Managing Turn Conflicts with Bicycles: AASHTO Bike Guide and NCHRP Research Report 1125

TOOLE DESIGN

ITE Mid-Colonial District Annual Meeting

Tina Fink, PE, PTOE
Principal Transportation Engineer
Toole Design

Intersection Design Objectives (AASHTO Bike Guide Chapter 5)

5.8.1. Minimize Exposure to Conflicts

5.8.2. Reduce Speeds at Conflict Points

5.8.3. Communicate Right-of-Way Priority

5.8.4. Providing Adequate Sight Distance

5.8.5. Transitions to Other Facilities

5.8.6. Accommodating Persons with Disabilities

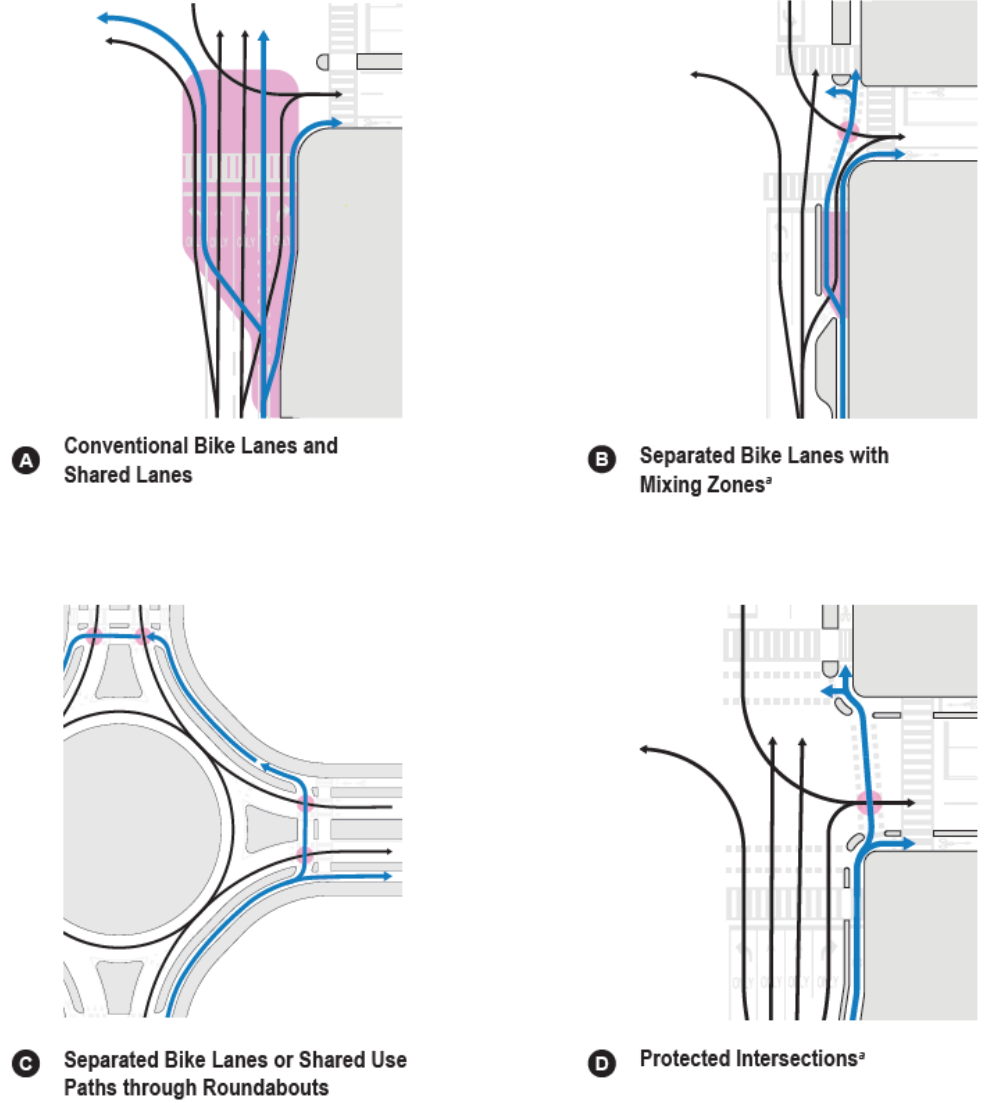
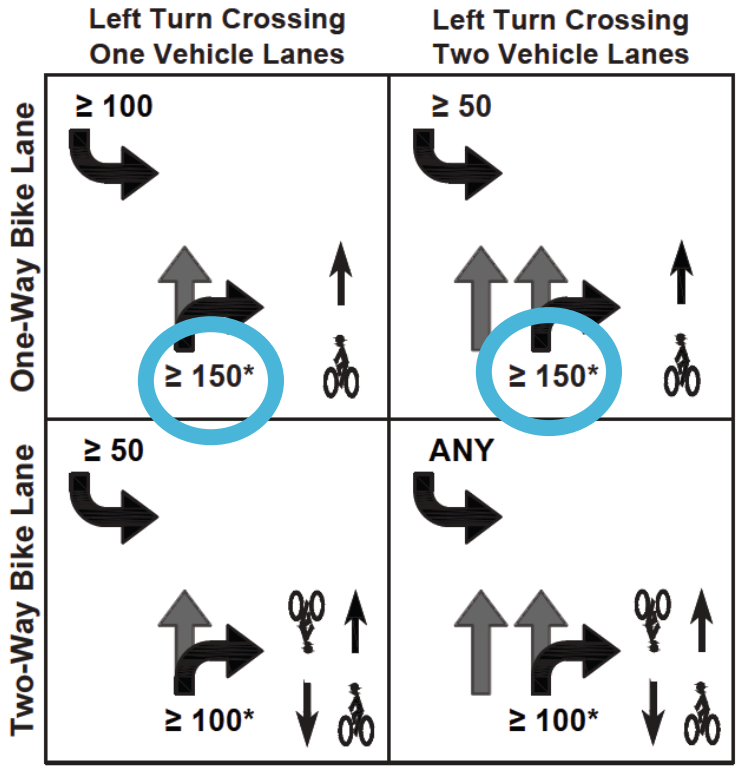


Figure 5-13: Comparison of Bicyclist Exposure to Motor Vehicles at Intersections

TOOLE DESIGN

AASHTO Section 10.3.5. Signal Phasing Schemes for Reducing Conflicts

Table 10-1: Recommended Hourly Turning Traffic Thresholds for Time-Separated Bicycle Movements



