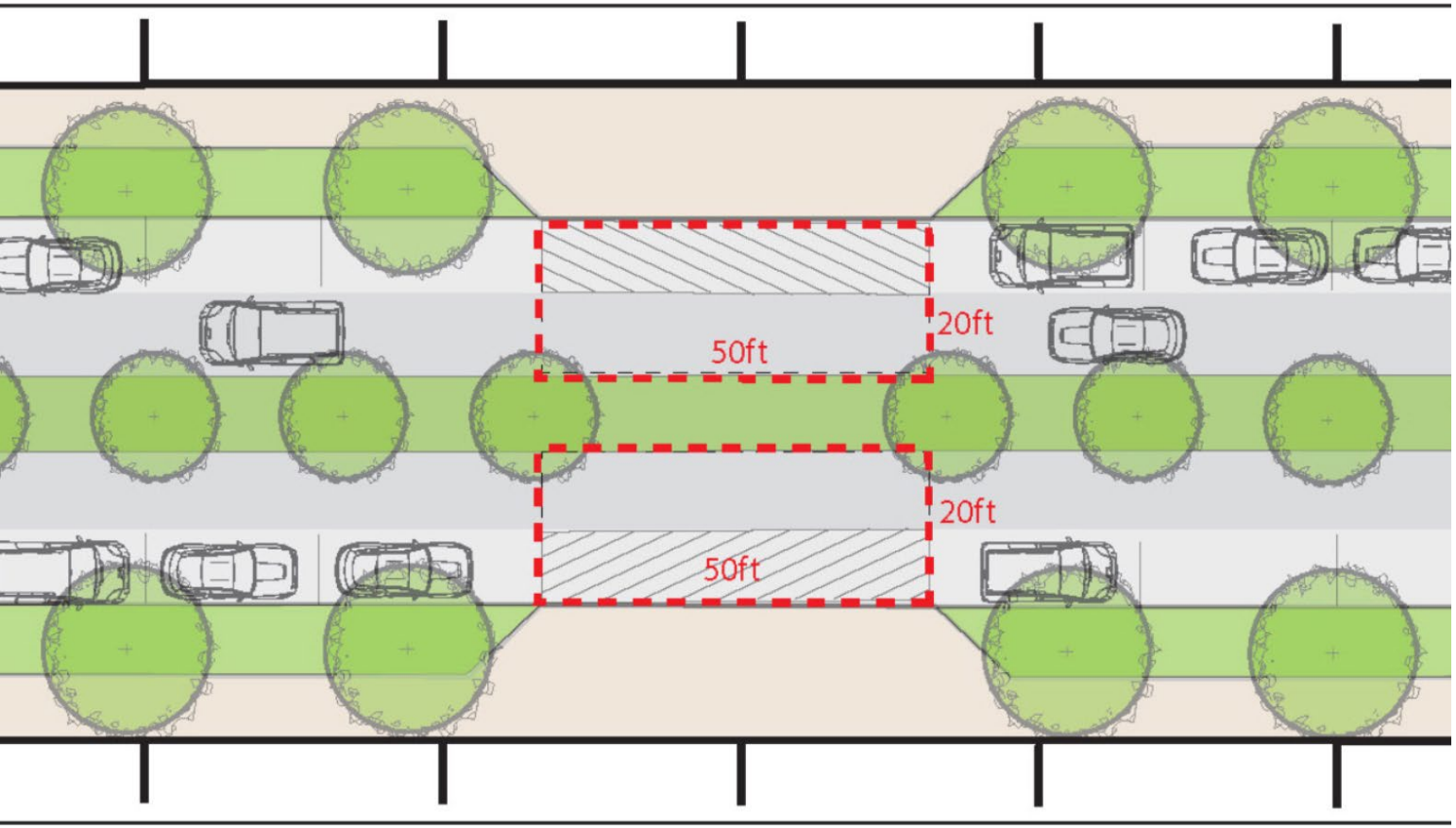


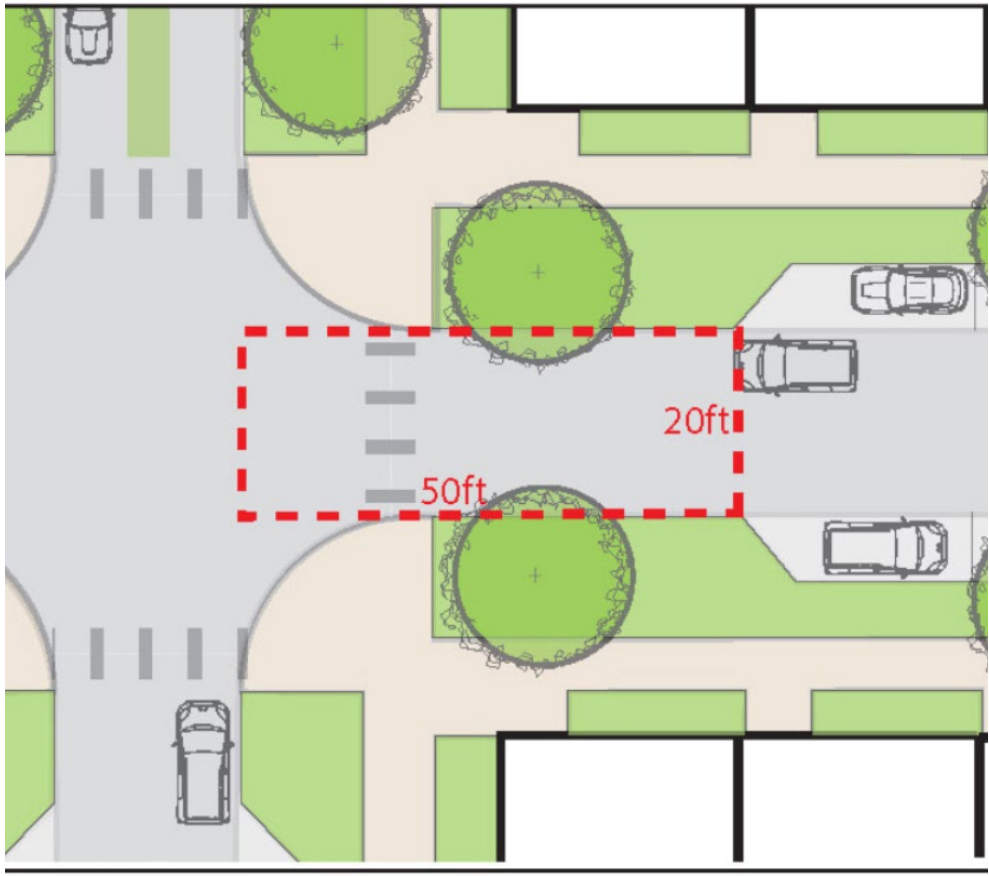
TOOLE DESIGN

FIRE DEPARTMENT ACCESS
PERFORMANCE-BASED DESIGN GUIDE
Approved August 2019

Fire Access Needs

Fire Access – Operational Bays





TOOLE DESIGN

TOOLE DESIGN

Thank you!