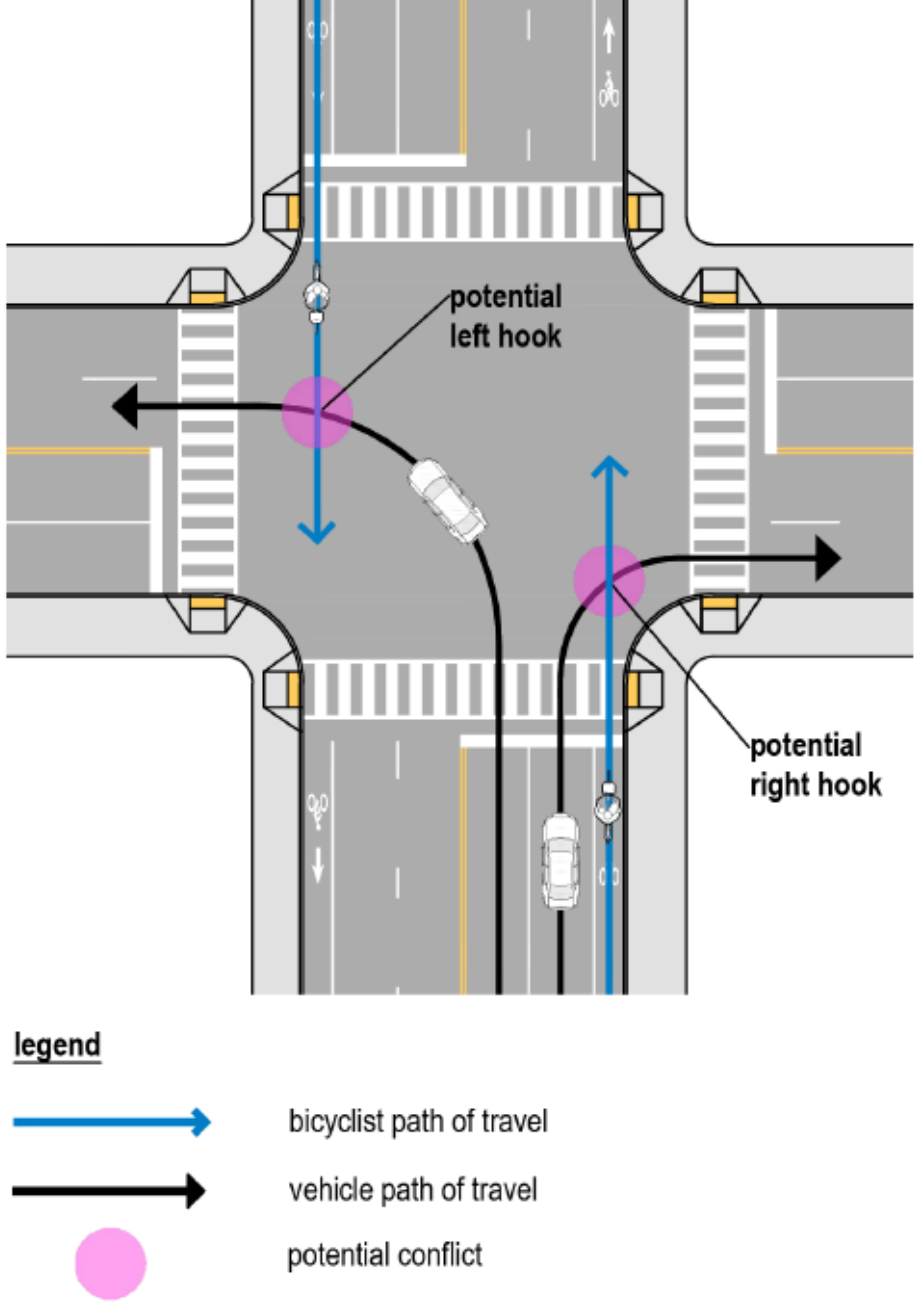


Figure 10-3: Left-Hook and Right-Hook Graphic

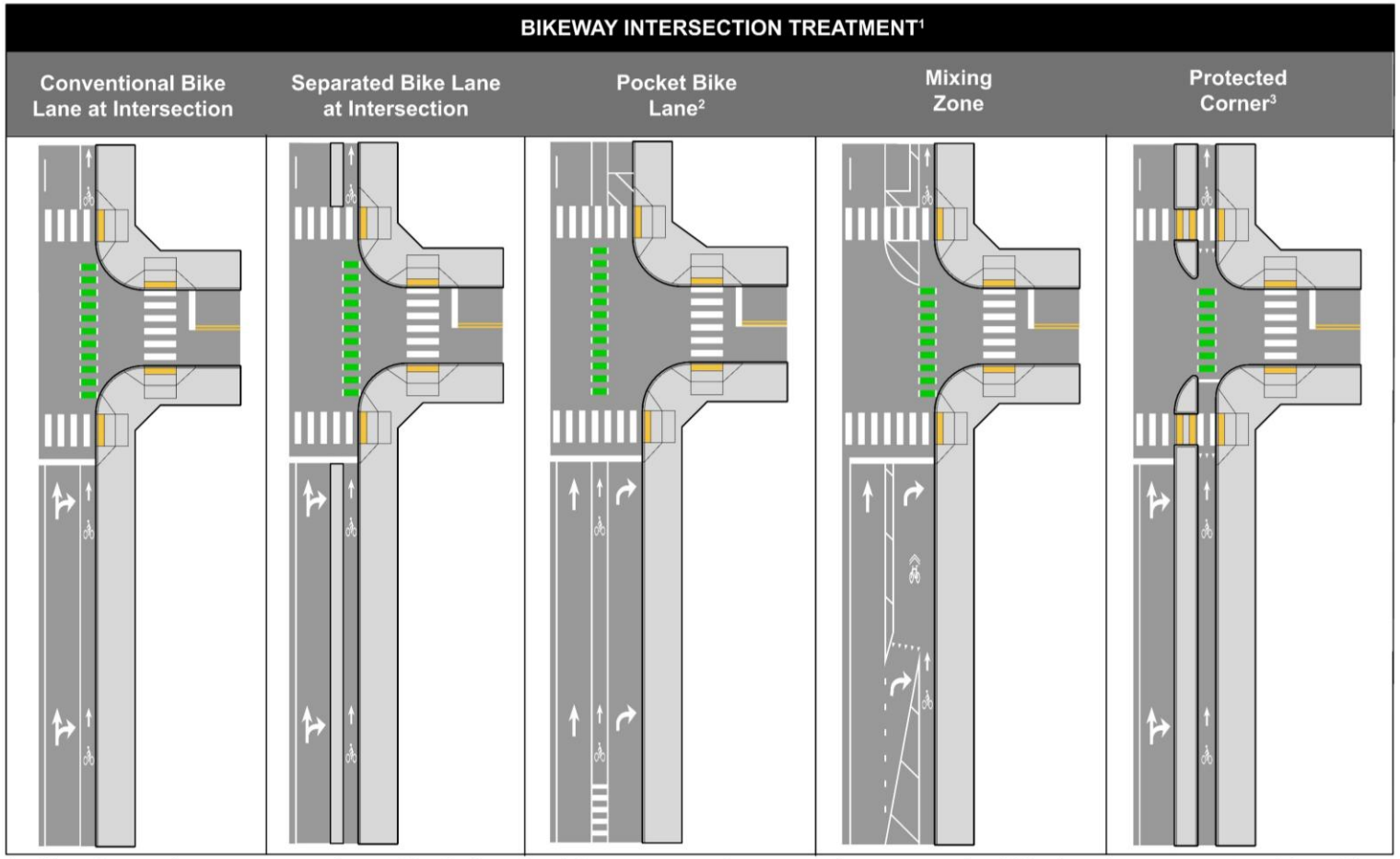
TOOLE DESIGN

NCHRP 15-73
Project Overview

Research Objective

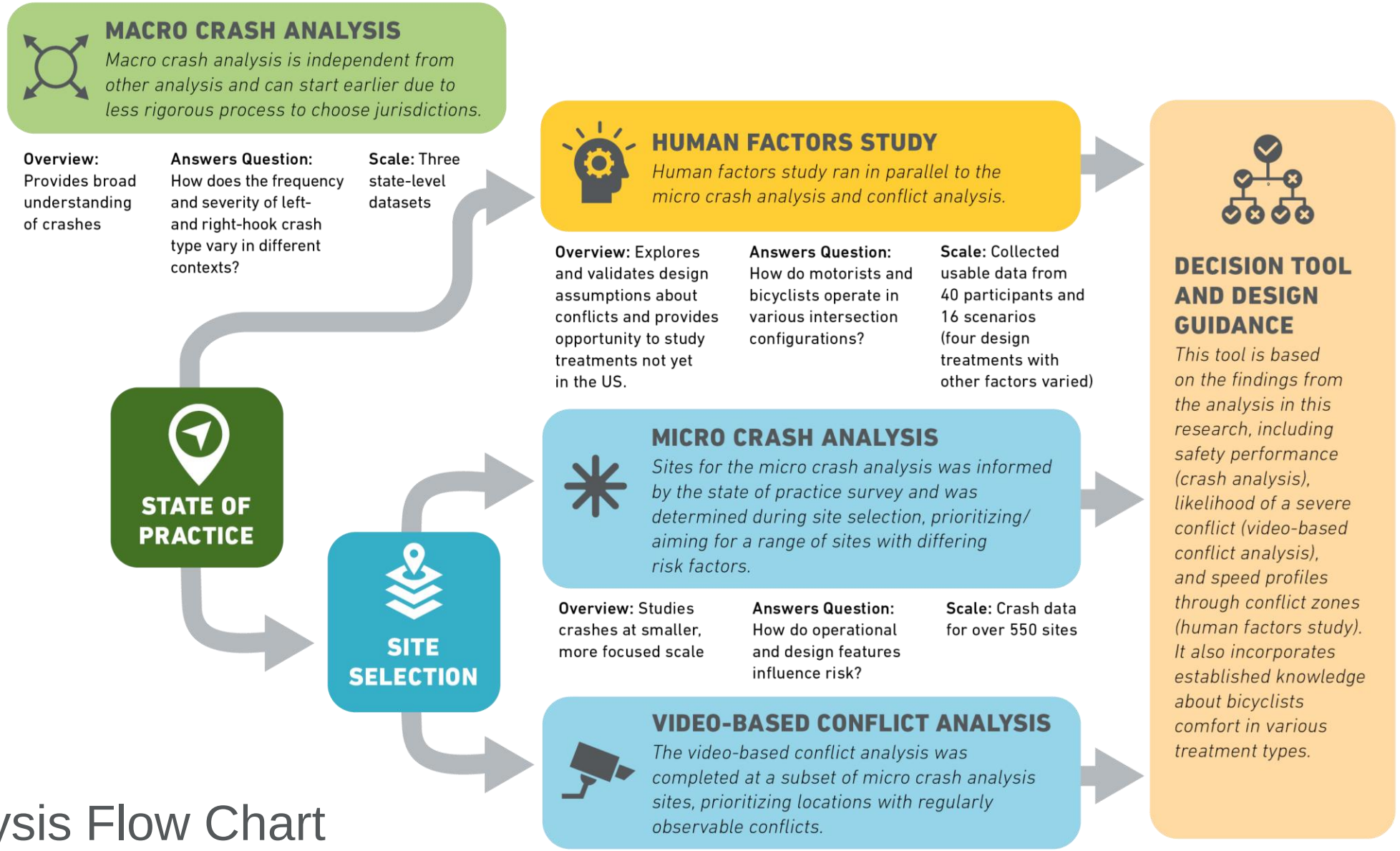
Develop tools and design guidance for transportation practitioners to use to reduce conflicts between turning motorists and bicyclists at controlled intersections.

Bikeway Intersection Treatments Studied



1. These intersection treatments can be combined with various bikeway types on the segment (e.g., a conventional bike lane along a segment could transition to a Protected Corner or it could transition to a Mixing Zone).
2. The Decision Tool and Design Guidance uses the term “Pocket Bike Lane” exclusively. Within in the body of the Final Report for NCHRP 15-73, the term “Pocket Bike Lane” and “Keyhole Bike Lane” are used interchangeably and refer to the same treatment.
3. The Decision Tool and Design Guidance uses the term “Protected Corner” exclusively, which refers to the treatment of one intersection approach with elements of a protected intersection. In the body of the Final Report for NCHRP 15-73, the terms “Protected Corner”, “Protected Intersection”, and “Offset Intersection” are used to refer to the same treatment.

TOOLE DESIGN



Portland State UNIVERSITY

Oregon State University

SAFE STREETS RESEARCH & CONSULTING

Task Analysis Flow Chart

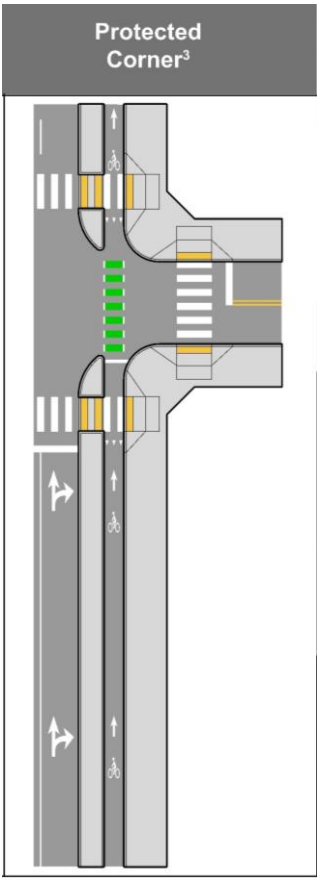
TOOLE DESIGN

Research Methods Overview

Methods	Scale	Strengths	Disadvantages
Micro-Crash Analysis	573 sites 233 crashes	• Direct measure of safety	• Observational method and rare events • Limited details of crash event actions • Variations in crash reporting • Needs accurate exposure information
Video-Based Conflict Analysis	28 sites 2,000+ hrs video 16k+ conflicts	• Detailed event-level data and many observations	• Observational method • Conflicts with VRUs harder to define consistently with metrics • Knowledge gap in correlation with crashes for VRUs
Human Factors Study (Simulator)	40 participants 640 turns ~8 hrs data	• Controlled experiment • Not limited to sites built • Detailed event and driver performance data	• Limited to drivers recruited to experiment • Challenge with translating performance measures to safety and design decisions • Practical limit on variables to explore

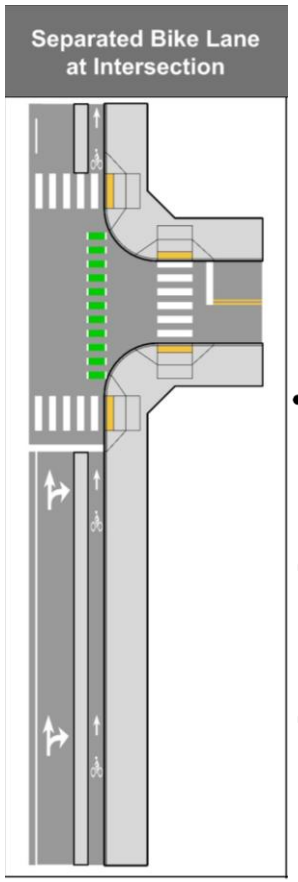
TOOLE DESIGN

Findings for Preferred Treatments



Protected corner are recommended for any locations where space can be reallocated to provide a protected corner.

- Middle crash rate in AUS, MSP, SEA* Lowest crash rate in NYC
- Similar number of conflicts as Mixing Zone
- Second lowest mean speed at conflict point
- People bicycling are the most comfortable with a Protected Corner



Separated bike lane treatment at the intersection is recommended where there is not space to provide a protected intersection.

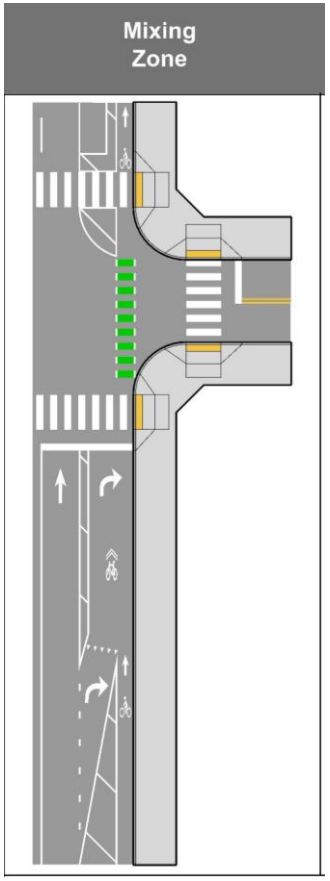
- Highest crash rate in AUS, MSP, SEA Second highest crash rate in NYC**
- Lowest predicted number of conflicts
- Moderate mean speeds at conflict point
- People bicycling are comfortable at intersections that maintain separation

TOOLE DESIGN

Limitation: small sample size

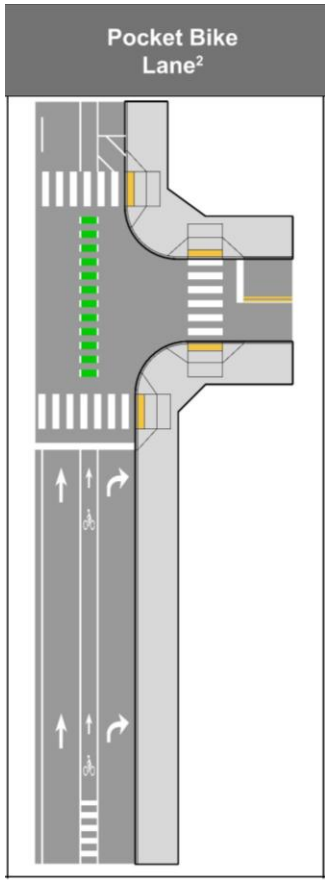
****Limitation: exposure models may not fully capture number of bicyclists using streets with these treatments***

Findings for Preferred Treatments



Mixing zones are only recommended where right-turning volumes are high (necessitating a right-turn lane) and there is not space to maintain a separated bike lane at the intersection.

- Lowest crash rates*
- Lowest predicted severe conflicts*
- Lowest mean speed at the conflict point
- People bicycling are the least comfortable in Pocket Bicycle Lanes and Mixing Zones



Pocket bike lanes are only recommended in limited situations and recommends a mixing zone rather than a pocket bike lane in most scenarios.

- Second lowest crash rate in AUS, SEA, MSP
- Lowest predicted number of conflicts
- Highest vehicles speeds at the conflict point
- People bicycling are the least comfortable in Pocket Bicycle Lanes and Mixing Zones

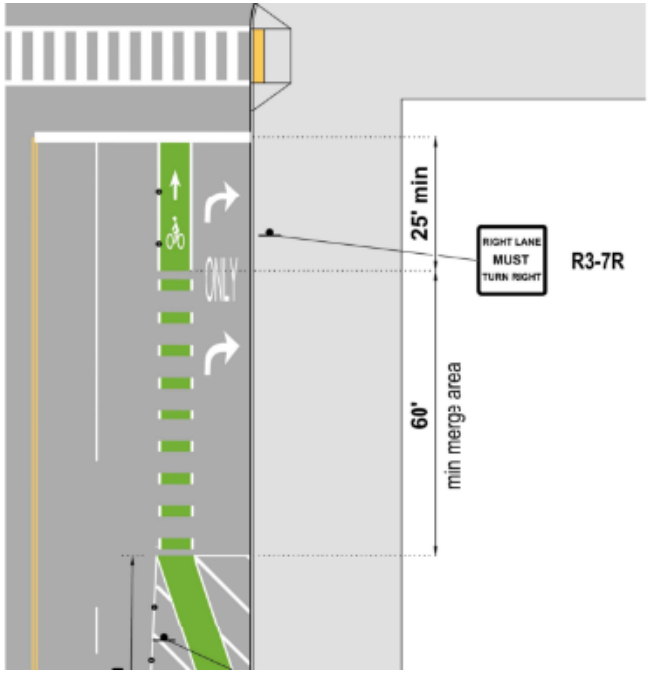
See NOTE on pocket bike lanes on next slide

TOOLE DESIGN

Limitation: likely highly-confident bicyclists are primary users, which may contribute to mixing zones having relatively good performance

A Note on Pocket Bike Lanes

- Pocket bike lanes in research had relatively longer right-turn lanes. Higher quality pocket bike lanes may have resulted in better safety performance.
- In locations where space is available, consider a pocket bike lane with a high-quality design, such as:
  - Short-turn lane (less than 150 feet)
  - Flex posts separating through lane from bike lane

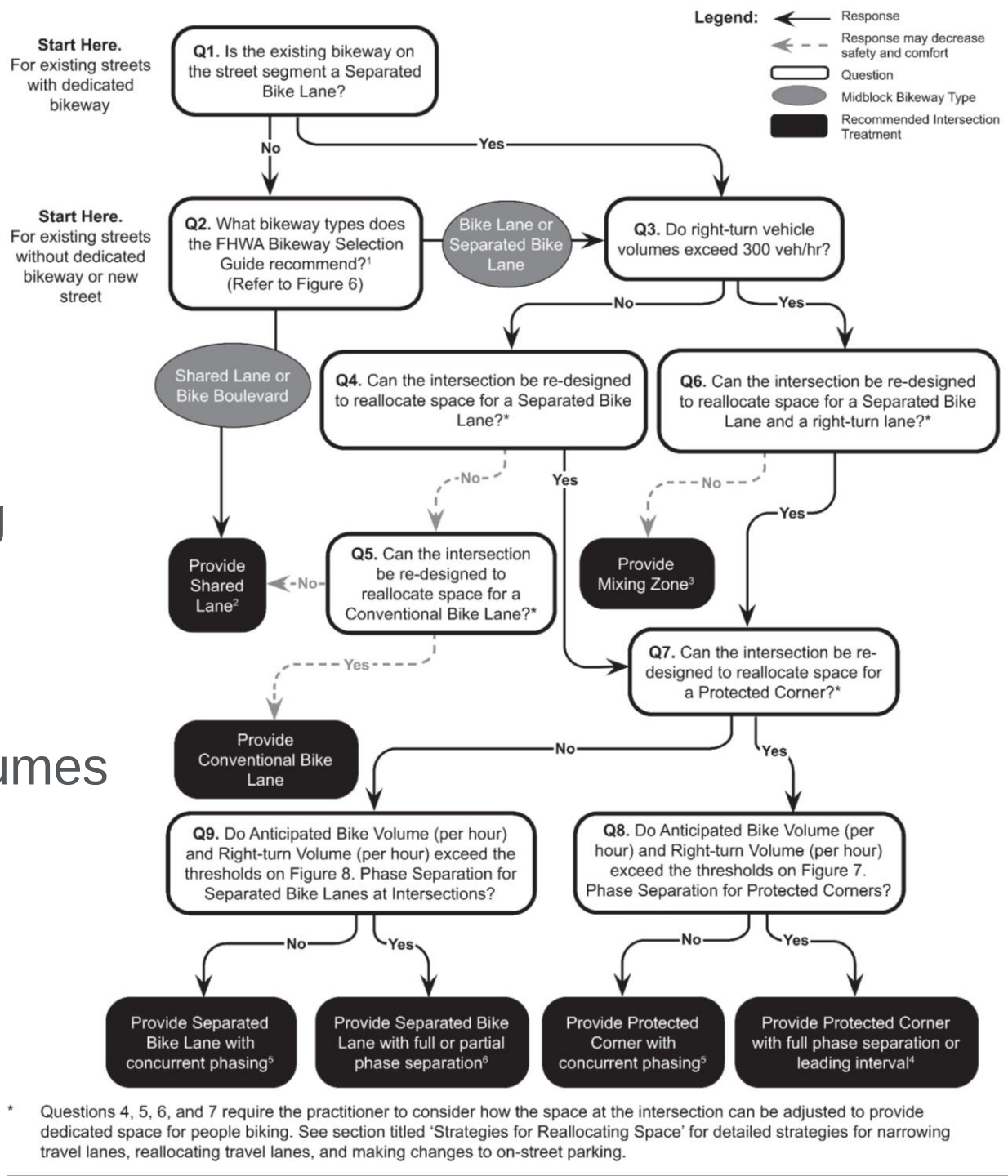


TOOLE DESIGN

Decision Tool

Data Needs

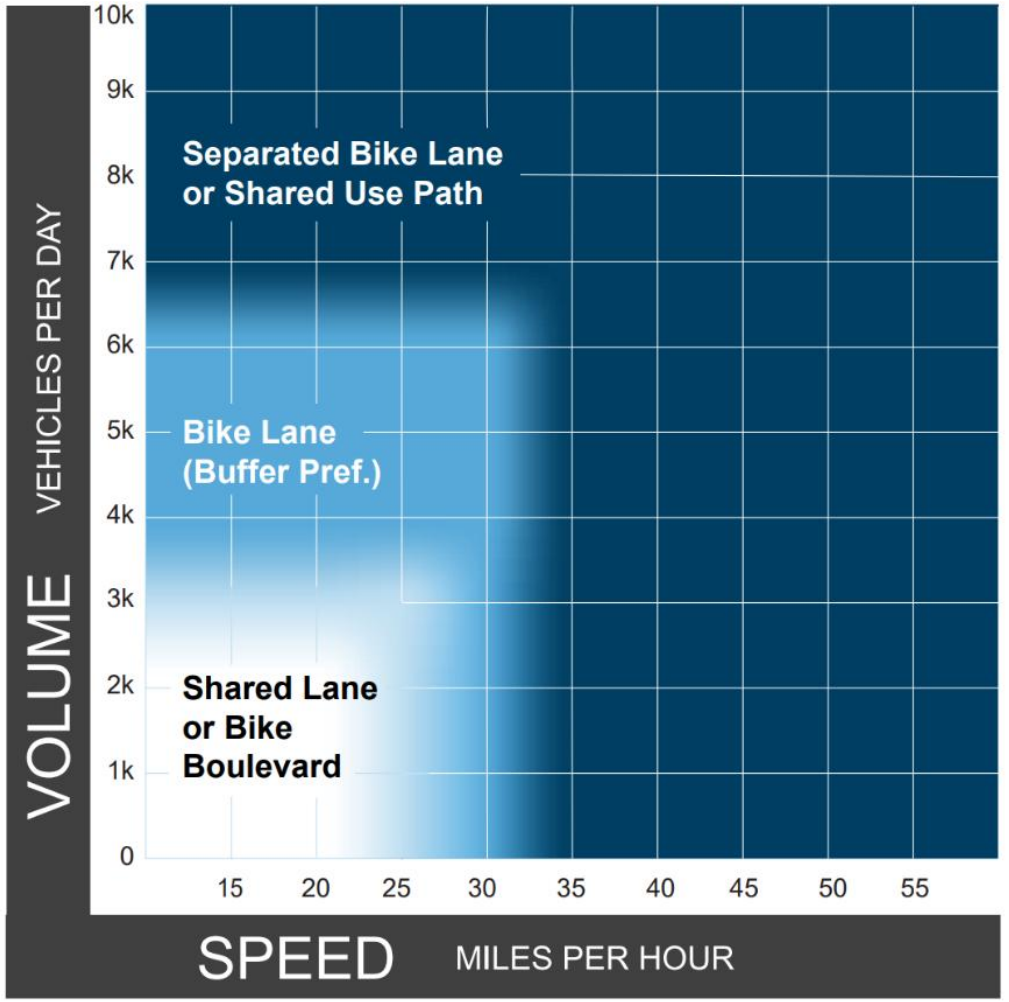
- Bikeway selection for the segment:
  - Motor vehicle daily volumes
  - Motor vehicle design speed/operating speed/target speed
- Intersection treatment selection:
  - Motor vehicle hourly right-turning volumes
  - Existing/anticipated hourly bicycle volumes



TOOLE DESIGN

Decision Tool

- Use Bikeway Selection Guide to determine preferred bikeway type on segment
- If a bike lane or separated bike lane is preferred, use decision tool to evaluate what type of intersection treatment is preferred to reduce turning conflicts between motor vehicles and bicyclists at controlled intersections



Notes

1 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.

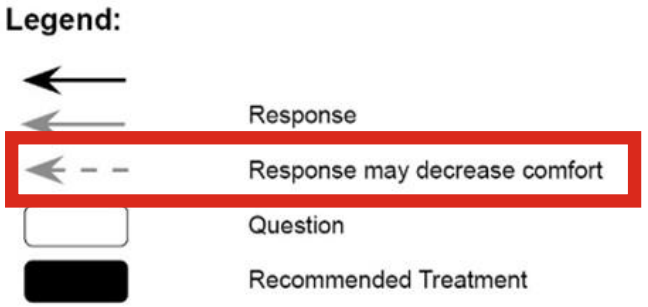
2 Advisory bike lanes may be an option where traffic volume is <3K ADT.

3 See page 32 for a discussion of alternatives if the preferred bikeway type is not feasible.

TOOLE DESIGN

Considering Bicycle Design Users in Design Decisions

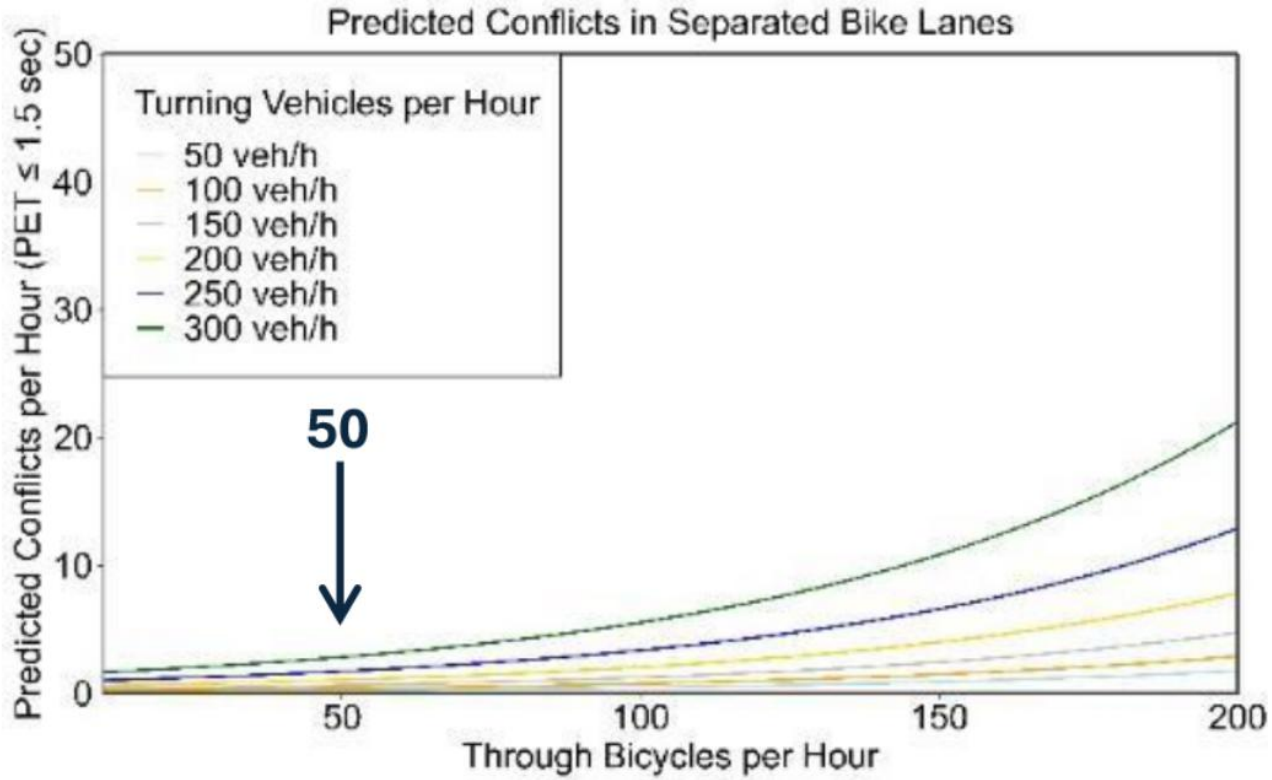
- Decision Tool is designed for Interested but Concerned Bicyclists; However, practitioners have the flexibility to choose designs to accommodate All Ages and Abilities. Thresholds in the decision tool can be considered minimums.
- Decision Tool includes:
  - Reference to NACTO's "Choosing an All Ages & Abilities Bicycle Facility"
  - Discussion on network and how community needs to determine their low-stress and/or All Ages and Abilities network



TOOLE DESIGN

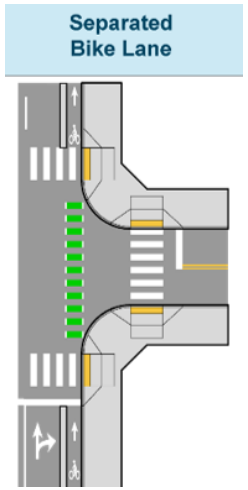
Likelihood of Severe Conflicts & Thresholds for Phase Separation

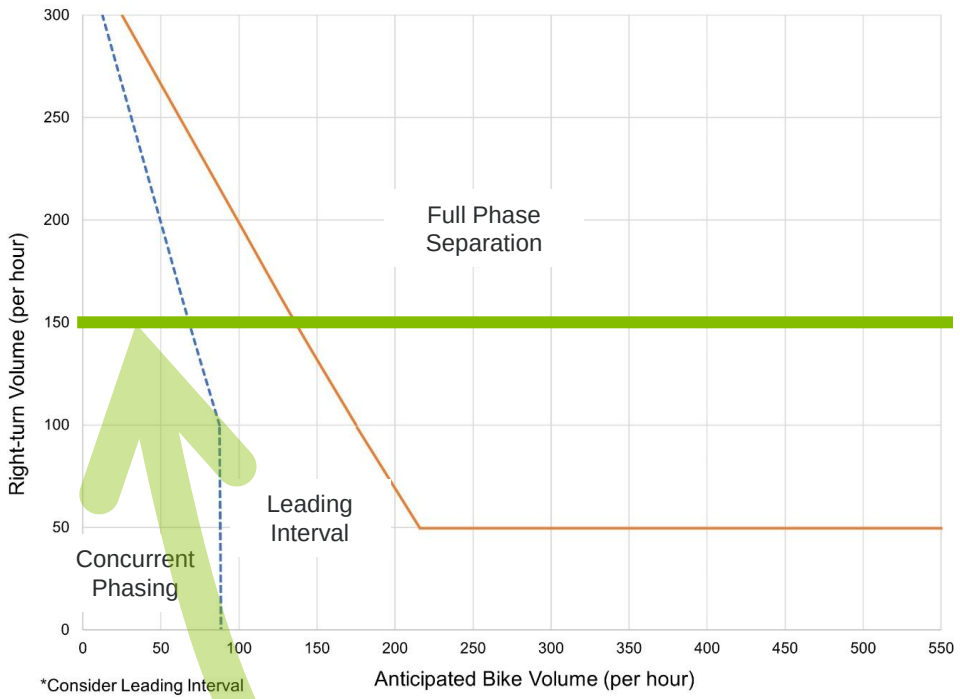
- Conflict analysis estimates number of severe conflicts based on vehicle volumes and bicycle volumes
- Decision Tool uses a threshold of two conflicts per hour to determine a minimum threshold for full phase separation

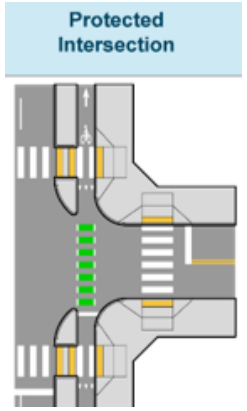


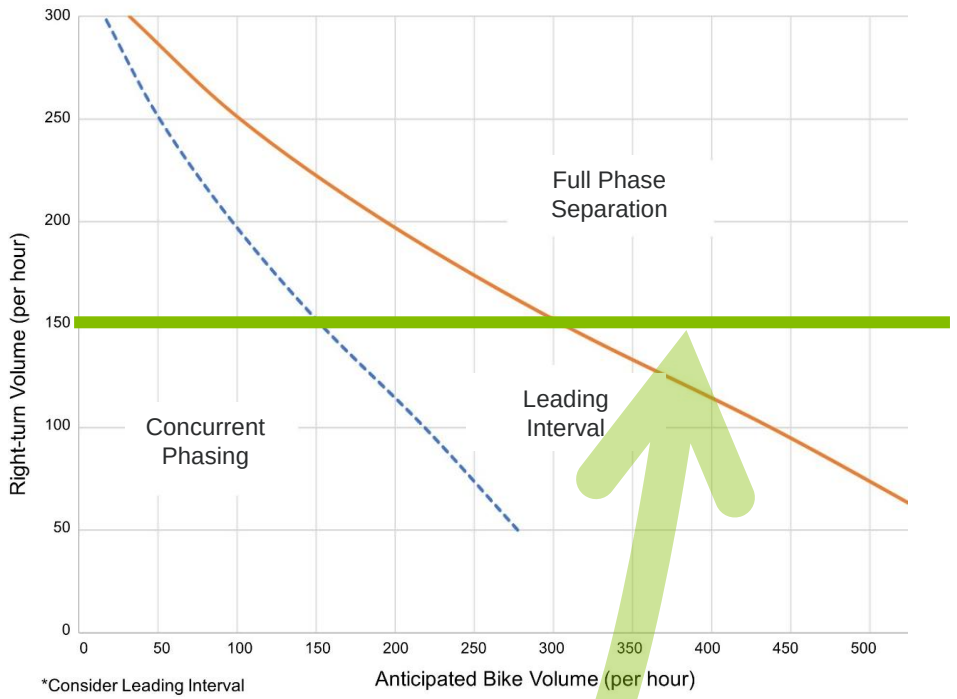
TOOLE DESIGN

Revised Thresholds for Phase Separation









Threshold from AASHTO is 150 vph regardless of intersection treatment and bicycle volume

TOOLE DESIGN

AASHTO Bike Guide

Traffic Signals and Pedestrian Hybrid Beacons

Chapter 10 – Traffic Signals and Pedestrian Hybrid Beacons

- 10.1 Introduction
- **10.2 Design Guidance for Traffic Signal Control**
- **10.3 Traffic Signal Phasing for Managing or Reducing Conflicts**
- **10.4 Traffic Signal Timing for Bicyclists**
- 10.5 Bicycle Signal Design Consideration
- 10.6 Detection for Bicycles
- 10.7 Design Guidance for Pedestrian Hybrid Beacons
- 10.8 Toucan Crossings with Traffic Signals

TOOLE DESIGN

AASHTO Section 10.2.4. Traffic Signal Indication Options for Bicyclists

- Bike signal head warrant:
  - Leading or protected phasing
  - Contra-flow movements
  - Signal heads beyond cone of vision
- Bike signal head application:
  - Can only be used without conflicting vehicle turns

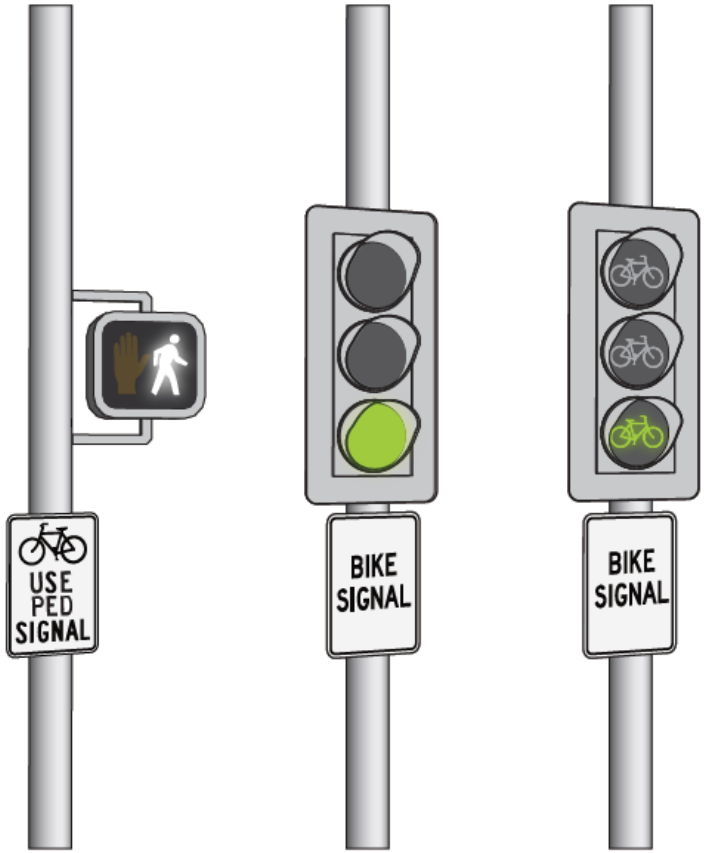
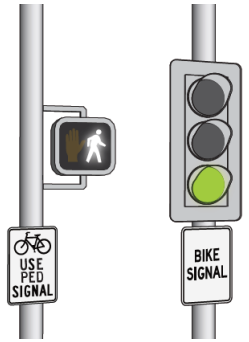


Figure 10-2: Examples of Signal Indication Options for Bicyclists

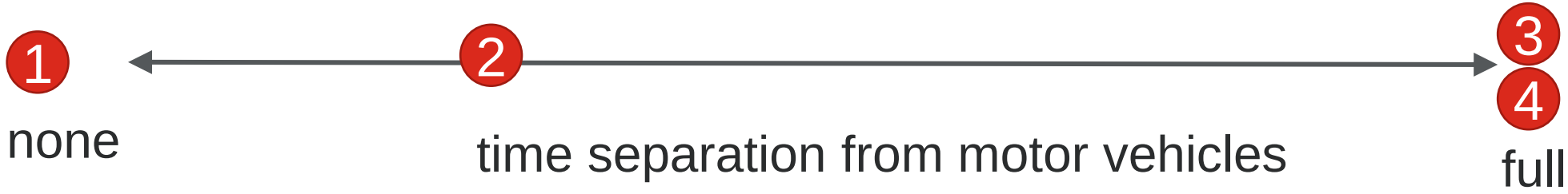
TOOLE DESIGN

AASHTO Section 10.3 Signal Phasing for Bicyclists



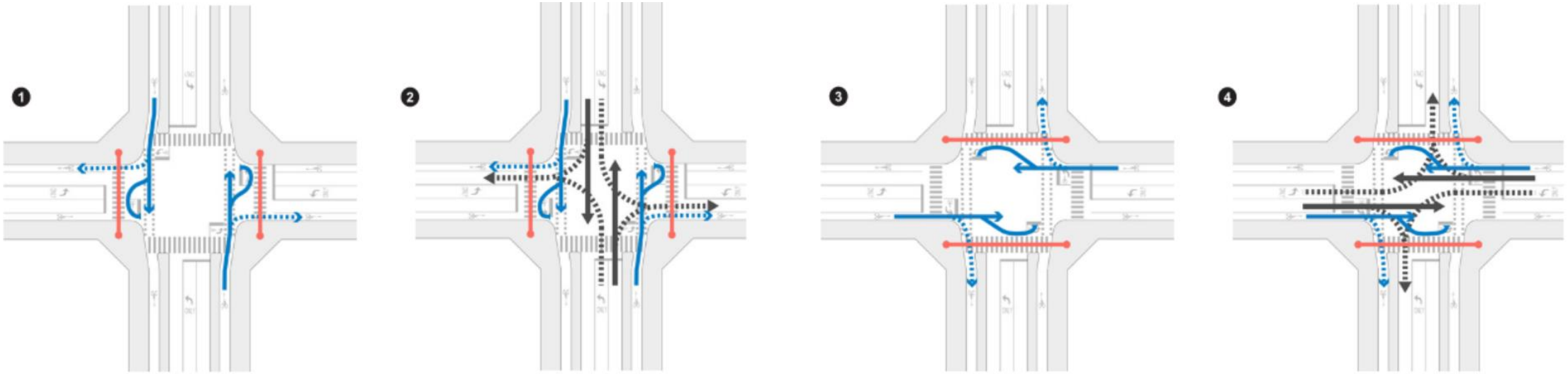
1. Bike phase with conflicting permissive vehicle turns
2. Leading bicycle interval

3. Bike phase with non-conflicting thru vehicle movement (no conflicts)
4. Protected bike phase: Bike phase on with no other vehicle movements

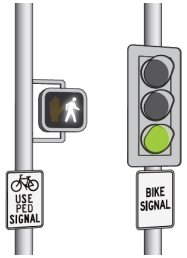


TOOLE DESIGN

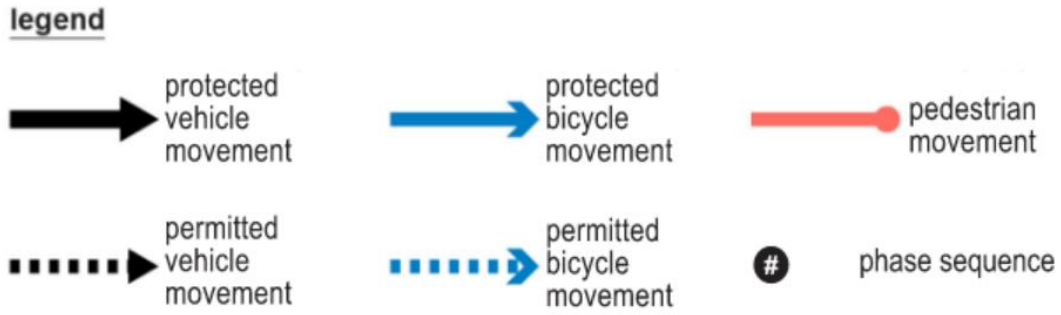
❷ Leading Bicycle Interval



Use this:

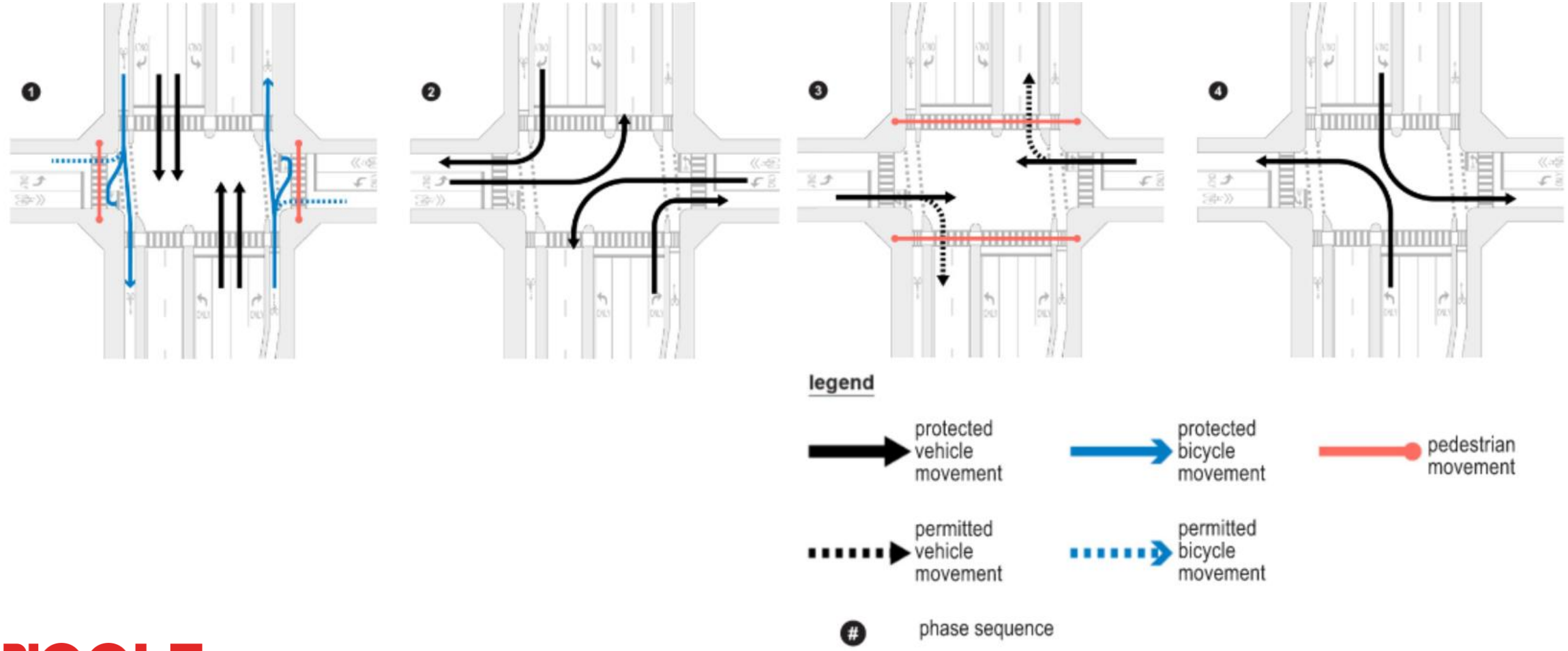


Or RTE with:



TOOLE DESIGN

❸ Protected Bicycle Phase



TOOLE DESIGN

❸ Protected Bicycle Phase

TOOLE DESIGN

4 Exclusive Bicycle Phase

TOOLE DESIGN

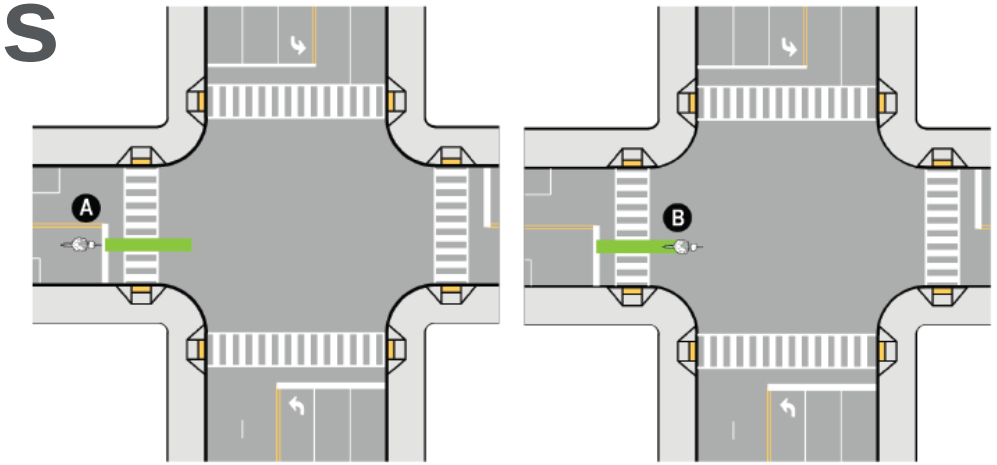
10.4.1.1 Green Time Intervals for Bicyclists

- Minimum green should be long enough for a bicyclist to travel halfway across the intersection so that the bicyclist is established in the intersection.

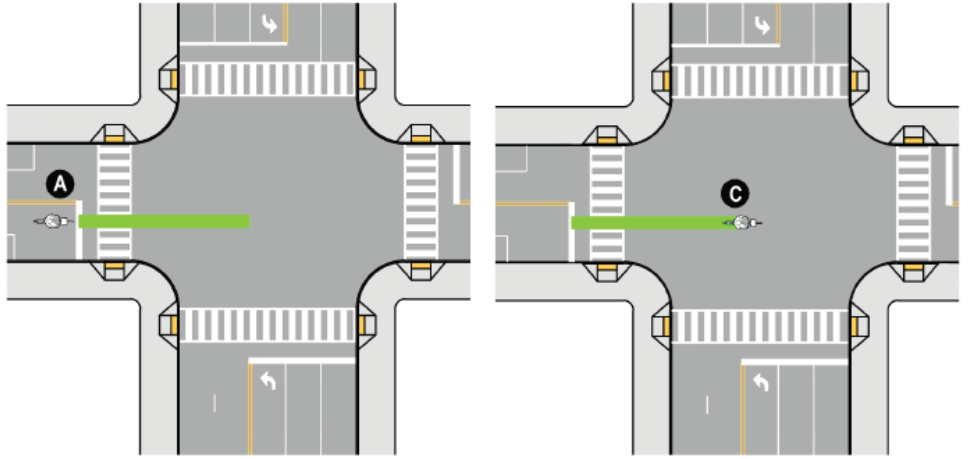
Table 10-2: Bicycle Minimum Green Time Equation

Bicycle Minimum Green Time Equation		
$G_{min} = t + \frac{1.47v}{2a} + \frac{d+L}{1.47v}$		
Where:		
G_{min}	=	bicycle minimum green time (s)
v	=	attained bicycle crossing speed (assumed 8 mph)
t	=	perception reaction time (generally 1.5 s)
a	=	bicycle acceleration (assumed 2.5 ft/s^2)
d	=	distance from stop bar to middle of the intersection (ft)
L	=	typical length of a bicycle (6 ft)

Bicycle Position with Vehicle Minimum Green Time



Bicycle Position with Bicycle Minimum Green Time



legend

- bicycle travel path during minimum green time
- A bicycle position waiting for green
- B bicycle position at end of vehicle minimum green
- C bicycle position at end of bicycle minimum green

TOOLE DESIGN

10.4.1.3 Clearance Intervals for Bicyclists

- Some red clearance always recommended
- A portion of the yellow change interval can be used to satisfy bicyclists clearance needs (see equation)

Table 10-5: Bicycle Red Clearance Equation

Bicycle Red Clearance		
$R_{bike} = \frac{D+L}{1.47v} + \left(t + \frac{1.47v}{2a}\right) - y$		
Where:		
D	=	width of intersection from stop bar to far side of travel lane
L	=	length of bike (6 ft)
v	=	speed of bicyclist (8 mph)
t	=	reaction time (1 sec)
a	=	bike deceleration (10 ft / s²)
y	=	vehicle yellow time

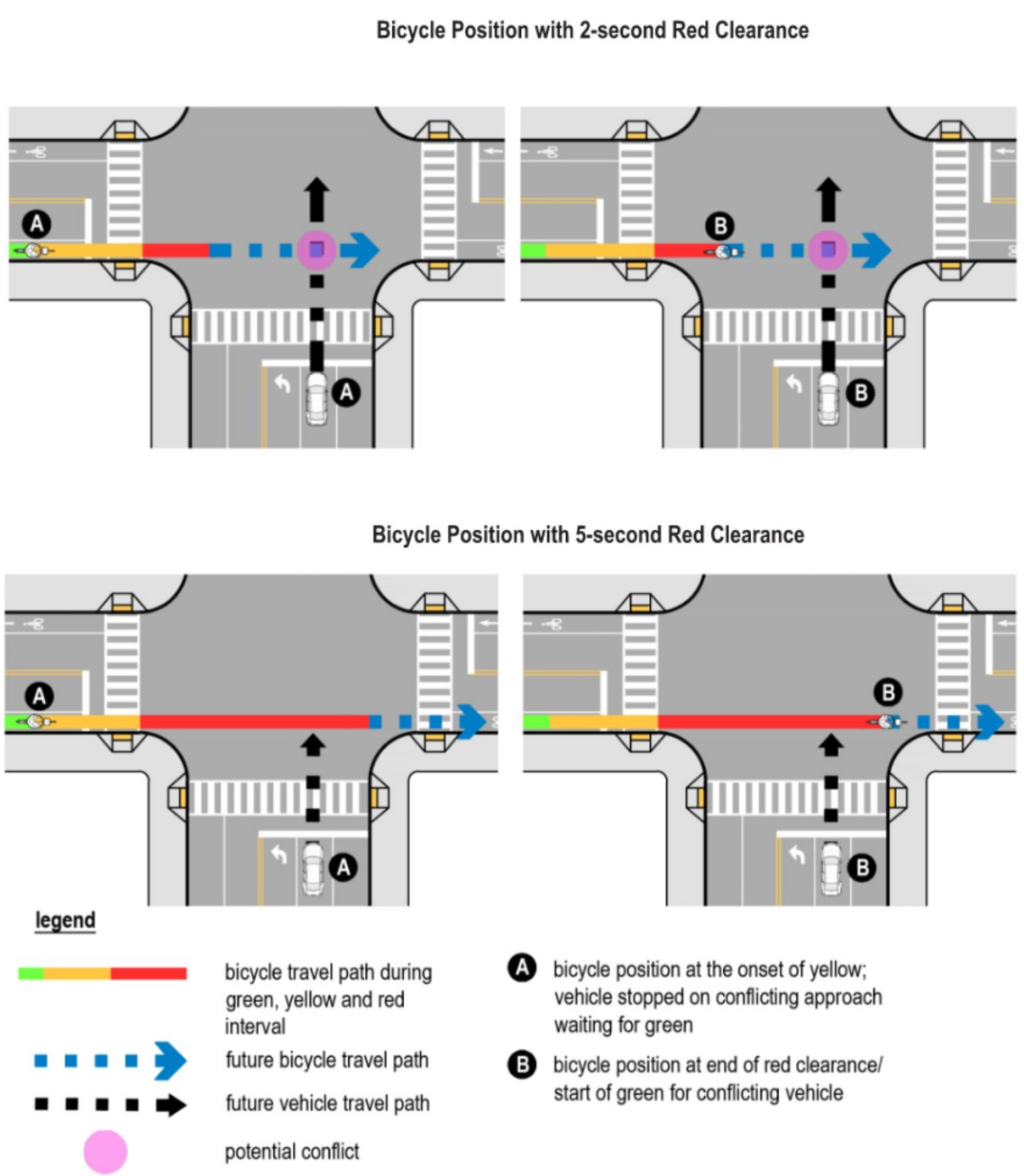


Figure 10-9: Bicycle Position During Red Clearance

TOOLE DESIGN

Thank you! Questions?

Tina Fink, PE, PTOE

Principal Transportation Engineer

cfink@tooledesign.com